Appendix 1: Beach Bacteria Analysis

1-A: Los Angeles County Beaches
1-B: State-wide Beaches
1-C: Compliance Data

Appendix 1-A: LA County Beaches

Heal the Bay analyzed statewide, routine beach monitoring data following the methods outlined in the State's Listing Policy. As part of our weekly Beach Report Card program, Heal the Bay maintains an extensive database of routine beach monitoring data collected by local health and water agencies for the purpose of public health protection at recreational marine beaches. For the past several years, we have received routine beach data on a weekly basis from over 20 different local agencies covering 350 beaches in the winter and 460 beaches during the summer. For this analysis, we included all data collected from the past five years (2000 to 2004). For the summer AB-411 time period of April to October, we included the summer of 2005, for a total of 6 years of data. All of the beaches are monitored at least weekly during this summer time period.

To analyze our database for the purposes of evaluating beaches for potential 303(d) listing, we divided the statewide beach data into two components: 1) LA County beach data and, 2) data from beaches located throughout the rest of the state. This division was necessary for two reasons. First, the method for listing and delisting beaches in LA County is different from other beaches in the State because the Los Angeles Regional Board has established site-specific exceedance frequencies for LA County (the preferred method for listing per Section 3.3 of the Listing Policy). For beaches outside LA County, the binomial model method was used (again per Section 3.3 of the Listing Policy). The second reason we analyzed LA County data separately from the rest of the State data is because, in addition to the routine monitoring data collected to protect public health at recreational beaches, we included TMDL compliance data available for several LA County beaches that are not routinely monitored through a public health protection program.

For both the LA County beaches and the rest of the beaches throughout the state, we calculated the number of exceedance-days of the State's bacteriological standards for recreational marine waters[1]. Using these exceedance-days numbers, we followed the State's policy on listing based on bacteria densities and then compared our results with the existing 303(d) list, the proposed delistings, and the proposed listings.

LA County Beaches

<u>Analysis Description</u>: The Los Angeles Regional Board has established site-specific exceedance frequencies for recreational beaches in LA County, with Leo Carrillo beach serving as the reference beach. Section 3.3 of the State's Listing Policy states that use of site-specific frequencies is the preferred method for evaluating beaches. The Los Angeles Regional Board established site-specific frequency exceedances in the Santa

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[1] State of California has 4 single-sample standards and 3 geometric mean standards for the bacteriological quality of marine recreational waters. See http://www.dhs.ca.gov/ps/ddwem/beaches/AB411_Regulations/default.htm and http://www.dhs.ca.gov/ps/ddwem/beaches/AB411_Regulations/default.htm.

Monica Bay Beaches Bacteria TMDL[2] in the form of exceedance-days, and has used these frequencies in subsequent bacteria TMDLs developed within LA County:

Time Period	**Site-Specific Allowable Exceedance-Days* (Single-sample standards)**
AB-411 period (April through October)	0
Dry Weather (November through March)	3 (daily monitoring) 1 (weekly monitoring)
Wet Weather (November through March)	17 (daily monitoring) 3 (weekly monitoring)

*No exceedances of the geometric mean standards are allowed for all three time periods.

For each of these time periods, we determined the number of exceedance-days of the State's bacteriological standards for each beach monitored, and compared these to the allowable, site-specific frequencies. Two sets of data were used: 1) the routine, public health monitoring data collected by local agencies from 2000 to 2005, and, 2) compliance monitoring data for the Santa Monica Bay Beaches Bacteria TMDL collected from November 2004 (the start of this monitoring program) to September 2005.

For the routine monitoring data, Heal the Bay calculated the number of exceedance-days of the single sample standards and compared these to the number of allowable, site-specific frequencies set by the LA Regional Board. Heal the Bay did not have the resources to calculate 30-day rolling geometric means, as defined by the Los Angeles Regional Board, within the 303(d) listing timeframe. Thus, our findings are based only on exceedance-days of the single-sample standards.

For the TMDL compliance data, the numbers of exceedance-days of all the State's bacteriological standards (single sample standards and geometric mean standards) were reported in two letter reports from the City of Los Angeles to the EPA, Region IX, dated October 27, 2005 (see attached). Heal the Bay used the reported number of exceedance-days to compare to the allowable site-specific frequencies.

<u>Results- Proposed De-listings</u>: The results of our analysis indicates that 11 routinely monitored beaches and four TMDL compliance beaches ***proposed for delisting by the SWRCB*** do not actually meet the delisting criteria (Tables 1 and 2). The 11 routinely monitored beaches are: Abalone Cove, Bluff Cove, Hermosa, Malaga Cove, Malibu, Whites Point, Manhattan, Nicholas Canyon, Portugese Bend, Puerco, and Royal Palms. All 11 beaches have exceeded the site-specific exceedance frequency set by the Los Angeles Regional Board during the AB-411 time period in multiple years from 2000 to

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[2] See RWQCB Basin Plan Amendments http://www.waterboards.ca.gov/losangeles/html/meetings/tmdl/santa_monica/02_0124_smb%20tmdl%20BP%20language%20final.pdf (dry weather Santa Monica Bay Beaches Bacteria TMDL) and http://www.waterboards.ca.gov/losangeles/html/meetings/tmdl/santa_monica/02_1025/02_12_BPA_WET_121202.pdf (wet weather Santa Monica Bay Beaches Bacteria TMDL).

2005. Nine of the 11 beaches also exceeded the site-specific frequency for dry winter weather during one or more years between 2000 and 2004, and three have exceeded the allowable number of exceedances during all three time periods.

The 4 TMDL compliance beaches proposed for delisting that do not meet the listing criteria are: Carbon, Escondido, Inspiration, and Las Tunas. TMDL compliance monitoring reports indicate that these four beaches exceeded both the single-sample and geometric mean site-specific exceedance-day frequencies not only during the AB-411 time period, but also during the dry winter, and wet winter periods (with the exception of Inspiration Point that exceeded the AB-411 and dry winter site-specific frequencies, but not the wet winter frequency.)

Additionally, based on our database and our knowledge of the beaches within LA County, we determined that data is not available for the following 11 beaches because they are not included in the routine monitoring programs (including the TMDL monitoring): Flat Rock Point, Point Fermin Park, Point Vicente, Resort Point, Rocky Point, Torrance Beach, Zuma Beach, La Costa, Lunada Bay, Point Dume, and Sea Level.

Finally, 5 beaches proposed for delisting are listed for other bacteria-related impairments: Dockweiler, Venice, Trancas, Will Rogers, and Topanga.

Results – New Proposed Listings: Heal the Bay also compared beaches that exceeded the site-specific frequencies to the current 303(d) list and the proposed new listings. We found 6 routinely monitored LA County beaches that should be listed, but are currently not listed or proposed for listing (for any bacteria or beach closure-related reason) (Table 3). These six beaches are: Long Beach City Beach, Alamitos Bay, Colorado Lagoon, Westward, Latigo Canyon, and Corral State. Our conclusion that these beaches should be listed are based on weekly monitoring data collected from 2000 – 2005. All six beaches exceeded the AB-411 site-specific exceedance frequency over multiple years (with the exception of Corral State, which exceeded the AB-411 frequency once). Long Beach City Beach, Alamitos Bay, Colorado Lagoon, and Latigo Canyon exceeded site-specific frequencies for all three time periods (AB-411, dry winter and wet winter) during at least one of the 5 years we evaluated. In fact, Colorado Lagoon is such a well know beach pollution problem, it was awarded major funding from the SWRCB under the Clean Beach Initiative.

Additionally, one of the TMDL monitoring beaches, Solstice Canyon, qualifies for listing, but is currently not listed. Solstice Canyon exceeded site-specific exceedance frequencies during the AB-411 time period (both single sample and geometric mean exceedances) and during the wet winter period (single sample standard exceedances.)

Conclusions

As discussion in section III of this letter, all proposed beach de-listings in LA County should be rejected because all Santa Monica Bay beaches are covered under existing bacteria TMDLs. Attainment of water quality standards therefore should be determined under the TMDL, which sets forth a procedure to accomplish this – not through the listing process. In addition, the first year of monitoring data under the TMDL has been compiled and does not indicate attainment. The proper action in this case is to retain these beaches on the 2006 List until compliance is determined under the already adopted TMDLs. Notably, of the 31 beaches proposed for de-listing, only five are also listed for bacteria in addition to "beach closures;" the remaining 26 beaches would no longer be listed *at all* if staff's proposed changes are adopted. As all of these beaches are addressed in the SMB TMDLs, it is inappropriate to de-list them for this impairment. If the State Board is not comfortable with the term "Beach Closures" for these listings, it should simply replace this term with the term "Bacteria Indicators" on the List for the 26 beaches so affected. All 31 beaches then should be placed in the WQLSBA category as provided for in Section 2.2 of the Listing Policy.

Even though the 31 Santa Monica Bay beaches should not even be considered for de-listing in this process, as discussed above, readily available data clearly shows that 15 of these beaches do not meet the de-listing criteria per the State's policy. The SWRCB has, in-house, a routine beach monitoring database used to generate annual reports to the U.S. EPA, that contains virtually all the data used in Heal the Bay's analysis. Clearly, the SWRCB did not use readily available information before proposing the de-listing of these beaches, as required.

Finally, analysis of readily available, routine monitoring and TMDL data, shows that 7 additional beaches meet the State listing criteria and should be added to the 303(d) list. We respectively request the SWRCB to add these beaches to the list for Region IV for bacteria impairment: Long Beach City Beach, Alamitos Bay, Colorado Lagoon, Westward, Latigo Canyon, Corral State, and Solstice Canyon.

Table 1

LA County Beaches

Summary of Exceedance-day Frequencies[1] for Routinely-monitored Beaches Proposed for Delisting that do not Meet Delisting Criteria[2,5]

Red blocks denote time periods when delisting criteria was not met[3,4]

Beach	Description	Monitoring Agency/ID	Monitoring Frequency	Exceedance Freq. - AB-411							Exceedance Freq. - Dry Winter						Exceedance Freq. - Wet Winter					
				Allow[3]	2000	2001	2002	2003	2004	2005	Allow[3]	2000	2001	2002	2003	2004	Allow[3]	2000	2001	2002	2003	2004
Abalone Cove	Abalone Cove Shoreline Park	LACSD2	daily	**0**	1	0	1	0	0	2	**3**	0	0	0	0	0	**17**	0	0	0	0	3
Bluff Cove	Palos Verdes (Bluff) Cove, Palos Verdes Estates	LACSDB	weekly	**0**	1	0	2	0	2	0	**1**	0	0	0	0	1	**3**	0	0	0	0	2
Hermosa	Hermosa City Beach at 26th St.	DHS (114)	weekly	**0**	0	1	0	2	2	0	**1**	0	1	0	0	0	**3**	2	2	2	2	2
Hermosa	Hermosa Beach Pier- 50 yards south	S15	daily	**0**	2	0	1	0	5	6	**3**	0	1	3	2	4	**17**	7	6	3	5	7
Malaga Cove	Malaga Cove, Palos Verdes Estates-daily	S18	daily	**0**	0	0	1	2	4	2	**3**	0	0	1	7	6	**17**	1	0	1	2	5
Malaga Cove	Malaga Cove, Palos Verdes Estates-weekly	LACSDM	weekly	**0**	0	0	0	2	2	1	**1**	0	0	0	1	1	**3**	1	0	0	1	1
Malibu	Malibu Point	DHS (003)	weekly	**0**	5	1	2	8	2	6	**1**	1	3	1	2	1	**3**	5	7	3	4	2
Whites Point	Wilder Annex, San Pedro	LACSD6	daily	**0**	0	0	0	1	1	0	**3**	1	0	0	0	3	**17**	0	1	0	0	3
Manhattan	Manhattan State Beach at 40th Street	S13	daily	**0**	1	1	0	2	1	6	**3**	1	0	1	1	4	**17**	2	3	1	4	4
Manhattan	Manhattan Beach, projection of 27th street	DHS (113)	weekly	**0**	0	0	1	4	6	4	**1**	0	0	1	1	2	**3**	0	0	2	2	2
Manhattan	Manhattan Beach Pier- 50 yards south	S14	daily	**0**	2	2	3	0	3	2	**3**	2	2	2	0	5	**17**	4	1	1	2	6
Nicholas Canyon	100 feet west of lifeguard tower	DHS (009)	weekly	**0**	1	2	1	0	0	1	**1**	0	2	1	0	0	**3**	2	4	2	1	1
Portugese Bend	Portuguese Bend Cove, Rancho Palos Verdes	LACSD3	daily	**0**	1	0	1	0	3	0	**3**	1	0	0	0	0	**17**	2	0	0	0	2
Puerco	Puerco Beach, 25500 PCH at lifeguard station	DHS (004)	weekly	**0**	0	0	1	2	1	2	**1**	1	0	0	0	2	**3**	0	4	2	2	1
Royal Palms	Royal Palms State Beach	LACSD5	daily	**0**	4	0	1	2	2	2	**3**	0	0	0	4	14	**17**	5	0	0	1	7

1. Single-sample standard exceedances only. Rolling geometric means were not calculated.
2. Source of data - Routine monitoring results from Los Angeles City Sanitation Department (LACSD) and Los Angeles County Department of Health Services (DHS)
3. Delisting policy states criteria for delisting beaches based on numeric water quality objectives for bacteria in water (Section 4.3) states that removing waters from the 303(d) list shall be based on the site-specific exceedance frequency assigned to the region. Region IV has a site specific exceedance frequency, in terms of exceedance-days, based on reference beach Leo Carillo.
4. Allow = Allowable number of exceedance-days (site specific exceedance frequency) per Santa Monica Bay Beaches Bacteria TMDLs. Allowable exceedance-days are set for three time periods: AB-411 (April - Oct.), Dry Winter (dry non-AB-411), and Wet Winter (wet, non-AB-411). Allowable exceedance-days varies with sampling frequency.
5. None of these beaches have mulitple listing such as beach closures, coliform counts, etc. So, if delisted as proposed, there is no other listing that will cover bacteriological pollution.

Table 2

LA County Beaches

Summary of Exceedance-day Frequencies for TMDL Compliance Beaches Proposed for Delisting that do not Meet Delisting Criteria[1,4,5]

Red blocks denote time periods when delisting criteria was not met[2,3]

Single-Sample Standards

Beach	Description	Monitoring Agency/ID	Monitoring Frequency	Exceedance Freq. - AB-411		Exceedance Freq. - Dry Winter		Exceedance Freq. - Wet Winter	
				Allow[3]	2005	Allow[3]	2004-2005	Allow[3]	2004-2005
Carbon Beach	Sweetwater Canyon outlet	LACSD/SMB 1-13	weekly	**0**	🟥 7	**1**	🟥 4	**3**	🟥 5
Escondido Beach	Escondido Creek outlet	LACSD/SMB 1-8	weekly	**0**	🟥 45	**1**	🟥 7	**3**	🟥 5
Inspiration Point	Tuna Canyon Outlet	LACSD/SMB 1-17	weekly	**0**	🟥 7	**1**	🟥 2	**3**	3
Las Tunas Beach	Pena Creek Outlet	LACSD/SMB 1-16	weekly	**0**	🟥 3	**1**	🟥 2	**3**	🟥 6

Rolling Geometric Mean Standards

Beach	Description	Monitoring Agency/ID	Monitoring Frequency	Exceedance Freq. - AB-411		Exceedance Freq. - Dry Winter	
				Allow[3]	2005	Allow[3]	2004-2005
Carbon Beach	Sweetwater Canyon outlet	LACSD/SMB 1-13	weekly	**0**	🟥 71	**0**	🟥 24
Escondido Beach	Escondido Creek outlet	LACSD/SMB 1-8	weekly	**0**	🟥 168	**0**	🟥 55
Inspiration Point	Tuna Canyon Outlet	LACSD/SMB 1-17	weekly	**0**	🟥 114	**0**	🟥 49
Las Tunas Beach	Pena Creek Outlet	LACSD/SMB 1-16	weekly	**0**	🟥 7	**0**	🟥 48

1. Source of data - Month of September Monitoring Report - Examination of SMBBB TMDL Stations of Santa Monica Bay, October 27, 2005.
2. Delisting policy states criteria for delisting beaches based on numeric water quality objectives for bacteria in water (Section 4.3) states that removing waters from the 303(d) list shall be based on the site-specific exceedance frequency assigned to the region. Region IV has a site specific exceedance frequency, in terms of exceedance-days, based on reference beach Leo Carillo.
3. Allow = Allowable number of exceedance-days (site specific exceedance frequency) per Santa Monica Bay Beaches Bacteria TMDLs. Allowable exceedance-days are set for three time periods: AB-411 (April - Oct.), Dry Winter (dry non-AB-411), and Wet Winter (wet, non-AB-411). Allowable exceedance-days varies with sampling frequency.
4. Monitoring of TMDL compliance beaches began November 2004.
5. None of these beaches have mulitple listing such as beach closures, coliform counts, etc. So, if delisted as proposed, there is no other listing that will cover bacteriological pollution.

Table 3

LA County Beaches

Summary of Exceedance-day Frequencies[1] for
Historically Monitored Beaches that meet the Listing Criteria but are not Listed[2,5]

Red blocks denote time periods when listing criteria are met[3,4]

Beach	Description	Monitoring Agency/ID	Monitoring Frequency	Exceedance Freq. - AB-411							Exceedance Freq. - Dry Winter						Exceedance Freq. - Wet Winter					
				Allow[3]	2000	2001	2002	2003	2004	2005	Allow[3]	2000	2001	2002	2003	2004	Allow[3]	2000	2001	2002	2003	2004
Long Beach City Beach	projection of 3rd Place	CLB/B63	weekly	0	10	3	3	3	4	3	1	2	5	5	3	0	3	1	3	1	1	3
Long Beach City Beach	projection of 5th Place	CLB/B5	weekly	0	3	2	2	2	4	3	1	2	4	3	1	2	3	0	2	0	0	3
Long Beach City Beach	projection of 10th Place	CLB/B56	weekly	0	10	0	1	3	2	6	1	0	0	3	2	0	3	0	0	0	0	2
Long Beach City Beach	projection of 16th Place	CLB/B6	weekly	0	10	2	1	2	3	5	1	0	1	5	1	1	3	1	0	1	1	3
Long Beach City Beach	projection of Molino Ave.	CLB/B60	weekly	0	2	1	1	3	2	3	1	2	3	3	5	2	3	1	1	1	0	4
Long Beach City Beach	projection of Coronado Ave.	CLB/B7	weekly	0	2	0	0	2	2	2	1	0	0	2	2	2	3	1	0	0	1	2
Long Beach City Beach	projection of 36th Place	CLB/B62	weekly	0	4	2	1	3	4	3	1	0	3	3	2	2	3	1	0	0	0	3
Long Beach City Beach	Belmont Pier - westside	CLB/B8	weekly	0	5	2	0	2	2	5	1	0	3	3	2	2	3	1	0	0	0	2
Long Beach City Beach	Belmont Pier - eastside	CLB/B3	weekly	0	4	4	1	2	2	1	1	0	0	6	2	1	3	1	1	1	1	3
Long Beach City Beach	projection of Prospect Ave.	CLB/B9	weekly	0	1	0	1	3	2	3	1	0	0	0	1	2	3	1	1	0	1	2
Long Beach City Beach	projection of Granada Ave.	CLB/B64	weekly	0	6	4	4	3	2	2	1	0	0	1	0	3	3	1	1	1	1	2
Long Beach City Beach	projection of 54th place	CLB/B65	weekly	0	6	3	4	4	2	1	1	1	1	0	1	1	3	1	1	0	1	2
Long Beach City Beach	projection of 55th place	CLB/B10	weekly	0	0	0	0	3	2	1	1	0	1	0	0	2	3	0	0	0	1	1
Long Beach City Beach	projection of 62 place	CLB/B66	weekly	0	1	0	1	4	2	2	1	0	0	1	0	1	3	0	0	0	1	1
Long Beach City Beach	projection of 72 place	CLB/B11	weekly	0	2	0	1	4	2	3	1	1	1	4	2	2	3	0	0	0	2	3
Alamitos Bay	56th Place on bayside	CLB/B31	weekly	0	2	0	0	1	1	1	1	1	0	1	0	0	3	1	1	0	0	3
Alamitos Bay	1st and Bayshore	CLB/B29	weekly	0	2	0	3	0	1	3	1	0	1	4	0	0	3	1	0	0	1	4
Alamitos Bay	Alamitos Bay - Shore Float	CLB/B14	weekly	0	0	0	1	2	1	3	1	0	2	0	1	0	3	0	1	0	0	2
Alamitos Bay	Mother's Beach	CLB/B22	weekly	0	4	0	2	0	5	1	1	1	0	2	1	1	3	0	1	1	0	3
Alamitos Bay	2nd St. Bridge and Bayshore	CLB/B67	weekly	0	4	0	2	1	3	2	1	0	0	1	3	1	3	1	0	0	0	4
Colorado Lagoon	north	CLB/B25	weekly	0	0	10	3	2	4	7	1	0	1	1	2	0	3	0	0	1	1	4
Colorado Lagoon	center	CLB/B26	weekly	0	0	1	1	0	4	4	1	0	2	2	1	0	3	0	0	0	0	3
Colorado Lagoon	south	CLB/B24	weekly	0	0	2	1	1	2	2	1	0	3	4	1	0	3	0	1	0	0	5
Westward Beach	East of Zuma Creek	DHS (007)	weekly	0	0	1	0	1	0	7	1	0	0	0	1	1	3	2	3	2	2	1
Latigo Canyon	Latigo Canyon Creek Outlet	DHS (005)	weekly	0	2	0	1	1	2	9	1	2	2	3	1	3	3	5	6	2	1	0
Corral State Beach	Corral Canyon Outlet	DHS (005)	weekly	0	1	0	0	0	0	0	1	0	0	0	0	0	3	3	0	0	0	0

1. Single-sample standards only. Rolling Geometric means were not calculated.

2. Source of data - Routine monitoring results from Long Beach Department of Health Services (CLB) and Los Angeles County Department of Health Services

3. Listing policy states criteria for listing beaches based on numeric water quality objectives for bacteria in water (Section 3.3) states thata site-specific exceedance frequency can, and to the extent possible and allowed by water quality ojectives, should be used to place waters on the 303(d) list. Region IV has a site specific exceedance frequency based on reference beach Leo Carillo.

4. Allow = Allowable number of exceedance-days (site specific exceedance frequency) per Santa Monica Bay Beaches Bacteria TMDLs. Allowable exceedance-days are set for three time periods: AB-411 (April - Oct.), Dry Winter (dry non-AB-411), and Wet Winter (wet, non-AB-411). Allowable exceedances varies with sampling frequency.

5. None of these beaches are currenty listed for any bacteriological-related pollution such as beach closures, high coliform densities, etc.

Table 4

LA County Beaches

Summary of Exceedance-Day Frequencies for TMDL Compliance Beaches that Meet the Listing Criteria[1,4]

Red blocks denote time periods when delisting criteria was not met[2,3]

Single-Sample Standards

Beach	Description	Monitoring Agency/ID	Monitoring Frequency	Exceedance Freq. - AB-411		Exceedance Freq. - Dry Winter		Exceedance Freq. - Wet Winter	
				Allow[3]	2005	Allow[3]	2004-2005	Allow[3]	2004-2005
Dan Blocker Beach	Solstice Canyon Outlet	LACSD/1-10	Weekly	**0**	10	**1**	0	**3**	4

Rolling Geometric Mean Standards

Beach	Description	Monitoring Agency/ID	Monitoring Frequency	Exceedance Freq. - AB-411		Exceedance Freq. - Dry Winter	
				Allow[3]	2005	Allow[3]	2004-2005
Dan Blocker Beach	Solstice Canyon Outlet	LACSD/1-10	Weekly	**0**	105	**0**	0

1. Source of data - Month of September Monitoring Report - Examination of SMBBB TMDL Stations of Santa Monica Bay, October 27, 2005.
2. Delisting policy states criteria for delisting beaches based on numeric water quality objectives for bacteria in water (Section 4.3) states that removing waters from the 303(d) list shall be based on the site-specific exceedance frequency assigned to the region. Region IV has a site specific exceedance frequency, in terms of exceedance-days, based on reference beach Leo Carillo.
3. Allow = Allowable number of exceedance-days (site specific exceedance frequency) per Santa Monica Bay Beaches Bacteria TMDLs. Allowable exceedance-days are set for three time periods: AB-411 (April - Oct.), Dry Winter (dry non-AB-411), and Wet Winter (wet, non-AB-411). Allowable exceedance-days varies with sampling frequency.
4. Monitoring of TMDL compliance beaches began November 2004.
5. None of these beaches have mulitple listing such as beach closures, coliform counts, etc. So, if delisted as proposed, there is no other listing that will cover bacteriological pollution.

Appendix 1-B: Statewide Beaches

As previously discussed, Heal the Bay analyzes bacteria data collected by local health and water agencies at approximately 450 of the State's beaches to develop the weekly Beach Report Card. Thus, in addition to evaluating beach bacteria data in Los Angeles County, we analyzed statewide beach data in the context of the 2006 303(d) List. As described in detail below, our analysis revealed that there are numerous beaches that do not have a bacteria-related listing and are not currently proposed for listing despite the fact that readily available data show these beaches meet the listing criteria (per the State's listing policy section 3.3). Thus, State Board should include these beaches in the 2006 303(d) List updates. In addition, a number of the State's beaches are proposed for de-listing where readily available data show that the de-listing criteria is not met (per the State's listing policy section 4.3).

<u>Analysis Description</u> Section 3.3 of the Listing Policy outlines listing factors for bacteria at coastal beaches. Since beaches outside of Los Angeles County do not have a site-specific exceedance-day frequency, we evaluated the data in terms of the binomial distribution if the beaches are monitored year-round and a 4% exceedance percentage if they are only AB411-monitored beaches, as outlined in the listing policy. The first step in our analysis was to calculate rolling geometric means for all beaches for any 30-day period in which 5 samples were collected, as defined by the State Department of Health Services. The number of geometric means calculated was used as the sample count in the binomial model to determine whether a beach should be listed because of geometric mean exceedances. Next, for beaches monitored only during the AB-411 period, the numbers of single-sample exceedance-days were evaluated based on a 4% allowable exceedance-day rate. Beaches monitored year-round were evaluated by looking at the exceedance-days in terms of the binomial model for de-listing conventional pollutants. Because the task of evaluating all of the State's beaches was extremely time consuming, we analyzed geometric mean exceedance days separately from single-sample exceedance-days. This analysis approach is more lenient than the State's listing policy, and likely resulted in fewer proposed listings.

Data were analyzed year-by-year, rather than grouping all years together, because of the significant effect annual rainfall has on bacteriological water quality. A single very wet year (e.g., 1998, 2004-05) could result in the listing of beaches that typically have good water quality. Likewise, a few drought years could result in beaches with poor water quality during moderately rainy years, to not be listed. The Listing Policy is silent on this issue. In this analysis, we recommend listing beaches that meet the listing criteria in 1 of the past 3 years, or 2 of the past 5 years.

Our analysis is based on exceedance-days, which is consistent with reporting protocols used by local agencies to report health standards exceedances to the SWRCB, and by the SWRCB to the U.S. EPA. Also exceedance-days, rather than the number of exceedances per bacteria indicator type, are the relevant measure of water quality at beaches. For instance, warning signs are posted at beaches and the beneficial use of recreational water use is lost each day a sign is posted regardless of the type of bacteria indicator(s) that exceeded the health standards. In addition, bacteria TMDLs are designed around exceedance-days, not the number of overall exceedances, because this measure directly targets the impairment as perceived by the average beach-goer. The State's Listing Policy is silent on this issue. However, if the 4% allowable exceedances for beaches monitored only during AB-411 were applied to each indicator type separately, the beach could be conceivably posted 16% of the summer (4 single-sample standards), and still not be listed. This is not consistent with the study that forms the basis of the 4%, in which the 4% was a reported rate of exceedance-days.[1]

The State Board Should Add 49 Statewide Beaches to the 2006 303(d) List Based Upon Readily Available Data.

Our data analysis shows that fourteen beaches (28 monitoring locations) which are not currently on the 303(d) List for bacteria indicators or proposed for listing meet the listing criteria based on exceedance-days of the geometric mean standards. Thus, the following statewide beaches should be added to the 303(d) List: *Campbell Cove State Park, Aquatic Park, Crissy Field, Baker Beach, Jackrabbit Beach, Windsurfer Circle, Sunnydale Cover, Linda Mar, Capitola, Rio Del Mar, Goleta, Leadbetter, Monarch, and San Diego Bay*. In addition, *Newport Bay* exceeded the geometric mean exceedance-day listing criteria. State Board staff is currently proposing to list this beach. Thus, our analysis supports the staff's decision to list Newport Bay for bacteria indicators. These data are summarized in Table 1.

As seen in Table 2, thirty-one beaches (37 monitoring locations) that are monitored only during the AB-411 time period meet the listing criteria based on exceedance-days of the single-sample standards. Two of these monitoring locations, Campbell Cover and San Diego Bay (Bayside Park) also meet the geometric mean listing criteria, as reported above. None of these beaches are currently on the 303(d) List or proposed for listing in the 2006 cycle. Given our analysis of readily available data, the following beaches should be included on the 303(d) List as impaired for bacteria indicators: *Trinidad State Beach, Luffenholtz Beach, Moonstone County Park (Little River State Beach), Clam Beach County Park, Russian Gulch Campground, Goat Rock State Park Beach, Salmon Creek State Park Beach, Campbell Cove State Park Beach, Doran Regional Park Beach, Lawson's Landing, Heart's Desire, Chicken Ranch Beach, Golden Hinde, Millerton Point, Bolinas Beach, Muir Beach-North, Baker Beach, Schoonmaker Beach, Paradise Cove, China Camp, McNears Beach, Monterey Municipal Beach, San Carlos Beach, Asilomar State Beach, Spanish Bay, Stillwater Cove, Pico Ave.-San Simeon, Encinitas-Swami's Beach, La Jolla, Pacific Beach, San Diego Bay*.

As illustrated in Table 3, seventeen beaches (30 monitoring locations) monitored year-round meet the listing criteria based on exceedance-days of the single-sample standards.

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[1] Noble, Rachel T., Dorsey, J., Leecaster, M., Mazur, M., McGee, C., Moore, D., Victoria, O., Reid, D., Schiff, K., Vainik P., Weisberg, S. 1999. Southern California Bight 1998 Regional Monitoring Program, Vol I: Summer Shoreline Microbiology. Southern California Coastal Water Research Project, Westminster, CA.

Twelve of these beaches also met the geometric mean criteria for listing. None of these beaches are on the 303(d) List or proposed for listing. Thus, the State Board should list the following beaches as impaired by bacteria indicators: *Aquatic Park Beach, Crissy Field Beach, Baker Beach, Fort Fuston, Candlestick Point-Jackrabbit Beach, Candlestick Point-Windsurfer Circle, Candlestick Point-Sunnydale Cove, Capitola Beach, Rio Del Mar Beach, Stillwater Cove, Pismo Beach, Haskell's Beach, Goleta Beach, Leadbetter Beach, Huntington State Beach, Newport Bay, Monarch Beach.*

Ormond Beach, San Buenaventura Beach, Mission Bay Shoreline and Pacific Ocean Shoreline – Scripps HA Should Remain on the 303(d) List.

State Board staff proposes to de-list Ormond Beach, San Buenaventura Beach, the beaches of Mission Bay Shoreline and the beaches of Pacific Ocean Shoreline – Scripps HA for bacteria indicators. However, our analysis indicates that these beaches do ***not*** meet the de-listing criteria outlined in Section 4.3 of the Listing Policy. First, Ormond Beach at the industrial drain does not meet the de-listing criteria based on the number of exceedance-days of the geometric mean standard (Table 4), and San Buenaventura Beach at San Jon Rd. does not meet the de-listing policy for exceedance-days of the geometric mean standard or the single-sample standard (see Tables 4 and 6). Thus Ormond Beach and San Buenaventura should remain on the 303(d) List as impaired by bacteria indicators. In the San Diego Region, the State Board lumps numerous beaches under the headings "Mission Bay Shoreline" and "Pacific Ocean Shoreline - Scripps HA." However, individual beaches within these units are monitored and should be evaluated. Our analysis found that 15 of the monitoring locations within Mission Bay Shoreline do not meet the de-listing criteria for the geometric-mean standards (Table 4). Additionally, twenty-one monitoring sites within the Mission Bay Shoreline and five sites within the Scripps HA do not meet the de-listing criteria for the single-sample standard (see Tables 5 and 6). Thus, the State Board should maintain the individual beaches of Mission Bay Shoreline and Pacific Ocean-Scripps HA that correspond to the monitoring locations that do not meet the de-listing criteria.

Conclusion

The statewide coastal beaches bacterial data described above and presented in Tables 1 to 3 demonstrate the need for numerous additional bacteria indicator listings. In addition, as illustrated in Tables 4 and 6, several of the proposed beach de-listings are erroneous. As these data were and are readily available to the State Board, as part of their routine beach monitoring database maintained by the SWRCB partially to meet reporting requirement of the U.S. EPA, they should be included in the evaluation for the 2006 303(d) updates.

Table 1

Statewide Beaches that meet the listing criteria for Geometric Mean Exceedances-days[1,2] but are not Listed[3,4]

Beach Name	Description	Monitoring ID	Data Start Date	Data End Date	Frequency	# of Geomeans	# of Exceed-Days
Campbell Cove State Park Beach		SON60	04/02/01	11/28/05	Weekly	129	63
Aquatic Park Beach	211 Station	SFC10	08/01/02	12/07/05	Weekly	196	93
Crissy Field Beach	East, 202.4 Station	SFC30	08/01/02	12/07/05	Weekly	163	74
Crissy Field Beach	West, 202.2 Station	SFC50	08/01/02	12/07/05	Weekly	138	36
Baker Beach	Lobos Creek outlet	SFC80	10/16/02	12/06/05	Weekly	243	54
Jackrabbit Beach	Candlestick Point	SFC170	08/01/02	12/07/05	Weekly	131	33
Windsurfer Circle	Candlestick Point	SFC180	08/01/02	12/07/05	Weekly	200	140
Sunnydale Cove	Candlestick Point	SFC190	08/01/02	12/07/05	Weekly	155	77
Linda Mar Beach	San Pedro Creek outlet	SMC50	10/06/98	11/28/05	Weekly	184	41
Capitola Beach	East of pier	SCC170	04/03/00	06/28/05	Weekly	46	8
Capitola Beach	West of Jetty	SCC180	06/14/01	12/05/05	Weekly	126	45
Capitola Beach	East of Jetty	SCC190	06/15/01	12/05/05	Weekly	127	25
Rio Del Mar Beach		SCC220	04/03/00	12/05/05	Weekly	173	64
Goleta Beach		SBC9	06/28/99	12/05/05	Weekly	274	61
Leadbetter Beach		SBC12	06/28/99	12/05/05	Weekly	272	62
Newport Bay[5]	Newport Dunes-North	BNB24N	03/19/01	11/21/05	Weekly	177	75
Newport Bay	Newport Dunes-East	BNB24E	03/19/01	11/21/05	Weekly	164	45
Newport Bay	Newport Dunes-Middle	BNB24M	03/19/01	11/21/05	Weekly	167	52
Newport Bay	Newport Dunes-West	BNB24W	03/19/01	11/21/05	Weekly	163	41
Newport Bay	Garnet Avenue Beach	BNB31	03/19/01	11/21/05	Weekly	163	27
Newport Bay	43rd Street Beach	BNB09	03/19/01	11/21/05	Weekly	147	61
Newport Bay	38th Street Beach	BNB10	03/19/01	11/21/05	Weekly	181	82
Newport Bay	19th Street Beach	BNB14	03/19/01	11/21/05	Weekly	165	35
Newport Bay	10th Street Beach	BNB17	03/19/01	11/21/05	Weekly	187	68
Newport Bay	Harbor Patrol Beach	BNB33	03/19/01	11/21/05	Weekly	190	85
Monarch Beach	North	OSL25	03/20/01	11/22/05	Weekly	187	54
Monarch Beach	South	OSL23	03/20/01	10/23/02	Weekly	66	14
San Diego Bay	Bayside Park (proj. of J Street)	EH120	04/05/00	10/26/05	Weekly	153	40

1. Geometric means calculated for every 30-day period in which 5 samples were collected, per DHS guidance and the State Health Code.
2. Source of data - Routine monitoring results from The County of Sonoma Environmental Health Division; The County of San Francisco, in partnership with the San Francisco Public Utilities Commission; The County of San Mateo Environmental Health Department; The County of Santa Cruz Environmental Health Services; The County of Santa Barbara Environmental Health Agency; The County of Orange Environmental Health; The South Orange County Wastewater Authority; The Orange County Sanitation District; The County of San Diego Department of Environmental Health.
3. Listing policy Section 3.3 process for using the binomial model used to evaluate number of exceedances for listing.
4. Based on the 2002 State 303(d) list, none of these beaches are currenty listed for any bacteriological-related pollution such as beach closures, high coliform densities, etc.
5. Newport Bay is currently proposed for listing.

Table 2

Statewide Beaches Monitored only during the AB-411 Period that meet the listing criteria for Single-sample Standard Exceedance-days[1,2] but are not Listed[3,4]

Red blocks denote time periods when listing criteria are met

		2000			2001			2002			2003			2004			2005		
Beach Name	Monitoring ID	Count	Exceed-Day	%	Count	Exceed-Day	%	Count	Exceed-Day	%	Count	Exceed-Day	%	Count	Exceed-Day	%	Count	Exceed-Day	%
Trinidad State Beach near Mill Creek	HC10										28			31	2	7%	27	2	7%
Luffenholtz Beach near Luffenholtz Creek	HC20										28			32	2	6%	27	3	11%
Moonstone County Park (Little River State Beach)	HC30										30	1	3%	33	4	12%	28	2	7%
Clam Beach County Park near Strawberry Creek	HC40										29	1	3%	32	3	9%	28	1	4%
Russian Gulch Campground	Men40										12	1	8%						
Goat Rock State Park Beach	SON40				31			30			33	3	9%	27			29		
Salmon Creek State Park Beach	SON50				31			31	1	3%	33	5	15%	28	1	4%	32	4	13%
Campbell Cove State Park Beach	SON60				38	10	26%	39	11	28%	35	13	37%	35	17	49%	30	6	20%
Doran Regional Park Beach	SON70				31			30			32	2	6%	28	2	7%	30	1	3%
Lawson's Landing	MC20										31	2	7%	30	4	13%			
Heart's Desire	MC50										31	2	7%	30	2	7%			
Chicken Ranch Beach at Channel	MC70										31	3	10%						
Chicken Ranch Beach at Creek	MC80										31	2	7%	30	1	3%			
Golden Hinde	MC90										31	1	3%	30	2	7%			
Millerton Point	MC100										31	3	10%	30	3	10%			
Bolinas Beach (Wharf Rd)	MC150										26			30	3	10%			
Muir Beach, North	MC200										31	8	26%	26	2	8%			
Baker Beach, Horseshoe Cove NW	MC270										26	3	12%	28	2	7%			
Baker Beach, Horseshoe Cove NE	MC280										26	3	12%	28	4	14%			
Schoonmaker Beach	MC290										23	1	4%	30					
Paradise Cove	MC300										25			30	2	7%			
China Camp	MC310										31	2	7%	30	2	7%			
McNears Beach	MC320										25	1	4%	30	4	13%			
Monterey Municipal Beach (at the commercial wharf)	MON20				32	4	13%	32	4	13%	27	1	4%	30	2	7%	28	2	7%
San Carlos Beach at San Carlos Beach Park	MON30				31	2	7%	29			27			30	2	7%	28		
Asilomar State Beach, projection of Arena Av.	MON50				30			30	1	3%	30	3	10%	28			29	1	3%
Spanish Bay (Moss Beach), end of 17 mile drive	MON60				31	2	7%	29			27			29	3	10%	29	1	3%
Stillwater Cove, at Beach and Tennis Club	MON70				33	4	12%	32	3	9%	33	9	27%	34	7	21%	27	3	11%
Pico Ave., San Simeon	PICO23													13			20	1	5%
Encinitas, Swami's Beach (Seacliff Park)	EH410	30			31			27			28			25	2	8%	30	3	10%
La Jolla (north), Scripps Pier	EH350	30	2	7%	31	2	7%	29	1	3%	28	1	4%	29	1	3%	29		
La Jolla, La Jolla Cove	FM070	29	2	7%	29			31	2	7%	33	3	9%	28	2	7%	30	2	7%
Pacific Beach, Crystal Pier (projection of Garnet)	FM020	26	1	4%	28			29	1	3%	29	2	7%	23	1	4%	26		
San Diego Bay, north of Kellogg St.	EH210	33	2	6%	34	4	12%	29			29	1	3%	27	1	4%	18	1	6%
San Diego Bay, Spanish Landing Park beach	EH160	31	2	7%	31	3	10%	37	9	24%	29	1	3%	30	2	7%	36	3	8%
San Diego Bay, Bayside Park (projection of J Street)	EH120	41	7	17%	39	5	13%	37	9	24%	33	3	9%	36	7	19%	35	7	20%
San Diego Bay, Glorietta Bay Park at boat launch	EH080	29	1	3%	33	2	6%	31	1	3%	28			27			23	2	9%

1. Single-sample exceedance day is a sample day in which one or more of the 4 state bacteriological single-sample standards were exceeded.
2. Source of data - Routine monitoring results from The County of Humboldt Environmental Health Department; The County of Mendocino Environmental Health Department; The County of Sonoma Environmental Health Division; The County of Marin Environmental Health Department; The County of Monterey Environmental Health Agency; The County of San Luis Obispo Environmental Health Department; The County of San Diego Department of Environmental Health
3. Listing policy Section 3.3 evaluation method specifies a maximum allowable exceedance frequency of 4% for beaches only monitored during the AB-411 time period. All of these beaches exceeded 4% during 1 of the 3 past years, or 2 of the last 5 years.
4. Based Heal the Bay's review of the 2002 State 303(d) list, none of these beaches are currenty listed for any bacteriological-related pollution such as beach closures, high coliform densities, etc.

Blue boxes denote beaches that also should be listed based on geometric mean exceedance days - see Table 1.

Table 3

Statewide Beaches Monitored Year-round
that meet the listing criteria for Single-sample Standard Exceedance-days[1,2]
but are not Listed[3,4]

Red blocks denote time periods when listing criteria are met

		2000			2001			2002			2003			2004		
Beach	fpkLocId	Count	Exceed-Day	List	Count	Exceed-Day	List	Count	Exceed-Day	List	Count	Exceed-Day	List	Count	Exceed-Day	List
Aquatic Park Beach, 211 Station	SFC10							50	16	yes	94	23	yes	61	10	
Crissy Field Beach East, 202.4 Station	SFC30							34	9	yes	76	14	yes	65	14	yes
Crissy Field Beach West, 202.2 Station	SFC50							32	7	yes	65	9		57	6	
Baker Beach, Lobos Creek	SFC80							37			151	12		71	14	yes
Fort Funston, opposite Lake Merced overflow structure	SFC160							15	1		112	5		9	5	yes
Candlestick Point, Jackrabbit Beach	SFC170							33	7	yes	68	9		51	4	
Candlestick Point, Windsurfer Circle	SFC180							53	26	yes	105	38	yes	60	11	yes
Candlestick Point, Sunnydale Cove	SFC190							37	13	yes	79	22	yes	59	8	
Capitola Beach, west of the jetty	SCC180				20	8	yes	48	13	yes	55	17	yes	52	8	
Capitola Beach, east of the jetty	SCC190				23	5	yes	47	7		55	9		52	7	
Rio Del Mar Beach	SCC220	38	10	yes	50	12	yes	47	8	yes	51	12	yes	52	6	
Stillwater Cove, at Beach and Tennis Club	MON70				34	4		36	3		37	9	yes	38	7	yes
Pismo Beach Pier, 50 feet south of the pier	PB4				31	1		34	3		55	10	yes	53	4	
Haskell's Beach (btwn. Tecolote and Winchester Cyn Creeks)	SBC75				27	5	yes	55	2		53	6		54	5	
Goleta Beach	SBC9	58	10	yes	60	14	yes	57	5		54	6		53	3	
Leadbetter Beach	SBC12	54	9	yes	60	16	yes	57	6		53	5		53	4	
Huntington State Beach, projection of Brookhurst Street	OHB03	180	36	yes	210	28		257	30		257	36		252	34	
Newport Bay, Newport Dunes-North[5]	BNB24N				41	10	yes	54	13	yes	58	14	yes	52	12	yes
Newport Bay, Newport Dunes-East	BNB24E				41	11	yes	53	9	yes	51	7		53	15	yes
Newport Bay, Newport Dunes-Middle	BNB24M				41	6		53	7		52	7		51	10	yes
Newport Bay, Via Genoa Beach	BNB07				41	3		54	9	yes	49	5		49	4	
Newport Bay, Lido Yacht Club Beach	BNB32				41	7	yes	53	5		50	6		49	3	
Newport Bay, Onyx Avenue Beach	BNB02				41	7	yes	54	6		52	7		49	6	
Newport Bay, Grand Canal	BNB34				41	7	yes	53	4		49	6		50	6	
Newport Bay, 43rd Street Beach	BNB09				41	11	yes	53	15	yes	48	23	yes	48	9	yes
Newport Bay, 38th Street Beach	BNB10				41	8	yes	53	10	yes	61	11	yes	59	14	yes
Newport Bay, 19th Street Beach	BNB14				41	9	yes	54	12	yes	53	9	yes	51	6	
Newport Bay, 10th Street Beach	BNB17				41	6		53	9	yes	66	17	yes	56	12	yes
Newport Bay, Harbor Patrol Beach	BNB33				41	9	yes	57	21	yes	59	10	yes	61	13	yes
Monarch Beach (North)	OSL25				40	3		54	5		61	10		60	12	yes

1. Single-sample exceedance-day is a sample day in which one or more of the 4 state bacteriological single-sample standards were exceeded.
2. Source of data - Routine monitoring results from The County of San Francisco, in partnership with the San Francisco Public Utilities Commission; The County of Santa Cruz Environmental Health Services; The County of Monterey Environmental Health Agency; The County of San Luis Obispo Environmental Health Department; The County of Santa Barbara Environmental Health Agency; The County of Orange Environmental Health; The South Orange County Wastewater Authority; The Orange County Sanitation District.
3. Listing policy Section 3.3 evaluation method specifies using the binomial model for evaluating beaches monitored year-round. All of these beaches exceeded the binomial model allowance during 1 of the 3 past years, or 2 of the last 5 years.
4. Based Heal the Bay's review of the 2002 State 303(d) list, none of these beaches are currenty listed for any bacteriological-related pollution such as beach closures, high coliform densities, etc.
5. Newport Bay is currenlty proposed for listing.

Blue boxes denote beaches that also should be listed based on geometric mean exceedance days - see Table 1.

Table 4

Statewide Beaches that do not meet the de-listing criteria for Geometric Mean Exceedance-days[1,2] but are Proposed for De-Listing[3,4]

Beach Name	Description	Monitoring ID	Data Start Date	Data End Date	Frequency	# of Geomeans	# of Exceed-Days
San Buenaventura Beach	south of drain at San Jon Rd.	VC19000	07/12/99	10/31/05	Weekly	243	62
Ormond Beach	Oxnard Industrial drain, 50 yds. no. of the drain	VC43000	07/12/99	10/25/05	Weekly	211	42
Mission Bay, Bonita Cove	north cove	MB170	03/22/00	08/27/04	Weekly	209	85
Mission Bay, Bahia Point-northside	apex of Gleason Rd.	MB160	03/22/00	10/25/05	Weekly	153	40
Mission Bay, San Juan Cove	west of boat launch	MB140	03/22/00	06/27/01	Weekly	54	12
Mission Bay, Santa Clara Cove	projection of Portsmouth Ct.	MB131	03/30/00	10/20/03	Weekly	52	18
Mission Bay, Fanuel Park	projection of Fanuel St.	MB120	03/22/00	10/25/05	Weekly	142	49
Mission Bay, Riviera Shores	projection of La Cima Dr.	MB110	03/22/00	10/20/03	Weekly	113	25
Mission Bay, Crown Point Shores		MB100	03/21/00	10/25/05	Weekly	143	28
Mission Bay, Wildlife Refuge near fence	projection of Lamont St.	MB090	03/21/00	10/25/05	Weekly	163	50
Mission Bay, Campland	west of Rose Creek	MB080	03/21/00	11/28/05	Weekly	258	158
Mission Bay, DeAnza Cove	mid-cove	MB070	03/21/00	10/25/05	Weekly	186	88
Mission Bay, Visitor's Center	projection of Clairemont Dr.	MB060	03/21/00	10/25/05	Weekly	242	149
Mission Bay, Tecolote Shores drain		MB040	03/21/00	10/25/05	Weekly	154	47
Mission Bay, Tecolote Playground	watercraft area	MB031	06/13/01	10/25/05	Weekly	41	7
Mission Bay, Tecolote Creek outlet		MB030	03/21/00	02/10/03	Weekly	106	73
Mission Bay, Hidden Anchorage		MB020	03/21/00	03/12/03	Weekly	74	36

1. Geometric means calculated for every 30-day period in which 5 samples were collected, per DHS guidance and the State Health Code.
2. Source of data - Routine monitoring results from The County of Ventura Environmental Health Division andCity of San Diego Stormwater Division.
3. De-listing policy Section 4.3 process for using the binomial model was used to evaluate number of exceedance-days for de-listing.
4. Based on the 2002 State 303(d) list, none of these beaches are currenty listed for any bacteriological-related pollution such as beach closures, high coliform densities, etc.

Table 5

Statewide Beaches Monitored only during the AB-411 Period
that do not meet the de-listing criteria for Single-sample Standard Exceedance-days[1,2]
but are Proposed for De-Listing[3,4]

Red blocks denote time periods when de-listing criteria are not met

		2000			2001			2002			2003			2004			2005		
Beach Name	Monitoring ID	Count	Exceed-Day	%	Count	Exceed-Day	%	Count	Exceed-Day	%	Count	Exceed-Day	%	Count	Exceed-Day	%	Count	Exceed-Day	%
La Jolla Shores, projection of Ave De La Playa	FM080	28	1	4%	29	2	7%	28			39	3	8%	32	4	13%	38	3	8%
La Jolla, South Casa Beach	EH305				30			29			29	2	7%	24			27	1	4%
Coast Blvd. (the Gazebo)	EH303							30	2	7%	28			27	3	11%	25		
La Jolla, projection of Vallecitos	EH320				6	3	50%				3	1	33%	3			4		
La Jolla, Children's Pool	EH310	25	16	64%	8	5	63%	3	2	67%	16	12	75%	14	9	64%			
Mission Bay, Mariners Basin (proj. of Balboa Ct.)	MB225	29			31	1	3%	31	3	10%	31	2	7%	28	1	4%	31	2	7%
Mission Bay, Bonita Cove (north cove)	MB170	48	8	17%	49	8	16%	40	3	8%	45	7	16%	1					
Mission Bay, Bonita Cove (east cove)	MB173													35	5	14%	32	2	6%
Mission Bay, Bahia Point-northside (apex of Gleason Rd.)	MB160	45	14	31%	30	4	13%	33	3	9%	26	1	4%	31	3	10%	30		
Mission Bay, Santa Clara Cove (proj. Portsmouth Ct.)	MB131	14	1	7%	6			37	6	16%	31	7	23%						
Mission Bay, Fanuel Park (proj. of Fanuel St.)	MB120	32	7	22%	31	5	16%	32	3	9%	35	5	14%	26	1	4%	32	2	6%
Mission Bay, Riviera Shores (proj. of La Cima Dr.)	MB110	30	5	17%	31	5	16%	34	5	15%	26								
Mission Bay, Crown Point Shores	MB100	38	5	13%	30	2	7%	29			27	2	7%	32	5	16%	31	2	7%
Mission Bay, Wildlife Refuge near fence (proj. of Lamont St.)	MB090	33	6	18%	30	5	17%	34	4	12%	32	1	3%	38	7	18%	30	1	3%
Mission Bay, DeAnza Cove (mid-cove)	MB070	41	11	27%	43	13	30%	34	5	15%	34	4	12%	34	5	15%	31	3	10%
Mission Bay, Visitor's Center (proj. of Clairemont Dr.)	MB060	44	14	32%	39	6	15%	38	13	34%	34	3	9%	43	16	37%	32	5	16%
Mission Bay, Comfort Station north of Leisure Lagoon	MB053													31	3	10%	32	3	9%
Mission Bay, Leisure Lagoon	MB050	36	3	8%	30	2	7%	34	5	15%	33	2	6%	34	3	9%	39	6	15%
Mission Bay, Tecolote Shores drain	MB040	37	11	30%	32	3	9%	31	2	7%	29			33	5	15%	29	1	3%
Mission Bay, Tecolote Playground (watercraft area)	MB031				5			12	1	8%	30	4	13%	29	2	7%	35	6	17%
Mission Bay, Tecolote Creek outlet	MB030	31	6	19%	40	9	23%	34	10	29%									
Mission Bay, Fiesta Island, NW shore	MB085													4	3	75%			
Mission Bay, Vacation Isle Ski Beach	MB203													34	2	6%	30		

1. Single-sample exceedance-day is a sample day in which one or more of the 4 state bacteriological single-sample standards were exceeded.
2. Source of data - Routine monitoring results from The County of San Diego Department of Environmental Health andCity of San Diego Stormwater Division.
3. De-listing policy Section 4.3 evaluation method specifies a maximum allowable exceedance frequency of 4% for beaches only monitored during the AB-411 time period. All of these beaches exceeded 4% during 1 of the 3 past years, or 2 of the last 5 years.
4. Based Heal the Bay's review of the 2002 State 303(d) list, none of these beaches are currenty listed for any bacteriological-related pollution such as beach closures, high coliform densities, etc.

Blue boxes denote beaches that should not bede- listed based on geometric mean exceedance-days - see Table 4.

Table 6

Statewide Beaches Monitored Year-round
that do not meet the de-listing criteria for Single-sample Standard Exceedance-days[1,2]
but are Proposed for De-Listing[3,4]

Red blocks denote time periods when de-listing criteria are not met

		2000			2001			2002			2003			2004			2005 [5]		
Beach	fpkLocId	Count	Exceed-Day	List	Count	Exceed-Day	List	Count	Exceed-Day	List	Count	Exceed-Day	List	Count	Exceed-Day	List	AB411 count	Exceed-Day	%
San Buenaventura Beach- south of drain at San Jon Rd.	VC19000	57	10	yes	56	13	yes	54	3		51	3		50	9	yes	31	6	19%
Mission Bay, Campland (west of Rose Creek)	MB080	54	10	yes	66	20	yes	51	17	yes	69	23	yes	48	12	yes			

1. Single-sample exceedance day is a sample day in which one or more of the 4 state bacteriological single-sample standards were exceeded.
2. Source of data - Routine monitoring results from The County of Ventura Environmental Health Division andCity of San Diego Stormwater Division.
3. De-listing policy Section 4.3 evaluation method specifies using the binomial model for evaluating beaches monitored year-round. All of these beaches exceeded the binomial model allowance during 1 of the 3 past years, or 2 of the last 5 years.
4. Based Heal the Bay's review of the 2002 State 303(d) list, none of these beaches are currenty listed for any bacteriological-related pollution such as beach closures, high coliform densities, etc.

Blue boxes denote beaches that also should be listed based on geometric mean exceedance days - see Table 4.

5. Previous Year-round beach sampling cut back to AB411 only in 2005. For this time period, the 4% allowable exceedance-day rate was applied.

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CALIFORNIA

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FAX: (310) 648-5731

October 27, 2005

Mr. Wayne Nastri
Regional Administrator
Environmental Protection Agency, Region IX
75 Hawthorne Street
San Francisco, CA 94105

EXAMINATION OF SMBBB TMDL STATIONS OF SANTA MONICA BAY
MONTH OF SEPTEMBER 2005

RE: SANTA MONICA BAY BEACHES BACTERIAL TOTAL MAXIMUM DAILY LOAD COORDINATED SHORELINE MONITORING PLAN

Dear Mr. Nastri:

The enclosed monthly monitoring report complies with the requirements of the Santa Monica Bay Beaches Bacterial Total Maximum Daily Load Coordinated Shoreline Monitoring Plan (SMBBB TMDL CSMP). These requirements are specified in the SMBBB TMDLs as adopted on July 15, 2003 for the responsible Jurisdictional Groups. The SMBBB TMDLs were issued by the California Regional Water Quality Control Board (CRWQCB), Los Angeles Region, and the Regional Administrator of the U.S. Environmental Protection Agency, Region IX. The monthly summaries include tabular data of concentrations of coliforms and enterococcus measured in water samples collected along the shoreline in Santa Monica Bay from the Los Aliso subwatershed in the north to the Ballona Creek subwatershed in the south, and a noncompliance remarks section.

The enclosed monitoring data were produced by the Environmental Monitoring Division (EMD).The EMD is responsible for monitoring and reporting data and observations for Jurisdictional Groups 1 through 6, 8, and 9.

If you have any questions regarding to these reports, please call Ms. Kay Yamamoto of my staff at (310) 648-5727.

Sincerely,

Masahiro Dojiri, Ph.D.
Division Manager
Environmental Monitoring Division

Enclosure

GEM: KMY
c. County of Los Angeles, Department of Health Services

Appendix 1-C

SEPTEMBER 2005

TABLE OF CONTENTS

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SECTION A

MONTHLY SUMMARY

SANTA MONICA BAY BEACHES BACTERIAL TMDL
SINGLE SAMPLE LIMIT EXCEEDANCE TABLE

November 2004 to September 2005 **PAGE 1 OF 2**

MONTH	1-2	1-3	1-6	1-8	1-10	1-12	1-13	1-14	1-16	1-17	1-18	2-1	2-2	2-4	2-7	2-10	2-11	2-13	3-3	3-4	3-5	3-6	3-8	BC-1	MC-2
	WINTER - DRY (NOVEMBER 1 - MARCH 31) EXCEEDANCE DAYS ^																								
NOV 2004						8					7	4	5	3	16	3		2	13	8	3		1	5	11
DEC 2004				1		1					8	6		1	13	1		1	9	5	4		4		12
JAN 2005	1			1			3	1	1		6	2	2	3	10				2	7	3	2	1	7	4
FEB 2005			1	2		3	1		1		2	3	2	2	9				5	6	1		1	5	
MAR 2005			2	3		5				2	4	2	1	7	11	1			9	8	1		1	6	1
TOTAL YTD	1		3	7		17	4	1	2	2	27	17	10	16	59	5		3	38	34	12	2	8	23	28
ALLOWANCES	1	1	1	1	1	1	1	1	1	1	3	1	1	3	3	3	1	2	3	3	3	1	2	3	3
EXCEEDED?			Yes	Yes		Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

MONTH	1-2	1-3	1-6	1-8	1-10	1-12	1-13	1-14	1-16	1-17	1-18	2-1	2-2	2-4	2-7	2-10	2-11	2-13	3-3	3-4	3-5	3-6	3-8	BC-1	MC-2
	SUMMER - DRY (APRIL 1 - OCTOBER 31) EXCEEDANCE DAYS *																								
APR 2005				6		2	1	4	1	1	8	5	3	8	21			3	8	9	1	2	1	5	14
MAY 2005				7	1	6		4		4	12	6		7	10	1		2	6	11			2	9	10
JUN 2005				13	2	4	1	1		1	10	7		6	23			8	12	4			1	10	20
JUL 2005				12	4	4	4		2	1	17	8	2	3	18				10	2	1	1	1	7	16
AUG 2005				6	1	11	1				7	10	7	1	13	3			12	1				11	10
SEP 2005				1	2	6					3	7	2	1	8				7	1				3	7
TOTAL YTD				45	10	33	7	9	3	7	57	43	14	26	93	4		13	55	28	2	3	5	45	77
ALLOWANCES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXCEEDED?				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

MONTH	1-2	1-3	1-6	1-8	1-10	1-12	1-13	1-14	1-16	1-17	1-18	2-1	2-2	2-4	2-7	2-10	2-11	2-13	3-3	3-4	3-5	3-6	3-8	BC-1	MC-2
	WET - WEATHER EXCEEDANCE DAYS @																								
NOV 2004																									
DEC 2004	1	1			1	1	1	1	1		6	1	1	6	7	3	1	4	7	7	6	1	4	6	7
JAN 2005	1	1	2	2	1	1	2	1	1		13	2	2	12	15	9	1	6	11	12	10	2	7	14	14
FEB 2005				1	1	3		3	4		11	5	1	11	12	3	1	6	11	11	7	2	7	12	8
MAR 2005				1		1				2	6	2	1	8	11	1		3	6	10	4		2	8	4
APR 2005											3		1	2	3	2		3	2	3	3		2	3	2
MAY 2005				1		1	1	1		1	1			2	4	1			2	2				2	2
JUN 2005																									
JUL 2005																									
AUG 2005																									
SEP 2005					1	1	1				2	1	1	1	4			1	2	2	2			3	2
TOTAL YTD	2	2	2	5	4	8	5	6	6	3	42	11	7	42	56	19	3	23	41	47	32	5	22	48	39
ALLOWANCES	3	3	3	3	3	3	3	3	3	3	17	3	3	17	17	17	3	17	17	17	17	3	13	17	17
EXCEEDED?				Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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WISARD - Legal TMDL - SMBBB Summary

LEGEND:
* - Summer-Dry compliance to be achieved by July 15, 2006
^ - Winter-Dry compliance to be achieved by July 15, 2009
@ - Wet-Weather compliance date 10-18 years from July 15, 2003

Shaded columns denote exceedance counts greater than allowances

Appendix 1-C

Single-Sample Limits:
Total coliform density shall not exceed 10,000/100 ml
Fecal coliform density shall not exceed 400/100 ml
Enterococcus density shall not exceed 104/100 ml
Total coliform density shall not exceed 1,000/100 ml
if the ratio of fecal-to-total coliform exceeds 0.1

SANTA MONICA BAY BEACHES BACTERIAL TMDL
ROLLING 30-DAY GEOMETRIC MEAN EXCEEDANCE TABLE

November 2004 to September 2005 **PAGE 2 OF 2**

MONTH	1-2	1-3	1-6	1-8	1-10	1-12	1-13	1-14	1-16	1-17	1-18	2-1	2-2	2-4	2-7	2-10	2-11	2-13	3-3	3-4	3-5	3-6	3-8	BC-1	MC-2
	WINTER - DRY (NOVEMBER 1 - MARCH 31) EXCEEDANCE DAYS ^																								
NOV 2004						1					1	1	1		1				1	1					1
DEC 2004						31					31	31	12		31				31	30					31
JAN 2005			24			17					12	31	20		12				31	2	17			5	31
FEB 2005			19	24		20	24	6	17	18	28	28	28	23	28				17	25	19			28	26
MAR 2005			31	31		31		31	31	31	31	23	31	31	31				13	28				31	31
TOTAL YTD			74	55		100	24	37	48	49	103	114	92	54	103				93	86	36			64	120
ALLOWANCES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXCEEDED?			Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes				Yes	Yes	Yes			Yes	Yes

	SUMMER - DRY (APRIL 1 - OCTOBER 31) EXCEEDANCE DAYS *																								
APR 2005			22	30		30		30		23	30	30	30	28	30				30	15				26	30
MAY 2005				31	2	31	14	28	4	20	31	31	31	31	31			21	9	28				12	31
JUN 2005				30	30	30	5	30		30	30	30	30	1	30			6	24	21				30	30
JUL 2005				31	31	31	26	31	3		31	31	12	23	31	5			31					31	31
AUG 2005				31	24	31	26			13	30	31	31	30	31	31			31					31	31
SEP 2005				15	18	30				28		30	11		30	11			30					30	9
TOTAL YTD			22	168	105	183	71	119	7	114	152	183	145	113	183	47		27	155	64				160	162
ALLOWANCES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXCEEDED?			Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes				Yes	Yes

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WISARD - Legal TMDL - SMBBB Summary

LEGEND:
* - Summer-Dry compliance to be achieved by July 15, 200
^ - Winter-Dry compliance to be achieved by July 15, 200

Shaded columns denote exceedance counts greater than allowances

Rolling 30-day Geometric Mean Limits:
Total coliform density shall not exceed 1,000/100 ml
Fecal coliform density shall not exceed 200/100 ml
Enterococcus density shall not exceed 35/100 ml

Appendix 1-C

CITY OF LOS ANGELES
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FAX: (310) 648-5731

October 27, 2005

Mr. Wayne Nastri
Regional Administrator
Environmental Protection Agency, Region IX
75 Hawthorne Street
San Francisco, CA 94105

EXAMINATION OF DHS SMBBB TMDL STATIONS OF SANTA MONICA BAY MONTH OF SEPTEMBER 2005

RE: SANTA MONICA BAY BEACHES BACTERIAL TOTAL MAXIMUM DAILY LOAD COORDINATED SHORELINE MONITORING PLAN – Department of Health Services Bacteriological Data

Dear Mr. Nastri:

The enclosed monthly monitoring report complies with the requirements of the Santa Monica Bay Beaches Bacterial Total Maximum Daily Load Coordinated Shoreline Monitoring Plan (SMBBB TMDL CSMP). These requirements are specified in the SMBBB TMDLs as adopted on July 15, 2003 for the responsible Jurisdictional Groups. The SMBBB TMDLs were issued by the California Regional Water Quality Control Board (CRWQCB), Los Angeles Region, and the Regional Administrator of the U.S. Environmental Protection Agency, Region IX. The monthly summaries include tabular data of concentrations of coliforms and enterococcus measured in water samples collected along the shoreline in Santa Monica Bay from the Arroyo Sequit subwatershed in the north to the Redondo subwatershed in the south, and a noncompliance remarks section.

The enclosed monitoring data were produced by the County of Los Angeles Department of Health Services (LACDHS) and reported by the City of Los Angeles. Please note that beginning July 1, 2005 EMD produced a portion of the monitoring data for SMB 5-2 (old DHS 113) and SMB 6-2 (old DHS 115). The EMD is responsible for submitting LACDHS bacteriological data for Jurisdictional Groups 1 through 6, 8, and 9.

Please note that data corrections to the August 2005 DHS report are included herein. The data changes affect the SMB-6-01 station on August 17, 2005. Please replace this page in your August 2005 report.

If you have any questions regarding to these reports, please call Ms. Kay Yamamoto of my staff at (310) 648-5727.

Sincerely,

Masahiro Dojiri, Ph.D.
Division Manager
Environmental Monitoring Division

Enclosure

GEM: KMY

c. County of Los Angeles, Department of Health Services

SANTA MONICA BAY BEACHES BACTERIAL TMDL
SINGLE SAMPLE LIMIT EXCEEDANCE TABLE
COUNTY OF LOS ANGELES DHS LABORATORY MONITORING

November 2004 to September 2005

WINTER - DRY (NOVEMBER 1 - MARCH 31) EXCEEDANCE DAYS ^

MONTH	1-1	1-4	1-5	1-7	1-9	1-11	1-15	2-3	2-5	2-6	2-8	2-9	2-12	2-14	2-15	3-1	3-2	3-7	3-9	4-1	5-2	5-4	6-1	6-4	MC-1	MC-3
NOV 2004		2	1	5	1	1	1	1	1	2					1	1		1	2		3		1	1		1
DEC 2004		1		1						1		1	1											1		
JAN 2005	2	5	2	1					2	4	1		1			2	2									3
FEB 2005	2	5	5	3	3					5			1			2			1	2					1	1
MAR 2005	1	2	1	2	2				1	3													1		2	1
TOTAL YTD	5	15	9	12	6	1	1	1	4	15	1	1	3		1	5	2	1	3	2	3		2	2	3	6
ALLOWANCES	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1
EXCEEDED?	Yes	Yes	Yes	Yes	Yes				Yes	Yes			Yes			Yes	Yes		Yes	Yes	Yes		Yes	Yes	Yes	Yes

SUMMER - DRY (APRIL 1 - OCTOBER 31) EXCEEDANCE DAYS *

MONTH	1-1	1-4	1-5	1-7	1-9	1-11	1-15	2-3	2-5	2-6	2-8	2-9	2-12	2-14	2-15	3-1	3-2	3-7	3-9	4-1	5-2	5-4	6-1	6-4	MC-1	MC-3
APR 2005	3	2	3	3	4				3	3	1	1	1			1		1			2				1	1
MAY 2005	4		4	6	4	1	1								1		1			1	2				1	1
JUN 2005			2	1			1									1										
JUL 2005				1	7				1												3		2		2	
AUG 2005				3	1	1	1		1			1					1				3		1			
SEP 2005							1	1							1								1		3	2
TOTAL YTD	7	2	9	14	16	2	4	1	5	3	1	2	1		2	2	2	1		1	10		4		7	4
ALLOWANCES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXCEEDED?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes		Yes	Yes		Yes		Yes	Yes

WET - WEATHER EXCEEDANCE DAYS @

MONTH	1-1	1-4	1-5	1-7	1-9	1-11	1-15	2-3	2-5	2-6	2-8	2-9	2-12	2-14	2-15	3-1	3-2	3-7	3-9	4-1	5-2	5-4	6-1	6-4	MC-1	MC-3
NOV 2004																										
DEC 2004																										
JAN 2005	1	2	2	1	1	1	1	2	2	4	2	2	1	1	2	2	2	2	2	1	2	2	2	1	1	1
FEB 2005	1	1	1	2	2	1	1	1	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MAR 2005	1	2	5	4	2				1	5		1		1	2				2		1		2			3
APR 2005									1																	
MAY 2005	1		1	2				1	1																	2
JUN 2005																										
JUL 2005																										
AUG 2005																										
SEP 2005																					1		3			
TOTAL YTD	4	5	9	9	5	2	2	4	6	12	3	4	2	3	5	3	3	3	5	2	5	3	8	2	2	7
ALLOWANCES	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	2	3	3	3	3
EXCEEDED?	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes		Yes			Yes				Yes		Yes	Yes	Yes			Yes

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WISARD - Legal TMDL - SMBBB Summary

LEGEND:
* - Summer-Dry compliance to be achieved by July 15, 2006
^ - Winter-Dry compliance to be achieved by July 15, 2009
@ - Wet-Weather compliance date 10-18 years from July 15, 2003

Shaded columns denote exceedance counts greater than allowances

Appendix 1-C

Single-Sample Limits:
Total coliform density shall not exceed 10,000/100 ml
Fecal coliform density shall not exceed 400/100 ml
Enterococcus density shall not exceed 104/100 ml
Total coliform density shall not exceed 1,000/100 ml
if the ratio of fecal-to-total coliform exceeds 0.1

SANTA MONICA BAY BEACHES BACTERIAL TMDL
ROLLING 30-DAY GEOMETRIC MEAN EXCEEDANCE TABLE
COUNTY OF LOS ANGELES DHS LABORATORY MONITORING

November 2004 to September 2005

MONTH	1-1	1-4	1-5	1-7	1-9	1-11	1-15	2-3	2-5	2-6	2-8	2-9	2-12	2-14	2-15	3-1	3-2	3-7	3-9	4-1	5-2	5-4	6-1	6-4	MC-1	MC-3
	WINTER - DRY (NOVEMBER 1 - MARCH 31) EXCEEDANCE DAYS ^																									
NOV 2004				1					1	1					1			1	1		1		1	1		
DEC 2004		30	24	31					28	10		4	6	5	11	28	24	31	1		16		18	31		
JAN 2005		7	31	31			2		8	1		31					6	3						31		
FEB 2005	16	28	28	28	15		5		27	28	20	28				15	20			23	24		6	11	17	25
MAR 2005		31	31	31	31		3		19	31	12	21								8	1		14	18	31	31
TOTAL YTD	16	96	114	122	46		10		83	71	32	84	6	5	12	43	50	35	2	31	42		39	92	48	56
ALLOWANCES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXCEEDED?	Yes	Yes	Yes	Yes	Yes		Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes

	1-1	1-4	1-5	1-7	1-9	1-11	1-15	2-3	2-5	2-6	2-8	2-9	2-12	2-14	2-15	3-1	3-2	3-7	3-9	4-1	5-2	5-4	6-1	6-4	MC-1	MC-3
	SUMMER - DRY (APRIL 1 - OCTOBER 31) EXCEEDANCE DAY																									
APR 2005	20	19	30	30	30				4	30											9				17	19
MAY 2005	26		31	31	31				8	5		13	8								30				30	20
JUN 2005	7		29	11	13																					19
JUL 2005	10				25	7																				21
AUG 2005				9	30	13			5			29												3		
SEP 2005				2								8														
TOTAL YTD	63	19	90	83	129	20			17	35		50	8								39			3	47	79
ALLOWANCES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EXCEEDED?	Yes	Yes	Yes	Yes	Yes	Yes			Yes	Yes		Yes	Yes								Yes			Yes	Yes	Yes

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WISARD - Legal TMDL - SMBBB Summary

LEGEND:

* - Summer-Dry compliance to be achieved by July 15, 2006
^ - Winter-Dry compliance to be achieved by July 15, 2009

Shaded columns denote exceedance counts greater than allowances

Rolling 30-day Geometric Mean Limits:
Total coliform density shall not exceed 1,000/100 ml
Fecal coliform density shall not exceed 200/100 ml
Enterococcus density shall not exceed 35/100 ml

Appendix 2: Compton Creek Trash

Issue Summary
Tonnage Data
Photographic Evidence

Compton Creek Trash

Compton Creek should be placed on the 303(d) List for trash based on the situation-specific weight of evidence under section 3.11of the Listing Policy. Compton Creek Watershed is arguably the most visibly polluted watershed in California, let alone Los Angeles County. Large volumes of trash collects in the flowing water and along the banks of Compton Creek. Compton Creek supports many beneficial uses including ground water recharge, water contact recreation, non-contact water recreation, warm freshwater habitat, wildlife habitat and wetland habitat. The high concentration of trash in Compton Creek impairs these beneficial uses. In addition, the trash pollution violates the LARWQCB Basin Plan's narrative water quality objective that "waters shall not contain floating materials including solids, liquids, foams and scum, in concentrations that cause nuisance or adversely affects beneficial uses."

There are three lines of evidence available to assess trash in Compton Creek. The first line of evidence is data on the tonnage of trash collected by Los Angeles County Department of Public Works between 2002 and 2005. In 2002, the County instituted a trash removal program for Compton Creek. As see in Table 1, large amounts of trash have been collected and removed from Compton Creek through this effort. For instance in July of 2002, over 23 tons of trash were removed through this program. The second line of evidence, presented in Table 2, is data on the tonnage of trash collected by volunteers at Coastal Cleanup Day and Earth Day events since 2002. At the April 2003 clean-up event, volunteers removed over 10 tons of trash in a period of less than three hours. The final line of evidence is Heal the Bay's photographic documentation of trash pollution in Compton Creek. The photographs below show large amounts of accumulated trash in various sections of Compton Creek. These photographs were taken at various Heal the Bay-sponsored clean-up activities. Heal the Bay has been the Los Angeles County coordinator for Coastal Cleanup Day and Adopt A Beach for 15 years. During that time, there have been regular clean-ups at over 60 locations. Not one of these locations is even close to as polluted with trash as Compton Creek. Based on these three lines of evidence, the weight of evidence clearly indicates that water quality standards are not attained. Thus, under section 3.11 of the Listing Policy, Compton Creek should be listed for trash on the 303(d) List.

Month	Tons Removed
Jul-02	23.35
Aug-02	3.98
Sep-02	3.16
Oct-02	4.84
Nov-02	2.63
Dec-02	3
Apr-03	13.73
May-03	5.53

Month	Tons Removed
Jul-03	7.55
Aug-03	7.2
Sep-03	8.36
Oct-03	8.18
Apr-04	1.61
May-04	4.21
Jun-04	3.34
Sep-04	4.15
Oct-04	3.21
Nov-04	5.6
Jun-05	6.23
Jul-05	3.37
Aug-05	4.65
Sep-05	4.6
Oct-05	2.7

Table 1: Tons of trash removed from Compton Creek by Los Angeles County Department of Public Works. (Daniel Sharp, Los Angeles County Department of public works (DSHARP@ladpw.org).)

Month	Tons Removed
21-Sep-02	1
1-Apr-03	2
20-Sep-03	2.5
17-Apr-04	10
18-Sep-04	5
30-Apr-05	2
17-Sep-05	4

Table 2: Tons of trash removed from Compton Creek by volunteers on Coastal Cleanup Day and Earth Day (Heal the Bay). All Clean-ups were three hours or less.

Compton Creek. Photographic taken by Heal the Bay staff in 2002.

Compton Creek. Photograph taken by Heal the Bay staff at Coastal Cleanup Day on September 20, 2003.

Compton Creek, across from Casino. Photograph taken by Heal the Bay staff in 2004.

Compton Creek: Heal the Bay Executive Director, Mark Gold. Photograph taken at a Heal the Bay-sponsored clean-up on December 22, 2005.

Compton Creek. Photograph taken at a Heal the Bay-sponsored clean-up on December 22, 2005.

Appendix 3:
Excess Algal Growth in Calleguas Creek

3 - A: UCLA Algal Coverage Data
3 - B: Photographic Evidence
3 - C: Map of Low IBI Scores in Watershed

Appendix 3-A: Calleguas Creek Transect Data

Source: Ambrose, R.F., Lee, S.F., and S.P. Bergquist, Environmental Monitoring and Bioassessment of Coastal Watersheds in Ventura and Los Angeles Counties (2003).

Site	Watershed	Macroalgae	Diatoms (Periphyton)		Macroalgae	Macrophytes	Moss	No Cover	Total Cover	Total Vegetation
		Biomass (g/m2)	All diatoms % cover	med. and thick % Cover	% Cover	% Cover	% Cover	%	%	% Cover
Calleguas at Deepwood	Calleguas	0.00	5	0	0	0	0	95	100	5
Calleguas at Deepwood	Calleguas	0.00	95	0	0	0	0	5	100	95
Calleguas at Deepwood	Calleguas	0.00	95	0	0	0	0	5	100	95
Calleguas at Deepwood	Calleguas	0.00	0	0	0	0	0	100	100	0
Calleguas at Deepwood	Calleguas	0.00	55	30	0	0	0	45	100	55
Calleguas at Deepwood	Calleguas	0.00	100	55	0	0	0	0	100	100
Oaks Mall	Calleguas	0.00	65	45	0	0	0	35	100	65
Oaks Mall	Calleguas	0.00	30	10	0	0	0	70	100	30
Oaks Mall	Calleguas	0.02	90	65	0	0	0	10	100	90
Oaks Mall	Calleguas	0.00	25	25	0	0	0	75	100	25
Oaks Mall	Calleguas	0.00	40	25	0	0	0	60	100	40
Oaks Mall	Calleguas	0.00	10	10	0	0	0	90	100	10
Reino Rd.	Calleguas	0.02	50	0	0	20	0	30	100	70
Reino Rd.	Calleguas	0.02	15	5	0	5	0	80	100	20
Reino Rd.	Calleguas	0.02	40	20	0	0	0	60	100	40
Reino Rd.	Calleguas	0.02	40	0	0	5	0	55	100	45
Reino Rd.	Calleguas	0.02	50	25	0	5	0	45	100	55
Reino Rd.	Calleguas	0.02	25	5	0	5	0	70	100	30
FC @ VentuPark Rd.	Calleguas	13.65	25	15	60	5	0	10	100	90
FC @ VentuPark Rd.	Calleguas	0.46	25	10	40	0	0	35	100	65
FC @ VentuPark Rd.	Calleguas	15.95	60	10	35	0	0	5	100	95
FC @ VentuPark Rd.	Calleguas	10.12	50	40	20	5	0	25	100	75
FC @ VentuPark Rd.	Calleguas	6.29	45	30	30	10	0	15	100	85
FC @ VentuPark Rd.	Calleguas	1.40	55	10	40	0	0	5	100	95
FC @ Young Rd.	Calleguas	0.04	50	0	0	0	0	50	100	50
FC @ Young Rd.	Calleguas	1.23	50	0	10	0	0	40	100	60
FC @ Young Rd.	Calleguas	2.05	0	0	40	0	0	60	100	40
FC @ Young Rd.	Calleguas	0.86	10	0	10	0	0	80	100	20
FC @ Young Rd.	Calleguas	0.04	10	0	20	0	0	70	100	30
FC @ Young Rd.	Calleguas	0.08	10	0	20	0	0	70	100	30
Upper Wildwood	Calleguas	0.00	0	0	0	0	0	100	100	0
Upper Wildwood	Calleguas	0.00	5	0	0	0	0	95	100	5
Upper Wildwood	Calleguas	0.00	65	0	0	0	0	35	100	65
Upper Wildwood	Calleguas	0.00	80	60	0	0	0	20	100	80
Upper Wildwood	Calleguas	0.00	0	0	0	0	0	100	100	0
Upper Wildwood	Calleguas	0.00	0	0	0	100	0	0	100	100
Leisure Village	Calleguas	0.15	45	10	20	0	0	35	100	65
Leisure Village	Calleguas	0.02	20	10	25	0	0	55	100	45
Leisure Village	Calleguas	0.02	5	0	20	20	0	55	100	45
Leisure Village	Calleguas	0.02	20	15	0	20	0	60	100	40
Leisure Village	Calleguas	0.02	5	0	5	30	0	60	100	40
Leisure Village	Calleguas	0.48	20	5	10	15	0	55	100	45
Bottom Conejo Creek	Calleguas	0.00	0	0	0	15	0	85	100	15
Bottom Conejo Creek	Calleguas	0.00	5	5	0	5	0	90	100	10
Bottom Conejo Creek	Calleguas	0.00	5	5	0	5	0	90	100	10
Bottom Conejo Creek	Calleguas	0.00	0	0	0	0	0	100	100	0
Bottom Conejo Creek	Calleguas	0.00	0	0	0	0	0	100	100	0
Bottom Conejo Creek	Calleguas	0.00	0	0	10	5	0	85	100	15

Appendix 3-B: Calleguas Creek Photographs

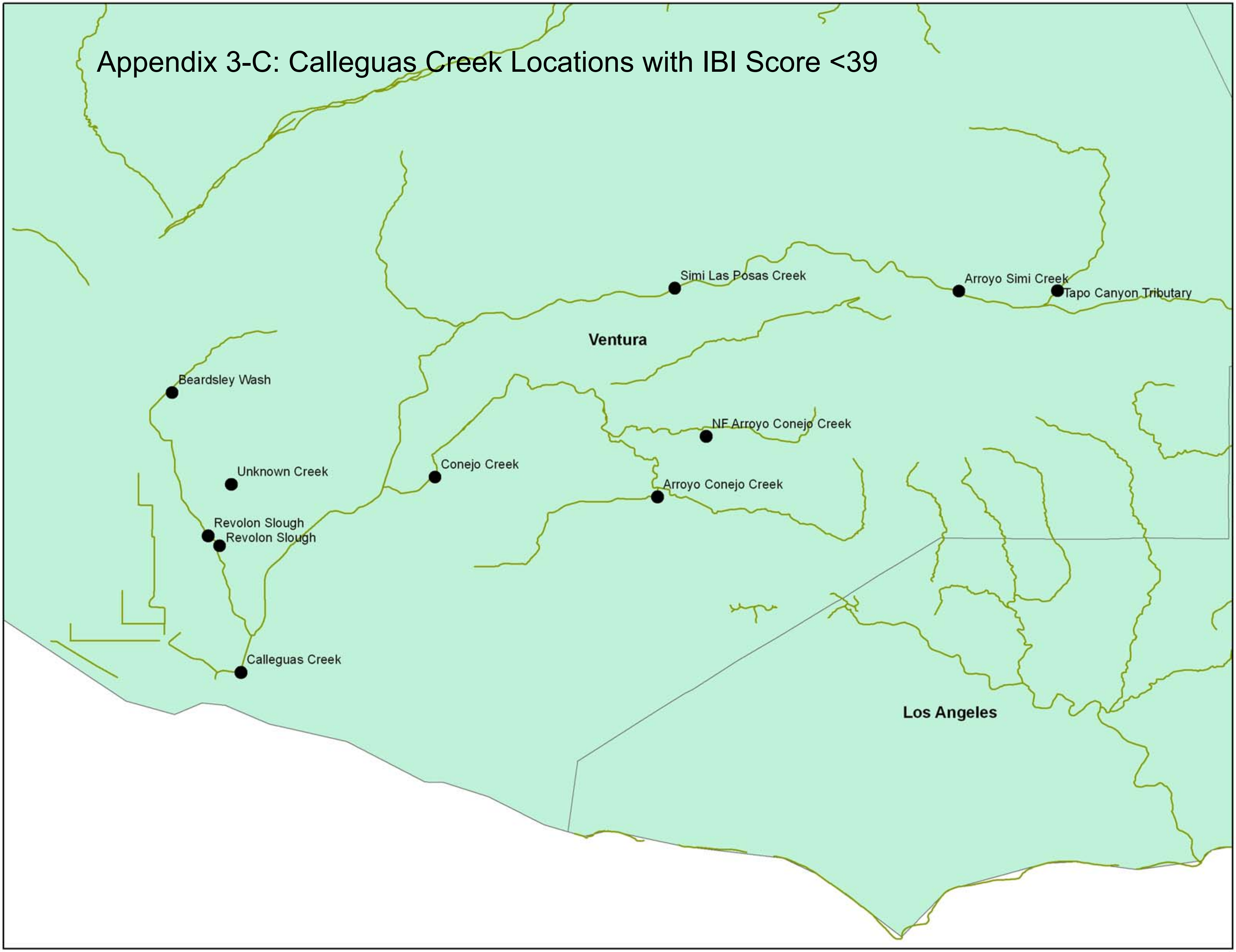
Calleguas Creek – Reach 10 (Arroyo Conejo Canyon). Photograph taken in summer 2004 by Steve Lee of UCLA.

Calleguas Creek – Reach 10 (Arroyo Conejo Canyon). Aerial photograph taken in summer 2004 by Steve Lee of UCLA.

Calleguas Creek – Reach 7 (Arroyo Simi). Photograph taken in summer 2004 by Steve Lee of UCLA.

Calleguas Creek – Reach 7 (Arroyo Simi). Photograph taken in summer 2004 by Steve Lee of UCLA.

Appendix 3-C: Calleguas Creek Locations with IBI Score <39



Appendix 4: Ballona Creek Sediment

ACOE Sediment Chemistry Data
Map of ACOE Monitoring Locations

ACOE Ballona Creek Sediment Sampling Data

TABLE 3
Ballona Creek Bed Load Sediment Quality
October 5 - 6, 1999

				Sediment Concentration by Site (Dry Weight Basis)																				
Parameters	**Units**	**Reporting Limits**	**Effect Range Low (ERL)***	**Ballona @ Pickford**	**648/Pickford St. Srain**	**494**	**54**	**Ballona @ Fairfax**	**9408/Holly Hills**	**DD1-11**	**84**	**Higuera**	**Ince Blvd. Drain/3867**	**Benedict Canyon Ch.**	**Ballona @ Madison**	**RDD 208**	**2901**	**425**	**Sepulveda Blvd.**	**Ballona @ Sawtelle**	**Sepulveda Channel**	**503**	**51**	**Centinela Channel**
Total Organic Carbon	mg/kg	80		442	22400	177755	1423	285	438	1142	2700	817	494	1741	2975	11340	3269	1119	1327	1012	563	4862	25442	1190
Total Recoverable Hydrocarbons	mg/kg	100		942	1200	2510	724	200	224	225	353	573	1010	413	201	258	632	36	673	74	139	1954	786	171
Silt/clay	proportion	NA		0.000	0.007	0.035	0.073	0.007	0.012	0.022	0.031	0.126	0.007	0.619	0.545	0.596	0.238	0.036	0.536	0.006	0.087	0.66	0.084	0.041
Metals:																								
Antimony	mg/kg	0.750		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	1.208	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	2.762	BLD
Arsenic	mg/kg	0.750	8.2	BLD	BLD	BLD	4.862	1.277	1.017	2.564	2.900	1.842	2.399	**10.888**	**9.008**	**9.361**	3.409	BLD	7.585	1.180	8.170	**17.231**	6.973	1.751
Barium	mg/kg	0.500		24.362	448.571	593.878	157.735	31.565	26.148	83.381	99.167	50.292	43.967	205.792	175.207	735.052	157.025	12.547	226.190	38.874	75.710	263.077	213.605	40.092
Beryllium	mg/kg	0.250		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Cadmium	mg/kg	0.500	1.2	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	**3.054**	**2.675**	BLD	BLD	BLD	BLD	BLD	BLD	**2.877**	**4.490**	BLD
Chromium	mg/kg	0.250		3.527	30.571	26.735	35.083	5.822	6.964	9.112	12.483	17.251	13.578	25.251	23.967	40.103	31.281	2.870	37.415	7.721	9.779	36.000	29.626	7.250
Cobalt	mg/kg	0.250		1.497	16.029	10.408	6.188	2.427	2.028	2.579	3.983	3.275	2.302	7.915	7.300	12.474	5.950	0.793	14.218	2.279	3.139	13.308	10.918	2.366
Copper	mg/kg	0.500	34.0	15.313	**614.286**	**310.204**	**76.243**	**78.249**	9.324	**39.255**	32.833	29.386	**49.515**	**213.900**	**173.278**	**600.000**	**230.579**	3.627	**283.673**	7.976	28.076	**253.846**	**242.857**	21.659
Lead	mg/kg	0.500	46.7	**53.828**	**221.714**	**106.735**	**127.348**	12.719	3.929	27.937	**72.500**	**270.468**	26.907	**61.390**	**77.410**	**117.526**	**67.355**	0.928	**100.000**	11.126	17.192	**150.462**	**214.966**	25.192
Mercury	mg/kg	0.084	0.2	BLD	BLD	BLD	BLD	BLD	BLD	**1.533**	0.167	BLD	BLD	BLD	BLD	BLD	BLD	0.129	BLD	BLD	BLD	**0.477**	**0.314**	BLD
Molybdenum	mg/kg	0.250		BLD	BLD	14.755	1.677	5.756	BLD	0.841	1.227	0.830	1.178	5.135	2.383	2.907	2.926	BLD	2.357	BLD	0.923	3.846	7.517	BLD
Nickel	mg/kg	0.250	20.9	2.981	**224.286**	**33.673**	**21.796**	6.220	4.273	7.622	9.350	14.035	9.182	**30.386**	**26.749**	**32.371**	19.174	1.317	**35.034**	6.408	10.142	**36.615**	**39.116**	4.071
Selenium	mg/kg	0.750		1.392	BLD	BLD	4.862	1.923	1.352	2.292	2.333	1.974	1.498	7.761	5.234	11.753	4.066	BLD	4.320	2.091	3.659	4.477	BLD	1.843
Silver	mg/kg	0.250	1.0	BLD	BLD	BLD	**5.000**	**1.277**	BLD	BLD	**1.160**	BLD	BLD	**1.162**	**1.455**	**3.330**	BLD	BLD	BLD	BLD	BLD	**3.769**	**1.133**	BLD
Thallium	mg/kg	0.750		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Vanadium	mg/kg	0.250		4.977	19.057	31.837	21.547	8.011	9.005	10.244	11.717	10.658	8.336	23.591	23.912	40.000	22.603	3.354	54.082	8.056	11.041	37.231	35.374	9.862
Zinc	mg/kg	1.000	150.0	54.408	**1830.000**	**1280.000**	**483.425**	149.867	67.092	**187.679**	**208.333**	**185.673**	**235.784**	**467.181**	**358.127**	**1247.423**	**495.868**	26.087	**642.857**	78.016	119.874	**887.692**	**1840.136**	86.329
Polynuclear Aromatic Hydrocarbons:																								
Acenaphthene	µg/kg	50	16.0	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Anthracene	µg/kg	50	85.0	BLD	BLD	**2449**	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	**92**	**680**	BLD
Benzo(a) anthracene	µg/kg	50	261.0	BLD	BLD	**2245**	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	**4422**	BLD
Benzo(a) pyrene	µg/kg	50	430.0	BLD	BLD	BLD	BLD	BLD	BLD	129	83	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	323	**28231**	BLD
Benzo(b) Fluoranthene	µg/kg	50		BLD	BLD	BLD	166	BLD	BLD	72	BLD	BLD	83	BLD	BLD	BLD	BLD	BLD	238	BLD	BLD	569	3741	BLD
Benzo(k) Fluoranthene	µg/kg	50		BLD	BLD	1020	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	246	1156	BLD
Benzo(g,h,I) Perylene	µg/kg	50		104	BLD	BLD	BLD	BLD	BLD	487	BLD	263	97	BLD	BLD	BLD	289	BLD	BLD	BLD	BLD	BLD	578	BLD
Chrysene	µg/kg	50	384.0	BLD	**1714**	BLD	138	BLD	BLD	143	BLD	88	69	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	431	**4422**	BLD
Dibenzo-a,h-anthracene	µg/kg	50	63.4	**139**	**1429**	BLD	**470**	BLD	BLD	**244**	**100**	**292**	**139**	BLD	BLD	BLD	BLD	BLD	BLD	BLD	**126**	**308**	**680**	BLD
Fluoranthene	µg/kg	50	600.0	BLD	BLD	BLD	249	80	BLD	401	BLD	278	166	BLD	138	BLD	BLD	BLD	BLD	BLD	126	**862**	**8163**	138
Fluorene	µg/kg	50	19.0	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	**146**	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	**108**	BLD	BLD
Indeno(1,2,3-c,d) Pyrene	µg/kg	50		70	BLD	BLD	138	66	BLD	100	167	146	BLD	309	193	BLD	248	BLD	204	BLD	126	385	2449	123
2-Methylnaphthalene	µg/kg	50	70.0	BLD	BLD	BLD	BLD	**80**	BLD	**201**	BLD	BLD	**111**	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	**748**	BLD
Naphthalene	µg/kg	50	160.0	**661**	BLD	BLD	BLD	**915**	BLD	BLD	BLD	**1155**	**416**	BLD	BLD	BLD	BLD	BLD	**1088**	BLD	BLD	**1492**	**11224**	138
Phenanthrene	µg/kg	50	240.0	BLD	BLD	BLD	221	**252**	BLD	**272**	BLD	**409**	**264**	BLD	BLD	BLD	BLD	BLD	BLD	BLD	142	**738**	**5102**	92
Pyrene	µg/kg	50	665.0	BLD	**2000**	BLD	193	BLD	BLD	287	BLD	234	194	309	165	BLD	BLD	BLD	272	BLD	95	**846**	**8163**	138
Total PAHS	µg/kg	50	4022.0	974	**5143**	**5714**	1575	1393	BLD	2335	350	3012	1540	618	496	BLD	537	BLD	**1803**	BLD	615	**6400**	**79762**	630
Pesticides:																								
Aldrin	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Alpha-BHC	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Gamma-BHC	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Beta-BHC	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	9	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Delta-BHC	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD

ACOE Ballona Creek Sediment Sampling Data

TABLE 3
Ballona Creek Bed Load Sediment Quality
October 5 - 6, 1999

Parameters	Units	Reporting Limits	Effect Range Low (ERL)*	Sediment Concentration by Site (Dry Weight Basis) Ballona @ Pickford	648/Pickford St. Srain	494	54	Ballona @ Fairfax	9408/Holly Hills	DD1-11	84	Higuera	Ince Blvd. Drain/3867	Benedict Canyon Ch.	Ballona @ Madison	RDD 208	2901	425	Sepulveda Blvd.	Ballona @ Sawtelle	Sepulveda Channel	503	51	Centinela Channel
Chlordane (Technical)	µg/kg	25	0.50	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
ppDDT	µg/kg	3	1.00	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
ppDDD	µg/kg	3	2.00	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
ppDDE	µg/kg	3	2.20	BLD	**1743**	BLD	**12**	BLD	BLD	BLD	**8**	**6**	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Total DDTs	µg/kg	3	1.60	BLD	**1743**	BLD	**12**	BLD	BLD	BLD	**8**	**6**	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Dieldrin	µg/kg	3	0.02	BLD	BLD	BLD	BLD	BLD	6	BLD	BLD	**7**	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Endosulfan I	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Endosulfan II	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Endosulfan Sulfate	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Endrin	µg/kg	3	0.02	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Endrin aldehyde	µg/kg	3	0.60	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Heptachlor	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Heptachlor epoxide	µg/kg	3	0.20	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Methoxyclor	µg/kg	3		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Toxaphene	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
PCBs:																								
Aroclor-1016	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1221	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1232	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1242	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1248	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1254	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1260	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Aroclor-1262	µg/kg	25		BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Total PCBs	µg/kg	25	22.7	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD

BLD denotes not detected at indicated reportable limit.
*Bold numbers exceed NOAA sediment guideline ERL toxicity values.

ACOE Ballona Creek Sediment Sampling Data

TABLE 4
Ranked Sites and Sediment Chemical Concentrations (Dry Weight Basis)
Concentrations are as Chemical (mg)/Sediment(kg) for metals and ug/kg for organics

Site Rank	Total Recoverable Hydrocarbons	Site Rank	Copper	Site Rank	Lead	Site Rank	Nickel	Site Rank	Zinc	Site Rank	Fluoranthene	Site Rank	Indeno(1,2,3-c,d)Pyrene	Site Rank	Phenanthrene	Site Rank	Pyrene	Site Rank	Total PAHS
494	2510	**648/Pickford St. Drain**	**614**	**Higuera**	**270**	**648/Pickford St. Drain**	**224**	**51**	**1840**	51	8163	51	2449	**51**	**5102**	**51**	**8163**	**51**	**79762**
503	1954	**RDD 208**	**600**	**648/Pickford St. Drain**	**222**	**51**	**39**	**648/Pickford St. Drain**	**1830**	503	862	503	385	**503**	**738**	**648/Pickford St. Drain**	**2000**	**503**	**6400**
648/Pickford St. Drain	1200	**494**	**310**	**Centinela Blvd.**	**215**	**503**	**37**	**494**	**1280**	DD1-11	401	Benedict Canyon Ch.	309	**Higuera**	**409**	**503**	**846**	**494**	**5714**
Ince Blvd. Drain/3867	1010	**Sepulveda Blvd.**	**284**	**503**	**150**	**Sepulveda Blvd.**	**35**	**RDD 208**	**1247**	Higuera	278	2901	248	**DD1-11**	**272**	Benedict Canyon Ch.	309	**648/Pickford St. Drain**	**5143**
Ballona @ 648/Pickford St. Drain	942	**503**	**254**	**54**	**127**	**494**	**34**	**503**	**888**	54	249	Sepulveda Blvd.	204	**Ince Blvd. Drain/3867**	**264**	DD1-11	287	Higuera	3012
51	786	**51**	**243**	**RDD 208**	**118**	**RDD 208**	**32**	**Sepulveda Blvd.**	**643**	Ince Blvd. Drain/3867	166	Ballona @ Benedict Canyon Ch.	193	**Ballona @ 54**	**252**	Sepulveda Blvd.	272	DD1-11	2335
54	724	**2901**	**231**	**494**	**107**	**Benedict Canyon Ch.**	**30**	**2901**	**496**	Ballona @ Benedict Canyon Ch.	138	84	167	54	221	Higuera	234	Sepulveda Blvd.	1803
Sepulveda Blvd.	673	**Benedict Canyon Ch.**	**214**	**Sepulveda Blvd.**	**100**	**Ballona @ Benedict Canyon Ch.**	**27**	**54**	**483**	Centinela Ch.	138	Higuera	146	Sepulveda Ch.	142	Ince Blvd. Drain/3867	194	54	1575
2901	632	**Ballona @ Benedict Canyon Ch.**	**173**	**Ballona @ Benedict Canyon Ch.**	**77**	**54**	**22**	**Benedict Canyon Ch.**	**467**	Sepulveda Ch.	126	54	138	Centinela Ch.	92	54	193	Ince Blvd. Drain/3867	1540
Higuera	573	**Ballona @ 54**	**78**	**84**	**73**	2901	19	**Ballona @ Benedict Canyon Ch.**	**358**	Ballona @ 54	80	Sepulveda Ch.	126	Benedict Canyon Ch.		Ballona @ Benedict Canyon Ch.	165	Ballona @ 54	1393
Benedict Canyon Ch.	413	**54**	**76**	**2901**	**67**	Higuera	14	**Ince Blvd. Drain/3867**	**236**	648/Pickford St. Drain		Centinela Ch.	123	2901		Centinela Ch.	138	Ballona @ 648/Pickford St. Drain	974
84	353	**Ince Blvd. Drain/3867**	**50**	**Benedict Canyon Ch.**	**61**	Sepulveda Ch.	10	**84**	**208**	494		DD1-11	100	Sepulveda Blvd.		Sepulveda Ch.	95	Centinela Ch.	630
RDD 208	258	**DD1-11**	**39**	**Ballona @ 648/Pickford St. Drain**	**54**	84	9	**DD1-11**	**188**	RDD 208		Ballona @ 648/Pickford St. Drain	70	Ballona @ Benedict Canyon Ch.		Ballona @ 54		Benedict Canyon Ch.	618
DD1-11	225	84	33	DD1-11	28	Ince Blvd. Drain/3867	9	**Higuera**	**186**	Sepulveda Blvd.		Ballona @ 54	66	84		2901		Sepulveda Ch.	615
9408/Holly Hills	224	Higuera	29	Ince Blvd. Drain/3867	27	DD1-11	8	Ballona @ 54	150	2901		Ince Blvd. Drain/3867		Ballona @ 648/Pickford St. Drain		84		2901	537
Ballona @ Benedict Canyon Ch.	201	Sepulveda Ch.	28	Centinela Ch.	25	Ballona @ Sawtelle	6	Sepulveda Ch.	120	Benedict Canyon Ch.		648/Pickford St. Drain		648/Pickford St. Drain		Ballona @ 648/Pickford St. Drain		Ballona @ Benedict Canyon Ch.	496
Ballona @ 54	200	Centinela Ch.	22	Sepulveda Ch.	17	Ballona @ 54	6	Centinela Ch.	86	84		494		494		494		84	350
Centinela Ch.	171	Ballona @ 648/Pickford St. Drain	15	Ballona @ 54	13	9408/Holly Hills	4	Ballona @ Sawtelle	78	Ballona @ Sawtelle		RDD 208		RDD 208		RDD 208		RDD 208	
Sepulveda Ch.	139	9408/Holly Hills	9	Ballona @ Sawtelle	11	Centinela Ch.	4	9408/Holly Hills	67	9408/Holly Hills		Ballona @ Sawtelle		Ballona @ Sawtelle		Ballona @ Sawtelle		Ballona @ Sawtelle	
Ballona @ Sawtelle	74	Ballona @ Sawtelle	8	9408/Holly Hills	4	Ballona @ 648/Pickford St. Drain	3	Ballona @ 648/Pickford St. Drain	54	Ballona @ 648/Pickford St. Drain		9408/Holly Hills		9408/Holly Hills		9408/Holly Hills		9408/Holly Hills	
425	36	425	4	425	1	425	1	425	26	425		425		425		425		425	

Bold, shaded values indicate sites where sediment values exceeded NOAA ERL values (presented in Table 2).

ACOE Ballona Creek Sediment Sampling Data

Table 5

Ranked Sites and Sediment Chemical Concentrations Normalized to Total Organic Carbon (TOC) Content

Concentrations are as Chemical (mg)/TOC(kg) for metals and ug/kg for organics (Dry Weight Basis)

Site Rank	Copper	Site Rank	Lead	Site Rank	Nickel	Site Rank	Zinc	Site Rank	Fluoranthene	Site Rank	Indeno (1,2,3-c,d) Pyrene	Site Rank	Phenanthrene	Site Rank	Pyrene	Site Rank	Total PAHS
Ballona @ 54	274419	Higuera	330948	Sepulveda Blvd.	26410	Ballona @ 54	525581	DD1-11	351317	Ballona @ 54	232558	Ballona @ 54	883721	Ince Blvd. Drain/3867	393258	Ballona @ 54	4883721
Sepulveda Blvd.	213846	Ballona @ 648/Pickford St. Drain	121785	Ballona @ 54	21814	Sepulveda Blvd.	484615	Higuera	339893	Sepulveda Channel	224090	Ince Blvd. Drain/3867	533708	51	320856	Higuera	3685152
Benedict Canyon Ch.	122838	54	89515	Ince Blvd. Drain/3867	18596	Ince Blvd. Drain/3867	477528	Ince Blvd. Drain/3867	337079	Higuera	178891	Higuera	500894	Higuera	286225	51	3135027
Ince Blvd. Drain/3867	100281	Sepulveda Blvd.	75385	Sepulveda Channel	18011	54	339806	51	320856	Benedict Canyon Ch.	177384	Sepulveda Channel	252101	DD1-11	250941	Ince Blvd. Drain/3867	3117978
2901	70544	Ince Blvd. Drain/3867	54494	Benedict Canyon Ch.	17450	Benedict Canyon Ch.	268293	Ballona @ 54	279070	Ballona @ 648/Pickford St. Drain	157480	DD1-11	238394	Sepulveda Blvd.	205128	Ballona @ 648/Pickford St. Drain	2204724
Ballona @ Benedict Canyon Ch.	58241	Ballona @ 54	44605	Higuera	17174	Higuera	227191	Sepulveda Channel	224090	Sepulveda Blvd.	153846	51	200535	Benedict Canyon Ch.	177384	DD1-11	2045169
54	53592	Benedict Canyon Ch.	35255	54	15320	Sepulveda Channel	212885	503	177215	Centinela Ch.	103226	54	155340	503	174051	Sepulveda Blvd.	1358974
RDD 208	52909	503	30949	648/Pickford St. Drain	10013	503	182595	54	174757	54	97087	503	151899	Sepulveda Ch	168067	503	1316456
503	52215	Sepulveda Channel	30532	9408/Holly Hills	9767	DD1-11	164366	Centinela Ch.	116129	51	96257	Centinela Ch.	77419	54	135922	54	1106796
Sepulveda Channel	49860	84	26852	Ballona @ Benedict Canyon Ch.	8991	9408/Holly Hills	153353	Ballona @ Benedict Canyon Ch.	46296	DD1-11	87829	Benedict Canyon Ch.	0	Centinela Ch.	116129	Sepulveda Channel	1092437
Higuera	35957	Ballona @ Benedict Canyon Ch.	26019	503	7532	2901	151707	Sepulveda Blvd.	0	503	79114	Ballona @ 648/Pickford St. Drain	0	648/Pickford St. Drain	89286	Centinela Ch.	529032
Ballona @ 648/Pickford St. Drain	34646	DD1-11	24467	Ballona @ 648/Pickford St. Drain	6745	Ballona @ 648/Pickford St. Drain	123097	Benedict Canyon Ch.	0	2901	75853	Sepulveda Blvd.	0	Ballona @ Benedict Canyon Ch.	55556	Benedict Canyon Ch.	354767
DD1-11	34379	Centinela Ch.	21161	DD1-11	6675	Ballona @ Benedict Canyon Ch.	120370	9408/Holly Hills	0	Ballona @ Benedict Canyon Ch.	64815	2901	0	Ballona @ 54	0	648/Pickford St. Drain	229592
648/Pickford St. Drain	27423	2901	20607	Ballona @ Sawtelle	6331	RDD 208	110000	2901	0	84	61728	Ballona @ Benedict Canyon Ch.	0	Ballona @ 648/Pickford St. Drain	0	Ballona @ Benedict Canyon Ch.	166667
9408/Holly Hills	21312	Ballona @ Sawtelle	10993	2901	5866	648/Pickford St. Drain	81696	Ballona @ 648/Pickford St. Drain	0	Ince Blvd. Drain/3867	0	84	0	2901	0	2901	164349
Centinela Ch.	18194	RDD 208 S	10364	84	3463	84	77160	RDD 208	0	9408/Holly Hills	0	9408/Holly Hills	0	84	0	84	129630
84	12160	648/Pickford St. Drain	9898	Centinela Ch.	3419	Ballona @ Sawtelle	77086	648/Pickford St. Drain	0	RDD 208	0	RDD 208	0	9408/Holly Hills	0	494	32147
51	9545	9408/Holly Hills	8980	RDD 208 S	2855	Centinela Ch.	72516	84	0	648/Pickford St. Drain	0	648/Pickford St. Drain	0	RDD 208	0	9408/Holly Hills	0
Ballona @ Sawtelle	7881	51	8449	51	1537	51	72326	Ballona @ Sawtelle	0	Ballona @ Sawtelle	0	Ballona @ Sawtelle	0	Ballona @ Sawtelle	0	RDD 208	0
425	3241	425	829	425	1176	425	23307	425	0	425	0	425	0	425	0	Ballona @ Sawtelle	0
494	1745	494	600	494	189	494	7201	494	0	494	0	494	0	494	0	425	0

ACOE Ballona Creek Sediment Sampling Locations

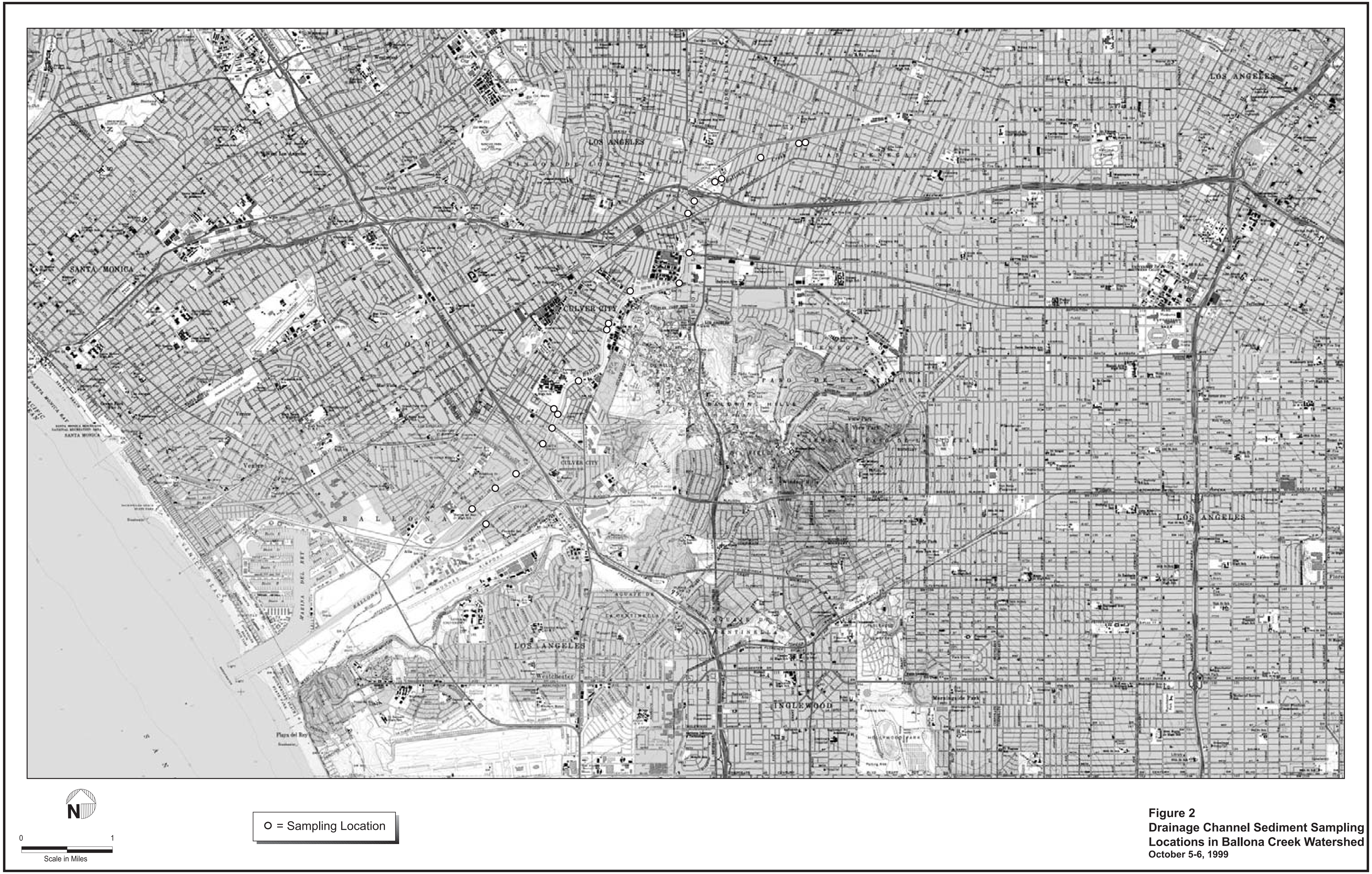


Figure 2
Drainage Channel Sediment Sampling Locations in Ballona Creek Watershed
October 5-6, 1999

SCO151545.f4.rp sediment3.fh10 07/02

Appendix 5:
Dominguez Channel Sediment Toxicity

NPDES Sediment Toxicity Data
Map of Monitoring Locations

Sediment Toxicity (Amphipod)
Dominguez Channel NPDES Monitoirng Stations

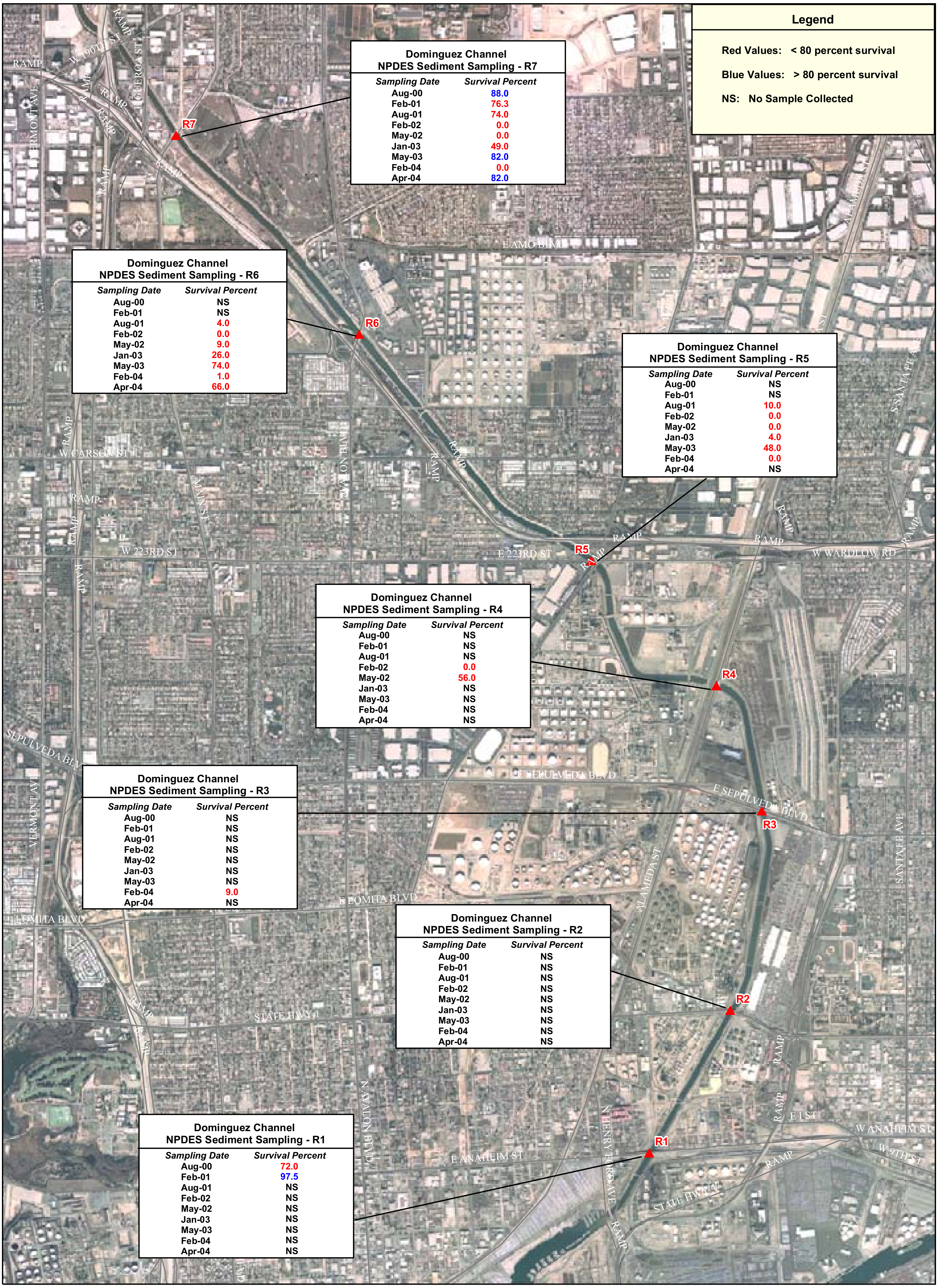
Location[1]	Aug-00	Feb-01	Aug-01	Feb-02	May-02	Jan-03	May-03	Feb-04	Apr-04
R1	72	97.5	NS	NS	NS	NS	NS	NS	NS
R2	NS	NS	NS	NS	NS	NS	NS	NS	NS
R3	NS	NS	NS	NS	NS	NS	NS	9	NS
R4	NS	NS	NS	0	56	NS	NS	NS	NS
R5	NS	NS	10	0	0	4	48	0	NS
R6	NS	NS	4	0	9	26	74	1	68
R7	88	76.3	74	0	0	49	82	0	82

[1] Sampling locations were established mid-channel at the intersection of the Dominguez Channel and Anaheim Street (R1), Pacific Coast Highway (R2), Sepulveda Boulevard (R3), Alameda Street (R4), 223rd Street/Wilmington Avenue (R5), Avalon Boulevard (R6), and Main Street (R7).

NS – Not sampled due to insufficient sediment at the sampling location.

Bold values are <70% survival. Control results not available; however, basic QA/QC standards require at least a 90% survival for controls. Assuming a 90% control, any test showing less than 70% would be considered a failed test.

Source of Data - Retec Group, Inc. 2004. Report of NPDES Sediment Sampling Results for Shell Los Angeles Refinery, NPDES Permit No. CA003778. Letter to Mr. Robert Stockdale (Shell Oil Products US, Los Angeles Refinery) 5 August.



Legend

Red Values: < 80 percent survival

Blue Values: > 80 percent survival

NS: No Sample Collected

Dominguez Channel
NPDES Sediment Sampling - R7

Sampling Date	*Survival Percent*
Aug-00	88.0
Feb-01	76.3
Aug-01	74.0
Feb-02	0.0
May-02	0.0
Jan-03	49.0
May-03	82.0
Feb-04	0.0
Apr-04	82.0

Dominguez Channel
NPDES Sediment Sampling - R6

Sampling Date	*Survival Percent*
Aug-00	NS
Feb-01	NS
Aug-01	4.0
Feb-02	0.0
May-02	9.0
Jan-03	26.0
May-03	74.0
Feb-04	1.0
Apr-04	66.0

Dominguez Channel
NPDES Sediment Sampling - R5

Sampling Date	*Survival Percent*
Aug-00	NS
Feb-01	NS
Aug-01	10.0
Feb-02	0.0
May-02	0.0
Jan-03	4.0
May-03	48.0
Feb-04	0.0
Apr-04	NS

Dominguez Channel
NPDES Sediment Sampling - R4

Sampling Date	*Survival Percent*
Aug-00	NS
Feb-01	NS
Aug-01	NS
Feb-02	0.0
May-02	56.0
Jan-03	NS
May-03	NS
Feb-04	NS
Apr-04	NS

Dominguez Channel
NPDES Sediment Sampling - R3

Sampling Date	*Survival Percent*
Aug-00	NS
Feb-01	NS
Aug-01	NS
Feb-02	NS
May-02	NS
Jan-03	NS
May-03	NS
Feb-04	9.0
Apr-04	NS

Dominguez Channel
NPDES Sediment Sampling - R2

Sampling Date	*Survival Percent*
Aug-00	NS
Feb-01	NS
Aug-01	NS
Feb-02	NS
May-02	NS
Jan-03	NS
May-03	NS
Feb-04	NS
Apr-04	NS

Dominguez Channel
NPDES Sediment Sampling - R1

Sampling Date	*Survival Percent*
Aug-00	72.0
Feb-01	97.5
Aug-01	NS
Feb-02	NS
May-02	NS
Jan-03	NS
May-03	NS
Feb-04	NS
Apr-04	NS

1 inch equals 2,500 feet

0 1,250 2,500 5,000 7,500 10,000 Feet

Legend

▲ NPDES Sampling Locations
(Permit CA0003778)

Figure 16

Dominguez Channel Restoration Project
NPDES Program Data
Bulk Sediment Toxicity Data
10-day Amphipod Exposure
(*Eohaustorius estuarius*)

Map Notes

Projection: State Plane California 405,
Feet, NAD 83
Data source:
Retec 2004
Date: January 7, 2004
Path: z:/sd04/aquatics/pola_dominguezc/mxd
/dominguez_channel_toxicity.mxd

Note: Chronic toxicity results are in percent (%) survival
- *Eohaustorius estuarius* species

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Appendix 6:
Malibu Creek Watershed Exotic Species

Exotic Species

There are numerous data sets and studies documenting both the numbers of native and non-native invasive species in the Santa Monica Bay Watershed. These studies cover large spatial areas and have occurred over many years. The studies include peer reviewed articles, detailed mapping surveys, snorkel survey results, and electro fishing results conducted in coastal watersheds that drain into Santa Monica Bay. Substantial data also exists regarding dramatic declines in native species abundance in these drainages. The species decline is so severe that all the native fish species are either federally endangered, or on the State list of species of special concern. Numerous research projects and studies have documented how the existing populations of exotic invasive predator species that occupy the Santa Monica Bay Watershed directly reduce the population numbers of the protected native species. The sum of this data surely warrants a listing for exotic species in the affected streams and coastal watersheds of Region 4.

The following paragraphs will document the most pertinent studies regarding non-native species distribution in the area, summarize previous studies on the impacts caused to the native species by exotic invasive predator species, and recommend which streams should be placed on the State 303 (d) list as impaired for Exotic Species.

Native Aquatic Species: The Malibu Creek Watershed has three native fish species that occupy freshwater streams: Steelhead trout, Pacific lamprey, and Arroyo chub. The Tidewater goby is a fish that occurs in the Malibu Creek watershed but utilizes brackish water habitat associated with tidal lagoons. Pacific lamprey and Arroyo chub are both on the State of California list of Species of Special Concern due to their dwindling numbers. Steelhead trout and Tidewater goby are federally endangered. Other aquatic species in the Malibu Creek Watershed and other coastal watersheds that drain to Santa Monica Bay are: California newts, Western pond turtles, and Red-legged frogs. Western pond turtles are Federally listed and State listed as a Species of Concern, California newts are listed by the State of California as a Species of Special Concern, and Red legged frogs are a Federally threatened species.

Southern steelhead trout: The Southern Steelhead ESU was listed as endangered by the National Marine Fisheries Service in 1997. “Of 92 streams which it (Steelhead) historically spawned in the six coastal counties, it is now absent from 39, including all streams south of Ventura County except Malibu Creek, and San Mateo Creek. The total stream miles in which juveniles now rear is less than 1 percent of the historical number ” Moyle,(Peter B., Inland Fishes of California Revised and Expanded. University of California Press, 2002, pg. 281.) Southern steelhead runs have been identified as “the most jeopardized of all California’s steelhead populations and have dropped to less than 1% of their pre-1940 estimated abundance (McEwan and Jackson as reported in (Dagit et al, Topanga Creek Watershed Southern Steelhead Trout Preliminary Watershed Assessment and Restoration Plan Report, Prepared for California Department of Fish and Game, March 2003).

In 1998, a small population of steelhead trout were found in the Topanga Creek watershed south of Malibu Creek. In the Santa Monica Mountains only three streams have an existing steelhead trout population: Arroyo Sequit Creek which drains to Leo Carrillo State Beach, Malibu Creek, and Topanga Creek. Snorkel surveys in these creeks have been conducted by the Resource Conservation District of the Santa Monica Mountains for nearly two years on Malibu and Arroyo Sequit Creeks and for nearly five years on Topanga Creek. Between June of 2001 and March of 2003, the highest number of steelhead trout large enough to possibly qualify as an adult fish (>26 cm or 10.25 inches) recorded in Topanga Creek was 15 with the average hovering at approximately 3 adult sized fish. (Dagit et al, Topanga Creek Watershed Southern Steelhead Trout Preliminary Watershed Assessment and Restoration Plan Report, Prepared for California Department of Fish and Game, March 2003). Similar numbers of adult sized steelhead were found in Malibu Creek and only once was a steelhead trout observed in Arroyo Sequit Creek during the snorkel surveys (Rosi Dagit per.com. October 2005). No Pacific lamprey were identified during any of the fish snorkel surveys on Malibu Creek

“Species diversity in Malibu Creek is low, but typical of a small coastal stream in southern California. In both numbers and biomass, the fish community downstream of Rindge Dam is dominated by introduced species, especially largemouth bass, although differences in species abundance among the study reaches were apparent. Largemouth bass abundance increased with distance downstream of Rindge Dam, the inverse of the juvenile distribution pattern of steelhead trout. Moreover, largemouth bass are known to be a predator of young salmonids” (Moyle 1976 as reported in Entrix Inc., Malibu Creek /Santa Monica Steelhead Investigations 1989).

Red-legged frogs: The Red legged frog has been extirpated from 70 percent of its former range and now is found primarily in coastal drainages of central California, from Marin County south to northern Baja California, Mexico. Potential threats to the species include elimination or degradation of habitat from land development and land use activities and habitat invasion by non-native aquatic species (*Recovery Plan Red legged frog* **(Rana aurora draytonii),** *Region 1 U.S. Fish and Wildlife Service Portland, Oregon May 28, 2002 pg IV).* Its population has declined by at least 90% (Center for Biological diversity website Species section California Red-legged frog visited http://www.biologicaldiversity.org/swcbd/species/rlfrog/ January 2006) The Malibu Creek Watershed and other Coastal Watersheds in the Santa Monica Mountains were designated as critical habitat for red legged frog by the USFWS (Department of the Interior, United States Fish and Wildlife Service, Part II **50 CFR Part 17 Endangered and Threatened Wildlife and Plants; Final Determinations of Critical Habitat for the California Red-legged Frog; Final Rule** Federal Register Vol. 66, No. 49 Tuesday March 13, 2001/Rules and Regulations)

According to (CDFG) website “Establishment of a diverse exotic aquatic predator fauna that includes bullfrogs, crayfish, and a diverse array of fishes likely contributed to the decline of the California red-legged frog (Hayes and Jennings 1986 as reported by http://www.dfg.ca.gov/hcpb/cgibin/more_info.asp?idKey=ssc_tespp&specy=amphibians&query= rana%20aurora% 20draytonii) visited January 06). According to the United State

Fish and Wildlife Service (USFWS) red-legged frog recovery plan available at http://ecos.fws.gov/docs/recovery_plans/2002/020528.pdf the "Factors associated with declining populations of the frog include degradation and loss of its habitat through agriculture, urbanization, mining, overgrazing, recreation, timber harvesting, non-native plants, impoundments, water diversions, degraded water quality, use of pesticides, and introduced predators. In 1999, a remnant population of Red-legged frogs were discovered in the Malibu Creek Watershed. This population is estimated to be approximately 25 adults and is currently the only known population in any coastal watershed draining to Santa Monica Bay.

Tidewater goby: Tidewater Goby was listed as endangered by the USFWS in 1994 and has had fully protected status from the State of California since 1987. "Somewhere between 25% and 50% of its population has been lost in the last 100 years, most of them south of Point Conception."(Moyle, Peter B., Inland Fishes of California Revised and Expanded. University of California Press, 2002, pg. 432)."

Arroyo chub: Arroyo chubs are small chunky fish that reach typical adult size between 70-100 mm (Moyle, Peter B., Inland Fishes of California Revised and Expanded. University of California Press, 2002, pg. 131). Arroyo chub are found in slow-moving or backwater sections of warm to cool (10-24°C) streams with mud or sand substrates with depths typically greater than 40 cm. Presently, arroyo chubs are common at only four places within their native range: upper Santa Margarita River and its tributary, De Luz Creek; Trabuco Creek below O'Neill Park and San Juan Creek; Malibu Creek (Swift et al. 1993); and West Fork San Gabriel River below Cogswell Reservoir (J. Deinstadt, unpubl. data). According to Swift et al. (1993), arroyo chubs are scarce within their native range because the low-gradient streams in which they do best have largely disappeared. (Moyle et al, Department of Wildlife & Fisheries Biology Davis, California 1995 Fish Species of Special Concern Second Edition, Prepared for California Department of Fish and Game, pg 151). Their native range, like that of the sympatric Santa Ana sucker, is largely coincident with the Los Angeles metropolitan area where most streams are degraded and populations reduced and fragmented especially the low-gradient stream reaches which formerly contained optimal habitat (Swift et al. 1993 as reported in Moyle, Peter B., Inland Fishes of California Revised and Expanded. University of California Press, 2002, pg. 132). "Chub generally decline when red shiners and other exotics become abundant. In the Santa Margarita River a dramatic increase in arroyo chub abundance was noted after extreme high-flow events in 1997-1998 reduced the abundance of green sunfish, largemouth bass, Red-eye bass and black bullehead The potential effects of introduced species, combined with the continued degradation of the urbanized streams that constitute much of its habitat, mean that this species is not secure despite its wide range." (Moyle, Peter B., Inland Fishes of California Revised and Expanded. University of California Press, 2002, pg. 132).

California newt (Coast range newt): California newts are moderate-sized (50.0-87.0 mm SVL) dark brown salamander with bright yellow-orange to orange undersurfaces (Riemer 1958); thick, relatively textured skin that becomes markedly rough-glandular during its terrestrial phase, but reverts to a relatively smooth condition during its aquatic phase (Nussbaum and Brodie 1981). Coast Range newts frequent terrestrial habitats, but breed in ponds, reservoirs, and slow-moving streams (Stebbins 1954b, 1985 as reported Jennings & Hayes. Amphibian and Reptile Species of Special Concern for California., November 1994 Prepared for CDFG pg. 40).

Historically, *T. t. torosa* may have been one of the most abundant, if not the most abundant amphibian through much of its range. This species has been depleted by large-scale historical commercial exploitation coupled with the loss and degradation of stream habitats, especially in Los Angeles, Orange, Riverside, and San Diego counties. “Our own observations indicated that the breeding habitat of *T. t. torosa* has, at best, been severely degraded over much of its range, largely due to a shift in sedimentation dynamics that has resulted in greater filling and less frequent scouring of pools to allow them to retain their characteristic structure” (Coming 1975 as modified and cited in Faber et al. 1989 as reported Jennings & Hayes. Amphibian and Reptile Species of Special Concern for California., November 1994 Prepared for CDFG pg. 40). Aquatic predators are particularly detrimental to the egg and larval stages of most amphibians because these stages are restricted to water until metamorphisis. (Kats and Gamradt. Conservation Biology, Volume 10. No4. August 1996, pgs. 1155-1162)

Western Pond Turtle: The Western Pond Turtle, *Clemmys marmorata*, is California's only freshwater turtle. The species ranges from southern British Columbia through Washington, Oregon, California, and into northern Baja California. It is listed as endangered in Washington and Oregon and as a species of special concern in California. It has declined by an estimated 95 % since the early 1900's. The primary cause of decline is loss of wetland habitat. The secondary cause is predation of hatchlings by non-native species, especially bullfrogs and large-mouth bass (Website Nature Alley Pond Turtle Page http://natureali.org/pondturtle.htm visited January 06). Additionally, some introduced exotic aquatic predators or competitors likely extract a significant toll on turtle populations. Bullfrogs prey on hatchling or juvenile turtles (Moyle 1973; Holland 1991a; H. Basey, P. Lahanas, and S. Wray, pers. comm.), and may be responsible for significant mortality because they occupy shallow-water habitats in which the youngest age groups of turtles are frequently observed (pers. observ.). Bass *(Micropterus* spp.) are also known to prey on the smallest juveniles (Holland 1991a), and sunfishes *(Lepomis* spp.), although they are not large enough to prey on hatchling western pond turtles, probably compete with them for food since they are known to be able to keep available nekton at very low levels, stunting their own growth (see Swingle and Smith 1940). (Jennings & Hayes. Amphibian and Reptile Species of Special Concern for California., November 1994 Prepared for CDFG) pg. 102.

Exotic Invasive Aquatic Species: Several aquatic invasive species have been identified in the Malibu Creek watershed and in adjacent coastal watersheds draining to Santa Monica Bay: Carp, Largemouth bass, Green sunfish, Bluegill, Mosquitofish, Black bullhead, Red swamp crayfish, and Bullfrogs. Exotic fish species like, largemouth bass (*Micropterus salmoides*), green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*) and black bullhead (*Ameiurus melas*), have been shown to have a strong competitive edge over resident trout. Green sunfish have been found to feed on juvenile trout and out-compete adult steelhead for benthic food (Swift 1975; Greenwood 1988). Largemouth bass take over as top predator in the habitat they occupy and can directly predate steelhead (Stouder et al, 1997). Black bullhead are highly tolerant of high water temperatures and low dissolved oxygen levels and are extremely prolific. By shear numbers, this species can exert a tremendous competitive pressure on an already limited resource. (As reported Hovey, Tim E. Current Status of Southern Steelhead/Rainbow trout In San Mateo Creek 2002).

Largemouth Bass: "Typically when largemouth bass are abundant native fishes are absent, although there are some exceptions" (Moyle, Peter B., Inland Fishes of California Revised and Expanded. University of California Press, 2002, pg. 400). " The flexible foraging strategies of largemouth bass and their wide environmental tolerances have made them a keystone predator in many bodies of water. A keystone predator is a species whose activities can cause changes throughout the ecosystem, usually by changing abundances of favored prey." (Moyle, Peter B., Inland Fishes of California Revised and Expanded. University of California Press, 2002, pg. 399). "In the lower Colorado River largemouth bass are regarded as part of the complex of predatory exotic fishes that prevent the reestablishment of native minnows and suckers. In southern California streams they prey heavily on endangered species, such as tidewater goby". Moyle,(Peter B., Inland Fishes of California Revised and Expanded. University of California Press, 2002, pg. 400.)

Bluegill and Green sunfish: "Bluegill are highly opportunistic feeders, feeding on whatever animal food is most abundant. Small fish , fish eggs, and crayfish may be eaten when available." (Moyle, Peter B., Inland Fishes of California Revised and Expanded. University of California Press, 2002, pg. 384). "The abundance, ubiquity, aggressiveness, and the broad feeding habits of bluegill in lakes and lowland streams of California make it likely that they are one of the alien fishes that limit native fish populations, especially through predation of larvae, or through indirect effects that make natives more vulnerable to larger predators." (Moyle, Peter B., Inland Fishes of California Revised and Expanded. University of California Press, 2002, pg. 384). "The upper, fresher reaches of goby lagoons often contain non-native species, such as mosquitofish, green sunfish, and largemouth bass. They can at times be significant predators on gobies; for example most of the diet of young-of-the-year largemouth bass in the upper Ynez River Estuary was tidewater gobies." (Moyle, Peter B., Inland Fishes of California Revised and Expanded. University of California Press, 2002, pg. 433).

Carp: "Carp have probably displaced or reduced populations of native fish in some areas and have been responsible for the destruction of shallow waterfowl habitat in various parts of the country. (Moyle, Peter B., Inland Fishes of California Revised and Expanded. University of California Press, 2002, pg. 174). "Fish, probably dead before eaten, and fish larvae and eggs, including carp eggs, have been found in their diets." (Moyle, Peter B., Inland Fishes of California Revised and Expanded. University of California Press, 2002, pg. 173).

Mosquitofish: "Mosquito fish have been accused of eliminating small fish species the world over through predation and competitive interactions and a number of such cases in the southwestern United States and Australia have been documented. For example, in small streams of southern California, mosquitofish can eliminate or reduce the abundance of eggs and larvae of California newts and Pacific treefrogs. In California it is quite likely that mosquitofish have contributed to the decline of isolated pupfish populations. In small experimental ponds introduction of mosquitofish resulted in large blooms of phytoplankton after zooplankton grazers had been eaten." (Moyle, Peter B., Inland Fishes of California Revised and Expanded. University of California Press, 2002, pg. 320).

Mosquitofish (*Gambusia affinis*) are native to the eastern United States and have been introduced to wetlands worldwide as biological control agents for mosquito larvae. Studies have also been conducted in Australia on the effects of a closely related species, *Gambusia holbrooki*, on frog tadpoles (*Crinia glauerti*,*C. insignifera*, and *Heleioporus eyrei*) under experimental conditions and on frog species richness and abundance in the field. These studies (Blyth 1994, Webb and Joss 1997) showed direct predation on tadpoles, injuries to tadpoles in tanks or ponds with *Gambusia*, and reduced survival and recruitment. This practice is a concern to conservationists because introduced Analysis of field data from Australia (Webb and Joss 1997) demonstrated a significant drop in the abundance of frogs when *Gambusia* were present. Results of a study in artificial ponds showed that mosquitofish and bluegill (*Lepomis machrochirus*) were significant predators of California red-legged frog larvae (Schmieder and Nauman 1994). as reported in *Recovery Plan Red legged frog* **(Rana aurora draytonii),** *Region 1 U.S. Fish and Wildlife Service Portland, Oregon May 28, 2002 pg 25* http://ecos.fws.gov/docs/recovery_plans/2002/020528.pdf.

Bullfrogs and Crayfish Introduced bullfrogs, crayfish, and species of fish have been a significant factor in the decline of the California red-legged frog. Introduced aquatic vertebrates and invertebrates are predators on one or more of the life stages of California redlegged frogs. These include bullfrogs, African clawed frogs (*Xenopus laevis*), red swamp crayfish (*Procambarus clarkii*), signal crayfish (*Pacifastacus leniusculus*), and various species of fishes, especially bass, catfish (*Ictalurus* spp.), sunfish, and mosquitofish (*Gambusia affinis*) (Hayes and Jennings 1986) as reported in *Recovery Plan Red legged frog* **(Rana aurora draytonii),** *Region 1 U.S. Fish and Wildlife Service Portland, Oregon May 28, 2002 pg 24* http://ecos.fws.gov/docs/recovery_plans/2002/020528.pdf.

Several researchers in central California have noted the decline and eventual disappearance of California red-legged frogs once bullfrogs become established at the same site (Moyle 1976, S. Barry *in litt*. 1992, L. Hunt *in litt.*1993, Fisher and Schaffer 1996). as reported in *Recovery Plan Red legged frog* **(Rana aurora draytonii),** *Region 1 U.S. Fish and Wildlife Service Portland, Oregon May 28, 2002 pg 24* http://ecos.fws.gov/docs/recovery_plans/2002/020528.pdf.
Lawler *et al.* (1999) found that fewer than 5 percent of California red-legged frogs survived in ponds with bullfrog tadpoles, and the presence of bullfrogs delayed frog metamorphosis. Hayes and Jennings (1986, 1988) found a negative correlation between the abundance of

introduced fish species and California red legged frogs. as reported in *Recovery Plan Red legged frog* **(Rana aurora draytonii),** *Region 1 U.S. Fish and Wildlife Service Portland, Oregon May 28, 2002 pg 24* http://ecos.fws.gov/docs/recovery_plans/2002/020528.pdf. On Vandenberg Air Force Base (Santa Barbara County), the reproductive success of California red-legged frogs in dune ponds with both non-native fish and bullfrogs was nearly eliminated; in ponds with bullfrogs but no fish, reproduction of California red-legged frogs was evident, though low. Reproductive rates were very high in ponds with neither non-native fish nor bullfrogs (S. Christopher *in litt.* 1998). as reported in *Recovery Plan Red legged frog* **(Rana aurora draytonii),** *Region 1 U.S. Fish and Wildlife Service Portland, Oregon May 28, 2002 pg 24* http://ecos.fws.gov/docs/recovery_plans/2002/020528.pdf. Overall, while California red-legged frogs are occasionally known to persist in the presence of either bullfrogs or mosquitofish (and other non-native species), the combined effects of both non-native frogs and non-native fish often leads to extirpation of red-legged frogs (Kiesecker and Blaustein 1998, Lawler *et al.*
2000, S. Christopher *in litt.* 1998). as reported in *Recovery Plan Red legged frog* **(Rana aurora draytonii),** *Region 1 U.S. Fish and Wildlife Service Portland, Oregon May 28, 2002 pg 26* http://ecos.fws.gov/docs/recovery_plans/2002/020528.pdf.

Exotic Invasive Species Distribution and Data Summary:
Heal the Bay conducted detailed GPS mapping and field surveys between 2000 and 2005. The Heal the Bay Stream Team conducted Level IV analysis based on the California Department of Fish and Game Salmonid Stream Habitat Restoration Manual methods created by Flosi and Reynolds1994 to survey and map every pool along 70.5 miles of streams throughout the Malibu Creek Watershed. In conjunction with this Level IV pool data, field crew members also conducted visual counts and identification of all aquatic species that were present at the time of the survey for each mapped and surveyed pool. These numbers were recorded on both the hard copy and GPS data forms. The map Figure 1 shows in black the precise pool locations where exotic invasive aquatic species were visually identified and counted. The map in Figure 1 further breaks down each mapped stream into 303 (d) list designated reaches, unless a reach was not previously designated on the 303 (d) list. The types and numbers of exotic invasive species were then totaled by each 303 (d) designated reach. Finally a bar graph showing the total numbers of invasive species by reach was included in the top left corner of the map. (The GIS data in the form of Arc View shapefiles and all appropriate metadata has been provided along with these comments on a CD).

The following reaches were documented as having exotic invasive species in the Malibu Creek watershed from Heal the Bay Stream Team mapping data (Figure 1).
Cold Creek, Liberty Canyon Creek, Unnamed tributary to Las Virgenes Creek (LV Trib), Las Virgenes Creek, Malibu Creek, Lindero Creek Reach 1 and Reach 2, Medea Creek Reach 1 and Reach 2, Triunfo Creek Reach 1 and Reach 2

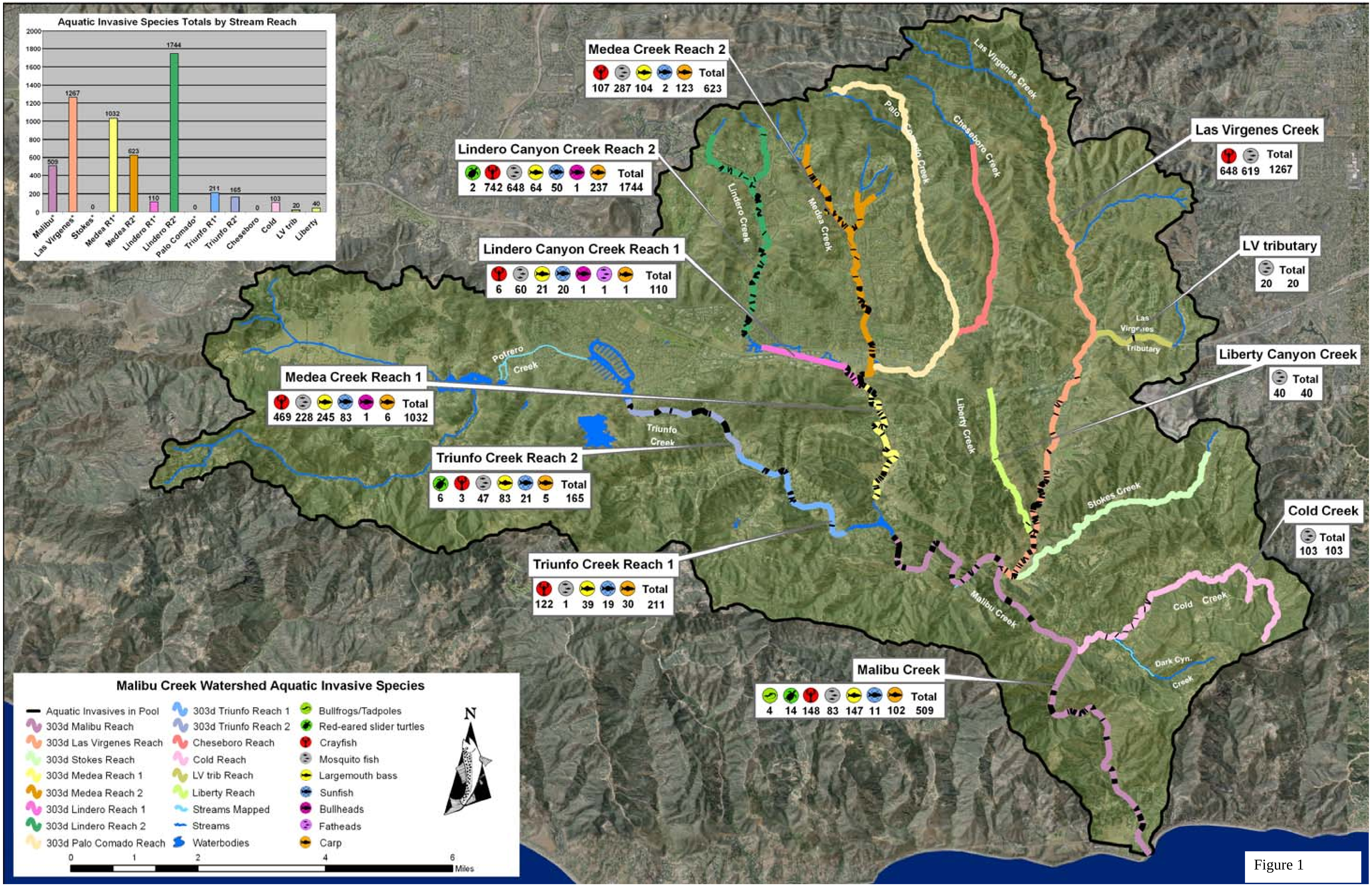
Aquatic Invasive Species Totals by Stream Reach
2000
1800
1600
1400
1200
1000
800
600
400
200
0
509
1267
0
1032
623
110
1744
0
211
165
0
103
20
40
Malibu*
Las Virgenes*
Stokes*
Medea R1*
Medea R2*
Lindero R1*
Lindero R2*
Palo Comado*
Triunfo R1*
Triunfo R2*
Cheseboro
Cold
LV trib
Liberty
Medea Creek Reach 2
107 287 104 2 123 Total 623
Lindero Canyon Creek Reach 2
2 742 648 64 50 1 237 Total 1744
Lindero Canyon Creek Reach 1
6 60 21 20 1 1 1 Total 110
Medea Creek Reach 1
469 228 245 83 1 6 Total 1032
Triunfo Creek Reach 2
6 3 47 83 21 5 Total 165
Triunfo Creek Reach 1
122 1 39 19 30 Total 211
Las Virgenes Creek
648 619 Total 1267
LV tributary
20 Total 20
Liberty Canyon Creek
40 Total 40
Cold Creek
103 Total 103
Malibu Creek
4 14 148 83 147 11 102 Total 509
Las Virgenes Creek
Palo Comado Creek
Cheseboro Creek
Lindero Creek
Medea Creek
Potrero Creek
Triunfo Creek
Liberty Creek
Las Virgenes Tributary
Stokes Creek
Malibu Creek
Cold Creek
Dark Cyn. Creek
Malibu Creek Watershed Aquatic Invasive Species
Aquatic Invasives in Pool
303d Malibu Reach
303d Las Virgenes Reach
303d Stokes Reach
303d Medea Reach 1
303d Medea Reach 2
303d Lindero Reach 1
303d Lindero Reach 2
303d Palo Comado Reach
303d Triunfo Reach 1
303d Triunfo Reach 2
Cheseboro Reach
Cold Reach
LV trib Reach
Liberty Reach
Streams Mapped
Streams
Waterbodies
Bullfrogs/Tadpoles
Red-eared slider turtles
Crayfish
Mosquito fish
Largemouth bass
Sunfish
Bullheads
Fatheads
Carp
N
0 1 2 4 6 Miles

Figure 1

Heal the Bay Monitoring: Heal the Bay's monthly monitoring program has been monitoring water chemistry and aquatic vertebrates in the Malibu Creek watershed and a few adjacent reference watersheds for more than 7 years. All water quality monitoring data is available for download via the web at www.healthebay.org/streamteam. This water quality sampling data was analyzed to determine where and which exotic invasive predator species were visually observed during monthly water quality sampling events. The results can be seen in Table 1.

Site	**Creek**	**Bull frogs**	**Mosquito fish**	**Largemouth bass**	**crayfish**	**carp**	**Sunfish bluegill**	**Fathead minnows**	**Black bullhead**	**Sample days**	**Observed days**	**Observed %**
1	Malibu	2	2	1	1	1	0	0	0	83	7	8.4%
2	Cold Creek	0	5	0	3	0	0	0	0	83	7	8.4%
4	Malibu (below Malibou Lake)	0	0	0	0	2	1	0	0	59	3	5.1%
5	Las Virgenes	0	4	1	1	0	0	0	0	83	4	4.8%
7	Medea	0	5	0	3	2	1	0	0	83	2	2.4%
12	Malibu @ Rock pool	1	0	2	6	0	0	0	0	42	7	16.7%
13	Las Virgenes @ Agoura Rd	0	1	0	9	0	0	1	0	42	10	23.8%
16	Stokes Creek	0	2	0	0	0	0	0	0	19	2	10.5%
17	Triunfo Creek	2	0	3	2	0	0	0	1	42	6	14.3%

Table 1: Heal the Bay Monitoring Data

The results of the water chemistry data mining indicate that all of Malibu Creek, Cold Creek, Las Virgenes Creek, Medea Creek, Stokes Creek and Triunfo Creek should be 303 (d) listed for exotic invasive predator species. These records are visual observations recorded in the field during water quality monitoring events. These numbers are believed to be extremely conservative as fish and other aquatic species generally are sheltered and not visible when potential predators, in this case water monitoring personnel, are present.

Kats and Gamradt. Conservation Biology, Volume 10. No4. August 1996, pgs. 1155-1162 Kats surveyed 10 streams in the Santa Monica Mountains of southern California May and June 1994 and May and June 1995 which were known to have had California newts when previously surveyed between 1981 and 1986. The 1994 and 1995 Kats surveys found crayfish in Trancas and Malibu Creeks and mosquitofish in Topanga Creek and Malibu Creek. The three streams that contained mosquitofish, and/or crayfish had no California newt eggs, larvae, or adults. The seven streams without crayfish or mosquitofish did contain California newts. Further, Kats conducted laboratory and field experiments that demonstrated crayfish consume California newt egg masses and both mosquitofish and crayfish consume larval newts. In Trancas Creek heavy rains of 1995 removed the crayfish and mosquitofish from the creek and the following spring newt larvae, egg masses, and adults were found.

In a recent paper by Riley et al published in Conservation Biology 2005 Effects of Urbanization on the Distribution and Abundance of Amphibians and Invasive Species in Southern California Streams, the distribution and abundance of native amphibians and exotic predators was determined in 35 streams throughout the Santa Monica mountains and Simi Hills. The study found that streams with crayfish and exotic fish species had fewer native species such as California newt and California treefrogs. Surveys for this study occurred in 2000-2002 and documented the presence of Crayfish in the following streams: Trancas Canyon Creek, Triunfo Canyon Creek, Topanga Canyon Creek, Las Virgenes Creek, Malibu Creek, Medea Creek, and Lindero Canyon Creek. Additionally, the researchers found exotic fish species in Triunfo Canyon Creek, Topanga Canyon Creek, Las Virgenes Creek, Malibu Creek, Liberty Canyon Creek, Medea Creek, and Lindero Canyon Creek. Bullfrogs were only present in Triunfo Creek during this study period.

The Lakes: The Malibu Creek Watershed has 6 man-made lakes that are hydrologically connected to the watershed: Westlake, Lake Sherwood, Lake Lindero Lake Enchanto, Century Lake and Malibou Lake. The lakes serve as protected breeding and rearing areas for largemouth bass, blue gill, green sunfish, black bullhead, carp, mosquito fish, bullfrogs, and crayfish. It is well known that the privately owned Malibou Lake, Lake Sherwood, Lake Lindero and Malibou Lakes are prized by the lakeside residents for their excellent bass, blue gill, and carp fishing. A cursory look at real estate websites for the private lakes tout the excellent fishing as one of the amenities for living in these areas. “Westlake’s 150-acre lake is stocked with bass, blue gill and catfish. Docking privileges, fishing licenses, boating and sailing are available to residents.” (Website Beach California .com Westlake Village page http://www.beachcalifornia.com/westlake.html visited January 06). Additionally the Malibu Creek Stream Team has documented red ear slider turtles at Westlake and Malibou Lake. We have recently added 10 sites on Malibou Lake including the inlet to the lake at Triunfo and Medea Creeks. Visual observations during monthly monitoring at these sites confirm that bass, and carp are pervasive throughout the lake.

These lakes afford protection to these species that are not adapted to the climatic conditions normally associated with arid southern California which includes large winter flows, flash flooding, and the drying of surface flows during summers and from prolonged droughts. Because these lakes are deep and perennially wet they provide shelter from these conditions even when the exotic species are flushed from the streams or stranded due to diminished flows. The streams are readily repopulated by exotic invasive species from the lakes. For example, Trancas Creek was the one natural stream in the study with less than 8% developed area that had crayfish. Natural streams were defined as having less than 8% development in the watershed draining to a particular stream. At the top of Trancas Creek the Malibu Country Club ponds have crayfish populations that provide a recurring source of propagules, and enough influence from the irrigation of the golf course to generate perennial water in the stream. (Riley et al, Effects of Urbanization on the Distribution and Abundance of Amphibians and Invasive Species in Southern California Streams, Conservation Biology, 2005).

Crayfish are continually introduced as they are used as fishing bait in the lakes. In order to address the issue of exotic invasive predator species it is necessary to control the sources from the lakes.

It is highly recommended that all the lakes in the Malibu Creek watershed be listed for exotic invasive species. They are a continual population source that allows these predator species to quickly repopulate streams even after catastrophic flood or drought events at the expense of native species. It is recommended that the following lakes be placed on the State 303 (d) list: Lake Sherwood, Malibou Lake, Lake Lindero, Century Lake (Century Reservoir), Lake Enchanto, and Westlake. Additionally, we recommend adding the ponds at the Malibu Country Club Golf Course which were specifically mentioned as the source problem for Trancas Creek (Riley et al Effects of Urbanization on the Distribution and Abundance of Amphibians and Invasive Species in Southern California Streams Conservation Biology 2005).

Index of Biological Integrity: Exotic species can also have a major impact on native macroinvertebrate diversity and abundance for reasons discussed throughout this document. As seen in Appendix 7-A, there are several reaches of the Malibu Creek Watershed that have calculated Index of Biological Integrity (IBI) scores in the "poor" and "very poor" ranges. Specifically, monitored sites within Malibu Creek, Medea Creek, Las Virgenes Creek, and Triunfo Creek have scores below the threshold of 39. These are all areas discussed above as having high densities of exotic predatory species. Thus, in addition to the persuasive information presented above, the low IBI scores should be used as another line of evidence which supports in the listing of exotic species in Malibu Creek Watershed.

Conclusion: This document has presented ample evidence as to the distribution of exotic invasive predator species and their impacts on the dwindling population of native aquatic species in the Santa Monica Mountains and Simi Hills. The documentation provided clearly shows the spatial locations and persistence over time of exotic invasive predator species. This document also clearly demonstrates the need to protect the remaining populations of native aquatic species whose abundance have declined so drastically that all are currently protected by the State of California, the Federal government or both. Based on the presented research and studies we believe that listing for exotic species is warranted and meets the listing criteria. Heal the Bay recommends that the following waterbodies be placed on the State 303 (d) list as impaired for exotic species:

1. Malibu Creek
2. Cold Creek
3. Las Virgenes Creek
4. LV Tributary (Unnamed tributary to Las Virgenes Creek that parallels the 101 fwy in Calabasas).
5. Stokes Creek
6. Liberty Canyon Creek
7. Triunfo Creek Reach 1
8. Triunfo Creek Reach 2
9. Medea Creek Reach 1
10. Medea Creek Reach 2
11. Lindero Creek Reach 1
12. Lindero Creek Reach 2
13. Malibou Lake
14. Lake Sherwood
15. Lake Enchanto
16. Century Lake (Century Reservoir)
17. Westlake
18. Lake Lindero

19. Malibu Country Club Golf Course Ponds
20. Trancas Creek
21. Topanga Creek

Effects of Urbanization on the Distribution and Abundance of Amphibians and Invasive Species in Southern California Streams

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Abstract: *Urbanization negatively affects natural ecosystems in many ways, and aquatic systems in particular. Urbanization is also cited as one of the potential contributors to recent dramatic declines in amphibian populations. From 2000 to 2002 we determined the distribution and abundance of native amphibians and exotic predators and characterized stream habitat and invertebrate communities in 35 streams in an urbanized landscape north of Los Angeles (U.S.A.). We measured watershed development as the percentage of area within each watershed occupied by urban land uses. Streams in more developed watersheds often had exotic crayfish (*Procambarus clarkii*) and fish, and had fewer native species such as California newts (*Taricha torosa*) and California treefrogs (*Hyla cadaverina*). These effects seemed particularly evident above 8% development, a result coincident with other urban stream studies that show negative impacts beginning at 10–15% urbanization. For Pacific treefrogs (*H. regilla*), the most widespread native amphibian, abundance was lower in the presence of exotic crayfish, although direct urbanization effects were not found. Benthic macroinvertebrate communities were also less diverse in urban streams, especially for sensitive species. Faunal community changes in urban streams may be related to changes in physical stream habitat, such as fewer pool and more run habitats and increased water depth and flow, leading to more permanent streams. Variation in stream permanence was particularly evident in 2002, a dry year when many natural streams were dry but urban streams were relatively unchanged. Urbanization has significantly altered stream habitat in this region and may enhance invasion by exotic species and negatively affect diversity and abundance of native amphibians.*

Key Words: amphibian declines, California newts, California treefrogs, crayfish, exotic species, Pacific treefrogs, urban streams

Efectos de la Urbanización sobre la Distribución y Abundancia de Anfibios y Especies Invasoras en Arroyos del Sur de California

Resumen: *La urbanización afecta de muchas formas negativas a los ecosistemas naturales, particularmente a los sistemas acuáticos. La urbanización también está reconocida como uno de los potenciales causantes de las dramáticas declinaciones recientes en las poblaciones de anfibios. Entre 2000 y 2002 determinamos la distribución y abundancia de anfibios nativos y depredadores exóticos y caracterizamos el hábitat y las comunidades de invertebrados en 35 arroyos en un paisaje urbanizado al norte de Los Ángeles. Medimos el desarrollo de la cuenca como el porcentaje de la superficie ocupada por usos urbanos en cada cuenca.*

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*Los arroyos en cuencas más desarrolladas a menudo tenían cangrejos de río exóticos (*Procambarus clarkii*) y peces, y tenían menos especies nativas, como tritones (*Taricha torosa*) y ranas arborícolas (*Hyla cadaverina*). Estos efectos parecieron particularmente evidentes arriba de 8% de desarrollo, un resultado que coincide con otros estudios de arroyos urbanos que muestran impactos negativos a partir de 10-15% de urbanización. La abundancia de* H. regilla*, el anfibio nativo con mayor distribución, fue menor en presencia de cangrejos de río exóticos, aunque no encontramos efectos directos de la urbanización. Las comunidades de macroinvertebrados bentónicos también fueron menos diversas en los arroyos urbanos, especialmente las especies sensitivas, Los cambios en la comunidad de la fauna en arroyos urbanos se pueden relacionar con cambios en el hábitat físico del arroyo, tales como menos hábitat con pozas y más hábitat con corriente y una mayor profundidad y flujo de agua, lo que produce arroyos más permanentes. La variación en la permanencia de los arroyos fue particularmente evidente en 2002, año en el que muchos arroyos naturales se secaron y los arroyos urbanos permanecieron relativamente sin cambios. La urbanización ha alterado significativamente a los hábitats de arroyos en esta región y puede incrementar la invasión de especies exóticas e incidir negativamente en la diversidad y abundancia de anfibios nativos.*

Palabras Clave: arroyos urbanos, cangrejos de río, declinaciones de anfibios, especies exóticas, *Hyla cadaverina*, *Hyla regilla, Taricha torosa*

Introduction

Freshwater ecosystems are particularly susceptible to disturbance and have become degraded throughout the world (Ricciardi & Rasmussen 1999; Baron et al. 2002). The severe disturbance of urbanization is a significant threat to freshwater systems such as streams (Paul & Meyer 2001). The increased area of impervious surfaces in urban areas produces increased runoff, leading to significant changes in hydrology and consequently in stream habitat, increased inputs of nutrients or pollutants, and, in the end, often radically altered ecological communities. Significant changes have been documented in the abundance and diversity of everything from algae to invertebrates to fishes in urban streams (reviewed in Paul & Meyer 2001). These changes can occur even at fairly low levels of urbanization, frequently beginning when 10–15% of the watershed has become urbanized or converted to impervious surface cover (Paul & Meyer 2001; e.g., Limburg & Schmidt 1990; Booth & Jackson 1997). Amphibian communities, however, have received little attention in urban streams, despite the fact that they may be particularly susceptible to urban impacts.

For more than a decade considerable attention has been paid to declines of amphibian populations worldwide (Blaustein & Wake 1990; Alford & Richards 1999). A range of causes of these declines has been identified, from disease to pollution to exotic species introductions. Many amphibian declines are also related to the loss, degradation, and fragmentation of remaining natural habitat (e.g., Lehtinen et al. 1999; Guerry & Hunter 2002), but perhaps because these threats are generally acknowledged for all taxa, they are less often implicated as a cause of amphibian declines. The sensitivity of amphibians to environmental change, however, renders them particularly susceptible to changes associated with habitat loss and disturbance. Most amphibians require some standing water, at least for breeding. The high rate of loss and degradation of wetlands, therefore, may particularly affect amphibian communities.

The impact of urbanization on amphibian communities has received some attention in the conservation literature, particularly at broad spatial scales. Davidson et al. (2001, 2002) evaluated causes for amphibian declines throughout California and found that the absence of four sensitive species from historical locations was significantly correlated with the amount of surrounding urbanization. Similarly, Knutson et al. (1999) found that urbanization was the strongest (negative) factor in multivariate models of the abundance and distribution of anurans in Iowa and Wisconsin. Although these broad-scale studies are important, there has been little published research at finer scales or on stream-dwelling species. More specific and intensive studies (e.g., Delis et al. 1996) are necessary to determine more local patterns and to evaluate the potential mechanisms of negative impacts. As Knutson et al. (1999) acknowledge, their broad-scale models explain relatively little of the variation in amphibian distribution. Landscape-level studies of multiple streams that also include information about relevant local factors may be particularly useful (Lowe & Bolger 2002). For instance, Orser and Shure (1972) found that dusky salamander (*Desmognathus fuscus*) abundance was inversely related to urbanization in six Georgia streams because of increased erosion and decreased bank soil stability and vegetative cover.

There are many specific ways that amphibians can be adversely affected by urbanization. Of particular concern for many aquatic taxa, including amphibians, is flow regime (Poff et al. 1997; Baron et al. 2002) because the timing and volume of water inputs can be dramatically altered in urban areas. Reduced or altered flow can affect native fish species and communities (e.g., Marchetti & Moyle 2001), but increases in water input can also threaten native aquatic biota, particularly in Mediterranean ecosystems, where native animals are adapted to a seasonal flow regime (Gasith & Resh 1999). In arid systems, more plentiful and permanent water can allow the invasion and persistence of exotic species, which may then eat (Knapp & Matthews 2000), compete with (Kiesecker et al. 2001) or hybridize with (Riley et al. 2003) native species (reviewed in Kats & Ferrer 2003). Significant disturbance of the streambed and surrounding habitats, such as the channelization and bank stabilization that is common in developed areas, most likely also negatively affects amphibian communities. Erosion and sedimentation of streams can increase in urban areas because of deliberate activities such as road construction (Welsh & Ollivier 1998), and as an indirect result of other factors such as increased fire frequency (Kerby & Kats 1998). Finally, collection by humans and predation by domestic cats and dogs may also affect urban amphibian populations.

We examined amphibian distribution, abundance, and reproduction across a range of natural and urban streams in a rapidly urbanizing landscape in southern California. Our goals were to evaluate the degree of urbanization in these watersheds; determine how the distribution and abundance of amphibians, introduced aquatic taxa, and benthic macroinvertebrates vary relative to urbanization; and measure how stream morphology and permanence are affected by urbanization. In the face of increasing urbanization, a better understanding of the threats to amphibians in urban areas will allow more effective conservation of amphibians and other aquatic species.

Methods

Study Area

The 76-km Santa Monica Mountains are bounded on the south by the Pacific Ocean, on the east by the city of Los Angeles, on the west by agricultural areas, and on the north by an eight-lane highway (Highway 101) and the Simi Hills (Fig. 1). The city of Malibu and parts of other incorporated areas are entirely within the mountains, and although much of the area remains undeveloped, new developments sprout up continually throughout the region. Many of the watersheds of the Santa Monica Mountains extend across Highway 101 into the Simi Hills (Fig. 1). Although much of the Simi Hills is protected open space, there is also considerable development within them, especially along streams and near the Highway 101 corridor. California is one of five locations in the world with a Mediterranean climate—cool, wet winters and hot, dry summers. Southern California is particularly arid, annually receiving 44 cm of rain, usually between October and April. Overall, the study area consists of a large expanse of typical Mediterranean climate habitat interspersed with pockets of urbanization and so provides an ideal landscape for investigating urban impacts.

Aquatic amphibian species in the region include California newts (*Taricha torosa*), Pacific treefrogs (*Hyla regilla*), California treefrogs (*H. cadaverina*), western toads (*Bufo boreas*), spadefoot toads (*Scaphiopus hammondii*), and red-legged frogs (*Rana aurora*). Red-legged frogs, formerly common in a number of streams in the

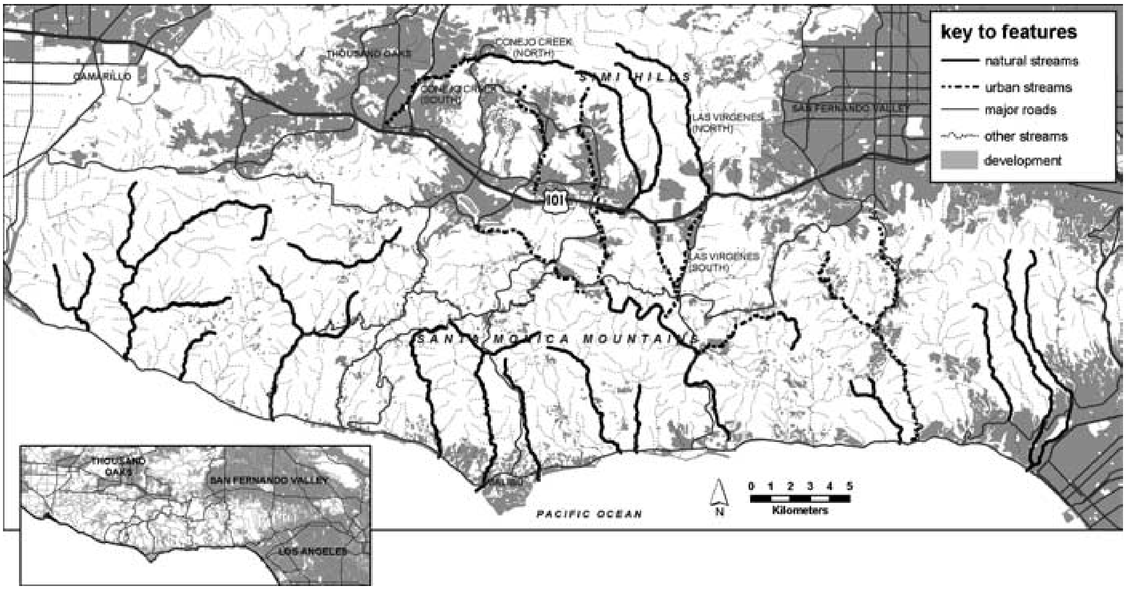

Figure 1. Streams surveyed for amphibians and introduced aquatic species in the Santa Monica Mountains and Simi Hills of southern California.

region (De Lisle et al. 1986), now occur only in one small population in the Simi Hills. Exotic stream species include red swamp crayfish (*Procambarus clarkii*) from the southeastern United States, bullfrogs (*R. catesbeiana*), and a number of fish species, including bass (*Micropterus* spp.), bluegill (*Lepomis macrochirus*), and mosquitofish (*Gambusia affinis*).

Reach Selection

Because our goal was a comprehensive survey of stream amphibian communities in the area, we attempted to survey all the major streams rather than selecting particular study streams. We surveyed a section of at least 500 m where possible. Along some longer streams there were major barriers such as freeways or significant changes in the degree of urbanization. For these streams we surveyed the stream above and below the barrier or change and treated each reach as a separate stream (e.g., north and south Las Virgenes, north and south Conejo Creek, Fig. 1). These reaches are not entirely independent because the upstream reach is contained within the watershed of the downstream reach. We believe, however, that the differences between the reaches were potentially significant in terms of the attributes we were examining. We surveyed 30 streams in 2000, 33 in 2001 (5 were new streams with 2 of the 2000 streams not sampled), and 35 in 2002. Streams were all first or second order except for two third-order streams, so they were generally small streams and of a similar size across the study area.

Stream Surveys

At each stream we selected a starting point based on accessibility and the likelihood of having water during the spring survey period (April–June). Most amphibians breed between February and June in this area, and many streams dry up by July or August. Starting points were recorded with a global positioning system to within 2–5 m. On first reaching the stream, we measured dissolved oxygen, salinity, air temperature, water temperature, pH, conductivity, water flow, and nitrate and phosphate levels.

Moving upstream, we determined whether each habitat segment was a run, riffle, or pool and measured its length, width, and depth; we also measured the length of dry stretches. We visually searched for larval and adult amphibians and exotic species in each segment, examining the water column and stream bottom. The relatively low density of aquatic vegetation in these streams increased the effectiveness of visual surveys. In segments with dense aquatic vegetation or algal blooms, we also used dipnets to capture and count animals. Counts were recorded for each species in each segment. If it was not feasible to count each individual, we used abundance categories of >20, >50, >100, >500, and >1000 (although the latter two categories were rarely used). We surveyed for adult and metamorphic amphibians along the stream edge. We also measured reproductive effort by counting egg masses. For egg masses of California newts and Pacific treefrogs, we searched under rocks and on submerged branches and vegetation. We used a diving mask to count newt egg masses in deep pools. California treefrogs lay eggs singly, which makes counting them impracticable, and we found egg strings from western toads in only one stream. To standardize efforts, our method was reviewed each year and senior personnel conducted survey-team training each spring before surveys and monitored the work periodically throughout the survey period.

In 2001 we also collected benthic macroinvertebrate samples at each stream. Aquatic invertebrates are important components of stream biota that can be sensitive to changes in stream habitat and water quality (Karr & Chu 1999). They are also important prey for aquatic amphibians (Kerby & Kats 1998). For invertebrate sampling, we followed Environmental Protection Agency and California Aquatic Bioassessment protocols (Harrington & Born 2000), modified as appropriate for these small Mediterranean streams. We collected three invertebrate samples at each stream in a random selection of three of the first five riffle habitats. We used kick-net sampling in the middle of the stream and at each edge. Samples were preserved in 70% ethanol and sent to Sustainable Land Stewardship International Institute (Sacramento, California) for identification to family, genus, and, where possible, species.

Analysis

WATERSHED URBANIZATION, STREAM GRADIENT, AND WATER QUALITY

We measured the degree of urbanization within the watershed by calculating the percentage of area upstream from the starting point that consisted of urban land uses. Although impervious surface cover has often been used to measure urban stream impacts and is particularly useful with respect to hydrology (Scheuler 1994; e.g., Finkenbine et al. 2000), the amount of urban land use in the watershed gives a more complete picture of the effects of urbanization. Morley and Karr (2002) found that percent urban cover was more highly correlated with their index of biological integrity for benthic invertebrates than impervious surface area.

We used geographic information systems (GIS) to generate land-use and stream-gradient information. Specifically, we used the grid module of Arc/Info 8.3 software (ESRI, Redlands, California) to calculate the watershed extent above the starting point from 10-m digital elevation models (DEMs) obtained from the U.S. Geological Survey. Land-use cover data provided by the Southern California Association of Governments were intersected with the watershed coverage to create a merged data set. The amount of urban area (industrial, commercial, residential, transportation, floodways) was then summarized for each watershed. Stream gradient was calculated by measuring the difference in elevation (based on the DEMs) over the surveyed stream reach and dividing by the surveyed length. We analyzed conductivity and flow data (from 2001) because we believed these parameters were the most reliably measured and often reflect impacts from urbanization (Paul & Meyer 2001; e.g., Willson & Dorcas 2003).

SPECIES DISTRIBUTION AND ABUNDANCE, BENTHIC MACROINVERTEBRATES, HABITAT CHARACTERISITICS, AND PERMANENCE

We were interested in how biological and physical stream characteristics changed relative to urbanization and whether those changes were continuous or related to a certain threshold of development. Many urban stream studies cite a threshold of development or impervious surface area when effects begin to appear, often about 10–15% (Paul & Meyer 2001). To examine differences between urban and natural streams on average, we classified streams in watersheds with > 8% development as urban and those with < 8% development as natural. Eight percent was the lowest level at which decreases in vertebrate diversity, specifically fishes, have been seen (Yoder et al. 1999; reviewed in Paul & Meyer 2001), and it is the level at which exotic species began to appear in the streams in our study area.

Because we attempted to survey all the major streams in the Santa Monica Mountains and Simi Hills, we realized other important factors would also vary among streams. Stream gradient, in particular, varied from 0.6% to 12.8% and was also correlated with urbanization: urban streams generally had lower gradients (Pearson correlation coefficient = −0.486). Therefore we also included stream gradient as a variable in our analyses. For categorical analyses, we classified streams below the median gradient of 3.5% as low gradient and streams above 3.5% as high gradient. We used two-way analysis of variance (ANOVA) to test for differences between urban and natural and high- and low-gradient streams. Then, to test for continuous relationships and further investigate the nature of potential changes around the threshold of 8% urbanization, we used multiple piece-wise regression analysis (Singer & Willet 2003), including gradient as a second continuous variable. Using piece-wise regression, we were able to test whether the dependent variables were significantly related to urbanization and gradient, whether the slope of the relationship with urbanization changed above and below the 8% threshold, and whether there was a significant jump effect at this threshold as measured by a significant change in the intercept of each regression line with the 8% level of urbanization (see Fig. 2 for examples).

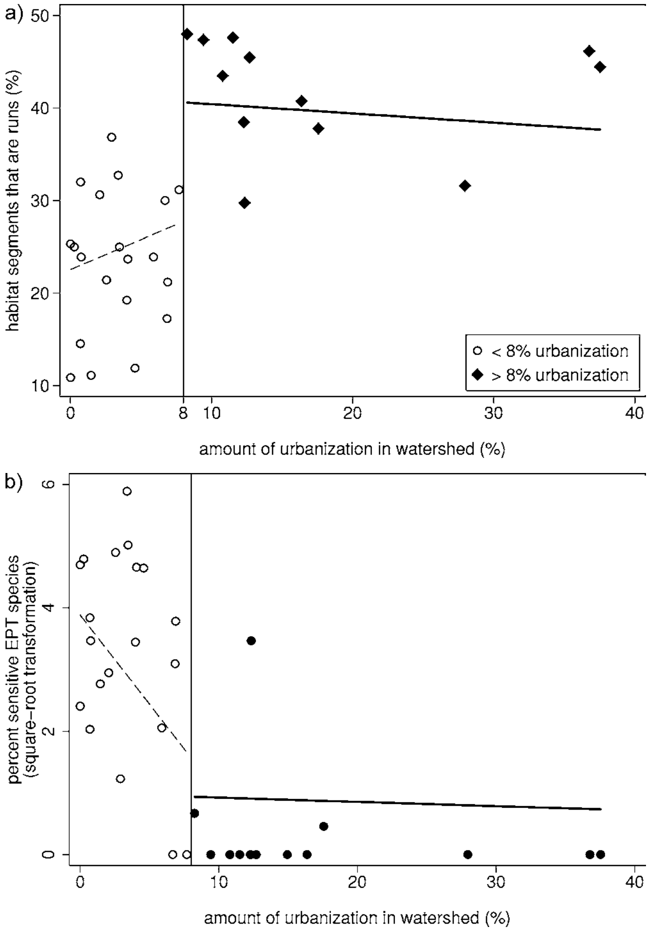

Figure 2. Piece-wise regression analyses of the percentage of watershed urbanization and (a) habitat segments that were runs in 2001 and (b) percent sensitive species (Ephemeroptera, Plecoptera, Trichoptera [EPT]), showing a significant difference in intercept but not slope in (a) and a significant difference in slope but not intercept in (b). The vertical line at 8% urbanization represents the cutoff between streams classified as urban or natural. Urban streams are filled circles (urban = 1) and natural streams are open circles (urban = 0). In (a) neither regression line is significantly different from zero, and the slopes of the lines are not significantly different from each other, but the intercepts where each line intersects the 8%-urbanization line are significantly different. In (b) the regression line for natural streams (< 8% urbanization) is significantly negative, whereas the line for urban streams is not different from zero. There is no significant difference in the intercepts with the line at 8% urbanization, but the slopes are significantly different from each other.

We tested for a relationship between species presence and urbanization with 2 × 2 contingency tables and used Fisher's exact tests when too many cell frequencies were < 5. We tested for relationships between urbanization and stream permanence with 2 × 2 contingency tables (percentage of streams with dry stretches) and Mann-Whitney tests (length of dry streambed). For stream flow, stream habitat characteristics, and invertebrate community indices, we used multiple piece-wise regression and two-way ANOVA to test for relationships with urbanization and stream gradient. We tested for multicollinearity in the piece-wise regression analyses, and tolerances were always > 0.177. Stream habitat characteristics included the average length of pools, riffles, runs, and of all habitat segments, average depth for runs, riffles, and pools, and the proportion of each stream that consisted of each habitat type, both the proportion of the length and the proportion of the segments.

Dependent variables for the invertebrate communities were species richness; diversity; the richness and percentage of insects from the Ephemeroptera, Plecoptera, and Trichoptera (EPT) orders; the percentage of insects from sensitive EPT taxa (tolerance values 0–2); the percentage of individuals from the most dominant taxon; the percentage of insects from intolerant taxa (tolerance values 0–3); and the percentage of insects from tolerant taxa (tolerance values 8–10). Mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) are orders of stream invertebrates that can be particularly susceptible to changes in stream habitat complexity and water quality. Because some families in these orders are less sensitive, we also evaluated EPT taxa and overall taxa that are particularly sensitive or insensitive to disturbance, based on tolerance values. Tolerance values represent the relative sensitivity of different invertebrate families within an order to aquatic disturbance and pollution generally but are not specific to the type of stressor (Harrington & Born 2000).

For Pacific treefrogs, we examined larval and egg mass density at the scale of the stream and the scale of the habitat segment within streams. For abundance classes, we used the minimum number of individuals as a conservative estimate of abundance (e.g., for class $x > 50$, we used 50). We used *t* tests and Mann-Whitney tests to test for relationships between treefrog density and both urbanization and crayfish presence. We report statistical results with a p value of 0.10 or less because of the high variability inherent in these data, the low power of the nonparametric tests used for most of the abundance data, and most importantly to increase our power to detect biologically important effects. Statistical tests were performed with SYSTAT and SPSS (for the piece-wise regressions) software (SPSS, Chicago, Illinois).

Results

Watershed Characteristics, Stream Flow, and Conductivity

The percentage of urbanization in the watersheds varied from 0.0 to 37.5%, with a mean of 8.4 ± 9.5% and a median of 5.9%. Stream gradient varied from 0.6% to 12.8%, with a mean of 4.6 ± 3.4% and a median of 3.5%.

Stream flow was not significantly related to gradient but was positively related to urbanization in the ANOVA (urban/natural $F_{1,29} = 5.33, p = 0.028$) and showed a significant jump effect in the piece-wise regression analysis (intercept difference: $t = 1.98, p = 0.057$). The interaction between gradient and urbanization was also significant in the ANOVA ($F_{1,29} = 5.33, p = 0.028$). For low-gradient streams, flow was significantly higher in urban streams (mean of 1.27 m^3/second) than in natural streams (mean of 0.11 m^3/second), but there was no significant difference in high-gradient streams. Conductivity in urban streams (1643.3 microsiemens), was significantly higher than in natural streams (903.8 microsiemens) (Mann-Whitney $U = 49, p = 0.005$). The conductivity data could not be transformed for the ANOVA or piece-wise regression analyses with gradient.

Species Distribution

In more urban watersheds, some native amphibians such as California newts and California treefrogs were conspicuously absent from streams, whereas exotic aquatic species such as crayfish and introduced fish species were often present (Table 1). In natural streams, species presence was significantly more likely for California newts and California treefrogs and significantly less likely for exotic crayfish and fishes (newts $\chi^2 = 6.37, p = 0.012$; California treefrogs $\chi^2 = 5.22, p = 0.022$; Fisher exact tests: crayfish $p = 0.000$, exotic fish $p = 0.000$). Western toads exhibited variability in distribution between years. In 2000, but not in 2001, toads were detected significantly more often in urban streams (Fisher exact tests: 2000 $p = 0.034$, 2001 $p = 0.130$). Bullfrogs were present in only one stream, and Pacific treefrogs were found in every stream surveyed. The small overall sample size and skewed nature of the presence/absence data rendered logistic regression models (incorporating both urbanization and stream gradient) inappropriate.

Abundance

Because Pacific treefrogs were present in every stream surveyed, we examined the abundance of larvae and egg masses relative to both urbanization and the presence of crayfish. At the stream scale, larval treefrog density was not related to crayfish presence (2000 Mann-Whitney $U = 74, p = 0.521$; 2001 $U = 84, p = 0.873$) or to urbanization in 2000 ($U = 96$, $p = 0.693$), although in 2001 larval density was marginally higher in urban streams (1.21 tadpoles/m vs. 0.82 tadpoles/m in natural streams; $t = -1.704$ df $= 30$, $p = 0.10$). Egg mass density was significantly lower in urban streams in 2001 ($U = 183$, $p = 0.014$), when there were 0.254 egg masses/m in urban streams and 0.395 egg masses/m in natural streams, but was not related to urbanization in 2000 ($U = 103$, $p = 0.453$). Egg mass density was also significantly lower in streams with crayfish both in 2000, with 0.081 egg masses/m in streams without crayfish versus 0.004 egg masses/m in streams with crayfish ($U = 95.5, p = 0.055$), and in 2001, with 0.244 egg masses/m in streams without crayfish and 0.050 egg masses/m in streams with crayfish ($U = 142, p = 0.013$).

Table 1. Distribution of native amphibians and introduced aquatic species in streams in the Santa Monica Mountains and Simi Hills, California.

		Native species[b]				*Introduced species*[b]		
Stream	*Area developed (%)*[a]	*TATO*	*HYCA*	*BUBO*	*HYRE*	*CRAY*	*RACA*	*exotic fishes*
Lang Ranch, north	0.00	X			X			
Palo Comado Canyon	0.00			X	X			
Temescal Canyon	0.01	X			X			
Sullivan Canyon	0.17				X			
Big Sycamore Canyon	0.26	X	X		X			
Las Virgenes, north	0.70				X			
Wood Canyon	0.71				X			
La Jolla Canyon	0.75				X			
Rustic Canyon	1.45	X			X			
Solstice Canyon	2.07	X	X		X			
Cold Creek, upper	2.55	X	X		X			
Corral Canyon	2.91			X	X			
Arroyo Sequit	3.38	X	X		X			
Ramirez Canyon	3.46	X	X		X			
Serrano Canyon	3.99		X		X			
Trancas Canyon	4.06	X	X		X	X		
Deer Creek	4.58		X		X			
Carlisle Canyon	5.88	X	X	X	X			
Zuma Canyon	6.69	X	X		X			
Newton Canyon	6.84	X	X		X			
Tuna Canyon	6.89	X	X		X			
Cheeseboro Canyon	7.68			X	X			
Triunfo Canyon	8.26			X	X	X	X	X
Old Topanga Canyon	9.42			X	X			X
Lang Ranch, south	10.79			X	X			
Topanga Canyon, Upper	11.51			X	X	X		
Las Virgenes, south	12.28			X	X	X		X
Cold Creek, Lower	12.34	X	X		X			
Topanga Canyon, Lower	12.69	X	X	X	X			
Lower Malibu Creek	14.95				X	X		X
Erbes	16.37				X	X		X
Liberty Canyon	17.57				X			
Medea Creek, north	27.96			X	X	X		X
Lindero Canyon	36.77				X	X		X
Medea Creek, South	37.54			X	X	X		X

[a] *Development includes industrial, commercial, residential, transportation, and floodway areas. Streams in watersheds with >8% development are classified as urban.*

[b] *Abbreviations: TATO,* Taricha torosa; *HYCA,* Hyla cadaverina; *HYRE,* Hyla regilla; *BUBO,* Bufo boreas; *CRAY, crayfish,* Procambarus clarkii; *RACA,* Rana catesbeiana.

In streams that had both crayfish and Pacific treefrogs, at the scale of the stream habitat segment larval treefrog density was significantly higher in segments without crayfish than in those with them, both in 2000 (0.730 tadpoles/m without crayfish and 0.293 tadpoles/m with them, $U = 2367$, $p < 0.001$) and in 2001 (2.820 tadpoles/m without crayfish and 0.820 tadpoles/m with them, Mann-Whitney $U = 3720$, $p < 0.001$).

Stream Habitats

Stream habitat was affected by urbanization (Table 2) and in some cases by gradient (Table 3). There was variation between years, but some effects were also consistent in both years, specifically the tendency for habitat segments, particularly runs, to be longer and for runs and pools to be deeper in urban streams. Overall, the effects of development were particularly strong in 2001, when urban streams had longer pools, riffles, and runs, a higher percentage of the stream length in runs, and a lower percentage of the habitat segments as pools but a higher percentage of them as runs (Table 2, Fig. 3). When gradient was also an important factor, some effects were difficult to test for in high-gradient streams because we had only two high-gradient urban streams. In a number of cases, however, particularly in 2000, urban low-gradient streams ($n = 10$) were significantly different from natural low-gradient streams ($n = 6$) (e.g., for average stream segment length in 2000; Tables 2 & 3).

Based on the piece-wise regression analyses, the habitat changes relative to urbanization were related more to a jump effect (i.e., a large change at about 8% watershed urbanization) than to a change in the slope of the relationship. There was never a significant difference in the slopes

Table 2. Stream habitat characteristics in urban and natural streams in the Santa Monica Mountains and Simi Hills, California.

Stream characteristic	*2000* *urban*	*2000* *natural*	*2001* *urban*	*2001* *natural*
Average stream segment length (m)	21.08[a]	9.46	17.65[b]	8.81
Average pool length (m)	12.16	6.99	13.93[b]	5.79
Average riffle length (m)	20.10[a]	11.37	16.40[b]	10.59
Average run length (m)	25.52[c]	10.43	19.25[b]	8.12
Stream length consisting of pools (%)	23.34	34.91	11.52	22.30
Stream length consisting of riffles (%)	43.85	47.75	41.82[a]	55.35
Stream length consisting of runs (%)	32.81[a]	17.34	46.35[b]	22.35
Segments that are pools (%)	29.96	45.02	13.63[d]	31.30
Segments that are riffles (%)	42.10	38.00	44.42	45.32
Segments that are runs (%)	27.93[a]	16.98	41.73[b]	23.38
Average pool depth (cm)	54.88[c]	39.04	81.09[c]	47.54
Average riffle depth (cm)	24.43[b]	14.25	17.96	16.53
Average run depth (cm)	40.65[b]	21.10	39.43[c]	26.39

[a] *Significant difference between urban and rural, low-gradient streams, Bonferroni comparisons based on overall* $p = 0.05$.

[b] *Significant difference between urban and rural streams at* $p < 0.01$.

[c] *Significant difference between urban and rural streams at* $p < 0.10$.

[d] *Significant difference between urban and rural streams at* $p < 0.05$.

above and below 8%, but there was a statistically significant intercept change in 2001 for average pool length, percentage of segments that were pools, and percentage of segments that were runs (Fig. 2a). Also, for the habitat variables that showed a significant effect of urbanization in the ANOVA (significant F test), in 11 of 13 cases (3 of 4 in 2000 and 8 of 9 in 2001) the intercept difference was greater than the slope difference based on inspecting the t and p values (Table 3). In fact, there was little statistical evidence of continuous effects of urbanization on habitat; only 1 of 52 regression coefficients (26 variables × 2 years × 2 coefficients, urban and rural) computed for habitat variables were significantly different from 0 (average pool length in 2000; $t = 2.634, p = 0.015$).

Stream Permanence

Although there was annual variation, urban streams consistently had less dry streambed than natural streams (Table 4). Urban streams were not significantly wetter than natural streams in 2000, which was an El Niño year (streams with any dry: $\chi^2 = 0.785, p = 0.376$; percent stream length dry: Mann-Whitney $U = 118, p = 0.278$), but in 2001 and 2002 more natural streams had dry streambed and a greater percentage of the surveyed reaches were dry (2001—streams with any dry: Fisher exact test $p = 0.035$; percent stream length dry: $U = 156, p = 0.040$; 2002—streams with any dry: $\chi^2 = 6.65, p = 0.010$; percent stream length dry: $U = 224, p = 0.003$). In 2002, a very dry year, most or all of the surveyed reach of some of the natural streams was dry.

Invertebrates

Invertebrate communities also varied between streams and were related strongly to urbanization and stream gradient. Urban streams had lower invertebrate diversity, greater dominance by the most common taxon and by more-tolerant taxa, and decreased percentages of more sensitive or intolerant taxa overall and within the EPT orders specifically. Within low-gradient streams, overall and EPT richness were also significantly lower in urban streams (Table 5). The piece-wise regression analyses for invertebrates were different from those for habitat variables, in that urbanization effects seemed to be more related to a change in slope than in intercept. Although there was a significant intercept difference for species richness, there was a significant slope difference for EPT taxa and for sensitive EPT taxa (Fig. 2b), and for four of the five variables where there was a significant urbanization effect in the ANOVA, the slope difference was greater than the intercept difference (t and p values, Table 3). The slopes of the relationship between urbanization and invertebrate indices were also significantly different from zero in three cases for natural streams (richness, $t = -2.43, p = 0.022$; EPT taxa, $t = -2.56, p = 0.016$; and sensitive EPT taxa, $t = -2.47, p = 0.020$) and in one case for urban streams (richness, $t = -2.31, p = 0.029$). For every variable, the slope of the relationship with urbanization was greater for natural streams than for urban streams.

The effect of stream gradient on invertebrates was consistently significant for five of the eight variables in both the categorical (ANOVA) and the continuous (piece-wise regression) analyses (Table 3). The proportion of EPT insects (EPT index) was not significantly related to urbanization, although it was related to gradient in both analyses.

Discussion

Habitat Changes, Distribution, and Abundance

In urban streams the absence of some native amphibians and the presence of exotic species such as crayfish and

Table 3. Statistical results for piece-wise regression analyses and two-way analysis of variance (ANOVA) for habitat variables in 2000 and 2001 and benthic macroinvertebrate community indices in 2001 for streams in the Santa Monica Mountains and Simi Hills, California.[a]

	2000					
	Piece-wise regression[b] t (p)			*Two-way ANOVA* F (p)		
	slope difference	*intercept difference*	*gradient*	*urbanization*	*gradient*	*interaction*
Habitat variables						
average stream segment length	0.094 (0.930)	1.220 (0.234)	ns	ns (urb>nat low[c])	ns	ns
average pool length	0.589 (0.969)	−0.756 (0.795)	−2.30 (0.031)	ns	ns	ns
average riffle length	−0.290 (0.774)	0.980 (0.337)	ns	ns (urb>nat low[c])	ns	ns
average run length	−0.485 (0.632)	1.430 (0.165)	−2.11 (0.046)	5.100 (0.033)	ns	ns
percent stream length in pools	−0.744 (0.464)	0.560 (0.581)	ns	ns	ns	ns
percent stream length in riffles	−1.160 (0.257)	−0.022 (0.883)	ns	ns	ns	ns
percent stream length in runs	−0.722 (0.477)	0.729 (0.473)	ns	ns (urb>nat low[c])	ns	ns
percent segments that are pools	0.483 (0.633)	−0.654 (0.519)	ns	ns	ns	ns
percent segments that are riffles	−0.833 (0.413)	0.705 (0.488)	ns	ns	ns	ns
percent segments that are runs	−0.319 (0.752)	0.193 (0.848)	ns	ns (urb>nat low[c])	3.770 (0.064)	3.430 (0.076)
average pool depth	0.032 (0.974)	0.176 (0.862)	ns	5.080 (0.034)	ns	ns
average riffle depth	0.293 (0.772)	1.580 (0.126)	ns	11.290 (0.003)	ns	ns
average run depth	−1.100 (0.283)	0.871(0.393)	ns	7.810 (0.010)	ns	ns
	2001					
average stream segment length	−0.567 (0.576)	1.420 (0.153)	ns	12.690 (0.001)	ns	ns
average pool length	−0.863 (0.397)	2.180 (0.040)	ns	14.200 (0.001)	ns	ns
average riffle length	−0.613 (0.545)	0.398 (0.694)	ns	3.120 (0.088)	ns	ns
average run length	−0.281 (0.781)	1.120 (0.273)	ns	12.090 (0.002)	ns	ns
percent stream length in pools	0.046 (0.963)	0.950 (0.350)	ns	ns	ns	ns
percent stream length in riffles	0.214 (0.832)	−0.071 (0.944)	ns	ns (urb>nat low[c])	ns	ns
percent stream length in runs	−0.440 (0.663)	1.260 (0.218)	-2.040 (0.051)	10.910 (0.003)	ns	ns
percent segments that are pools	0.268 (0.790)	−2.330 (0.028)	ns	6.620 (0.016)	ns	ns
percent segments that are riffles	0.518 (0.609)	1.020 (0.315)	ns	ns	ns	ns
percent segments that are runs	0.268 (0.790)	2.600 (0.015)	−1.780 (0.086)	10.270 (0.003)	ns	ns
average pool depth	−0.856 (0.401)	1.390 (0.179)	ns	3.240 (0.084)	5.630 (0.026)	7.030 (0.014)
average riffle depth	0.248 (0.806)	−0.350 (0.729)	ns	ns	ns	ns
average run depth	0.117 (0.908)	−0.372 (0.713)	ns	3.880 (0.059)	ns	ns
	2001					
Invertebrate community indices						
richness	1.610 (0.119)	2.030 (0.052)	2.370 (0.025)	ns (urb<nat low[c])	4.640 (0.040)	ns
EPT[d] taxa	1.970 (0.059)	1.460 (0.156)	2.610 (0.014)	ns (urb<nat low[c])	7.860 (0.009)	ns
EPT index (% EPT inds)	1.050 (0.301)	0.865 (0.394)	2.800 (0.009)	ns	4.090 (0.053)	ns
sensitive EPT taxa	2.280 (0.031)	−0.716 (0.480)	2.510 (0.018)	12.250 (0.002)	5.700 (0.031)	ns
Shannon diversity	1.340 (0.192)	−0.518 (0.609)	ns	7.620 (0.010)	ns	ns
percent dominant taxon	−0.986 (0.332)	0.629 (0.535)	ns	4.400 (0.045)	ns	ns
percent intolerant taxa (TV[e] 1–3)	0.858 (0.398)	−0.856 (0.399)	2.36 (0.026)	6.150 (0.019)	4.280 (0.048)	ns
percent tolerant taxa (TV 8–10)	1.450 (0.159)	−0.072 (0.943)	ns	3.360 (0.077)	ns	5.590 (0.025)

[a] *Piece-wise regression analyses had an urbanization cutoff of 8% between urban and natural streams and gradient as a continuous second factor. Two-way ANOVA factors included urbanization (natural and urban streams with 8% cutoff) and gradient (high- and low-gradient streams with median gradient of 3.5% as the cutoff). Nonsignificant results are listed as "ns" except for slope and intercept differences in the piece-wise regressions to further evaluate whether threshold differences are related to a "jump effect" or to a change in the slope of the relationship (see text for details).*

[b] *Slope difference measures whether the slope of the regression between urbanization and the dependent variable is significantly different between urban streams (>8% watershed urbanization) and natural streams (<8% urbanization). Intercept difference measures whether there is a significant difference between where the urban stream regression line and the natural stream regression line intercepts the vertical line of the cutoff, 8% watershed urbanization.*

[c] *Significant difference between urban and rural, low-gradient streams, bonferroni comparisons based on overall* $p = 0.05$.

[d] *Aquatic insect orders Ephemeroptera, Plecoptera, and Trichoptera.*

[e] *Tolerance values, a measure of sensitivity to disturbance and pollution with 0 being most sensitive and 10 most tolerant.*

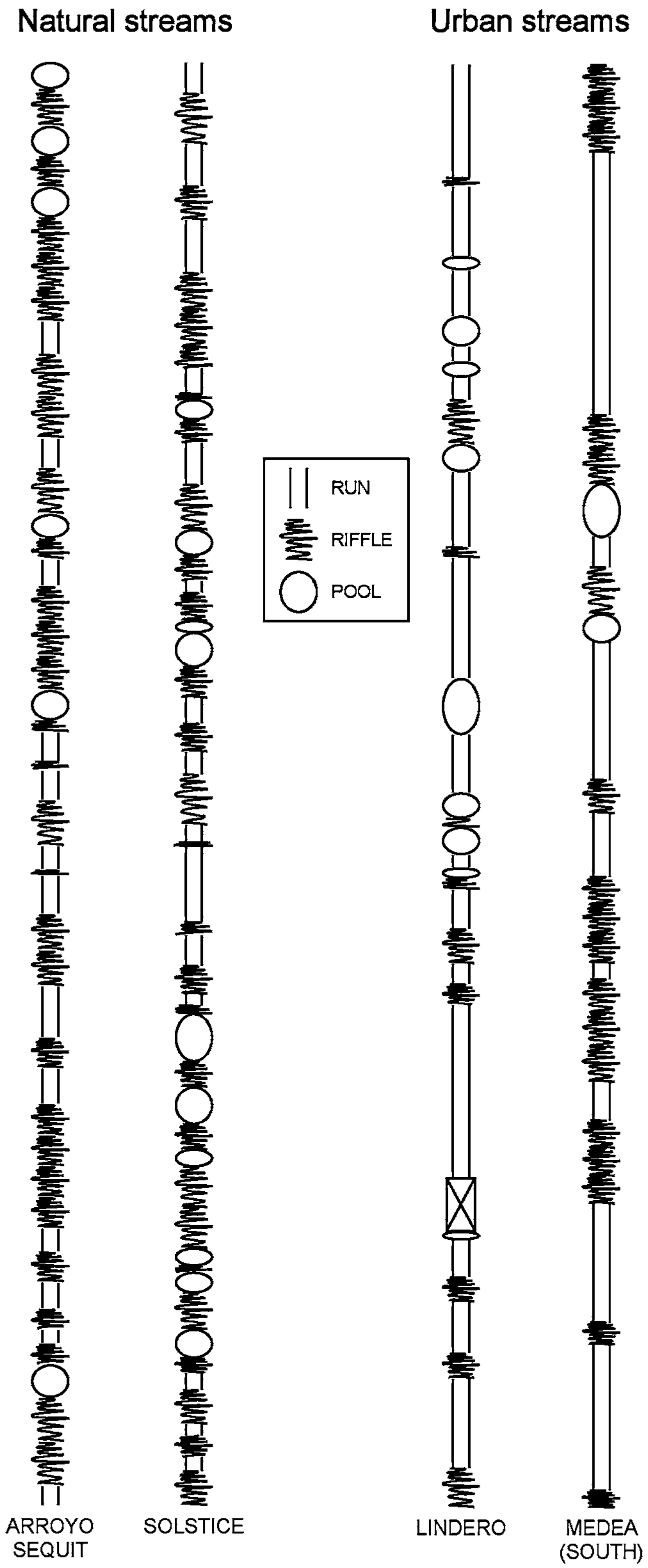

Figure 3. Schematic representation of habitat diversity (runs, riffles, and pools) in two urban and two natural streams in the Santa Monica Mountains and Simi Hills of southern California. The rectangle with an X *on Lindero Creek represents a culvert.*

Table 4. Stream permanence in urban and natural streams in the Santa Monica Mountains and Simi Hills, California.

Year and stream type	*Length of dry stream (%)*	*Streams with dry bed (%)*
2000		
urban	0.57	16.7 (2/12)
natural	8.22	33.3 (6/18)
2001		
urban	0.00	0 (0/12)
natural	5.79	30 (6/20)
2002		
urban	4.41	23.1 (3/13)
natural	38.11	68.2 (15/22)

introduced fishes are striking. Exotic crayfish also affect the abundance of Pacific treefrogs, the most widely distributed native amphibian. Macroinvertebrate communities were also less diverse and weighted toward tolerant species in urban streams. These faunal changes are most likely related to the significant differences in habitat structure, water quantity, and stream permanence associated with urban streams. The larger quantity of water in more urban streams is not surprising given increased water inputs in urban areas from, for example, watering lawns and gardens and washing cars and especially from increased runoff from impervious surfaces. These increased amounts of water most likely contribute to the changes in stream habitat structure that we saw, and both these factors have profound implications for populations of native and exotic species. In urban streams, habitat segments are longer and a greater percentage of the stream

Table 5. Macroinvertebrate community indices in urban and natural streams in the Santa Monica Mountains and Simi Hills, California.

	2001	
	urban (n = *13*)	*natural* (n = *20*)
Taxonomic richness	23.15[a]	29.40
EPT[b] taxa	5.08[a]	9.40
Percent EPT invertebrates	23.26	32.98
Percent senstive EPT (TV[c] = 0–2)	0.97[d]	13.33
Percent intolerant (TV = 0–3) organisms	1.03[e]	10.65
Percent tolerant (TV = 8–10) organisms	13.34[f]	9.90
Percent most dominant taxon	45.91[e]	33.69
Shannon diversity	1.65[d]	2.23

[a] *Significant difference between urban and rural, low-gradient streams, bonferroni comparisons based on overall* $p = 0.05$.
[b] *Aquatic insect orders Ephemeroptera, Plecoptera, and Trichoptera.*
[c] *Tolerance values, a measure of sensitivity to disturbance and pollution with 0 being most sensitive and 10 most tolerant.*
[d] *Significant difference between urban and rural streams at* $p < 0.01$
[e] *Significant difference between urban and rural streams at* $p < 0.05$.
[f] *Significant difference between urban and rural streams at* $p < 0.10$.

consists of runs. Overall, the result is fewer pools and a general decrease in habitat complexity (Fig. 3).

Determining the precise mechanisms behind the species distributions in these streams will require more detailed study, but there is already information about some of the important interactions in this system. For example, crayfish can negatively affect populations of native amphibians such as newts and treefrogs (Gamradt & Kats 1996; Goodsell & Kats 1999). For native species, a critical question is whether they would be present in the "urban" streams without the influences of development and exotic species. In the case of the California newt, it seems likely that they would be. In the Santa Monica Mountains and Simi Hills newts prefer pools for egg laying, and lower-gradient streams may have less pool habitat, but newts also lay eggs in slow-moving runs (Gamradt & Kats 1997). California newts breed in "ponds, reservoirs and slow-flowing streams" (Stebbins 1985), and in some parts of their range, newts will breed in cattle ponds and other bodies of water that are not particularly pristine (P. C. Trenham, personal communication).

At least three factors are detrimental to newt populations in urban streams. The increased quantity and flow of water and the concomitant increase in run habitat, decrease in pools, and decrease in habitat diversity reduce high-quality newt breeding habitat and negatively affect invertebrate prey communities. More permanent water in urban streams also allows increased presence and abundance of exotic predators, specifically crayfish. Although crayfish presence does not exclude newts, dense crayfish populations can reduce and even eliminate newt reproduction (Gamradt & Kats 1996). Finally, newts are highly visible, slow-moving animals that are easily collected by people. It is perhaps not surprising then that newts have been eliminated from virtually all urban streams in this area. At least 15 years ago, newts were present in two streams (Triunfo Canyon and Lower Malibu Creek), where we did not detect them (De Lisle et al. 1986). These streams were classified as urban in our study and now contain crayfish, introduced fishes, and in one case, bullfrogs.

The distribution of California treefrogs may be more strongly related to specific habitats, but urbanization may still play a role. Of the 14 streams with California treefrogs, the average gradient was 6.7%. All 14 had a gradient greater than the 3.5% median, and the two urban streams had gradients of 4.8% and 4.9%. California treefrogs prefer streams with large boulders and significant rock pool habitat (Cunningham 1964; Dole 1974; Harris 1975), both of which were typical of many of the higher-gradient streams. Nonetheless, the stream habitat alteration that appears to frequently accompany development, specifically an increase in run habitat and a decrease in pools, would be likely to negatively affect this species. California treefrogs are also very closely associated with stream habitat, in one study never moving more than 10 m from the stream, and only 5 m during the active season (Harris 1975); significant alteration of the streambed could reduce or eliminate populations. As with newts, we did not detect California treefrogs in the highly modified streams of Triunfo Canyon and Lower Malibu Creek, where they were found before 1985 (De Lisle et al. 1986).

Pacific treefrogs were present in every stream we surveyed, even those with the highest percentage of development in the watershed. Pacific treefrog density was also high in some of the most urban streams. It is not surprising that this species was the most prevalent amphibian in our surveys because it is a very widespread and adaptable frog that has not suffered the significant declines of other amphibians in California (e.g., Fisher & Shaffer 1996). Even Pacific treefrogs, however, were affected in this area: larval and egg mass densities were significantly lower in the presence of crayfish, and these exotic predators were more common in urban streams. Matthews et al. (2001) found that exotic trout species significantly restricted the distribution and reduced the abundance of Pacific treefrogs in the Sierra Nevada. Goodsell and Kats (1999) found Pacific treefrog tadpoles in 65% of the stomachs of exotic mosquitofish, and the presence of exotic fishes can reduce Pacific treefrog survival to near zero (Adams 2000). In the Washington studies, pond permanence by itself also reduced the survival and presence of native anurans (Adams 1999, 2000), a factor that could be leading to detrimental effects on this species in more permanent urban streams.

Our stream surveys were probably not the most effective tool for measuring the distribution and abundance of western toads. Toads often breed in ponds or small pools, and although we detected them in some of our streams, often we found them in only a few places or in a side pool, or we detected few individuals. Toads were most likely breeding in other pools and possibly human-made ponds (e.g., on golf courses) that we did not survey. Toads also can breed and develop quickly, so multiple visits within a year would be more effective for detection. Their association with urban streams, at least in 2001, may be related to an association with lower-gradient streams, where ephemeral pools may be more likely to form. Overall, stream gradient was significantly lower in streams with toads (0.025 with toads vs. 0.056 without toads, $t = 3.33$, df $= 32.8$, $p = 0.002$). Because of their more terrestrial habits, fast development time, and ability to breed in other, often ephemeral bodies of water, toads may be less affected than other native amphibians by the habitat and flow changes and introduced aquatic predators associated with urban streams. However, other effects of urbanization such as terrestrial habitat loss and fragmentation and the loss of ephemeral pools could negatively affect toads.

The presence of introduced species such as crayfish, exotic fishes, and bullfrogs generates two important questions: How did they get into a stream? Why do they persist? Most likely these species were dropped off by people using them as fish bait or releasing pets. Bait-bucket introductions are a common potential mechanism of introduction for many aquatic animals, but they are difficult to document. Although the cause of the introduction is important in terms of preventing future instances, the more critical issue is why these animals persist. Permanent water is almost certainly the most important factor in exotic persistence. The climate in southern California is characterized by a long, dry summer, and many of the natural streams in the area are ephemeral. The increased likelihood of permanent water in urban streams (Table 4) coupled with the increased likelihood of introductions because of the higher human density could explain why so many of the urban streams have exotic species. Trancas Creek, the one natural stream with crayfish, is the exception that proves the rule. At the top of Trancas Creek is the Malibu golf club. The golf club ponds have crayfish populations that provide a recurring source of propagules, and golf-course maintenance generates perennial water availability.

Benthic macroinvertebrate communities were also significantly altered in urban streams, where they were less diverse and consisted more of disturbance-tolerant species and less of sensitive EPT taxa. Although more intensive monitoring would be necessary to reliably measure water-quality differences and their potential effects on invertebrates, the habitat changes, specifically the decrease in stream habitat diversity, associated with urban streams would definitely adversely affect invertebrate communities.

Stream Gradient and Urbanization Threshold Effects

Stream gradient can be an important determinant of stream ecological characteristics, and this was true for macroinvertebrate communities in particular in streams in the Santa Monica Mountains (Table 3). For habitat variables, gradient was rarely significant, although lower-gradient streams generally had more runs and longer pools and runs in 2000.

A confounding problem in our study, and possibly in other studies of development and stream ecology, is that stream gradient and urbanization are strongly negatively correlated (see also Morley & Karr 2002). Because our goal was to survey the entire region, we did not select only the most comparable streams. Therefore it is difficult for us to conclude as much about the effects of urbanization on high-gradient streams because we had only two streams in this category. The strong negative correlation between urbanization and gradient is not surprising, given that it is much easier to build on ground with gradual slopes and people like to live and work near water. This trend is especially dangerous for organisms like amphibians that require intact aquatic systems.

The effects of urbanization on amphibian distribution, stream habitat, and macroinvertebrate communities appeared to be related to a threshold level of development within the watershed more than to the absolute level of development. Differences between urban and natural streams were often significant, but coefficients in the piecewise regression analyses were generally not. In other words, below about 8% watershed development, the effects of development may not yet be visible, but once this level of development was reached significant changes occurred and further effects were not as great as the jump across the threshold. Interestingly, the type of threshold effects may be different for macroinvertebrate communities than for habitat. For habitat the change around 8% urbanization seemed to be related more to a jump in the value of the variable rather than to a change in the slope or strength of the relationship. For invertebrates, the change in slope was generally more important than a jump effect. Two facts, that for a number of invertebrate indices the slope for natural streams was significantly different from zero, and that the natural slopes were always greater than the urban slopes, suggest that urban impacts on invertebrate communities may actually start below the 8% threshold apparent for habitat changes and amphibian and invasive species distributions.

The threshold effect of urbanization has been detected in other studies of urban streams (Paul & Meyer 2001), although in Santa Monica Mountain streams the threshold level appears to be at the low end of the 10–15% seen elsewhere. Stream communities in arid areas such as deserts or Mediterranean ecosystems may be particularly susceptible to urban impacts because the increased regularity of water flow increases stream permanence beyond that of natural conditions. In North Carolina the abundance of two plethodontid salamanders decreased with increasing watershed disturbance (including both agricultural and urban development), and for one species, the southern two-lined salamander (*Eurycea cirrigera*), there was a strong threshold effect at 20% disturbance (Willson & Dorcas 2003).

Conservation Management Implications

Land managers in urban areas should be aware that urban development can have profound implications for aquatic communities and that these effects may be manifested before they are expected. A relatively low level of development, as little as 10% or even 8%, as in our study, may be enough to significantly affect the system. Given the threshold nature of the effects, arresting watershed development just after the threshold is reached may be too late. Also, development does not have to be next to the riparian area itself, or even directly upstream, to have an effect; development within the watershed overall is the most significant factor. Directly addressing this issue for amphibians in the Southeast, Willson and Dorcas (2003) found that development within three different buffer zones regularly used in land-use planning had no effect on amphibian populations, whereas overall watershed development had a strong impact. Morley and Karr

(2002) also found that, while local effects can also be important, watershed development was a better predictor of stream changes than local development.

Those concerned with amphibian conservation must similarly be aware of the effects of urbanization on stream-dwelling species. Urban impacts on stream communities in general and on amphibian communities in particular may be especially severe and occur especially easily in arid environments, where the extra inputs of water in urban areas represent a great departure from the natural hydrological regime. Flow and permanence changes can then greatly facilitate the establishment of exotic species with the accompanying damage to native communities (e.g., Eby et al. 2003).

Our results indicate that monitoring for amphibians and exotics should be included as a regular component of stream-monitoring protocols. Although physical and chemical measures of stream conditions are clearly important, whenever possible it is desirable to measure biological conditions directly (Morley & Karr 2002). Frequently, biological conditions are evaluated by integrating multiple measures into an index of biological integrity, including measures of taxa such as algae, fish, and aquatic invertebrates. Both the evaluation of overall stream health and amphibian conservation would benefit greatly from including amphibians in the biological assessment of streams in general and of urban streams in particular.

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Appendix 7:
Index of Biological (IBI) Scores

7-A: CDFG, LA County, Ventura County, & Heal the Bay Data
7-B: CDFG IBI Study (Ode et al.)
7-C: Map of Low IBI Scores in Calleguas Creek Watershed

Appendix 7-A: Region 4 IBI Scores

REGION 4 CDFG IBI SCORES

Stream Name	Year	IBI Score[1,2]
Piru Creek	2000	31.46
Unknown Creek	2000	27.17
Revolon Slough	2001	11.44
Unnamed Creek	2001	28.6
Cattle Creek	2000	31.46
Boulder Creek	2001	31.46
Arroyo Conejo Creek	2001	22.88
NF Arroyo Conejo Creek	2001	21.45
Arroyo Simi Creek	2001	17.16
Bouquet Canyon Creek	2001	24.31
Beardsley Wash	2001	14.3
Conejo Creek	2001	27.17
Castaic Creek	2001	25.74
Calleguas Creek	2001	1.43
Piru Creek	2001	25.74
Revolon Slough	2001	5.72
Santa Clara River	2001	20.02
Santa Clara River	2001	37.18
Santa Clara River	2001	37.18
San Francisquito Creek	2001	31.46
Simi Las Posas Creek	2001	17.16
Tapo Canyon Tributary	2001	17.16

Table 1: IBI scores for Region 4 calculated in a CDFG study. Ode, P.R., A.C. Rehn and J.T. May., A Quantitative Tool for Assessing the Integrity of Southern Coastal California Streams, *Environmental Management*. 35:493-504 (2005).

1: IBI Scores are normalized
2: Only scores in "poor" and "very poor" ranges are presented.

LA COUNTY IBI SCORES

SAMPLING LOCATION	IBI SCORE (Oct-03)[1]	IBI SCORE (Oct-04)[1]
Santa Clara River - Station 1	30	27.14
Coyote Creek - Station 2	4.29	2.86
San Jose Creek - Station 3	11.43	18.57
San Gabriel River - Station 4	42.86	57.14
Walnut Channel - Station 5	10	8.57
Arroyo Seco - Station 6	NA	NA
Arroyo Seco - Station 7	15.71	12.86
Compton Creek - Station 8	1.43	4.29
Zone 1 Ditch - Station 9	28.57	NA
Eaton Wash - Station 10	NA	NA
Los Angeles River - Station 11	1.43	4.29
Los Angeles River - Station 12	15.71	12.86
Los Angeles River - Station 13	2.86	10
Ballona Creek - Station 14	8.57	14.29
Madea Creek - Station 15	4.29	7.14
Las Virgenes Creek - Station 16	NA	NA
Cold Creek - Station 17	60	74.29
Triunfo Creek - Station 18	31.43	NA
Dominguez Channel - Station 19	4.29	8.57

Table 2: IBI scores for LA County. Highlighted scores are in the "poor" or "very poor" ranges. Los Angeles County. Los Angeles County 1994-2005 Integrated Receiving Water Impacts Report, (2005).

1: Scores are normalized to a scale of 0-100
NA: not sampled due to dry conditions

VENTURA COUNTY IBI SCORES

SAMPLING LOCATION	IBI Score (2004/2005)
Ventura River - Main St Bridge	31
Ventura River - Foster Park	47
Ventura River - Below Matilija Dam	40
Ventura River - Santa Ana Rd	NA
Canada Larga - Below Grazing	NA
Canada Larga - Above Grazing	NA
San Antonio Creek - u/s Ventura Rv Confluence	NA
San Antonio Creek - Lion Canyon u/s San Antonio	NA
San Antonio Creek - u/s Lion Canyon	45
San Antonio Creek - Stewart Canyon u/s San Antonio	54
San Antonio Creek - u/s Steward Canyon Creek	53
North Fork Matilija Creek - u/s Ventura Rv Confluence	50
North Fork Matilija Creek - At gauging station	64
Matilija Creek - Below Community	39
Matilija Creek - Above Community	NA

Table 3: IBI scores for Ventura County. Highlighted scores are in the "poor" or "very poor" ranges. Ventura County Watershed Protection District, Ventura River Watershed 2004 Bioassessment Monitoring Report, (2005).

NA: not sampled due to dry conditions

MALIBU CREEK WATERSHED IBI SCORES

Site	Spring 2000	Fall 2000	Spring 2001	Fall 2001	Spring 2002	Fall 2002	Spring 2003	Fall 2003
Mid-Malibu Creek -12		23	20	37	33	27	21	31
Mid-Las Virgenes Creek - 13			21	40	26	24	21	27
Malibu Creek Outlet -1	16	24	26	39	19		26	23
Outlet of Las Virgenes Creek - 5	29	34	33	33	39	26	20	29
Outlet of Madea Creek - 7	23	26	19	34	23	17	9	9
Mid-Malibu Creek - 15	33	17	24	43	40	24	34	23
Triunfo Creek - 17	20		19		19		4	

Table 4: IBI scores for Malibu Creek Watershed. Highlighted scores are in the "poor" or "very poor" ranges. Heal the Bay, Watershed Assessment of Malibu Creek: Final Report, (2005).

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A Quantitative Tool for Assessing the Integrity of Southern Coastal California Streams

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ABSTRACT / We developed a benthic macroinvertebrate index of biological integrity (B-IBI) for the semiarid and populous southern California coastal region. Potential reference sites were screened from a pool of 275 sites, first with quantitative GIS landscape analysis at several spatial scales and then with local condition assessments (in-stream and riparian) that quantified stressors acting on study reaches. We screened 61 candidate metrics for inclusion in the B-IBI based on three criteria: sufficient range for scoring, responsiveness to watershed and reach-scale disturbance gradients, and minimal correlation with other responsive metrics. Final metrics included: percent collector-gatherer + collector-filterer individuals, percent noninsect taxa, percent tolerant taxa, Coleoptera richness, predator richness, percent intolerant individuals, and EPT richness. Three metrics had lower scores in chaparral reference sites than in mountain reference sites and were scored on separate scales in the B-IBI. Metrics were scored and assembled into a composite B-IBI, which was then divided into five roughly equal condition categories. PCA analysis was used to demonstrate that the B-IBI was sensitive to composite stressor gradients; we also confirmed that the B-IBI scores were not correlated with elevation, season, or watershed area. Application of the B-IBI to an independent validation dataset (69 sites) produced results congruent with the development dataset and a separate repeatability study at four sites in the region confirmed that the B-IBI scoring is precise. The SoCal B-IBI is an effective tool with strong performance characteristics and provides a practical means of evaluating biotic condition of streams in southern coastal California.

Assemblages of freshwater organisms (e.g., fish, macroinvertebrates, and periphyton) are commonly used to assess the biotic condition of streams, lakes, and wetlands because the integrity of these assemblages provides a direct measure of ecological condition of these water bodies (Karr and Chu 1999). Both multimetric (Karr and others 1986; Kerans and Karr 1994; McCormick and others 2001; Klemm and others 2003) and multivariate (Wright and others 1983; Hawkins and others 2000; Reynoldson and others 2001) methods have been developed to characterize biotic condition and to establish thresholds of ecological impairment. In both approaches, the ability to recognize degradation at study sites relies on an understanding of the organismal assemblages expected in the absence of disturbance. Thus, the adoption of a consistent and quantifiable method for defining reference condition is fundamental to any biomonitoring program (Hughes 1995).

Southern California faces daunting challenges in the conservation of its freshwater resources due to its aridity, its rapidly increasing human population, and its role as one of the world's top agricultural producers. In recent years, several state and federal agencies have become increasingly involved in developing analytical tools that can be used to assess the biological and physical condition of California's streams and rivers. For example, the US Environmental Protection Agency (EPA), the US Forest Service (USFS), and California's state and regional Water Quality Control Boards (WQCBs) have collected fish, periphyton and benthic macroinvertebrates (BMIs) from California streams and rivers as a critical component of regional water

KEY WORDS: Benthic macroinvertebrates; B-IBI; Biomonitoring; Mediterranean climate

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quality assessment and management programs. Together, these agencies have sampled BMIs from thousands of sites in California, but no analysis of BMI assemblage datasets based on comprehensively defined regional reference conditions has yet been undertaken. In the only other large-scale study within the state, Hawkins and others (2000) developed a predictive model of biotic integrity for third- to fourth-order streams on USFS lands in three montane regions in northern California. This ongoing effort (Hawkins unpublished) is an important contribution to bioassessment in the state, but the emphasis of this work has been concentrated on logging impacts within USFS lands. The lack of a broadly defined context for interpretation of BMI-based bioassessment remains the single largest impediment to the development of biocriteria for the majority of California streams and rivers. This article presents a benthic index of biotic integrity (B-IBI) for wadeable streams in southern coastal California assembled from BMI data collected in the region by the USFS, EPA, and state and regional WQCBs between 2000 and 2003.

Methods

Study Area

The Southern Coastal California B-IBI (SoCal B-IBI) was developed for the region bounded by Monterey County in the north, the Mexican border in the south, and inland by the eastern extent of the southern Coast Ranges (Figure 1). This Mediterranean climate region comprises two Level III ecoregions (Figure 1; Omernik 1987) and shares a common geology (dominated by recently uplifted and poorly consolidated marine sediments) and hydrology (precipitation averages 10–20 in./year in the lower elevations and 20–30 in./year in upper elevations, reaching 30–40 in./year in the highest elevations and in some isolated coastal watersheds (Spatial Climate Analysis Service, Oregon State University, www.climatesource.com). The human population in the region was approximately 20 million in 2000 and is projected to exceed 28 million by 2025 (California Department of Finance, Demographic Research Unit, www.dof.ca.gov).

Field Protocols and Combining Datasets

The SoCal B-IBI is based on BMI and physical habitat data collected from 275 sites (Figure 1) using the 3 protocols described in the following subsections. Sites were sampled during base flow periods between April and October of 2000–2003.

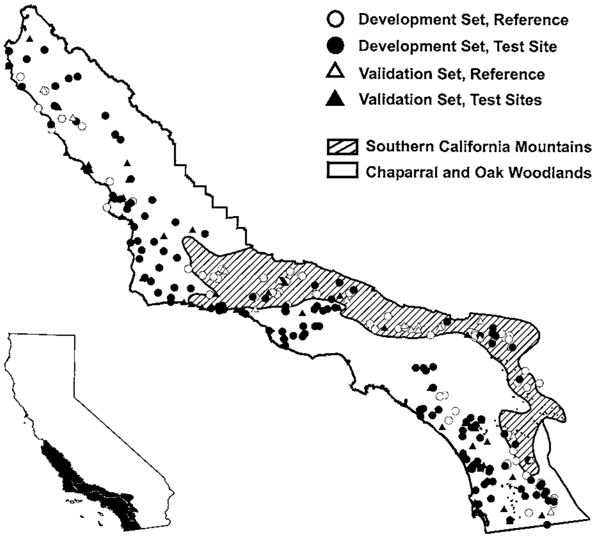

Figure 1. Map of study area showing the location of the study area within California, the distribution of test and reference sites and development and validation sites, and the boundaries of the two main ecoregions in the study area.

California Stream Bioassessment Protocol (CSBP, 144 sites). Several of the regional WQCBs in southern coastal California have implemented biomonitoring programs in their respective jurisdictions and have collected BMIs according to the CSBP (Harrington 1999). At CSBP sites, three riffles within a 100-m reach were randomly selected for sampling. At each riffle, a transect was established perpendicular to the flow, from which three separate areas of 0.18 m^2 each were sampled upstream of a 0.3-m-wide D-frame net and composited by transect. A total of 1.82 m^2 of substrate was sampled per reach and 900 organisms were subsampled from this material (300 organisms were processed separately from each of 3 transects). Water chemistry data were collected in accordance with the protocols of the different regional WQCBs (Puckett 2002) and qualitative physical habitat characteristics were measured according to Barbour and others (1999) and Harrington (1999).

USFS (56 sites). The USFS sampled streams on national forest lands in southern California in 2000 and 2001 using the targeted riffle protocol of Hawkins and others (2001). All study reaches were selected nonrandomly as part of a program to develop an interpretive (reference) framework for the results of stream biomonitoring studies on national forests in California. BMIs were sampled at study reaches (containing at least four fast-water habitat units) by disturbing two separate 0.09-m^2 areas of substrate upstream of a 0.3-m-wide D-frame net in each of four separate fast-water units; a total of 0.72 m^2 was disturbed and all sample material from a reach was composited. Field crews used a combination of qualitative and quantitative measures to collect physical habitat and water chemistry data (Hawkins and others 2001). A 500-organism subsample was processed from the composite sample and identified following methods described by Vinson and Hawkins (1996).

Environmental Monitoring and Assessment Program (EMAP, 75 sites). The EPA sampled study reaches in southern coastal California from 2000 through 2003 as part of its Western EMAP pilot project. A sampling reach was defined as 40 times the average stream width at the center of the reach, with a minimum reach length of 150-m and maximum length of 500-m. A BMI sample was collected at each site using the USFS methodology described earlier (Hawkins and others 2001) in addition to a standard EMAP BMI sample (not used in this analysis). A 500-organism subsample was processed in the laboratory according to EMAP standard taxonomic effort levels (Klemm and others 1990). Water chemistry samples were collected from the midpoint of each reach and analyzed using EMAP protocols (Klemm and Lazorchak 1994). Field crews recorded physical habitat data using EPA qualitative methods (Barbour and others 1999) and quantitative methods (Kaufmann and others 1999).

As part of a methods comparison study, 77 sites were sampled between 2000 and 2001 with both the CSBP and USFS protocols. The two main differences between the methods are the area sampled and the number of organisms subsampled (discussed earlier). To determine the effect of sampling methodology on assessment of biotic condition, we compared the average difference in a biotic index score between the two methods at each site. Biotic index scores were computed with seven commonly used biotic metrics (taxonomic richness, Ephemoptera, Plecoptera, and Trichoptera (EPT) richness, percent dominant taxon, sensitive EPT individuals, Shannon diversity, percent intolerant taxa, and percent scraper individuals) according to the following equation:

$$Score = \sum (x_i - \bar{x})/sem_i$$

where x_i is the site value for the ith metric, x is the overall mean for the ith metric, and SEM_i is the standard error of the mean for the ith metric. A score of zero is the mean value.

Because USFS-style riffle samples were collected at all EMAP sites, only two field methods were combined in this study. All EMAP and CSBP samples were collected and processed by the California Department of Fish and Game's Aquatic Bioassessment Laboratory (ABL) and all USFS samples were processed by the US Bureau of Land Management's Bug Lab in Logan, Utah. Taxonomic data from both labs were combined in an MS Access© database application that standardized BMI taxonomic effort levels and metric calculations, allowing us to minimize any differences between the two labs that processed samples. Taxonomic effort followed standards defined by the California Aquatic Macroinvertebrate Laboratory Network (CAMLnet 2002; www.dfg.ca.gov/cabw/camlnetste.pdf). Sites with fewer than 450 organisms sampled were omitted from the analyses.

Screening Reference Sites

We followed an objective and quantitative reference site selection procedure in which potential reference sites were first screened with quantitative Geographical Information System (GIS) land-use analysis at several spatial scales and then local condition assessments (instream and riparian) were used to quantify stressors acting within study reaches. We calculated the proportions of different land-cover classes and other measures of human activity upstream of each site at four spatial scales that give unique information about potential stressors acting on each site: (1) within polygons delimiting the entire watershed upstream of each sampling site, (2) within polygons representing local regions (defined as the intersection of a 5-km-radius circle around each site and the primary watershed polygon), (3) within a 120-m riparian zone on each side of all streams within each watershed, and (4) within a 120-m riparian zone in the local region. We used the ArcView® (ESRI 1999) extension ATtILA (Ebert and Wade 2002) to calculate the percentage of various land-cover classes (urban, agriculture, natural, etc.) and other measures of human activity (population density, road density, etc.) in each of the four spatial areas defined for each site. Two satellite imagery datasets from the mid-1990s were combined for the land-cover analyses: California Land Cover Mapping & Monitoring Program (LCMMP) vegetation data (CalVEG) and a recent dataset produced by the Central Coast Watershed Group (Newman and Watson 2003). Population data were derived from the 2000 migrated TIGER dataset (California Department of Forestry and Fire Protection, www.cdf.ca.gov). Stream layers were obtained from the US Geological Survey (USGS) National Hydrography Dataset (NHD). The road network was obtained from the California Spatial Information Library (CaSIL, gis.ca.gov) and elevation was based on the USGS National Elevation Dataset (NED). Frequency histograms of land-use percentages for all sites were used to establish subjective thresholds for elim-

Table 1. List of minimum or maximum landuse thresholds used for rejecting potential reference sites

Stressor metric	Definition	Threshold
N_index_L	Percentage of natural land use at the local scale	≤ 95%
Purb_L	Percental of urban land use at the local scale	> 3%
Pagt_L	Percentage of total agriculture at the local scale	> 5%
Rddens_L	Road density at the local scale	> 2.0 km/km^2
PopDens_L	Population density (2000 census) at the local scale	> 150 $indiv./km^2$
N_index_W	Percentage of natural landuse at the watershed scale	≤ 95%
Purb_W	Percentage of urban landuse at the watershed scale	> 5%
Pagt_W	Percentage of total agriculture at the watershed scale	> 3%
Rddens_W	Road density at the watershed scale	> 2.0 km/km^2
PopDens_W	Population density (2000 census) at the watershed scale	> 150 $indiv./km^2$

inating sites from the potential reference pool (Table 1). Sites were further screened from the reference pool on the basis of reach-scale conditions (obvious bank instability or erosion/ sedimentation problems, evidence of mining, dams, grazing, recent fire, recent logging).

Eighty-eight sites passed all the land-use and local condition screens and were selected as reference sites, leaving 187 sites in the test group. We randomly divided the full set of sites into a development set (206 sites total: 66 reference/140 test) and a validation set (69 sites total: 22 reference/47 test). The development set was used to screen metrics and develop scoring ranges for component B-IBI metrics; the validation set was used for an independent evaluation of B-IBI performance.

Screening Metrics and Assembling the B-IBI

Sixty-one metrics were evaluated for possible use in the SoCal B-IBI (Table 2). A multistep screening process was used to evaluate each metric for (1) sufficient range to be used in scoring, (2) responsiveness to watershed-scale and reach-scale disturbance variables, and (3) lack of correlation with other responsive metrics.

Pearson correlations between all watershed-scale and reach-scale disturbance gradients were used to define the smallest suite of independent (nonredundant) disturbance variables against which to test biological metric response. Disturbance variables with correlation coefficients $|r| \geq 0.7$ were considered redundant. Responsiveness was assessed using visual inspection of biotic metric versus disturbance gradient scatterplots and linear regression coefficients. Metrics were selected as responsive if they showed either a linear or a "wedge-shaped" relationship with disturbance gradients. Biological metrics often show a "wedge-shaped" response rather than a linear response to single disturbance gradients because the single gradient only defines the upper boundary of the biological response; other independent disturbance gradients and natural limitations on species distributions might result in lower metric values than expected from response to the single gradient. Biotic metrics and disturbance gradients were log-transformed when necessary to improve normality and equalize variances. Metrics that passed the range and responsiveness tests were tested for redundancy. Pairs of metrics with product–moment correlation coefficients $|r| \geq 0.7$ were considered redundant and the least responsive metric of the pair was eliminated.

Scoring ranges were defined for each metric using techniques described in Hughes and others (1998), McCormick and others (2001), and Klemm and others (2003). Metrics were scored on a 0–10 scale using statistical properties of the raw metric values from both reference and nonreference sites to define upper and lower thresholds. For positive metrics (those that increase as disturbance decreases), any site with a metric value equal to or greater than the 80th percentile of reference sites received a score of 10; any site with a metric value equal to or less than the 10th percentile of the nonreference sites received a score of 0; these thresholds were reversed for negative metrics (20th percentile of reference and 90th percentile of nonreference). In both cases, the remaining range of intermediate metric values was divided equally and assigned scores of 1 through 9. Before assembling the B-IBI, we tested whether any of the final metrics were significantly different between chaparral and mountain reference sites in the southern California coastal region, in which case they would require separate scoring ranges in the B-IBI. Finally, an overall B-IBI score was calculated for each site by summing the constituent metric scores and adjusting the B-IBI to a 100-point scale.

Table 2. The 61 BMI metrics screened for use in the SoCal IBI

Candidate metrics	Disturbance variables										
	U_index_W	Pagt_W	Purb_L	RdDens_L	Channel Alteration	Bank Stability	Percent Fines	Total Dissolved Solids	Total Phosphorus	Total Nitrogen	Range Test
Taxonomic group metrics											
Coleoptera richness*	M	w	M	S	S	—	—	—	—	—	P
Crustacea + Mollusca richness	—	—	—	—	—	—	—	—	—	—	F
Diptera richness	—	—	—	—	—	—	—	—	—	—	P
Elmidae richness	w	—	w	M	S	M	S	M	—	—	F
Ephemerellidae richness					S	M	M	S	—	M	F
Ephemeroptera richness	S	S	M	S	w	M	S	S	—	S	P
EPT richness*	S	S	S	S	S	S	S	S	—	S	P
Hydropsychidae richness	—	—	w	—	S	—	—	—	—	—	F
Percent Amphipoda individuals	—	—	—	—	—	—	—	—	—	—	P
Percent Baetidae individuals	—	—	—	—	w	—	—	—	—	—	P
Percent Chironomidae individuals	—	—	—	—	—	—	—	—	M	—	P
Percent Corbicula individuals	—	—	—	—	—	—	—	—	—	—	P
Percent Crustacea individuals	—	—	—	—	—	—	—	—	—	—	P
Percent Diptera individuals	—	w	—	—	—	—	—	—	—	—	P
Percent Elmidae individuals	—	—	—	w	M	S	S	w	—	M	P
Percent Ephemeroptera individuals	—	w	w	—	M	w	—	—	—	—	P
Percent EPT individuals	—	—	M	M	M	M	—	—	—	—	P
Percent Gatropoda individuals	—	—	—	w	—	—	—	—	—	—	P
Percent Glossosomatidae individuals	—	—	—	—	w	—	—	—	—	M	F
Percent Hydropsychidae individuals	—	—	—	M	w	M	—	—	—	—	P
Percent Hydroptilidae individuals	—	—	—	M	—	w	—	—	—	—	F
Percent Mollusca individuals	—	—	—	w	w	—	—	—	—	—	P
Percent non-*Baetis/Fallceon* Ephemeroptera individuals	w	w	—	M	w	M	—	—	w	—	P
Percent non-*Hydropsyche* Hydropsychidae individuals	—	—	—	M	w	w	—	—	—	—	F
Percent non-*Hydropsyche/Cheumatopsyche* Trichoptera individuals	w	w	—	M	w	M	M	w	—	—	P
Percent non-insect Taxa*	M	w	M	M	w	—	—	—	w	M	F
Percent Oligochaeta individuals	—	—	—	—	w	—	—	—	—	—	P
Percent Perlodidae individuals	—	—	—	w	w	—	—	—	—	—	F
Percent Plecoptera individuals	—	—	—	M	M	M	M	M	w	S	P
Percent Rhyacophilidae individuals	—	—	—	w	S	S	w	—	—	M	F
Percent Simuliidae individuals	—	w	—	w	S	w	—	—		—	P
Percent Trichoptera	w	—	—	M	M	M	M	w	w	—	P
Plecoptera richness	M	S	w	M	w	w	M	S	—	S	F
Total taxa richness	M	M	w	S	w	w	w	w	w	M	P
Trichoptera richness	S	S	S	S	S	M	S	w	—	w	P

Table 2. Continued.

Candidate metrics	Disturbance variables U_index_W	Pagt_W	Purb_L	RdDens_L	Channel Alteration	Bank Stability	Percent Fines	Total Dissolved Solids	Total Phosphorus	Total Nitrogen	Range Test
Functional feeding metrics											
Collector (filterers) richness	w	—	M	S	S	M	w	—	—	—	F
Collector (gatherers) richness	—	—	—	—	—	—	—	—	—	w	P
Percent collector (filterer) + collector (gatherer) individuals*	M	—	—	S	—	w	—	M	w	M	P
Percent collector (filterer) individuals	—	—	—	w	M	M	w	—	—	—	P
Percent collector (gatherer) individuals	—	—	—	w	M	—	—	w	M	w	P
Percent predator individuals	—	—	—	w	M	—	—	—	—	—	P
Percent scraper individuals	w	w	—	M	M	w	w	—	—	—	P
Percent scraper minus snails individuals	—	—	—	w	—	w	—	—	—	—	P
Percent shredder individuals	—	—	—	w	w	—	—	—	—	—	P
Predator richness*	S	S	w	M	w	—	—	S	—	M	P
Scraper richness	S	M	M	S	S	S	S	S	—	S	P
Shredder richness	M	M	—	M	S	—	—	—	—	M	F
Tolerance metrics											
Average tolerance value	M	w	w	S	w	—	M	—	—	w	P
Intolerant EPT richness	M	w	w	M	S	—	S	S	—	S	P
Intolerant taxa richness	M	w	w	M	S	M	S	S	—	S	P
Percent intolerant Diptera individuals	—	—	—	—	—	—	—	—	—	—	F
Percent intolerant individuals*	M	w	—	M	S	M	M	S	—	M	P
Percent intolerant scraper individuals	—	—	—	w	M	w	w	w	—	—	P
Percent of intolerant Ephemeroptera individuals	—	—	—	w	w	—	w	w	—	—	P
Percent of intolerant Trichoptera individuals	—	w	—	—	w	w	w	w	—	—	P
Percent sensitive EPT individuals	w	w	—	M	M	M	M	M	w	M	P
Percent tolerant individuals	—	—	—	—	—	—	w	w	—	—	P
Percent tolerant taxa*	w	—	w	M	—	—	—	w	—	M	P
Tolerant taxa richness	—	—	—	—	—	M	—	—	—	—	P
Others											
Percent dominant taxon	—	—	—	—	—	—	—	—	—	—	P
Shannon Diversity Index	w	w	w	M	M	w	—	w	w	w	P

Note: Each metric is indicated as having either no response (—), weak response (w), moderate response (M), or strong response (S) to each of eleven minimally correlated disturbance variables and whether each metric passed (P) or failed (F) the range test. The final seven minimally correlated metrics are indicated with an asterisk (*).

Table 3. Scoring ranges for seven component metrics in the SoCal B-IBI

Metric score	Coleoptera taxa (all sites)	EPT taxa		Predator taxa (all sites)	% Collector individuals		% Intolerant individuals		% Noninsect taxa (all sites)	% Tolerant taxa (all sites)
		6	8		6	8	6	8		
10	>5	>17	>18	>12	0–59	0–39	25–100	42–100	0–8	0–4
9		16–17	17–18	12	60–63	40–46	23–24	37–41	9–12	5–8
8	5	15	16	11	64–67	47–52	21–22	32–36	13–17	9–12
7	4	13–14	14–15	10	68–71	53–58	19–20	27–31	18–21	13–16
6		11–12	13	9	72–75	59–64	16–18	23–26	22–25	17–19
5	3	9–10	11–12	8	76–80	65–70	13–15	19–22	26–29	20–22
4	2	7–8	10	7	81–84	71–76	10–12	14–18	30–34	23–25
3		5–6	8–9	6	85–88	77–82	7–9	10–13	35–38	26–29
2	1	4	7	5	89–92	83–88	4–6	6–9	39–42	30–33
1		2–3	5–6	4	93–96	89–94	1–3	2–5	43–46	34–37
0	0	0–1	0–4	0–3	97–100	95–100	0	0–1	47–100	38–100

Note: Three metrics have separate scoring ranges for the two Omernik Level III ecoregions in southern coastal California region (6 = chaparral and oak woodlands, 8 = Southern California mountains).

Validation of B-IBI and Measurement of Performance Characteristics

To test whether the distribution of B-IBI scores in reference and test sites might have resulted from chance, we compared score distributions in the development set to those in the validation set. We also investigated a separate performance issue that ambient bioassessment studies often neglect: spatial variation at the reach scale. Although our use of a validation dataset tests whether the B-IBI scoring range is repeatable (Fore and others 1996; McCormick and others 2001), we designed a separate experiment to explicitly measure index precision. Four sites were resampled in May 2003. At each site, nine riffles were sampled following the CSBP, and material from randomly selected riffles was combined into three replicates of three riffles each. B-IBI scores were then calculated for each replicate. Variance among these replicates was used to calculate the minimum detectable difference (MDD) between two B-IBI scores based on a two-sample *t*-test model (Zar 1999). The index range can be divided by the MDD to estimate the number of stream condition categories detectable by the B-IBI (Doberstein and others 2000; Fore and others 2001).

Results

Combining Datasets

Unmodified CSBP samples (900 count) had significantly higher biotic condition scores ($t = -6.974$, $P < 0.0001$) than did USFS samples (500 count). However, there was no difference in biotic condition scores between USFS samples and CSBP samples that were randomly subsampled to reduce the 900 count to 500 ($t = -0.817$, $P = 0.416$). Thus, data from both targeted-riffle protocols were combined in B-IBI development.

Selected Metrics

Ten nonredundant stressor gradients were selected for metric screening: percent watershed unnatural, percent watershed in agriculture, percent local watershed in urban, road density in local watershed, qualitative channel alteration score, qualitative bank stability score, percent fine substrates, total dissolved solids, total nitrogen, and total phosphorous. Twenty-three biotic metrics that passed the first two screens (range and dose response) were analyzed for redundancy with Pearson product–moment correlation, and a set of seven minimally correlated metrics was selected for the B-IBI: percent collector-gatherer + collector-filterer individuals (% collectors), percent noninsect taxa, percent tolerant taxa, Coleoptera richness, predator richness, percent intolerant individuals, and EPT richness (Table 3). All metrics rejected as redundant were derived from taxa similar to those of selected metrics, but they had weaker relationships with stressor gradients. Dose–response relationships of the selected metrics to the 10 minimally correlated stressor variables are shown in Figure 2 and reasons for rejection or acceptance of all metrics are listed in Table 2. Regression coefficients were significant at the $P \leq 0.0001$ level among all seven selected metrics and at least two stressor gradients: percent watershed unnatural and road density in local watershed (Table 4). The final seven metrics included several metric types: richness, composition, tolerance measures, and func-

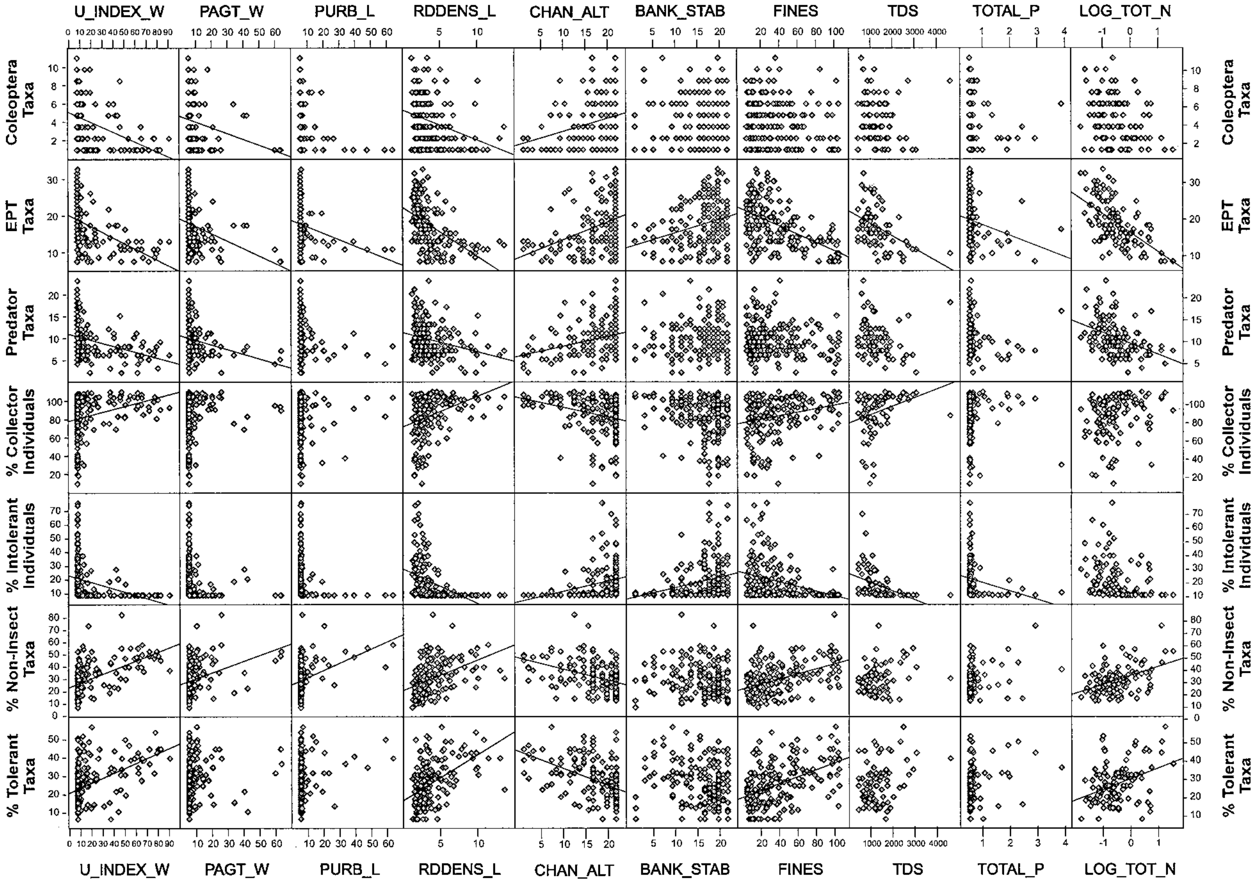

Figure 2. Scatterplots of dose–response relationships among 10 stressor gradients and 7 macroinvertebrate metrics (lines represent linear "best-fit" relationships; see text for abbreviations).

Table 4. Significance levels of linear regression relationships among 10 stressor metrics and 7 biological metrics

Metric	Coleoptera taxa	EPT taxa	Predator taxa	% Collector individuals	% Intolerant individuals	% Noninsect taxa	% Tolerant taxa
Bank Stability	0.813	**<0.0001**	0.3132	0.0009	0.0001	0.1473	0.0013
Fines	0.0017	**<0.0001**	0.0171	**0.0003**	**<0.0001**	**<0.0001**	**<0.0001**
Chan_Alt	**<0.0001**	**<0.0001**	**<0.0001**	**0.0003**	**<0.0001**	**<0.0001**	**<0.0001**
Log_U_Index_W	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Log_PAgT_W	**0.0007**	**<0.0001**	**0.0004**	0.0054	0.0014	**<0.0001**	0.0012
Log_PUrb_L	0.0367	**0.0007**	0.0344	0.6899	0.0045	**0.0002**	0.0215
Log RdDens_L	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**
Log_TDS	0.0094	**<0.0001**	0.0035	**0.0005**	**<0.0001**	0.0271	0.004
Log_Tot_N	0.0019	**<0.0001**	**<0.0001**	0.0078	0.0019	**<0.0001**	**<0.0001**
Log_Tot_P	0.062	**<0.0001**	0.0085	0.0162	**0.0001**	0.0018	0.0059

Note: Significant P-values corrected for 70 simultaneous comparisons ($P < 0.0007$) are highlighted in bold. Abbreviations are defined in Table 1 and in the text.

tional feeding groups. Because there are only seven metrics in the B-IBI, final scores calculated using this IBI are multiplied by 1.43 to adjust the scoring range to a 100-point scale.

The B-IBI scores were lower in chaparral reference sites than in mountain reference sites when calculated using unadjusted metric scores (Mann–Whitney U-test; $P = 0.02$). Although none of the final seven metrics

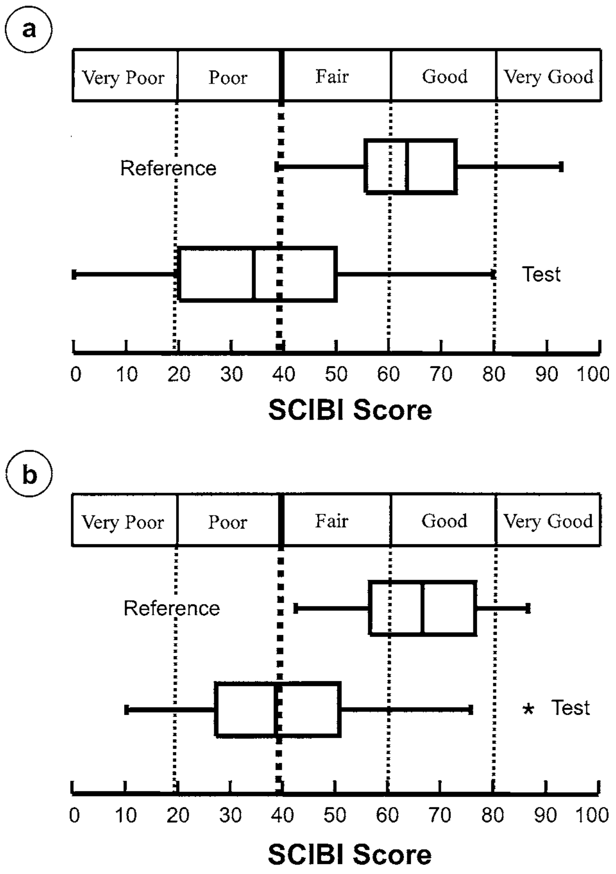

Figure 3. Box plots of B-IBI site scores for reference and test groups showing B-IBI scoring categories: (a) development sites and (b) validation sites. Dotted lines indicate condition category boundaries and heavy dotted lines indicate impairment thresholds.

were significantly different between chaparral reference sites and mountain reference sites at the $P = 0.05$ level ($P < 0.007$ after Bonferroni correction), scores for three metrics (EPT richness, percent collector-gatherer + collector-filterer individuals, and percent intolerant individuals) were substantially lower in chaparral reference sites than in mountain reference sites. We adjusted for this difference by creating separate scoring scales for the three metrics in the two ecoregions (Table 3). There was no difference in B-IBI scores between reference sites in the two ecoregions after the adjustment (Mann–Whitney U-test, $P = 0.364$).

Validation of B-IBI and Measurement of Performance Characteristics

The distribution of B-IBI scores at reference and nonreference sites was nearly identical between the development and validation data sets (Figure 3), indicating that our characterization of reference conditions and subsequent B-IBI scoring was repeatable and not likely due to chance. Based on a two-sample t-test model (setting $\alpha = 0.05$ and $\beta = 0.20$), the MDD for the SoCal IBI is 13.1. Thus, we have an 80% chance of detecting a 13.1-point difference between sites at the $P = 0.05$ level. Dividing the 100-point B-IBI scoring range by the MDD indicates that the SoCal B-IBI can detect a maximum of seven biological condition categories, a result similar to or more precise than other recent estimates of B-IBI precision (Barbour and others 1999; Fore and others 2001). We used a statistical criterion (two standard deviations below the mean reference site score) to define the boundary between "fair" and "poor" conditions, thereby setting B-IBI = 39 as an impairment threshold. The scoring range below 39 was divided into two equal condition categories, and the range above 39 was divided into three equal condition categories: 0–19 = "very poor", 20–39 = "poor", 40–59 = "fair", 60-79 = "good", and 80–100 = "very good" (Figure 3).

We ran two principle components analyses (PCAs) on the environmental stressor values used for testing metric responsiveness: 1 that included all 275 sites for which we calculated 4 watershed scale stressor values and another based on 124 sites for which we had measurements of 9 of the 10 minimally correlated stressor variables. We plotted B-IBI scores as a function of the first multivariate stressor axis from each PCA. We log-transformed percent watershed unnatural, percent watershed in agriculture, percent local watershed in urban, road density in local watershed, total nitrogen, and total phosphorous. Only PCA Axis 1 was significant in either analysis, having eigenvalues larger than those predicted from the broken-stick model (McCune and Grace 2002). In both PCAs, the B-IBI score decreased with increasing human disturbance (Figure 4) and was correlated (Spearman ρ) with PCA Axis 1 ($r = -0.652$, $P < 0.0001$ for all 275 sites; $r = -0.558$, $P \leq 0.0001$ for 124 sites). In the analysis of all 275 sites, all 4 watershed-scale stressors had high negative loadings, with percent watershed unnatural and local road density being the highest (Figure 5a). In the analysis of 124 sites, percent watershed unnatural, percent watershed in agriculture, and local road density had the highest negative loadings on the first axis, and channel alteration had the highest positive loading (Figure 4b).

Finally, we found no relationship between B-IBI scores and ecoregion (Mann–Whitney U, $P = 0.364$), Julian date ($R^2 = 0.01$, $P = 0.349$), watershed area ($R^2 = 0.002$, $P = 0.711$), or elevation ($R^2 = 0.01$, $P = 0.349$), indicating that the B-IBI scoring is robust with respect to these variables (Figure 5). Our ecoregion scoring adjustment probably corrects for the

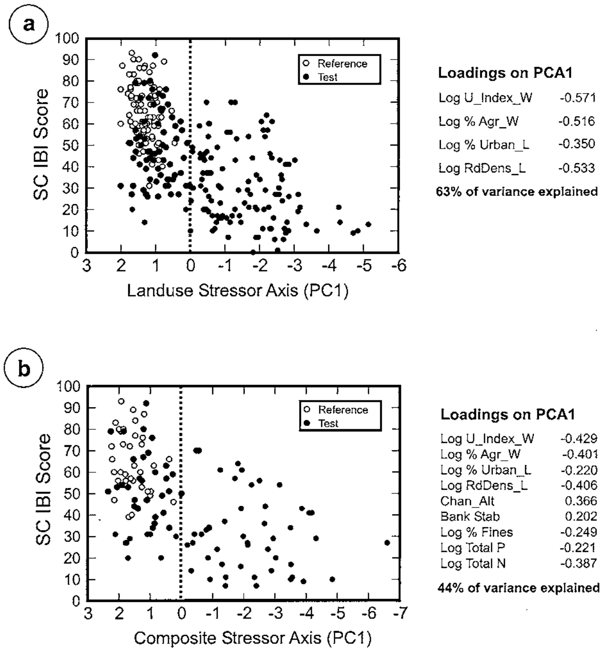

Figure 4. Scatterplots of SoCal B-IBI scores against two composite stressor axes from PCA: (a) values for all 275 sites; composite axis includes 4 land-use gradients; (b) values for 124 sites; composite axis includes 9 local and watershed scale stressor gradients.

strongest elevation effects, but there is no evidence that B-IBI scores are related to elevation differences within each ecoregion.

Discussion

The SoCal B-IBI is the most comprehensive assessment to date of freshwater biological integrity in California. As in other Mediterranean climate regions, the combination of aridity, geology, and high-amplitude cycles of seasonal flooding and drying in southern coastal California makes its streams and rivers particularly sensitive to disturbance (Gasith and Resh 1999). This sensitivity, coupled with the burgeoning human population and vast conversion of natural landscapes to agriculture and urban areas, has made it the focus of both state and federal attempts to maintain the ecological integrity of these strained aquatic resources.

Unfortunately, growing interest in biomonitoring is unmatched by financial resources available for this monitoring. Thus, combination of data among programs is very desirable, although this goal is rarely achieved in practice. We demonstrated that macroinvertebrate bioassessment data from multiple agencies could be successfully combined to produce a regional index that is useful to all agencies involved. This index is easy to apply, its fundamental assumptions are transparent, it provides precise condition assessments, and it is demonstrated to be responsive to a wide range of anthropogenic stressors. The index can also be applied throughout a long index period (mid-spring to mid-fall): Just as biotic factors tend to have more influence on assemblage structure during the summer dry period of Mediterranean climates than during the wet season when abiotic factors dominate (Cooper and others 1986; Gasith and Resh 1999), it is likely that our biotic index is more sensitive to anthropogenic stressors during the summer dry period. Because of these qualities, we expect the SoCal B-IBI to be a practical management tool for a wide range of water quality applications in the region.

This B-IBI is a regional adaptation of an approach to biotic assessment developed by Karr (1981) and subsequently extended and refined by many others (Kerans and Karr 1994; Barbour and others 1996; Fore and others 1996; Hughes and others 1998). We drew heavily upon recent refinements in multimetric index methodology that improve the objectivity and defensibility of these indices (McCormick and others 2001; Klemm and others 2003). A central goal of bioassessment is to select metrics that maximize the detection of anthropogenic stress while minimizing the noise of natural variation. One of the most important recent advances in B-IBI methods is the emphasis on quantitative screening tools for selecting appropriate metrics. We also minimized sources of redundancy in the analysis: (1) between watershed and local-scale stressor gradients for dose–response screening of biotic metrics and (2) in the final selection of metrics. The former guards against a B-IBI that is biased toward a set of highly correlated stressors and is, therefore, of limited sensitivity; the latter assures a compact B-IBI with component metrics that contribute independent information about stream condition. Combined with an assessment of responsiveness to specific regional disturbance gradients, these screening tools minimize the variability of B-IBI scores and improve its sensitivity.

The seven component metrics used in this B-IBI are similar to those selected for other B-IBIs (DeShon 1995; Barbour and others 1995, 1996; Fore and others 1996; Klemm and others 2003), but some of the metrics are either unique or are variations on other commonly used metrics. Like Klemm and others (2003), we found noninsect taxa to be responsive to human stressors, but richness was more responsive than percent of individuals. Some authors have separated the EPT metric into two or three metrics based on its component orders because the orders provided unique signals (Clements 1994; Fore and others 1996; Klemm

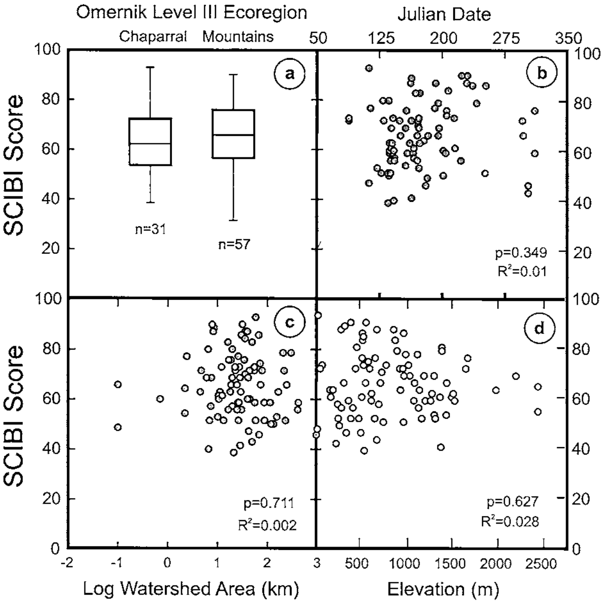

Figure 5. Relationship between B-IBI scores at 88 reference sites and (a) Omernik Level III ecoregion, (b) Julian date, (c) log watershed area, and (d) elevation.

and others 2003), but we found very similar patterns in these orders' response to various stressors we measured. To our knowledge, Coleoptera richness has not previously been included in a B-IBI, but beetle taxa might be a good indicator of the effects of fine sediments at impaired sites in this region (Brown 1973). A recent study of benthic assemblages in North Africa noted a high correspondence between EPT and EPTC (EPT + Coleoptera) (Beauchard and others 2003), but these orders were not highly correlated in our dataset. Feeding groups appear less often in B-IBIs than other metric types (Klemm and others 2003), but they were represented by two metrics in this B-IBI: predator richness and percent collectors (gatherers and filterers combined). Scraper richness was also responsive, but was rejected here because it was highly correlated with EPT richness.

The SoCal IBI should prove useful as a foundation for state and regional ambient water quality monitoring programs. Because the 75 EMAP sites were selected using a probabilistic statistical design, it will also be possible to use those samples to estimate the percentage of stream miles that are in "good", "fair", and "poor" condition in the southern California coastal region. These condition estimates, combined with stressor association techniques, have great potential to serve as a scientifically defensible basis for allocating precious monitoring resources in this region.

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Appendix 7-C: Calleguas Creek Locations with IBI Scores <39