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4 Source Assessment

TMDLs require an estimate of loadings from point and non-point sources, known as a source assessment. The results of the source assessment are used to gain an understanding of contributions of bacteria from various sources, which assists with development of wasteload and load allocations (**Section 6**) and the TMDL implementation strategy (**Section 7**). The challenge of identifying and quantifying potential bacteria sources in the Watershed is immense, as it is one of the most highly engineered in the world, with most of the LA River and tributary channels being concrete-lined, over 1,000 miles of connected storm drain infrastructure, and a population of more than 10-million people. Sources of bacteria to the LA River from the 834-square-mile watershed (Watershed) are ubiquitous and possibly include, but are not limited to, urban runoff, domestic pets, wildlife, leaks and overflows from wastewater collection systems, failing septic systems, soils, and sediments.

A comprehensive analysis of the potential sources of bacteria and pathogens in the Watershed was generated by the Cleaner Rivers though Effective Stakeholder-led TMDLs (CREST) stakeholder group, attached as **Appendix A**. The report is a combination of quantitative and qualitative analyses. The quantitative components analyze monitoring datasets from various agencies in the Watershed, which were compiled by CREST into a TMDL database (web link?). The qualitative components summarize available information for potential bacteria and pathogen sources in the Watershed whose discharges are not well characterized (e.g., industrial discharges, onsite wastewater treatment systems, etc.).

This section presents a summary of sources in the Watershed, an overview of the NPDES-permitted discharges, and a characterization of loadings from point and non-point sources. In addition, this section refers the reader to the appropriate sections of Appendix A for additional details and supporting information.

4.1 NPDES-permitted Discharges

Municipal, industrial, construction-related, and other discharges to surface waters are regulated by both Clean Water Act National Pollutant Discharge Elimination System (NPDES) permits and Porter-Cologne Water Quality Control Act Waste Discharge Requirements (WDRs). Combined NPDES/WDR permits are issued by the Regional Board for discharges to surface waters. This subsection describes the NPDES/WDR Permits for discharges in the Watershed.

4.1.1 Municipal Stormwater

Municipal stormwater is regulated, per the Clean Water Act, as a point source by the Regional Board. Three NPDES permits cover municipal separate storm sewer system (MS4) discharges within the Watershed (see **Table 4 - 1**): Los Angeles County, City of Long Beach, and Caltrans. A large majority of the urban areas of the Watershed are covered under the joint MS4 Permit for Los Angeles County. The current MS4 Permit for Los Angeles County permit was issued in 2001 by the Regional Board under Order No. 01-182, NPDES No. CAS004001. The total area covered includes approximately 3,100 square miles and serves a population of approximately 10 million (2000 census) within Los Angeles County and 84 incorporated cities including the City of Los Angeles. There are over 2,000 storm drain outfalls in the Watershed that may flow into receiving waters during wet weather. Hundreds of these outfalls likely flow during dry weather.

Stormwater discharges from the City of Long Beach are covered under a separate MS4 NPDES Permit (Order No. 99-060 NPDES No. CAS004003). The City of Long Beach serves a population of approximately 462,000 people in an area of approximately 50 square miles. Approximately 44% of the land area discharges to the Los Angeles River, 7% to the San Gabriel River, and the remaining 49% drains directly to Long Beach Harbor and San Pedro Bay.

The Caltrans MS4 permit is an individual, statewide Permit that is regulated by the various Regional Water Quality Control Boards (Order No. 99-06 NPDES No. CAS000003).

Table 4 - 1. Summary of Municipal Stormwater NPDES Permits in the LA River Watershed

Permittee	NPDES Permit Number	NPDES Permit Effective Date	Total Area Covered (sq. mi.)	Total Area Covered in Watershed (sq. mi.)	% of LA River Watershed
Los Angeles County (and 84 incorporated cities)	Order No. 01-82 CAS004001.	2001	3,100	801	96%
City of Long Beach	Order No. 99-060 CAS004003	1999	50	22	3%
Caltrans	Order No. 99-06 CAS000003	1999	136	11	1%

4.1.2 Municipal Wastewater

The Cities of Los Angeles, Burbank, and Glendale operate an integrated network of wastewater treatment facilities in the Watershed, which includes four water reclamation plants (WRPs), as follows:

- Donald C. Tillman Water Reclamation Plant (Tillman WRP)
- Los Angeles-Glendale Water Reclamation Plant (LA-Glendale WRP)
- Burbank Water Reclamation Plant (Burbank WRP)
- Hyperion Treatment Plant (Hyperion TP)

The Tillman WRP, LA-Glendale WRP, and Burbank WRP discharge Title 22 quality, tertiary-treated and disinfected municipal wastewater into waters of the Watershed (**Table 4 - 2**) [1]. The residual solid wastes generated at these upstream WRPs are conveyed in the sanitary sewer system to the Hyperion TP, which discharges into the Pacific Ocean (outside of the Watershed).

During dry weather, a majority of the flow in the LA River is comprised of tertiary-treated, disinfected effluent from WRPs. During a snapshot monitoring events by SCCWRP in 2000, it was reported that 72% of the flow discharged into the LA River was WRP effluent (Ackerman Ackerman et al., 2003). According to the LA River Metals TMDL, WRP mean monthly discharges total 70% to

[1] The processes and facilities of the Tillman, LA-Glendale, and Burbank WRPs are described in detail in **Section** 5.1.1 of Appendix A

nearly 100%[2] of the dry season monthly average flow in the LA River. Daily average WRP effluent discharge rates are shown in **Figure 4- 1**. The NPDES effluent limitations for WRPs require concentrations of total coliform in WRP effluent to be very low, with a 7-day median value of non-detect, or less than 2.2 MPN/100mL, as shown in **Table 4 - 2**. The following is a description of the WRP discharges[3]:

- **Tillman WRP –** discharges to Reach 4 of the LA River at a point located downstream of the Sepulveda Dam Spillway. In addition to the direct discharge to Reach 4, effluent is also conveyed to the following:
    - Japanese Garden (~8 cfs) adjacent to the WRP
    - Wildlife Lake (~10 cfs) which discharges to Haskell Flood Control Channel. During the summer months, the Wildlife Lake may be drained (for maintenance and to minimize nuisance resulting from mosquito breeding), resulting in increased discharge of treated effluent to Haskell Flood Control Channel up ~8 cfs.
    - Lake Balboa (~20 cfs), which discharges through weirs, spillways and a bottom drain to three outfalls at Bull Creek, Hayvenhurst Channel and the LA River (Reach 5). Bull Creek and Hayvenhurst Channel are tributaries to the LA River.
- **Burbank WRP** – discharges to Burbank Western Channel, tributary to the LA River, near Burbank Boulevard (~9 cfs). The WRP reclaims a significant portion of its effluent for irrigation and cooling water.
- **LAG WRP –** discharges to Reach 3 of the LA River downstream of Colorado Boulevard (~19 cfs). A significant portion of LAG WRP's treated wastewater is reclaimed.

Table 4 - 2. Summary of Municipal Wastewater Discharges in the LA River Watershed

Municipal Wastewater Reclamation Plant	NPDES Permit Number	NPDES Permit Adoption Date	Design Capacity (mgd)	Effluent Limitations for Total Coliform (MPN/100mL)	
				7-day Median	30-day Single Sample
Donald C. Tillman Water Reclamation Plant	CA0056227 R4-2006-0091	9/28/2006	80	<2.2	<23
Los Angeles-Glendale Water Reclamation Plant	CA0053953 R4-2006-0092	9/28/2006	20	<2.2	<23
Burbank Water Reclamation Plant	CA0055531 R4-2006-0085	12/29/2006	12.5	<2.2	<23

[2] The flow in Reach 6 of the LA River, which is upstream of WRP discharges, is perennial and therefore WRP effluent never makes up 100% of the flow in the LA River.

[3] The discharge locations for the upstream WRPs and their effluent discharge rates and bacteria concentrations are described in detail in Section 5.1.2 of Appendix A.

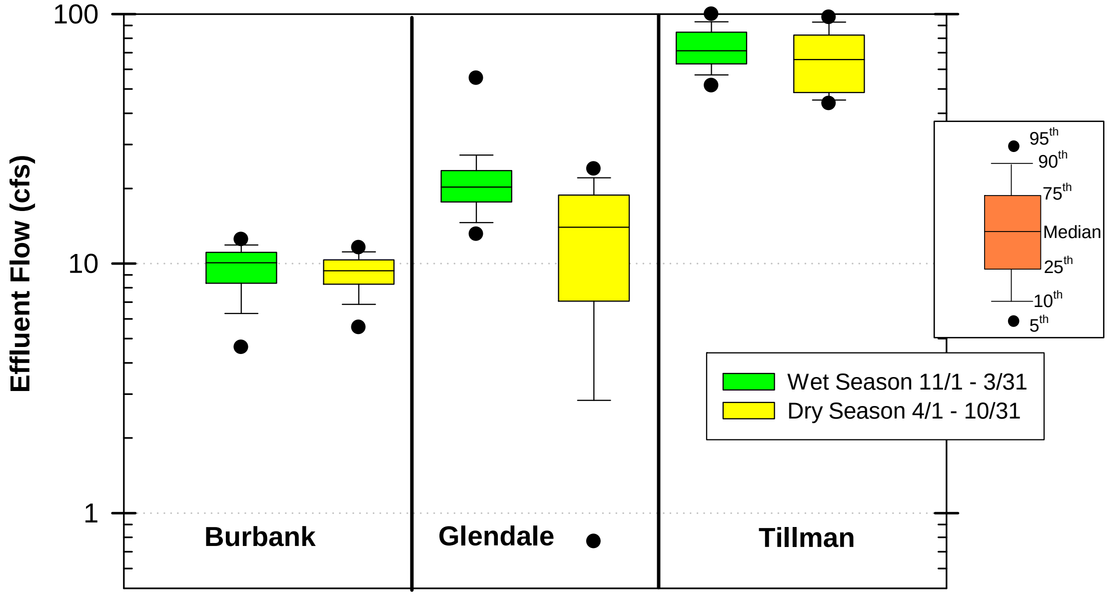

Figure 4- 1. WRP Daily Effluent Flow Rates by Dry and Wet Season

(Burbank: 1997-2008, Glendale: 1996-2007, Tillman: 1994-2007)

4.1.3 Industrial Stormwater

The industrial stormwater regulations require that stormwater discharges from industrial activity either directly to surface waters or indirectly through MS4s must be regulated by an NPDES permit. Industrial stormwater is regulated through California's statewide General Permit or individual permits. The statewide General Permit, issued by the State Water Resources Control Board (SWRCB) in November 1991, applies to all stormwater discharges requiring a permit except construction activity. As of November 2008, there are 2,929 industrial facilities enrolled under the industrial stormwater general permit program in the Los Angeles Region. An estimated 1,384 of these are in the Watershed.

A small subset of industrial stormwater discharges are regulated by individual permits. In general, the stormwater runoff from these facilities has the potential to mix with process waste water and materials (e.g., oil) and thus requires treatment prior to discharge. A total of eight such permits were identified for facilities within the Watershed (**Table 4-3**).

Table 4 - 3. Individual Permits in the Watershed for Industrial Stormwater[1]

Permittee	Facility	Location
Chevron U.S.A. Inc.	Van Nuys Terminal	Van Nuys, CA
Lubricating Specialties Co.	Pico Rivera, Oil Blending	8015 Paramount Blvd
Hexion Specialty Chemicals, Inc.	Hexion Specialty Chemicals, Inc.	2801 Lynwood Rd
Pabco Paper Products	Paperboard & Carton Mfg.	4460 Pacific Blvd
Metropolitan Transit Authority	Eastside Light Rail Trans Project	Altadena, CA 91001
BP West Coast Products LLC	East Hynes Facility	Alameda/Soto/Clarence
The Boeing Company	Santa Susana Field Lab	5800 Woolsey Canyon Rd
Los Angeles Turf Club	Santa Anita Park	285 W. Huntington Dr

1 – From http://www.waterboards.ca.gov/losangeles/board_decisions/adopted_orders/

4.1.4 Industrial Wastewater

There are a variety of industries in the Watershed that have NPDES permits to discharge industrial wastewater. Most of these discharges are for non-process wastewater (e.g., cooling water) regulated under the *General NPDES and Waste Discharge Requirements for Discharges of Nonprocess Wastewater to Surface Waters in Coastal Watersheds of Los Angeles and Ventura Counties*. This general permit includes effluent limitations that prohibit discharges that would cause WQO exceedances for fecal coliform or *E. coli*. However, indicator bacteria are not required as a component of the Monitoring and Reporting Program. There are approximately 40 industrial wastewater dischargers under this General Permit in the Watershed.

A subset of industrial wastewater discharges are regulated under individual permits; a total of seven NPDES permits for discharges of industrial wastewater were identified in the Watershed (**Table 4-4)** These discharges mostly include non-process wastewater, but a few include discharges of backwash water from drinking water treatment filters. The NPDES permit for Boeing includes an array of discharges, including wastewater treatment plants. None of the reviewed NPDES permits contained effluent monitoring requirements for indicator bacteria.

Overall, it seems industrial wastewater discharges have a low potential to be a significant source of indicator bacteria loading to the Watershed, but no monitoring data are available to support this hypothesis.

Table 4 - 4. Individual Permits in the Watershed for Industrial Wastewater Discharges[1]

Permittee	Facility	Location
Lincoln Avenue Water Co.	South Coulter Water Treatment	564 W. Harriet St
The Boeing Company	Santa Susana Field Lab	5800 Woolsey Canyon Rd
Owens-Brockway Glass Container	Glass Container Div, Vernon	2901 Fruitland Ave
Kaiser Aluminum Fabricated Products, LLC	Los Angeles, California Plant	6250 E. Bandini Blvd
Pacific Terminals, LLC	Dominguez Hills Tank Farm	2500 E. Victoria St

1 – From http://www.waterboards.ca.gov/losangeles/board_decisions/adopted_orders/

4.1.5 Non-Stormwater and Non-wastewater Discharges

There are an array of NPDES-permitted sources that potentially discharge to the Watershed other than wastewater and stormwater. Many of the discharges are related to one of the following:

- **Project Dewatering** – construction projects that require dewatering are regulated under the *General NPDES and Waste Discharge Requirements for Groundwater Discharges from Construction and Project Dewatering to Surface Waters in Coastal Watersheds of Los Angeles and Ventura Counties*
- **Potable Supply Well Discharges** – potable water supply wells that discharge are regulated under the *General NPDES and Waste Discharge Requirements for Discharges of Groundwater from Potable Water Supply Wells to Surface Waters in Coastal Watersheds of Los Angeles and Ventura Counties.*

In addition, there are NPDES permits for discharges from volatile organic compound and petroleum fuel cleanup sites, landfills, and other activities. The numbers of non-wastewater and non-stormwater NPDES permits currently found in the Watershed are listed in **Table 4-5**. These types of permits do not typically require monitoring for indicator bacteria and generally considered a minor source of bacteria to the Watershed.

Table 4 - 5. NPDES Permits in the Watershed for Non-Wastewater and Non-Stormwater Discharges[1]

Type of Permit	Number
Municipal Construction and Dewatering Projects	6
Municipal Miscellaneous Activiites	2
Construction and Project Dewatering	6
Petroleum Fuel Cleanup Sites	28
VOCs Cleanup Sites	2
Potable Water	48
Landfill Operations	2
Total	**94**

1 – From http://www.waterboards.ca.gov/losangeles/board_decisions/adopted_orders/

4.2 Loadings from Point Sources

This section describes available estimates of bacteria loading from major NPDES-permitted discharges (municipal wastewater and stormwater). Minor NPDES discharges (industrial wastewater, industrial stormwater, construction activities and other non-stormwater/non-wastewater inputs) are not considered to be a significant source of bacteria loading, particularly during dry weather. As such, loadings from these sources are not quantified.

4.2.1 Municipal Wastewater Effluent

The hypochlorite dosage at the three WRPs is adjusted to surpass the bacterial effluent limits codified in Title 22, California Code of Regulations (Table 4 - 2). The NPDES effluent limitations require median total coliform concentrations in WRP effluent to be non-detect (<2.2 MPN/100mL). Because disinfection results in very low bacteria concentrations, WRP effluent is a major component of the bacteria assimilative capacity in the LA River.

4.2.2 Municipal Wastewater Collections Systems

There is an extensive wastewater collection system within the Watershed[4]. Numerous maintenance programs are in place to prevent water quality impacts from collected wastewater. Multiple municipalities and agencies have responsibility for installing and maintaining collection system infrastructure. Each Enrollee maintains their own records with regard to the location and specific information (i.e., size, age, material type etc.) of the infrastructure within their jurisdiction. Nonetheless, wastewater collection systems can be a source of bacteria and pathogens to the Watershed – either due to aged/damaged infrastructure or via sanitary sewer overflows (SSOs).

Discharges of untreated wastewater are illegal and there is zero tolerance by the Regional Board for SSOs. Sanitary sewer system agencies covered under the Statewide General Waste Discharge Requirements for SSOs (WQO No. 2006-0003-DWA), referred to as Enrollees, are required to report all SSOs for which their agency has responsibility to the SWRCB's SSO database. As of January 2,

[4] See Section 5.1.3 of Appendix A for more details on wastewater collection systems in the Watershed.

2007, enrollees were required to begin reporting all SSOs through the California Integrated Water Quality Systems (CIWQS) website.

Untreated wastewater generally contains very high levels of human pathogens including viruses, protozoa, and pathogenic bacteria (Harwood et al., 2005). During the summer of 2007, the LA River Bacteria Source Identification (BSI) Study collected 12 samples of untreated wastewater from Tillman and LAG WRPs and nearly 100% of the collected sewage samples were positive for human adenovirus 40/41 (CREST, 2008)[5]. The *E. coli* loading rate from an SSO measured during the BSI Study[6] was more than 1,000 times the allowable in-stream loading along Reach 4. In addition, human adenovirus was detected in both samples from the SSO discharge.

Based on an analysis of the SSOs reported to CIWQS, there were a total of 359 SSOs that occurred in the Watershed between September 14, 2006 and August 24, 2008.[7] These SSOs released approximately 535,866 gallons of sewage on 265 unique days (out of 711 total days in period of record). An estimated 371,410 gallons (69%) was reported to have reached surface water, which would eventually include the LA River either through a storm drain or a tributary, as shown in **Figure 4-2**. The reported SSOs that reached surface waters, grouped by estimated volume, are also tabulated in **Figure 4-2**.

Discharges from SSOs are episodic, with large instantaneous loading rates. Over longer time scales, however, SSOs appear to be a minor contributor to the total bacteria discharged from the Watershed. To assess the relative magnitude of *E. coli* loading from SSOs on an annual basis, the estimates above can be used, as follows:

- **Wet season –** loading from SSOs on an annual basis is small when compared to discharges during winter storm events. In fact, the *E. coli* load discharged from the LA River over the course of a single storm event (e.g., 2/2/2004 at Wardlow Road; 1.52×10^{15} MPN) was nearly 100x greater than the estimated loading from all 87 SSOs reported during the entire year of 2007. While SSOs are a human source-of-concern, this comparison to storm characteristics suggests that sewage is a minor component of indicator bacteria loading during LA River storm events.
- **Dry season–** a simple approach can be used to compare the SSO loading to all loading from the Watershed. The dry weather flow rate at Wardlow Road is approximately 120 cfs, and the median concentration of *E. coli* at Willow Street (which is near Wardlow Road) is approximately 1,000 MPN/100mL. Thus, a rough estimate of dry weather loading from the Watershed is 3×10^{12} MPN/day. To evaluate the role of SSOs in terms of dry season loading, a comparison can be made to the SSO loading between February and October 2007, which is approximately 2×10^{13} MPN of *E. coli*. This period includes 272 days, for an estimated total dry season load of 8×10^{14} MPN of *E. coli* from the mouth of the Watershed. Thus the estimated component of *E. coli* loading from SSOs is 2% of the estimated total dry season load.

In addition to SSOs, wastewater collection systems may affect LA River waterbodies via discharges to the subsurface. That is, there is potential for leaking wastewater infrastructure to

[5] See Section 5.1.3.1 of Appendix A for details on traditional indicator, alternative indicator, and pathogen concentrations in untreated wastewater.
[6] An SSO was observed to occur along Reach 4 through outfall R4-T during Events 5 and 6.
[7] See section 5.1.3.3.1 of Appendix A for an analysis of the SSOs (and methods) reported between 9/14/06 and 8/24/08.

discharge through the subsurface either directly into nearby waters or into conveyances (e.g., storm drains). However, there is little information regarding relative impacts of leaking sewer infrastructure in the Watershed. Influences of leaking wastewater collection systems are addressed by routine inspections including closed-circuit television (CCTV) inspections by wastewater agencies. The CCTV programs are ongoing, regularly monitoring the condition of the collection systems in a step-by-step process of televising, reviewing, ranking and reporting. In addition, potential wastewater influences are addressed by MS4 programs to detect illicit discharges and illicit connections to storm drain infrastructure, which is one of the six minimum control measures of MS4 NPDES Permits.

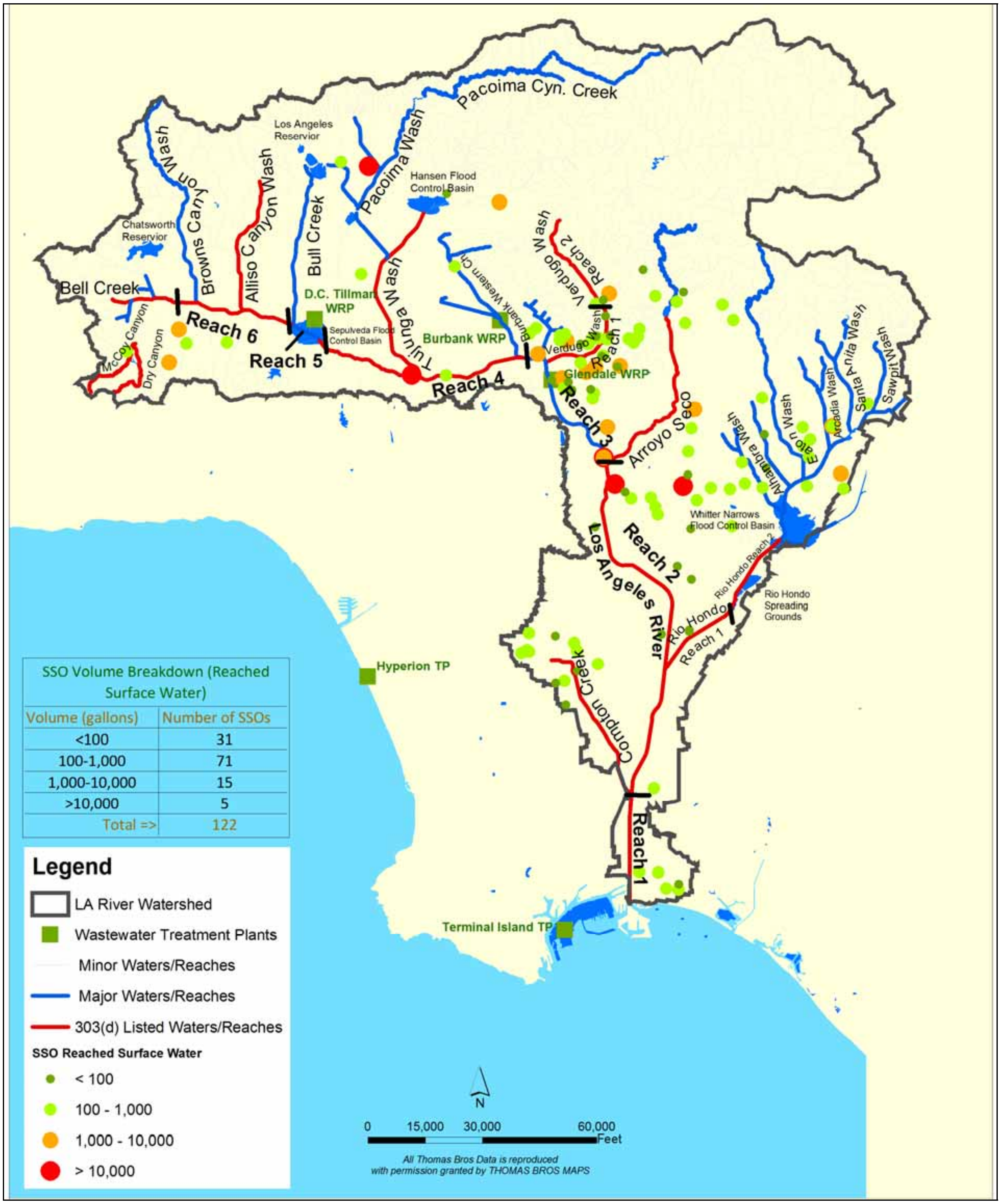

Figure 4-2. SSOs Reported to Reach Surface Water in the Los Angeles River Watershed between 9/2006 and 8/2008

4.2.3 Storm Drain Discharges

A myriad of bacteria sources are present in the Watershed and can potentially degrade the quality of storm drain discharges, including sewage sources[8], homeless persons[9], domestic pets[10], food waste[11], trash[12], horses[13], wildlife[14], illicit discharges, sediment[15], and regrowth[16]. At least 2,000 storm drain outfalls are connected to the LA River and its tributaries, and hundreds of these likely flow during dry weather. The large impervious areas of the Watershed can generate enormous volumes of stormwater, with extreme values approaching 50,000 cfs near the mouth of the Watershed[17]. However, rainfall in the arid Watershed is generally limited to the months of November through April, and even during the wet season, storm events are relatively rare. On average, approximately 315 days each year are categorized as dry weather[18] (<0.1 inches of rainfall). Thus the LA River and tributaries are usually at baseflow. Baseflow in Reaches 1 through 5 of the LA River is predominantly WRP effluent (~85%), with the remaining flow from storm drain discharges and exfiltrated groundwater[19]. For Reach 6 and all tributaries, baseflows are entirely exfiltrated groundwater and storm drain discharges. The one exception is Burbank Western Channel, which receives effluent from Burbank WRP.

4.2.3.1 Dry Weather Storm Drain Discharges

During dry weather (i.e., absent of rainfall runoff), storm drain discharges from MS4s include runoff from domestic and commercial water uses (e.g., landscape irrigation, car washing, etc.). Industrial facilities and schools can also discharge into the MS4 system. In addition, groundwater can exfiltrate into storm drain infrastructure, particularly for outfalls with large drainage areas. Finally, though MS4 Permittees have programs to identify and eliminate illicit discharges and illegal connections (ID/ICs), these illegal inputs can also be discharged into and then ultimately from storm drains. Together, all of these sources comprise the "storm drain discharges" from outfalls along the LA River[20]. Note this section focuses on the MS4s as a source from the viewpoint of *discharges from outfalls*. A large number of sources can be responsible for the bacteria in these discharges.

While most of the dry weather flow in the LA River is WRP effluent, the total loading of bacteria to the LA River by WRPs is very small (non-detect) compared to discharges from storm drains. In the case of storm drain discharges, however, the median bacteria concentration is approximately 1,000 MPN/100mL, with maximum values >1 million MPN/100mL (**Figure 4- 3**). The SCCWRP snapshot

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[8] See Section 5.1 and 5.2 of Appendix A for assessment of bacteria inputs from municipal wastewater and onsite wastewater treatment systems.

[9] See Section 6.1 of Appendix A for assessment of bacteria inputs from homeless persons.

[10] See Section 6.2 of Appendix A for assessment of bacteria inputs from dogs and cats.

[11] See Section 6.3 of Appendix A for assessment of bacteria inputs from food waste.

[12] See Section 6.3 of Appendix A for assessment of bacteria inputs from trash.

[13] See Section 6.4 of Appendix A for assessment of bacteria inputs from equestrian activities.

[14] See Section 6.5 of Appendix A for assessment of bacteria inputs from wildlife.

[15] See Section 2.2.1.2.1 of Appendix A for assessment of bacteria inputs from sediment

[16] See Section 2.2.1.2 of Appendix A for assessment of bacteria inputs from regrowth

[17] See Section 4.1.1 of Appendix A for an analysis of historic daily average flow rates in the LA River and several tributaries.

[18] See Section 3.2 of Appendix A for an analysis of historic rainfall in the Watershed

[19] See Section 4.1.2 of Appendix A for graphs of dry weather LA River flow rates that show the influence of WRP discharges.

[20] See Section 8.3.2 of Appendix A for a detailed analysis of dry weather storm drain emissions, including flow rates (8.3.2.2) and traditional indicator bacteria (8.3.2.3), alternative indicator bacteria (8.3.2.4) and human virus (8.3.2.5) concentrations and loading rates.

in 2000 reported that storm drain and tributary discharges made up less than 30% of the measured flow discharged from point sources to the LA River but nearly 90% of the measured bacteria loading from point sources (Ackerman et al., 2003). The *E. coli* loading from individual storm drain outfalls during dry weather can vary over 11 orders of magnitude, from 10^{-5} to 10^{6} billions of MPN per day (**Figure 4-4**). In some cases, the *E. coli* loading from a single outfall with very low flow rates (e.g., ~0.1 cfs) can exhibit loading rates much greater than those measured in the LA River, even though the LA River might have 1000 times more flow (e.g., ~100 cfs).

During the BSI Study (CREST, 2008), the loading rates of *E. coli* from all storm drain discharges were found to exceed the assimilative capacity of Reach 2 and 4 of the LA River[21], which would contribute to WQO exceedances. Surprisingly, while the dry weather loading rates from individual outfalls along Reach 2 and 4 were highly variable, the total *E. coli* loading from all outfalls along each reach (e.g., from approximately 40 outfalls along Reach 2) was relatively steady from event-to-event.[22]

4.2.3.1.1 *Sources of Bacteria to Dry Weather Storm Drain Discharges*

Attempts to characterize sources of bacteria to storm drain discharges have had mixed results[23]. During the BSI Study, approximately 50% of the sampled storm drain discharges were positive for human fecal contamination, based on measurements of human *Bacteroidales* (using methods described in Kildare et al., 2007)[24]. However, many of these positive samples exhibited very low levels of human *Bacteroidales*, near background levels found in field blanks (<10 gc/mL). Furthermore, while storm drain discharge samples with exceptionally high concentrations of human-specific *Bacteroidales* also exhibited high levels of *E. coli*, the inverse was not true[25]. Many samples with exceptionally high concentrations of *E. coli* (greater than 1 million MPN/100mL) were negative for human fecal contamination, suggesting the non-human inputs can be important sources of bacteria to storm drain discharges. In addition, human viruses – a pathogen-of-concern for recreational waters (Fong and Lipp, 2005) – were detected in 6% of collected runoff samples, compared to 100% of sewage samples (CREST, 2008).

The BSI Study employed a Weight of Evidence (WOE) Approach to highlight the “most problematic” storm drain outfalls along Reach 2 and 4[26]. The results – based on universal *Bacteroidales*, human *Bacteroidales*, *Enterococcus*, *E.coli* and adenovirus – can be used to identify outfalls with high levels of both traditional indicator bacteria and human-specific fecal discharges. Outfalls with these types of discharges could be prioritized by stakeholders for early TMDL implementation actions.

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[21] See Section 4.1.2.1 of Appendix A for a mass balance analysis of dry weather *E. coli* loading to Reach 2 and 4 of the LA River.
[22] See Section 8.3.2.3 for an analysis of total dry weather loading rates from Reach 2 and 4 storm drain discharges.
[23] See Section 2.1 of Appendix A for a discussion of using measurements of traditional indicators, alternative indicators (e.g., *Bacteroidales*), and pathogens to identify sources of bacteria and potential health risks in dry weather runoff.
[24] See Section 8.3.2.4 and 8.3.2.5 for analyses of human fecal contamination in dry weather storm drain discharges
[25] See Section 8.3.2.7.5 of Appendix A for analyses of human *Bacteroidales* versus *E. coli* in dry weather storm drain discharges.
[26] See Section 8.2.3.6 of Appendix A for a detailed description of the BSI Study Weight of Evidence Approach.

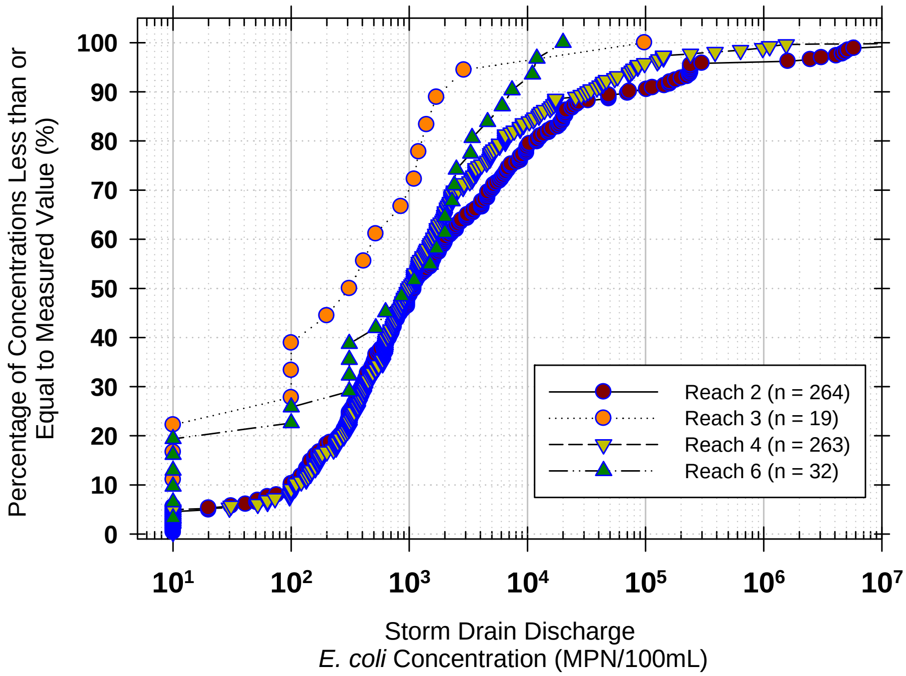

Figure 4- 3. Dry Weather Storm Drain Discharge *E. coli* Concentrations

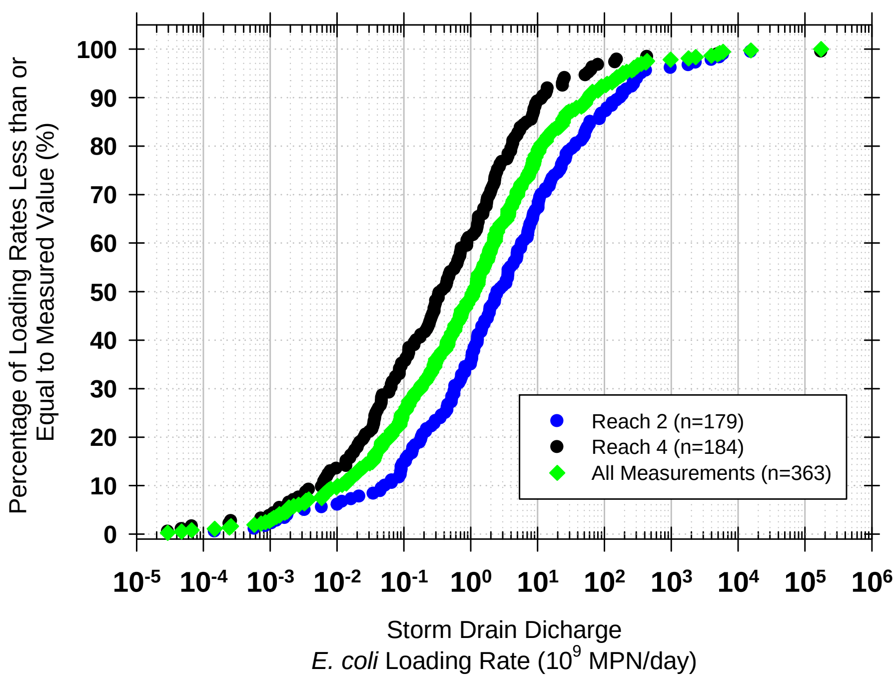

Figure 4- 4. Instantaneous *E. coli* Loading Rates from Dry Weather Storm Drain Discharges

4.2.3.2 Wet Weather Storm Drain Discharges

The onset of rainfall events drastically changes the water quality conditions of the mainstem LA River. While dry weather flows in the LA River are approximately 85% WRP effluent, during storm events flows in the LA River are often less than 1% WRP effluent. Monitoring of storm drain discharges during wet weather is a challenge, as direct access to the outfalls is normally not possible due to dangerous conditions. Annually, approximately 50 wet days occur, with approximately 13 of these having rainfall depths sufficient for suspension of recreational uses in portions of the Watershed per the High Flow Suspension Basin Plan Amendment[27].

The only available wet weather urban runoff dataset for the Watershed was collected by SCCWRP over five wet seasons from 2000-2005 (Stein et al., 2007). Eight land uses, from high density residential to open space were sampled[28] (**Figure 4-5**). The results highlight the magnitude of the wet weather bacteria problem in the Watershed, as follows:

- All land uses exhibited event mean concentrations (EMCs) at least an order of magnitude (10x) greater than the single sample maximum (SSM) water quality objectives (WQOs).
- Over 80% of the samples from all land use sites exhibited concentrations above the *E. coli* SSM WQO for fresh receiving waters (235MPN/100mL).
- Open space had a median fecal coliform concentration greater than 5,000 MPN/100mL and a maximum value greater than 24,000 MPN/100mL. Similarly, the total number of *E. coli* discharged per acre (the "flux") was similar among open space and developed land uses.
- *E. coli* and *Enterococcus* concentrations in many of the land use runoff samples were as high as found in untreated wastewater, 10^6-10^7 MPN/100mL.
- *E. coli* concentrations from the horse recreation land use site were the highest, significantly higher than all of the other land use categories. There were no statistical differences in *E. coli* concentrations among other land use sites.

Overall, the SCCWRP land use data support a hypothesis that wet weather runoff from all land uses exhibits *E. coli* concentrations well above the WQOs.

[27] See Section 3.2 of Appendix A for an analysis of historic rainfall in the Watershed
[28] Some land use sites were outside of the Watershed, but are still considered representative of Watershed conditions.

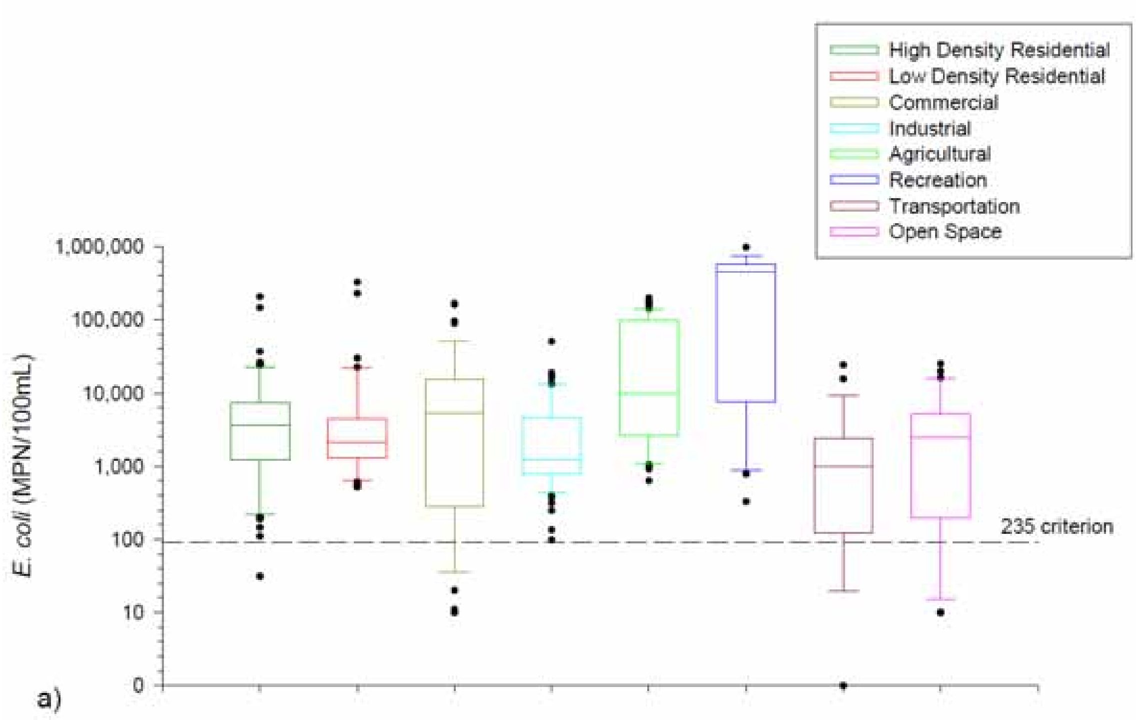

Figure 4- 5. Wet Weather *E. coil* Concentrations in Runoff from SCCWRP Land Use Sites

(This figure was incorporated directly from SCCWRP Technical Report 510)

4.2.3.2.1 *Sources of Bacteria to Wet Weather Runoff*

Because the LA River and tributaries are dominated by stormwater runoff during rainfall events, receiving water data can be used to assess the sources of wet weather bacteria, both point and non-point, and the magnitude of their loading[29]. During the aforementioned land use study by SCCWRP (Stein et al., 2007), monitoring events were also conducted at receiving water sites (mass emission stations) in the LA River and some tributaries. The pollutograph data were used by SCCWRP to calculate the total loading of *E. coli* over the course of each storm[30]. Subsequent data analysis in **Appendix A** suggests that just after the onset of storm events, concentrations of bacteria quickly increased several orders of magnitude as stormwater levels rise in the LA River channel. Further, once concentrations rose to a high level they remained relatively constant for the duration of the storm, well into the receding limb of the hydrograph. Also, occurrence of peak flows had little effect on bacteria concentrations, with concentrations remaining relatively steady before and after peak discharge.

These results support the occurrence of a phenomenon referred to as the "mud puddle effect", as described by researchers from UC-Irvine (Surbeck et al., 2006):

> Indeed, the simplest conceptual model that appears to explain our data is one in which fecal pollution is present at more-or-less the same concentration in every "mud-puddle" in the rain-impacted drainage area. The concentration of fecal pollution measured

[29] See Section 4.1.3 of Appendix A for analysis of wet weather bacteria data from the LA River. For tributary conditions during wet weather, see Section 4.2.2 and 4.2.3 of Appendix A.
[30] See Section 4.1.3 of Appendix A for analyses of storm total loading and equivalent human fecal production.

downstream therefore would be expected to remain constant as these mud puddles connect and cascade into large streamflows.

The storm mean total loading from the Watershed near its mouth (Wardlow Road) for the four SCCWRP-sampled storms was approximately 10^{15} bacteria colonies. This total loading rate can be used to assess whether sources of bacteria to wet weather flows in the LA River are human or non-human. A simple approach is to compare the storm total loading rate to the daily fecal production from a human (Surbeck et al., 2006). A storm total discharge of 10^{15} bacteria colonies is equivalent to the daily fecal production of approximately 3 million humans. The storm-total loading for the 2001-2002 seasonal first flush storm at Figueroa Street (upstream of Wardlow Road) discharged a indicator bacteria load equivalent to the daily fecal production of approximately 31 million humans. For comparison, approximately 10 million people live in the Watershed, and measured storm events were late season, limiting the possibility that bacteria “built up” prior to the rainfall. Thus, while sanitary sewer overflows (SSOs) and other sewage discharges occur in the Watershed during storm events, most human waste is treated by WRPs, and therefore the measured bacteria loading exceeds the amount that could be discharged from human feces. Instead, bacteria discharged during storm events are predominantly from non-human sources. These non-human sources possibly include domestic pets (dogs and cats), wildlife, horses, and bacteria that persist or grow in the landscape of the Watershed.

Studies of human pathogens in the LA River have also generated information regarding the sources of bacteria to wet weather flows[31]. Concentrations of human pathogens and indicator bacteria are generally uncorrelated in wet weather flows in the LA River, which suggests that non-human sources are an important component of wet weather bacteria loading, as described by Choi and Jiang (2005):

> Indicator bacteria may be generated by natural sources such as birds, animal feces, and/or regrowth in nutrient-rich soil and/or riverbed sediments. They are flushed out by rainwater and transported to rivers during storm events. Human adenoviruses and enteroviruses are only from human source contamination. The pollution of the river from human sources may be sporadic throughout the season, which is independent of rain events.

4.3 Non-Point Sources

Nearly all discharges to the LA River and its tributaries are regulated as point sources, predominantly as discharges from WRPs and storm drains. Sources categorized as non-point include the following:

- Onsite Wastewater Treatment Systems (OWTS, aka septic systems)
- Runoff from the National and State forests outside of the MS4s into the headwaters of many tributaries[32]
- Sources that occur *within* the channels of the LA River and tributaries (“in-channel sources”)

[31] See Section 4.1.2.2.2 of Appendix A for discussion of human pathogen studies in the Watershed

[32] The LA River technically begins at the confluence with Bell Creek and Calabasas Creek and thus does not receive direct runoff from State and National forest.

4.3.1 Onsite Wastewater Treatment Systems

While the overwhelming majority of households in the Watershed discharge to the sanitary sewer system, onsite wastewater treatment systems (OWTS) are also utilized[33]. OWTS, commonly referred to as septic systems, are passive systems designed to treat small quantities of sewage waste. The basic systems are designed to conduct primary treatment of wastewater by settling out heavier solids in the sewage and slowly discharging the liquid into a subsurface drainage field. It is generally held that when correctly sited, operated, and maintained OWTS are highly effective at removing bacteria.

However, when OWTS are not properly designed or maintained, bacteria removal efficiencies can decrease dramatically, and pathogens-of-concern can be discharged to the environment (Harris, 1995). In the Malibu Watershed Bacteria TMDL (RWQCB, 2004), it was assumed that normally operating leach field systems remove 100% of the fecal coliform bacteria, failing systems remove 60%, and short-circuited systems (i.e., wastewater flows directly to the outlet) remove none of the bacteria. Further, it was estimated that OWTS failure rates were between 20 to 30% in the unincorporated parts of Los Angeles County in the Malibu Creek Watershed. On the other hand, a failed OWTS does not necessarily impact surface waters due to attenuation, decay, and dilution during subsurface transport of discharged bacteria.

In the Watershed, multiple agencies have the responsibility of processing permits to install and maintain OWTS. In the unincorporated areas of LA County, the Los Angeles County Department of Public Works (LACoDPW) issues building permits after approval by the County Department of Health Services (LACDHS), which inspects OWTS installation as part of overall building inspection. Within the City of Los Angeles, the Department of Building and Safety (LADBS) processes OWTS permits applications including new construction, repairs, replacements, additions, and abandonment. In instances where OWTS are proposed in close proximity to streams, the LADBS staff work with the Bureau of Sanitation (BOS) staff and with the Regional Board to determine the best course of action, including but not limited to requiring supplemental systems to increase OWTS reliability. The remaining potentially responsible agencies, including municipalities and Regional Board, vary on their approach to addressing OWTS permitting issues.

The lack of readily accessible information on the number and location of septic systems within the Watershed makes an analysis of their potential impact on receiving waters difficult. The City of Los Angeles is the only municipality with a database of the number and locations of OWTS within their jurisdiction, as a result of a Memorandum of understanding (MOU) with the Regional Board. Based on an analysis of the available data, it appears more than 10,000 OWTS were once located in the Watershed. Of these, more than 2,000 OWTS were identified on currently sewered parcels, and thus are not likely to be in operation.

Given the scarcity of readily accessible information on OWTS, it was not possible to fully evaluate the potential for failing OWTS to impact bacteriological water quality in the Watershed.

[33] See Section 5.2 of Appendix A for more detailed information on OWTS in the Watershed.

4.3.2 Natural Runoff from Headwaters

Indicator bacteria are discharged by wildlife[34] and bacteria can persist in watersheds that have little or no human influence[35]. Thus, there is a natural “background level” of non-human indicator bacteria in natural runoff. This natural background motivates the use of a reference watershed approach for bacteria TMDLs in Region 4, and the targets for this TMDL allow for occasional exceedances due to natural non-point sources.

The dataset used to develop the targets for this TMDL includes data from a SCCWRP study called *Fecal Indicator Bacteria in Reference Streams* (Technical Report 542; Tiefenthaler et al., 2008)[36]. The dataset, which is representative of a wide range of geological, hydrological, and biological conditions, includes samples from the headwaters of Arroyo Seco, which drain a portion of the Angeles National Forest. Many natural watersheds in the hills of the Watershed are intermittent, only flowing during the winter or storm events, but the Arroyo Seco headwaters are perennial. Water samples were collected by SCCWRP from the Arroyo Seco reference site with sufficient frequency to calculate rolling 30-day geometric mean concentrations. Samples were only collected from Arroyo Seco during dry weather. This is the only available data for natural runoff in the Watershed.

The samples from the Arroyo Seco reference site exhibited an low rate of WQO exceedance during dry weather (**Table 4-6**)[37]. Dry weather concentrations of *E. coli* at the Arroyo Seco headwater site were orders of magnitude lower than those found in the LA River or any of its tributaries. The median *E. coli* concentration from the Arroyo Seco headwaters was non-detect (<10 MPN/100mL). Runoff from the hills[38] of the Watershed likely contributes a small portion of the dry weather loading to the LA River and its tributaries.

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[34] See Section 6.5 of Appendix A for a summary of the types of wildlife that inhabit the Watershed.
[35] See Section 2.2.1.2.1 of Appendix A for a discussion of persistence of indicator bacteria in soils and sediment.
[36] See Section 6.6 of Appendix A for analyses of SCCWRP reference watershed datasets.
[37] An observation of zero WQO exceedances at the Arroyo Seco headwaters does not mean that zero exceedance days should be allowed. Unlike the dataset used to develop TMDL targets, the Arroyo Seco headwaters site may not be representative of most natural runoff in the Watershed. In addition, natural sources in the channels of the LA River and its tributaries could lead to WQO exceedances, as discussed in Section 4.2.4.2 of Appendix A.
[38] Compared to the coastal mountains, bacteria loading from natural sources may be higher in lower elevation watersheds that are less-steep (e.g,, due to presence of wetlands and coastal birds). But due to coastal urbanization in southern California, SCCWRP has only been able to identify reference sites in watersheds with steep topography.

Table 4 - 6. ***E. coli*** **Concentrations in Natural Dry Weather Runoff at the Headwaters of the Arroyo Seco** (Tiefenthaler et al., 2008)

E. coli **Statistic**	**Single Samples**	**30-day Geometric Means**[1]
Number of Samples	49	30
Number of Samples > WQO	0 (0%)	0 (0%)
Mean [2]	23	21
Minimum [2]	< 10	< 10
10^{th} Percentile [2]	< 10	< 10
25^{th} Percentile [2]	< 10	12
Median [2]	< 10	15
75^{th} Percentile [2]	15	28
90^{th} Percentile [2]	56	41
Maximum [2]	148	53

1 – Based on instances when five samples were collected within a 30-day period. The calculated geometric mean was rolling based on approximately weekly sampling.
2 – Units are MPN/100mL

4.3.3 In-channel Sources

Inputs from *within* the channels of the LA River and its tributaries ("in-channel sources") are potential non-point sources[39] of bacteria, including:

- Groundwater discharges
- Homeless Persons
- Illicit/illegal discharges
- Wildlife and birds
- Regrowth and/or suspension of sediment-associated bacteria
- Regrowth of bacteria in the water column
- Resuscitation of injured bacteria discharged with disinfected wastewater effluent

The cumulative impact of in-channel sources of *E. coli* during dry weather has been analyzed during two studies by the CREST stakeholder group, the Tier 2 Study (CREST, 2006) and the BSI Study (CREST, 2008). Both of these studies focused on Reach 2 and 4 of the LA River, and used a mass balance approach to compare dry weather loading from in-channel sources to loading from all storm drains and tributaries. The sampling and analyses conducted during the BSI Study were the most comprehensive. Overall, the BSI Study concluded that dry weather loading of *E. coli* from in-channel sources along Reach 4 was relatively small compared to discharges from tributaries and storm drains.

[39] Potential discharges of untreated wastewater within the channel (e.g., leaking sewer lines) are not included in the list below, because they are regulated as point sources.

In the case of Reach 2, on the other hand, dry weather loading of *E. coli* from storm drains and tributaries often accounted for a fraction of the *E. coli* in the LA River, Thus in-channel sources were concluded to be an importance source to Reach 2[40]. It is unknown until other reaches are studied in detail, but the situation in Reach 2 may (or may not) be unique (i.e., as was the case in Reach 4, in-channel sources may be relatively small in other reaches).

A variety of analyses were used by the BSI Study to assess and rank the potential causes of in-channel *E. coli* sources along Reach 2, as follows:

- **Groundwater –** Shallow groundwater sampled from multiple "weep holes" that discharge along Reach 2 was found to be non-detect for indicator bacteria, suggesting groundwater is not a significant in-channel source of *E. coli* along Reach 2.
- **Human fecal discharges**[41] **–** Along the section of Reach 2 where in-channel sources were estimated to be the strongest (the segment between 6th Street and Rosecrans Avenue), measurements of human-specific *Bacteroidales* in the LA River exhibited little or no upstream-downstream increase. The potential effects of *Bacteroidales* decay were incorporated. Thus, it was concluded that in-channel sources of *E. coli* were non-human. This finding limits the potential for homeless persons, illicit discharges (e.g., from recreational vehicles), or leaking sewer infrastructure to be predominant in-channel sources along Reach 2.
- **Birds**[42] **–** Birds were commonly observed by field personnel in the LA River channel between 6th Street and Rosecrans Avenue, and were classified as potentially important in-channel sources of bacteria. The Audubon Society describes the seven mile lower portion of the River (north Long Beach through Compton and Paramount) as "one of the most important shorebird stopover sites in southern California. During the summer, a thin sheet of water forms in the river channel, and becomes rich with algae and micro-invertebrates that attract shorebirds. This environment has replaced formerly extensive shorebird habitat once present in the vast marshes along the coast of the Los Angeles Basin (e.g., Long Beach/Wilmington)."
- **Regrowth and persistence in sediments**[43] **–** Sediment deposits are relatively uncommon along the concrete-lined LA River. However, notable exceptions include (1) large swaths of sediment near Washington Boulevard bridge in Reach 2 and (2) at "outlets" along the side of the low flow channel along the lower portion of Reach 2. The potential for *E. coli* growth in sediment deposits is well documented (e.g., Anderson et al., 2005; Fujioka et al., 1999; Solo-Gabriele et al., 2000; Byappanahalli et al., 2003;Byappanahalli and Fujioka, 2004; Ishii et al., 2006;Ishii et al., 2007;Ishii and Sadowsky, 2008). During the CREST Tier 2 Study (CREST, 2006), sediment bacteria concentrations were measured, and fecal coliform was two orders of magnitude (100x) more abundant in sediments than water[44]. In many cases, sediment bacteria are in a slimy matrix and do resuspend easily. However, biofilms, or active/growing colonies of bacteria, that might be attached to benthic sediments have the potential "release" bacteria into the water column even without suspension of sediments. Regrowth in sediments were considered to have moderate likelihood of being a significant component of the in-channel *E.coli* loading to Reach 2.

[40] See **Figure 13** in Appendix A
[41] See Section 6.1 of Appendix A for discussion of potential impacts from homeless persons in the Watershed.
[42] See Section 6.5 of Appendix A for discussion of potential impacts from wildlife in the Watershed
[43] See Section 2.2.1.2.1 of Appendix A for discussion of the potential impacts of sediments.
[44] See Figure 4 of Appendix A

- **Regrowth or resuscitation in the water column**[45] **–** Under suitable conditions, traditional indicator bacteria may regrow or resuscitate in the water column. Regrowth is when indicator bacteria are generated in the environment. Resuscitation is when indicator bacteria that are initially viable-but-nonculturable (VNC) become culturable. Resuscitation can occur after injury (but not death) by treatment or environmental stress. Laboratory studies under ideal condition have highlighted the potential for post-disinfection resuscitation (Bolster et al., 2005; Rockabrand et al., 1999; Dukan et al., 1997), and a field study in Orange County concluded that bacteria were resuscitated after dry weather runoff was UV-treated (County of Orange, 2004). As for regrowth, field studies in southern California have suggested growth in the water column may be an important source of bacteria (Boehm et al., 2002; Jiang et al., 2007). During the BSI Study, a simple approach was used to determine whether or not regrowth in the water column could be ruled out as an important *E. coli* source to Reach 2. Calculated (potential) in-channel *E. coli* growth rates from *E. coli* concentrations measured in Reach 2 were compared to reported literature values from laboratory studies to evaluate if growth was a potential source. Based on this comparison, regrowth or resuscitation in Reach 2 of the LA River during dry weather could not be ruled out. These results do not demonstrate that regrowth/resuscitation is occurring; instead, they highlight it as a potential source that could be further evaluated with special studies during TMDL implementation.

4.4 Summary of Sources

Identification of bacteria sources and control of bacteria discharges in the Watershed will pose a significant challenge for implementing agencies. The urbanized nature of the Watershed has led to an overwhelming majority of discharges being regulated as point sources under NPDES permits. In most cases, contributions from non-point sources are considered a minor component of bacteria loading to the Watershed, particularly during dry weather. One potential exception is along Reach 2, where non-point, in-channel sources may cause or contribute to more frequent dry weather WQO exceedances than allowed by the Exceedance Day Approach. Additional special studies conducted during TMDL Implementation could be used to determine whether in-channel sources are natural and/or uncontrollable and whether the targets, TMDLs, and/or WLAs need to be reconsidered by the Regional Board during a TMDL reopener.

4.5 References

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[45] See Section 2.2.1.2.2 of Appendix A for discussion of potential impacts from regrowth/resuscitation

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