Section 2 - Water Quality Analysis

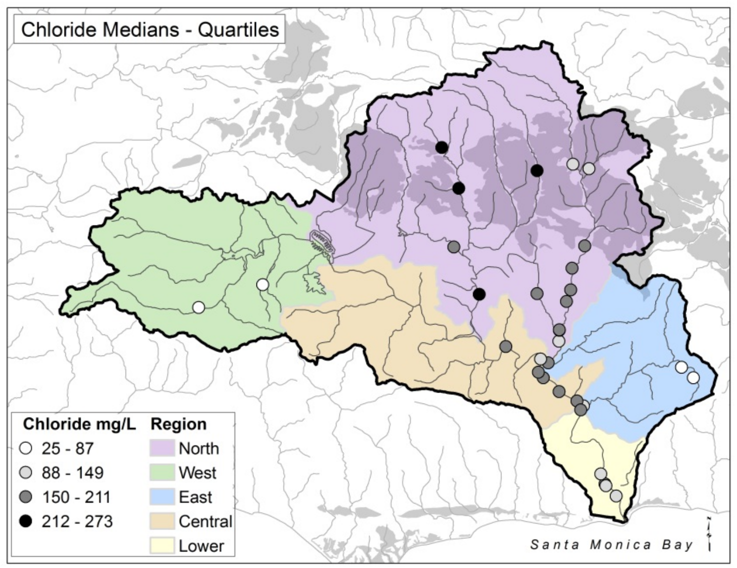
An analysis of recent records (2000 – 2010) and long-term historical trends (1971 – 2010) in the Malibu Creek watershed

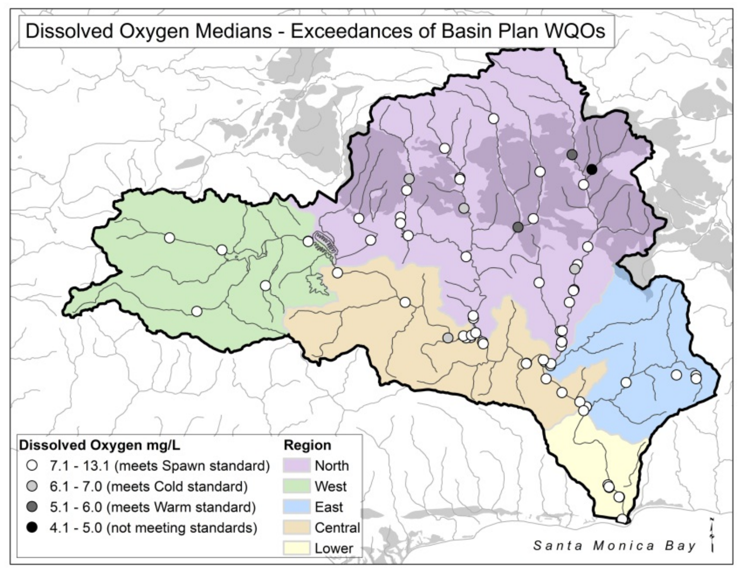
Water quality: This section summarizes the available data for specific pollutants in the Malibu Creek watershed identified on the current state 303(d) list as responsible for impairing one or more beneficial uses identified in the Los Angeles Region Water Quality Control Plan. **Our main objective** was to identify where current water quality is not meeting Basin Plan water quality objectives or other applicable standards. Wherever we had sufficient data (most cases), we provide additional detail on annual and seasonal variation, historical trends, pollutant sources and impacts on human health and aquatic life.

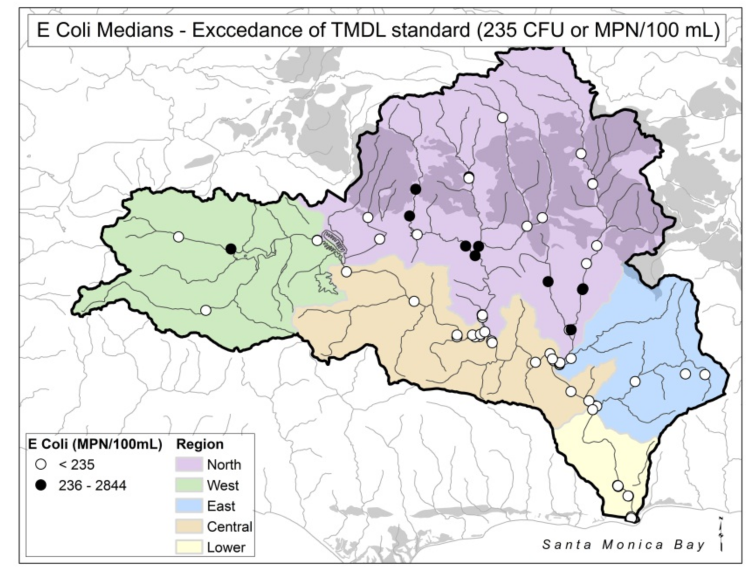
Water quality parameters analyzed: Ammonia, Benthic Macroinvertebrate Assessments, Chloride, Coliform / Indicator Bacteria and Viruses, Eutrophication (Algae, Nutrients, Dissolved Oxygen, pH, Scum & Foam, Odors), Invasive Species, Lead & Mercury, Selenium, Specific Conductivity, Sulfate and over 50 organic compounds, and Pesticides. **Not analyzed:** Benthic Community Effects in Malibu Lagoon (no data found), Sedimentation / Siltation (no data), Swimming Restrictions (beaches not included), and Trash (no data).

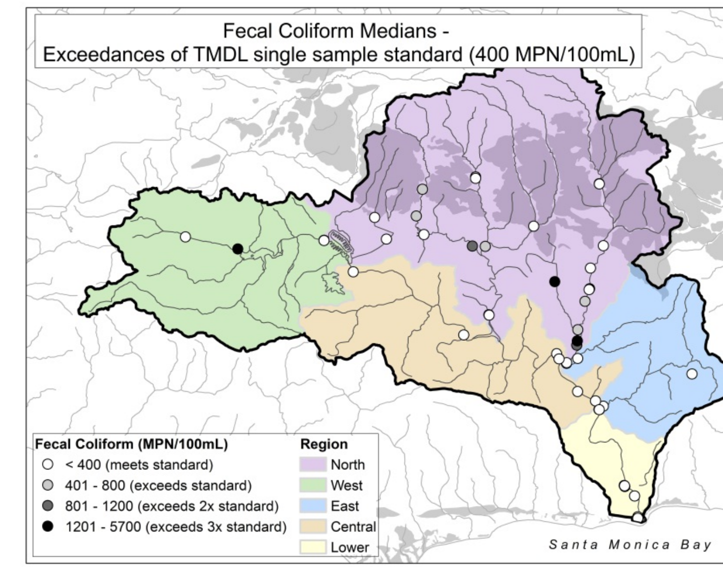
Water quality at a glance

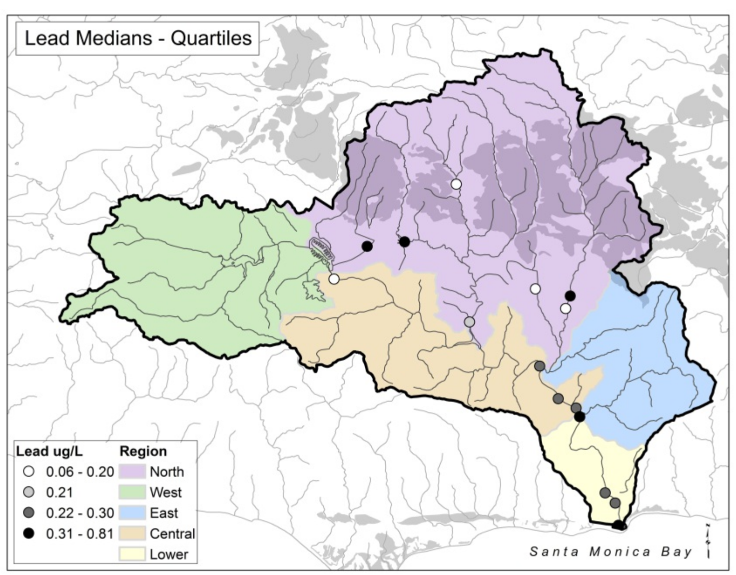
Updated geographic spot maps for 303(d) listed pollutants based on recent data (2000 – 2010) in the combined dataset

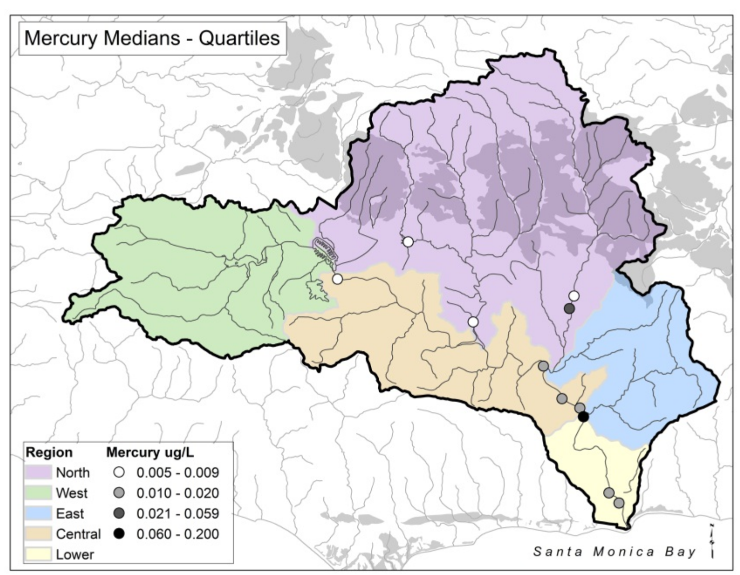


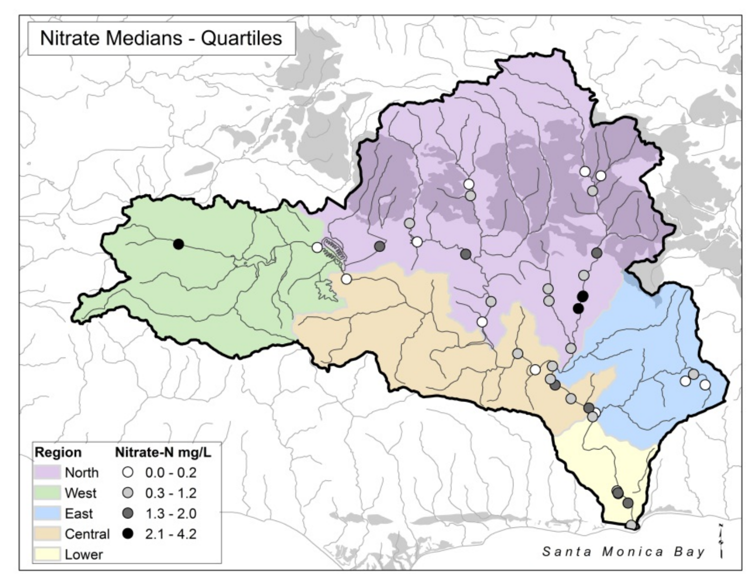


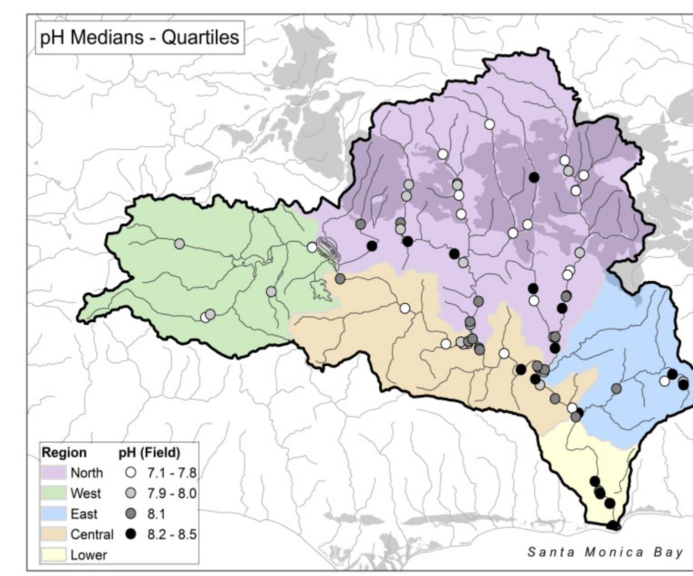


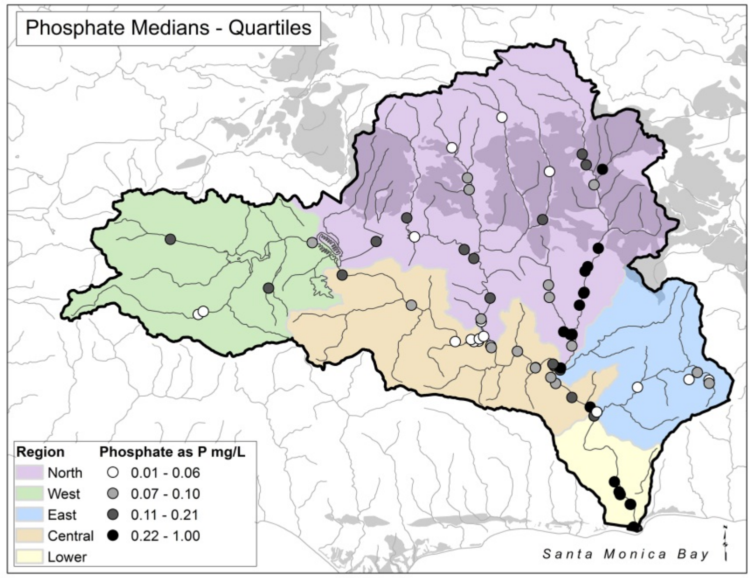


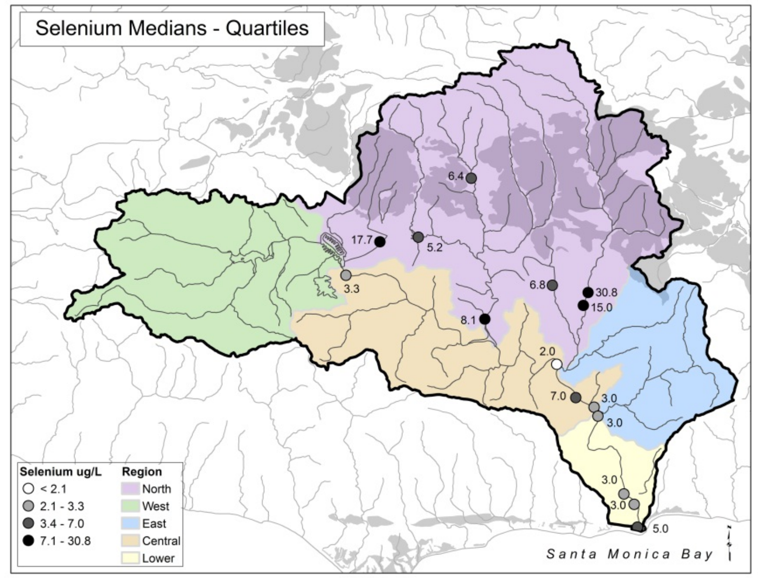


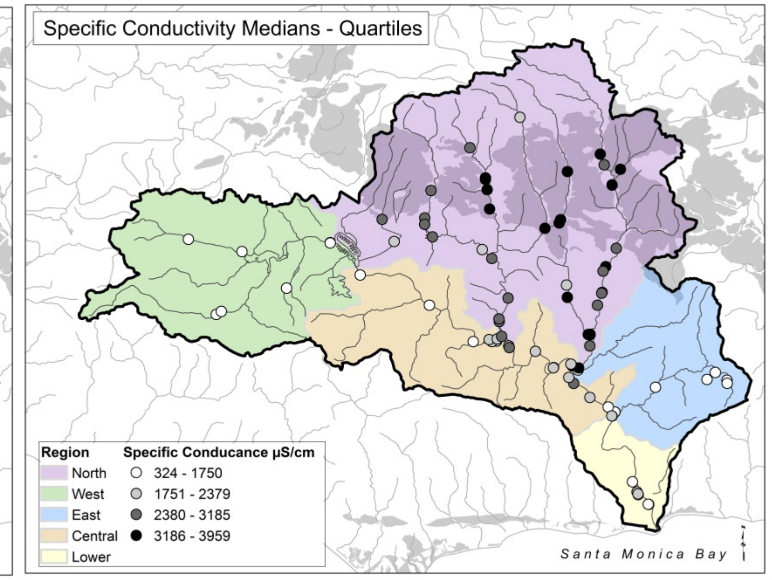


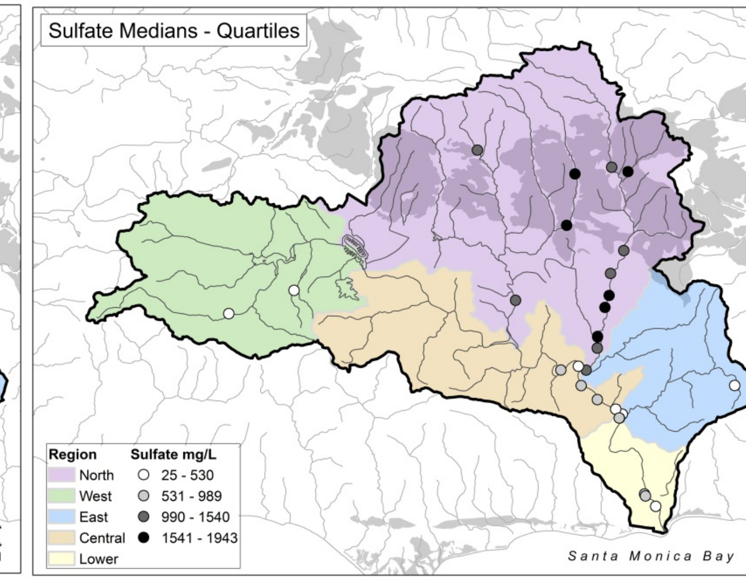


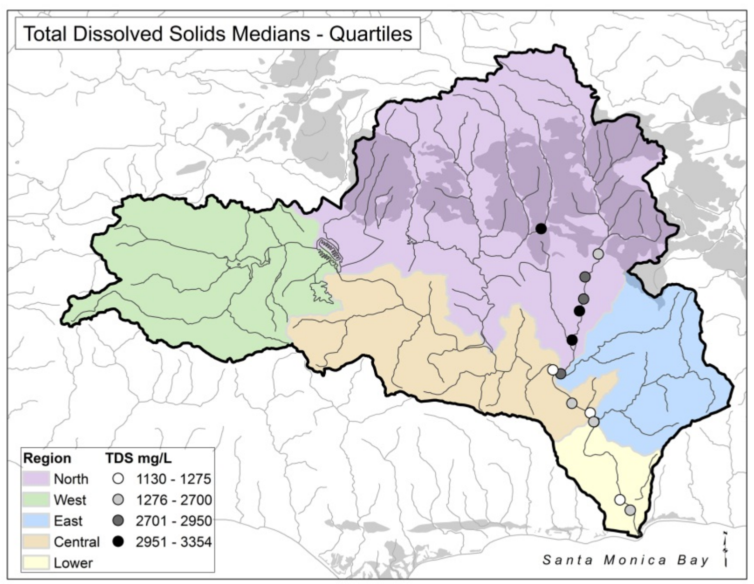


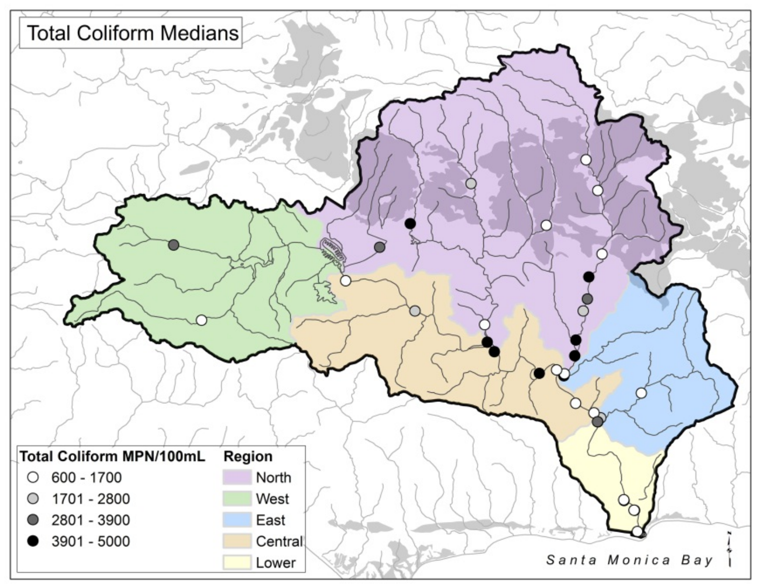












In these figures and many of those that follow, the Malibu creek watershed is color-coded by its west, north, east, and central tributary streams. The dark grey shading in the northern region is the Monterey / Modelo formation, an important source of sub-standard water discussed in the next section.

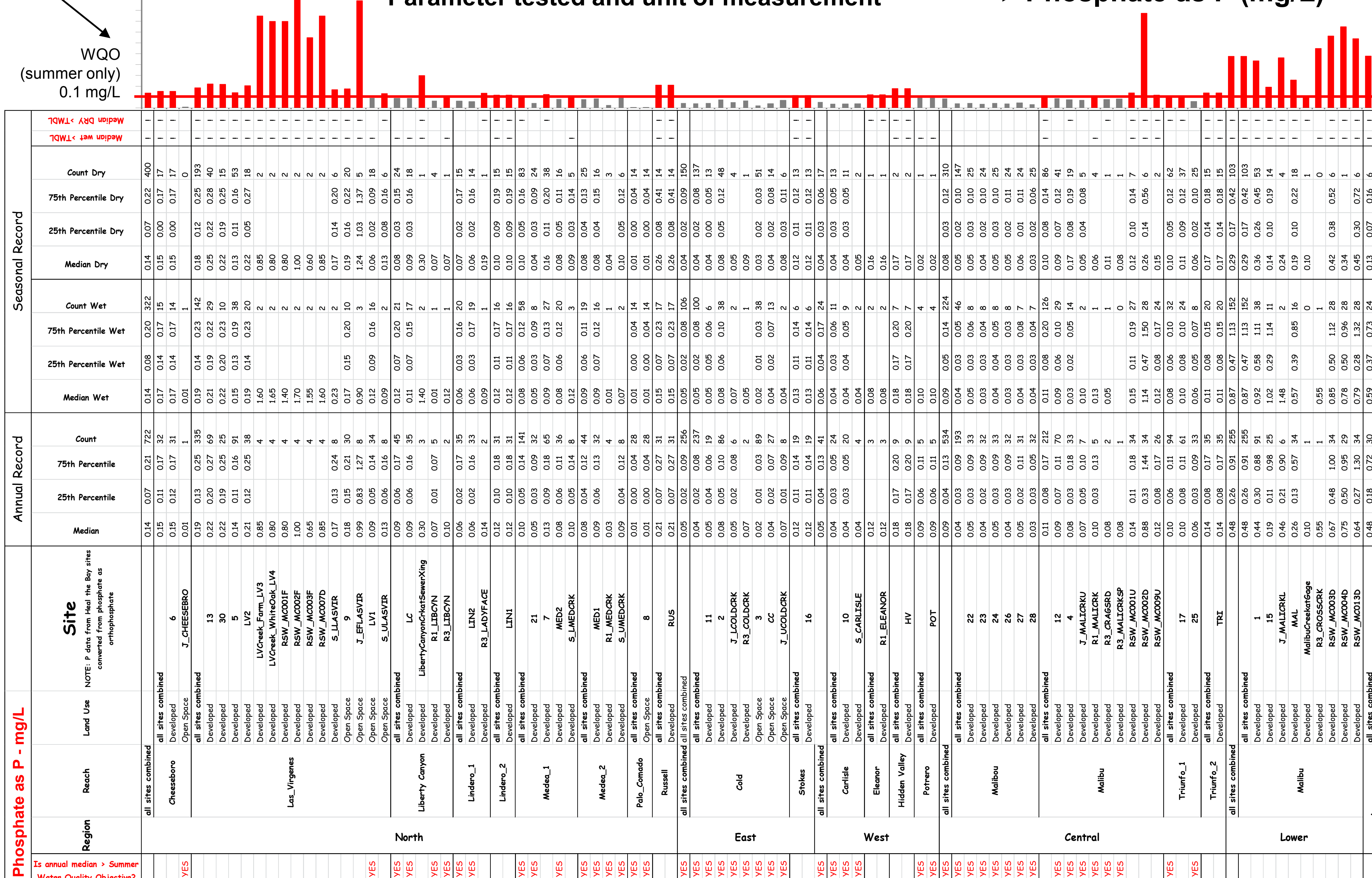
Water quality at a glance

Updated geographic spot maps for 303(d) listed pollutants based on recent data (2000 – 2010) in the combined dataset

How to read the data summary tables

Bar graph shows median values at each site, **colored red** where they exceed the applicable water quality objective (horizontal line)

Parameter tested and unit of measurement → **Phosphate as P (mg/L)**



Some tables include additional "at a glance" detail on the seasonality of exceedances.

Most tables include tabular summaries of the **seasonal record**, where it varied over the year, including median values, percentile values and sample sizes for wet and dry seasons separately

Annual record shows median values, 25th and 75th percentile values, and sample sizes at each station.

Site names as they are known by the agencies reporting the data.

Additional site details: Region, location by creek name & land use (developed or open space)

Exceedances: A "YES " in this row identifies sites with median values exceeding the water quality objective or TMDL target for the listed pollutant.

Only sample sites with reported data for the particular parameter shown are included. In addition to sample sizes, separate median and percentile results are shown individual streams and regions.

Mineral Quality

Total Dissolved Solids (TDS), Specific Conductance (SC), Sulfate, Magnesium, Calcium, Chloride, Selenium, Metals (in part – see Human Health for mercury & lead)

"Mineral quality in natural waters is largely determined by the mineral assemblage of solids and rocks and faults near the land surface. Point and nonpoint source discharges of poor quality water can degrade the mineral content of natural waters. High levels of dissolved solids renders waters useless for many beneficial uses. "

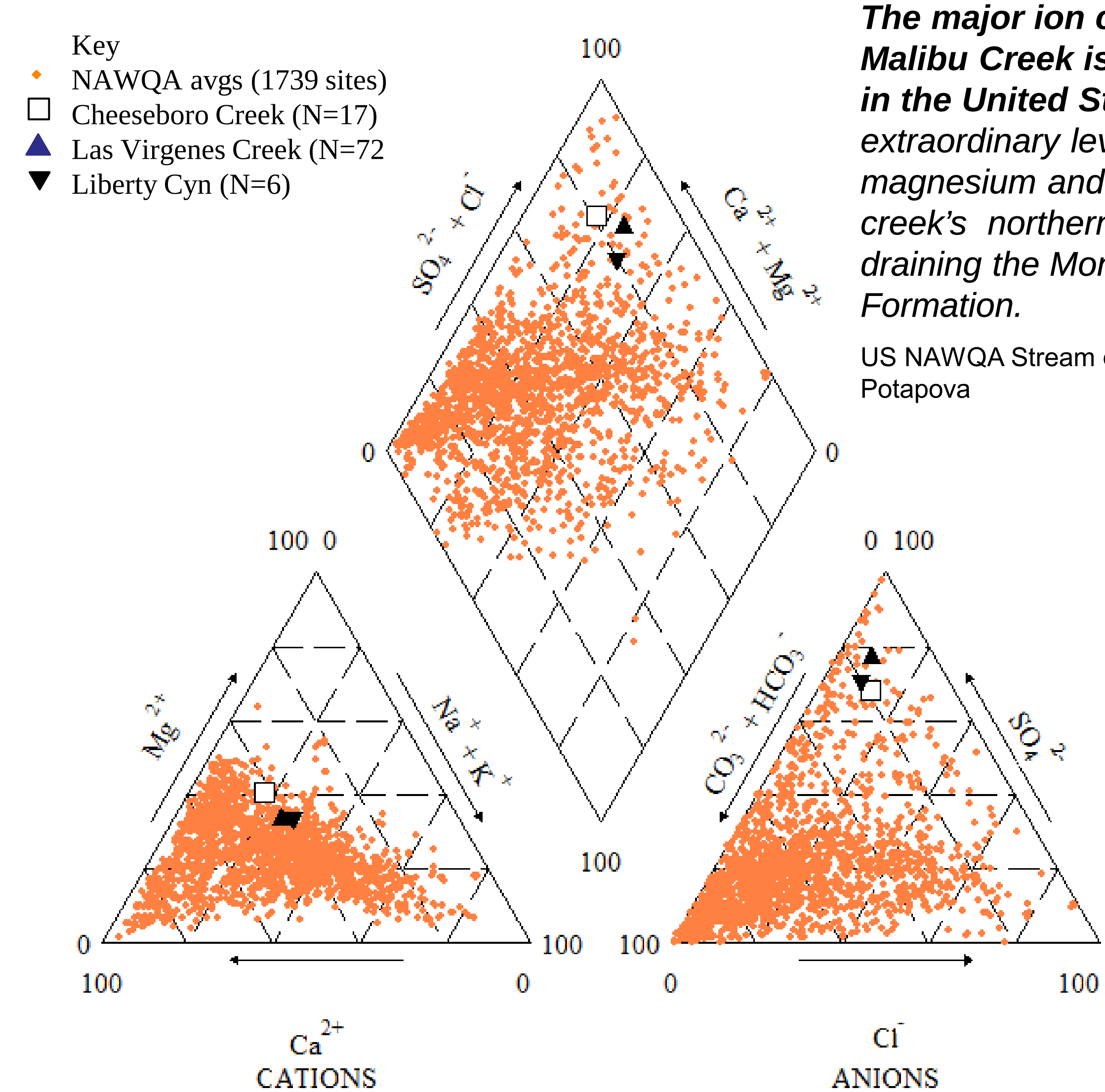
Los Angeles Region Water Quality Control Plan, p. 3-11

Our analysis: We compared mineral quality in the Malibu Creek watershed across sites and decades for the above parameters, and also compared our results with mineral quality for other US streams from the U.S. Geological Survey National Water-Quality Assessment (NAWQA) Program dataset. We identified sites, creeks and regions within the watershed not meeting various mineral water quality objectives and guidelines, and reviewed historical data on TDS levels in local groundwater prior to the importation of non-native water.

Our findings: Mineral concentrations are naturally high in the Malibu Creek watershed except for those tributaries not draining the Monterey Formation (e.g. Cold and Carlisle Creeks). The mineral quality data provide strong support for our Natural Source Assessment.

Seasonal variation: All mineral parameters show strong seasonal variance, with lower levels during wet-weather (dilution effect). **Exceptions:** At two locations in the upper watershed adjacent to steep hillsides, mineral quality was found to counter-intuitively increase during a "first rain event" study. This may be the result of hydraulic forcing of older, high-mineral groundwater within bedrock cracks or faults into Las Virgenes and Lindero Creeks. Alternatively, surface precipitates dissolved in the first flush could also account for the increase. There are no consistent long-term trends evident in the data, aside from lower levels during runs of high-rainfall years.

A major finding is that Malibu Creek consists of brackish water (SC > 1,500 µS/cm) from the Lagoon to its northern headwaters, which are extraordinarily brackish (SC>3,000 µS/cm, with single-sample results of > 4,000 µS/cm common. *A more detailed look at ionic composition in comparison with national data shows that Malibu Creek's mineral composition is almost unique in the United States.* **Regulatory implications:** Fully a third of the Malibu Creek watershed's 303(d) listed impairments are likely due to a single, natural source of enriched rock in the upper watershed (see Natural Source Assessment).



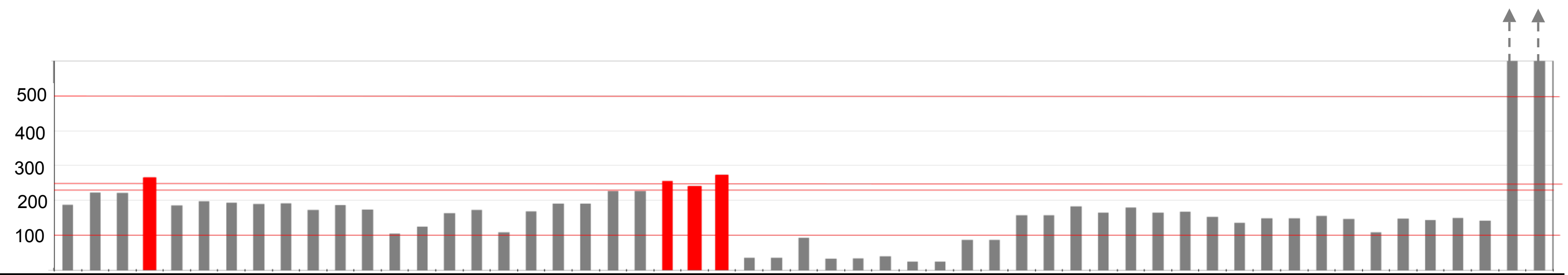
The major ion composition of Malibu Creek is almost unique in the United States, *with extraordinary levels of sulfate, magnesium and calcium in the creek's northern tributaries draining the Monterey / Modelo Formation.*

US NAWQA Stream data courtesy M. Potapova

Basin Plan Water Quality Objective for Malibu Creek – 500 mg/L; EPA Drinking Water MCL (250 mg/L); Basin Plan Aquatic Life WQO (230 mg/L) & AGR WQO (100 mg/L)

Chloride mg/L

Basin Plan WQO - Malibu Creek = 500
Drinking Water MCL = 250
303(d) listing: Aquatic Life WQO = 230
Basin Plan Agriculture WQO = 100



Chloride - mg/L

Region	Creek	LandUse	Site	Median DRY >Aquatic WQO	Median WET>Aquatic WQO	Count Dry	75th Percentile Dry	25th Percentile Dry	Median Dry	Count Wet	75th Percentile Wet	25th Percentile Wet	Median Wet	Count	75th Percentile	25th Percentile	Median	Is annual median > Aquatic Life Water Quality Objective?
North	all sites combined					82	215	164	192	66	199	171	186	148	211	170	188	
North	Cheeseboro	all sites combined				8	243	169	216	9	266	215	223	17	266	201	223	
North	Cheeseboro	Developed	Ches			8	243	169	216	8	238	214	222	16	243	197	222	
North	Cheeseboro	Open Space	J_CHEESEBRO		–	0				1			266	1			266	Yes
North	Las_Virgenes	all sites combined				53	197	161	187	43	194	171	184	96	195	166	186	
North	Las_Virgenes	Developed	LVCreek_Farm_LV3			6	210	194	198	6	198	190	196	12	199	192	198	
North	Las_Virgenes	Developed	LVCreek_WhiteOak_LV4			6	208	195	198	6	193	159	188	12	198	189	194	
North	Las_Virgenes	Developed	RSW_MC001F			6	192	186	190	6	194	179	186	12	194	180	190	
North	Las_Virgenes	Developed	RSW_MC002F			6	204	188	192	6	197	186	191	12	200	187	192	
North	Las_Virgenes	Developed	RSW_MC003F			6	191	173	176	6	172	146	171	12	178	171	173	
North	Las_Virgenes	Developed	RSW_MC007D			6	197	174	183	6	187	185	187	12	189	180	187	
North	Las_Virgenes	Developed	S_LLASVIR			6	182	159	169	2			176	8	182	160	174	
North	Las_Virgenes	Open Space	J_EFLASVIR			5	104	93	94	3			113	8	109	94	105	
North	Las_Virgenes	Open Space	S_ULASVIR			6	129	121	125	2			128	8	130	120	125	
North	Liberty Canyon	all sites combined				6	160	102	115	7	173	152	166	13	172	109	164	
North	Liberty Canyon	Developed	LibertyCanyonCrkatSewerXing			1			212	5	178	164	168	6	186	165	173	
North	Liberty Canyon	Developed	R1_LIBCYN			4			105	1			140	5	121	100	109	
North	Liberty Canyon	Developed	R3_LIBCYN			1			172	1			166	2			169	
North	Lindero_1	all sites combined				1			216	1			167	2	204	179	191	
North	Lindero_1	Developed	R3_LADYFACE			1			216	1			167	2	204	179	191	
North	Medea_1	all sites combined				5	233	221	224	3			230	8	235	218	227	
North	Medea_1	Developed	S_LMEDCRK			5	233	221	224	3			230	8	235	218	227	
North	Medea_2	all sites combined		–	–	9	291	248	259	3			249	12	283	247	256	Yes
North	Medea_2	Developed	R1_MEDCRK	–		3			247	1			224	4			241	Yes
North	Medea_2	Developed	S_UMEDCRK	–	–	6	293	265	286	2			258	8	291	257	273	Yes
East	all sites combined					11	81	33	36	5	78	34	34	16	80	33	36	
East	Cold	all sites combined				11	81	33	36	5	78	34	34	16	80	33	36	
East	Cold	Developed	J_LCOLDCRK			4			93	2			112	6	112	80	93	
East	Cold	Developed	R3_COLDCRK			1			44	1			22	2			33	
East	Cold	Open Space	J_UCOLDCRK			6	36	33	35	2			34	8	36	33	34	
West	all sites combined					3			40	4			44	7	76	25	40	
West	Carlisle	all sites combined				2			34	2			21	4			25	
West	Carlisle	Developed	S_CARLISLE			2			34	2			21	4			25	
West	Eleanor	all sites combined				1			87	2			145	3			87	
West	Eleanor	Developed	R1_ELEANOR			1			87	2			145	3			87	
Central	all sites combined					26	185	159	174	83	177	124	150	109	181	128	158	
Central	Malibu	all sites combined				26	185	159	174	83	177	124	150	109	181	128	158	
Central	Malibu	Developed	J_MALICRKU			5	184	170	183	2			214	7	202	164	183	
Central	Malibu	Developed	R1_MALICRK			4			160	1			179	5	179	155	165	
Central	Malibu	Developed	R3_CRAGSRD			1			198	1			161	2			180	
Central	Malibu	Developed	R3_MALICRKSP			1			165	0				1			165	
Central	Malibu	Developed	RSW_MC001U			7	196	168	179	27	181	124	148	34	182	126	168	
Central	Malibu	Developed	RSW_MC002D			6	184	173	178	28	162	134	150	34	170	135	153	
Central	Malibu	Developed	RSW_MC009U			2			112	24	191	116	136	26	184	112	136	
Lower	all sites combined					23	174	146	157	92	164	125	146	115	166	128	149	
Lower	Malibu	all sites combined				23	174	146	157	92	164	125	146	115	166	128	149	
Lower	Malibu	Developed	J_MALICRKL			4	162	153	157	2			154	6	158	152	156	
Lower	Malibu	Developed	MalibuCreekatGage			1	147	147	147	0				1	147	147	147	
Lower	Malibu	Developed	R3_CROSSCRK			0				1			109	1	109	109	109	
Lower	Malibu	Developed	RSW_MC003D			6	159	144	156	28	164	129	146	34	162	132	148	
Lower	Malibu	Developed	RSW_MC004D			1			78	28	164	130	144	29	163	124	144	
Lower	Malibu	Developed	RSW_MC013D			6	181	167	176	28	170	128	148	34	173	129	150	
Lower	Malibu	Developed	S02			5	175	148	149	5	136	121	125	10	166	122	142	
	Lagoon	all sites combined		–	–	6	7592	1413	5080	24	5308	1318	3554	30	5443	1232	3554	NA
	Lagoon	Developed	RSW_MC011D	–	–	6	7592	1413	5080	24	5308	1318	3554	30	5443	1232	3554	NA

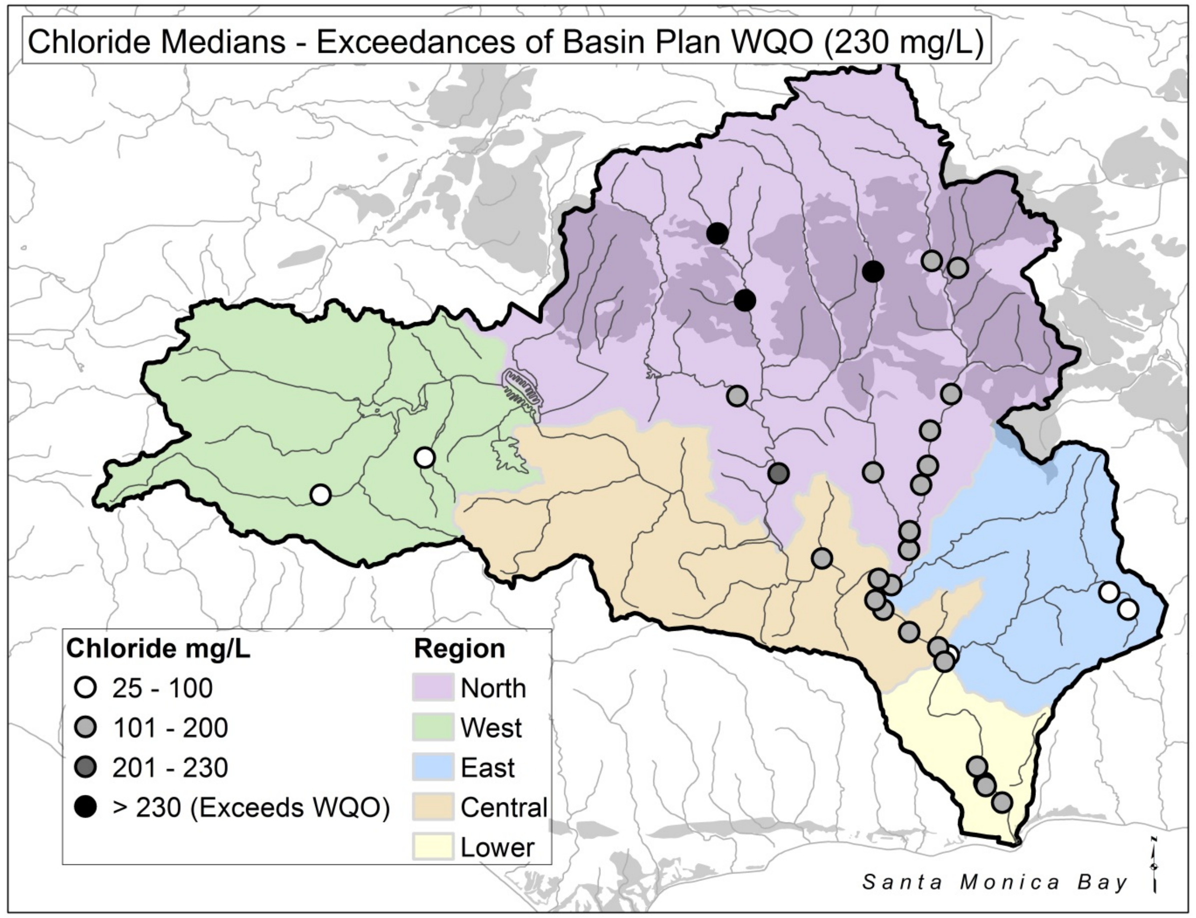
Seasonal Record & Exceedances / Annual Record

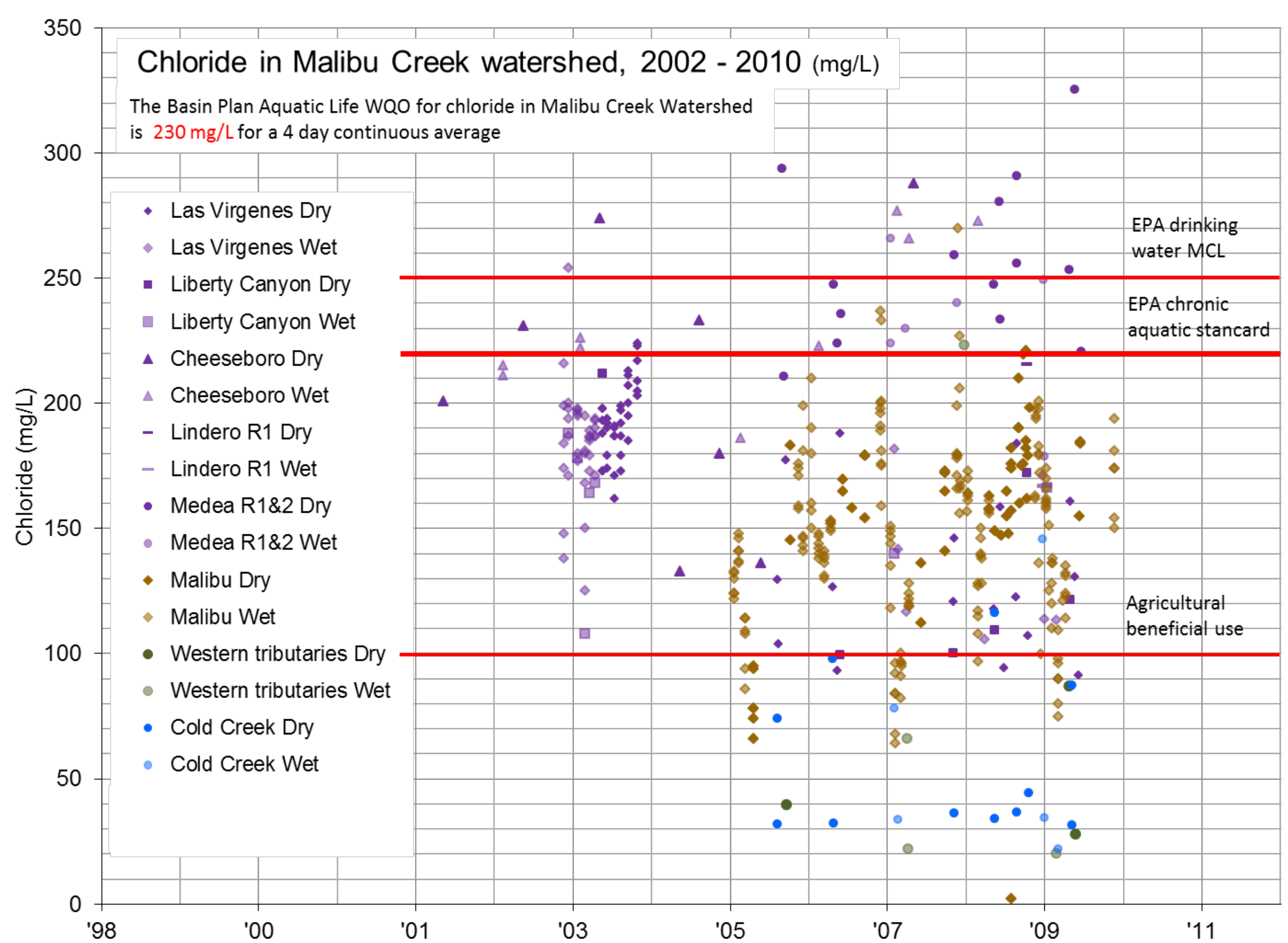
The standard for listings is the Basin Plan Aquatic Life standard of 230 mg/L for a 4-day average of continuous concentration. Because chloride levels are seldom measured for 4 consecutive days, the median values reported here are for all available data, regardless of sample date or sampling frequency.

Chloride

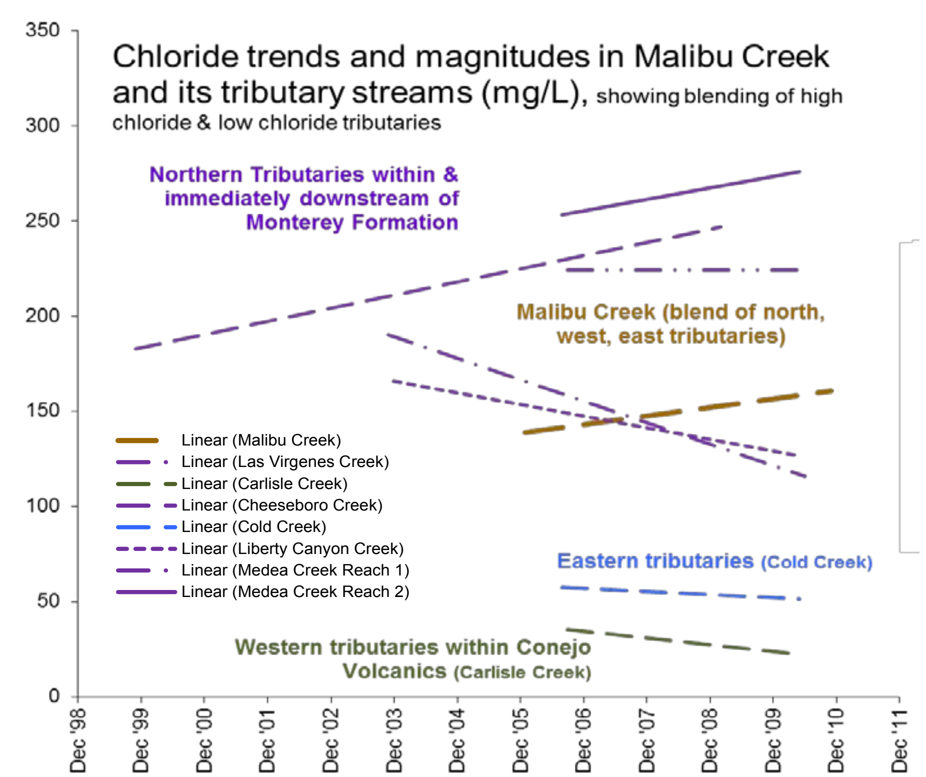
Median monthly chloride levels meet the aquatic life water quality objectives at most sites tested (see figure, left), although single samples more frequently exceed the objective in Malibu Creek and northern headwaters draining the Monterey / Modelo Formation.

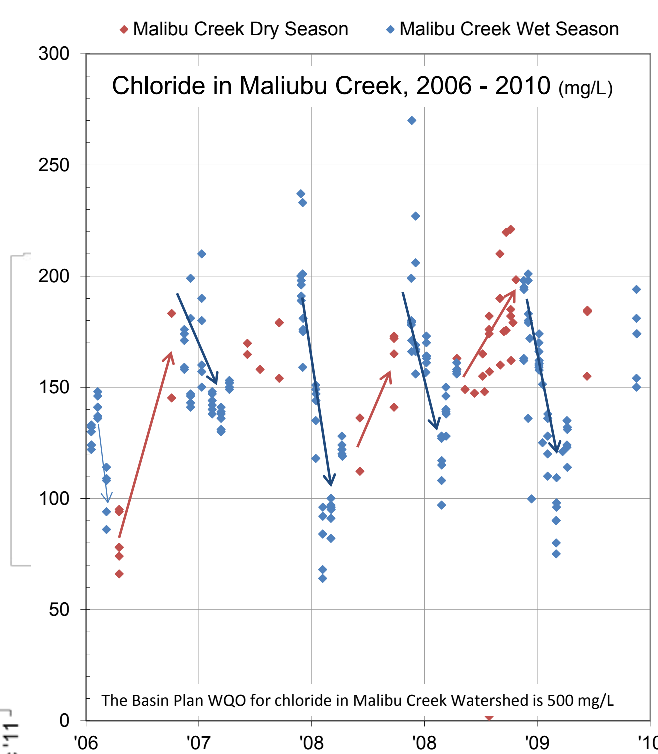
Water Quality: Shown in the lower left graph are all available data on chloride levels in Malibu Creek and its tributary streams, sorted by creek or region. **Annual & Seasonal variation:** Chloride is too seldom sampled in other than Malibu Creek where the trend is flat at an annual scale. Seasonally, Malibu Creek chloride concentration appears to decrease as winter seasons progress (dilution), but with slight upticks in concentration later in the wet season with the return to groundwater dominated base flow. Dry season chloride concentration increases are apparent most years observed. **Source assessment:** Malibu Creek's northern tributaries are clearly the major source of chloride in the watershed. These tributaries drain the marine sedimentary Monterey Formation. Concentration may vary by source location within the M Fm. **Historical Trends:** Consistent with a natural source, there are no apparent long-term trends in chloride levels in the watershed aside from decreases in winter from rain dilution. **Potential impacts on aquatic life:** None known at the levels observed.





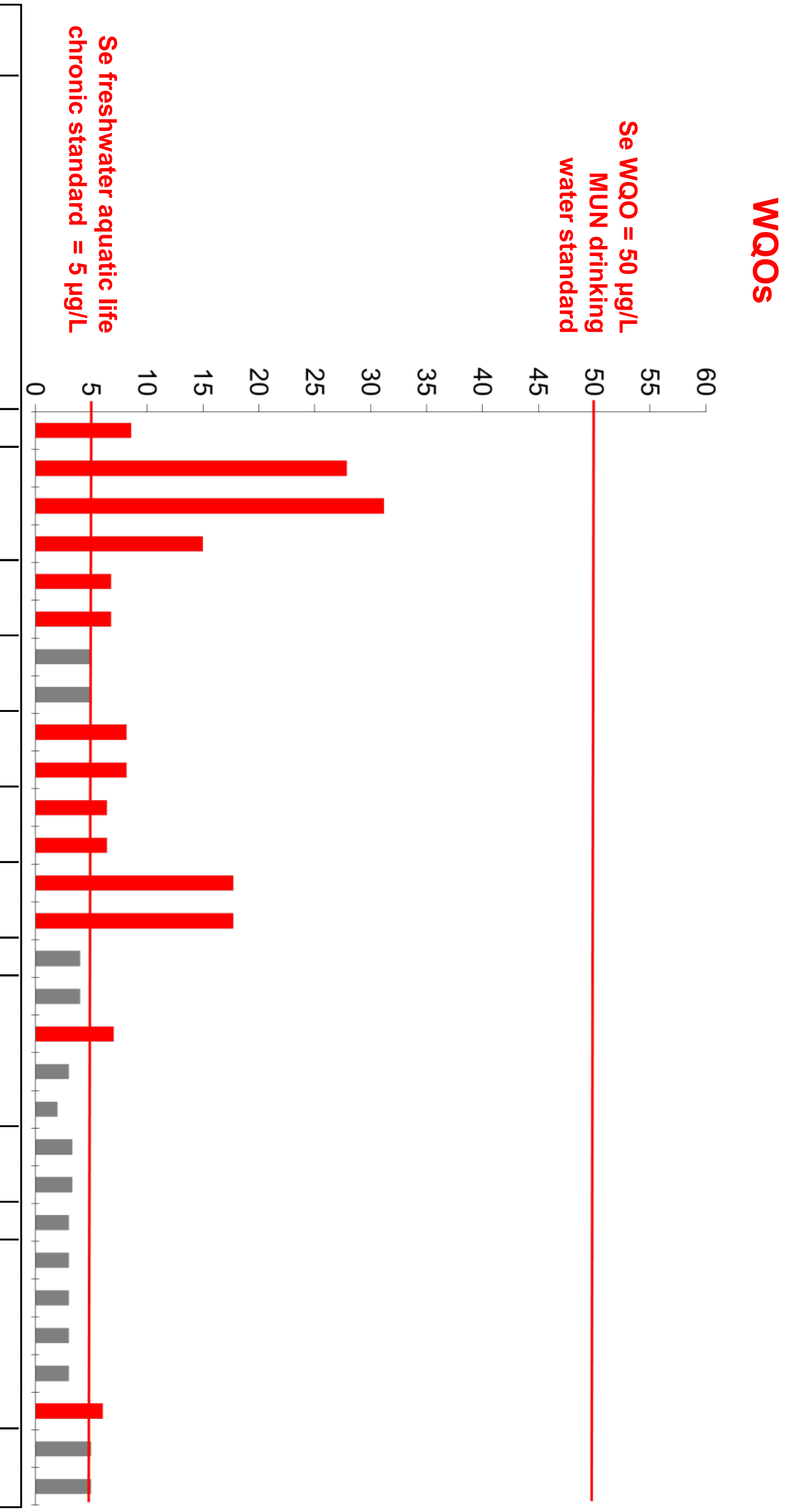
The Los Angeles Regional Water Quality Control Board uses the Basin Plan aquatic life water quality objective for chloride listing purposes in Malibu Creek watershed. That standard is 230 mg/L (4-day average). The additional thresholds shown at left, are guidance values: US EPA secondary drinking water MCL of 250 mg/L; and an agricultural guideline of 100 mg/L used for chloride sensitive plants. The Basin Plan standard, which is not used for listing, is 500 mg/L.





Selenium µg/L

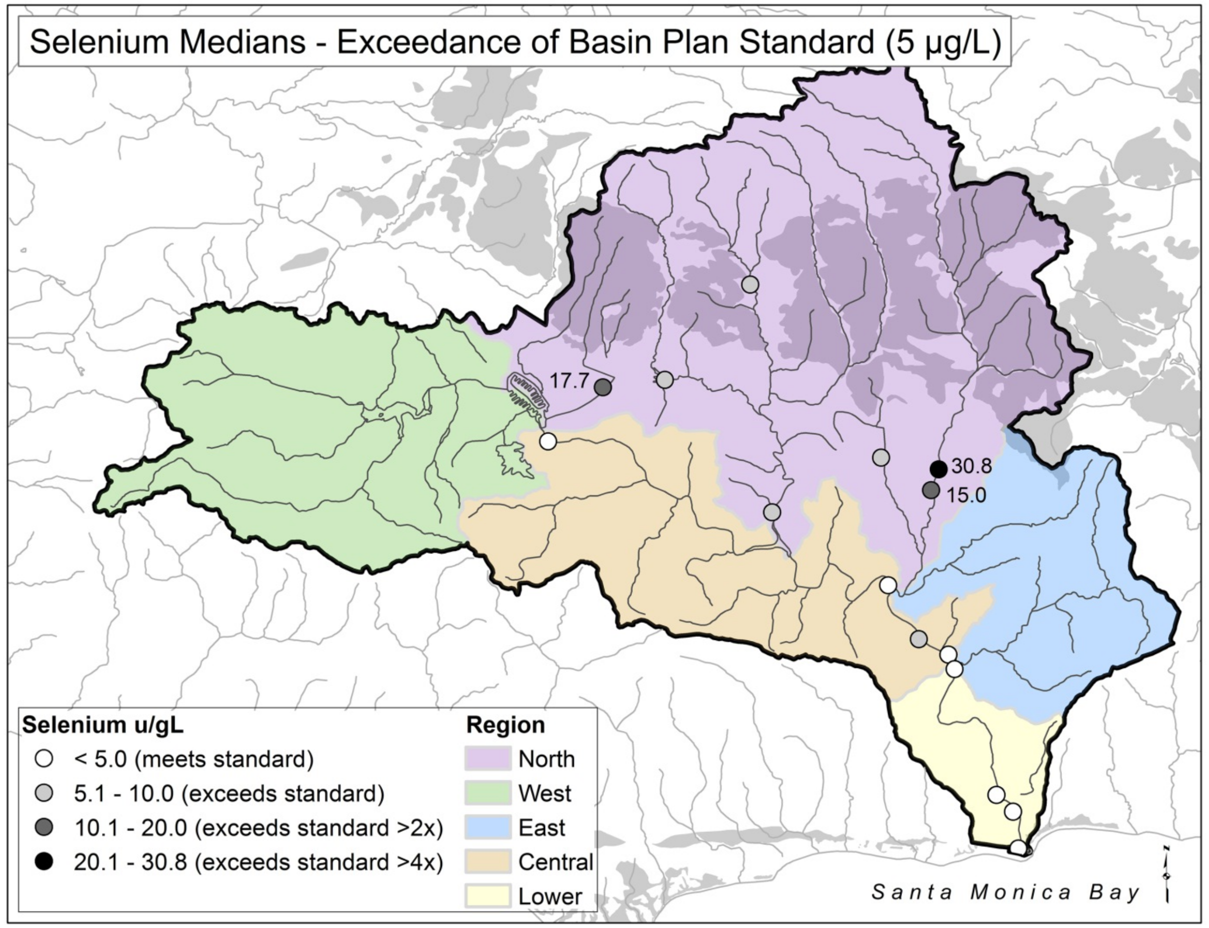
Selenium µg/L Basin Plan Standard = 50 µg/L					Annual Record				Seasonal Record								Exceedances					
Is annual median > Water Quality Objective?	Region	Reach	Land Use	Site	Median	25th Percentile	75th Percentile	Count	Median Wet	25th Percentile Wet	75th Percentile Wet	Count Wet	Median Dry	25th Percentile Dry	75th Percentile Dry	Count Dry	Median wet >WQO	25th Percentile Wet >WQO	75th Percentile Wet >WQO	Median DRY >WQO	25th Percentile Dry > WQO	75th Percentile Dry > WQO
	North	all sites combined			9	7	19	12	9	7	19	12				0						
		Las_Virgenes	all sites combined		28			4	28			4				0						
			Developed	LV2	31			3	31			3				0						
			Developed	LVCreek_Farm_LV3	15			1	15			1				0						
		Liberty Canyon	all sites combined		7			1	7			1				0						
			Developed	LC	7			1	7			1				0						
		Lindero_1	all sites combined		5			3	5			3				0						
			Developed	LIN2	5			3	5			3				0						
		Medea_1	all sites combined		8			2	8			2				0						
			Developed	MED2	8			2	8			2				0						
		Medea_2	all sites combined		6			1	6			1				0						
			Developed	MED1	6			1	6			1				0						
		Russell	all sites combined		18			1	18			1				0						
			Developed	RUS	18			1	18			1				0						
	Central	all sites combined			4	2	7	112	3	2	6	84	7	2	10	28						
		Malibu	all sites combined		4	2	7	109	3	2	6	81	7	2	10	28						
			Developed	RSW_MC001U	7	5	10	51	6	4	9	31	8	6	10	20						
			Developed	RSW_MC002D	3	3	5	33	3	3	5	27	2	2	5	6						
			Developed	RSW_MC009U	2	2	2	25	2	2	2	23	2			2						
		Triunfo_2	all sites combined		3			3	3			3				0						
			Developed	TRI	3			3	3			3				0						
	Lower	all sites combined			3	3	4	103	3	3	4	86	2	2	5	17						
		Malibu	all sites combined		3	3	4	103	3	3	4	86	2	2	5	17						
			Developed	RSW_MC003D	3	2	4	33	3	3	4	27	2	2	2	6						
			Developed	RSW_MC004D	3	3	3	28	3	3	3	27	2			1						
			Developed	RSW_MC013D	3	2	5	33	4	3	5	27	2	2	4	6						
			Developed	S02	6	4	7	9	7	4	7	5	5			4						
	Lagoon		all sites combined		5	3	10	29	5	4	10	23	7	3	10	6						
			Developed	RSW_MC011D	5	3	10	29	5	4	10	23	7	3	10	6						

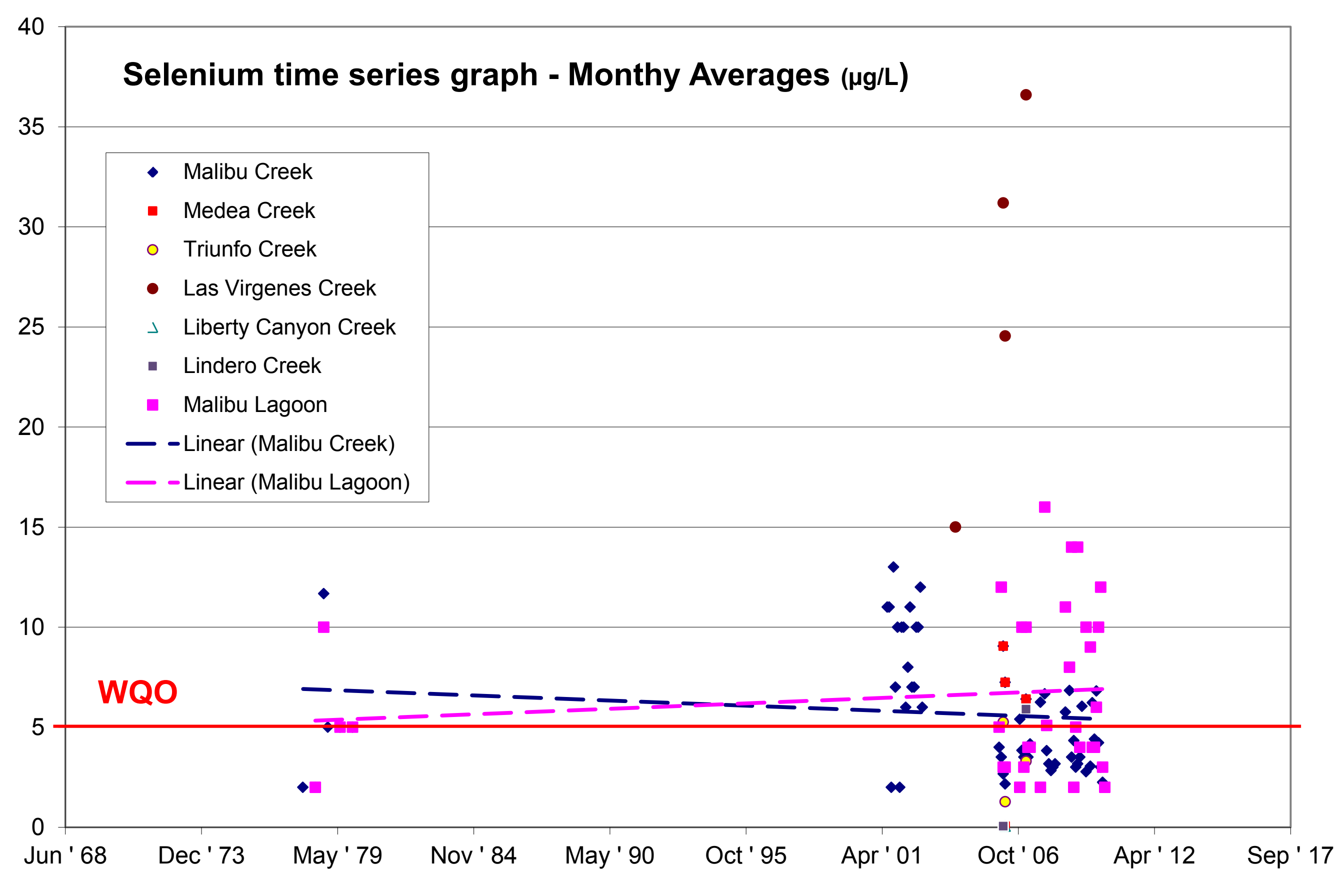


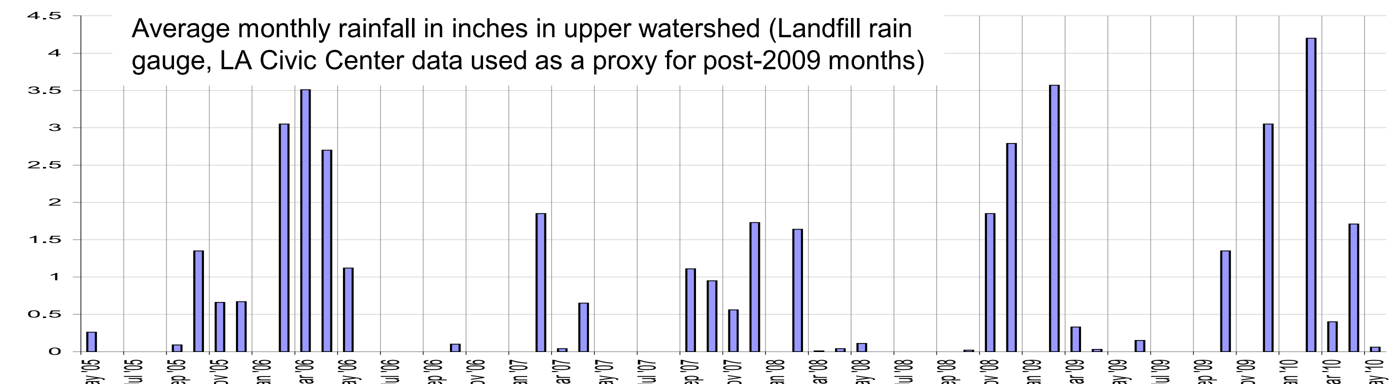
Selenium

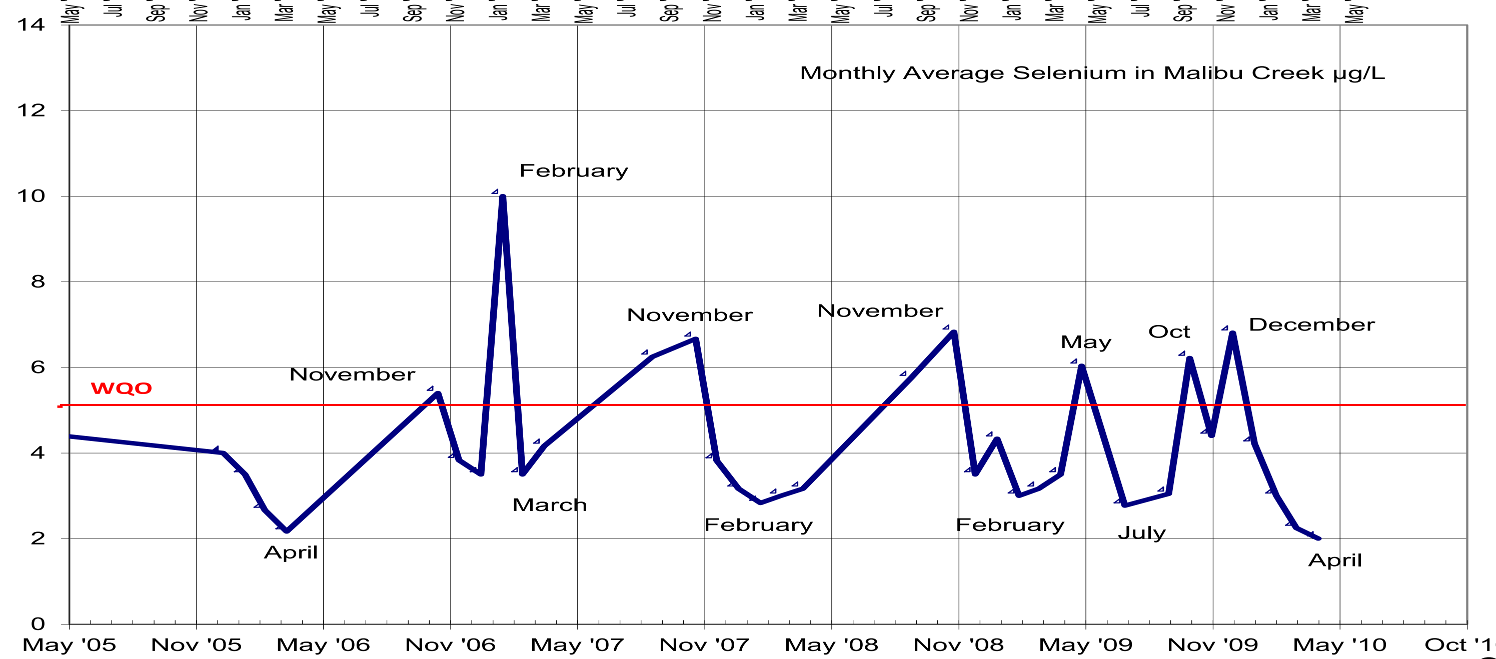
Selenium exceeds its water quality objective in tributaries draining Monterey / Modelo Formation rock, with very high levels in Las Virgenes Creek and Russell Creek.

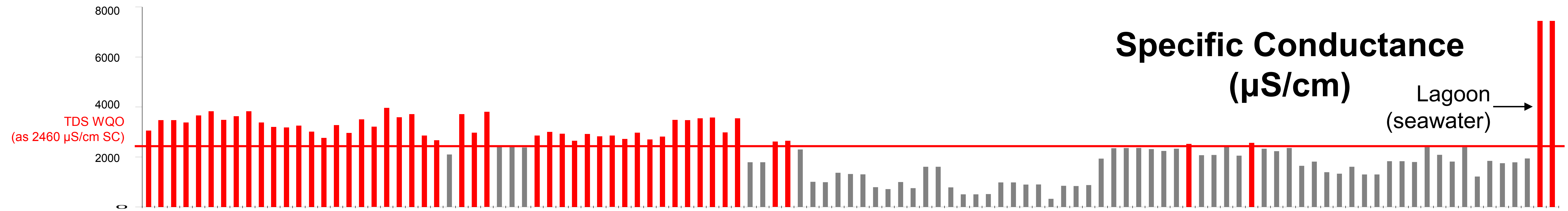
Water Quality: Shown in the lower left graph are monthly averages from all available data on selenium levels in Malibu Creek and its tributary streams, sorted by creek. In most cases monthly averages reflect only one, sometimes two, samples. Very high levels (4x the WQO) were measured in Las Virgenes Creek, which is also enriched in other mineral elements (sulfate, phosphorus, TDS, SC) even in comparison with other creeks draining the Monterey / Modelo Formation, and Russell Creek (2x the WQO). Selenium does not exceed the WQO in lower Malibu Creek, possibly due to dilution by Cold Creek (no selenium data, but Cold Creek's mineral concentrations are significantly lower than northern tributaries draining the Monterey / Modelo Formation). **Annual & Seasonal variation:** Selenium levels rise above the Water Quality Objective (5 µg/L) during extended periods of no rainfall (see below), and levels tend to be highest in the late dry season fall months (Oct – Dec). The high May 2009 level is an **exception** to this rule (see figure below). **Source assessment:** Malibu Creek's northern tributaries are clearly the major source of selenium in the watershed. These tributaries drain Monterey Formation rock, which contains high levels of selenium (See US Geological Survey website on Monterey Formation selenium hazards and Natural Source Assessment section.) **Historical Trends:** Consistent with a natural source, there are no apparent long-term trends in selenium levels in the watershed beyond decreases in winter. **Potential impacts on aquatic life:** See Discussion in Natural Source Assessment section. **Regulatory implications**: Selenium concentrations may be naturally elevated in northern headwaters due to a geologic source. The Basin Plan standard for the Malibu Creek watershed should be reviewed.









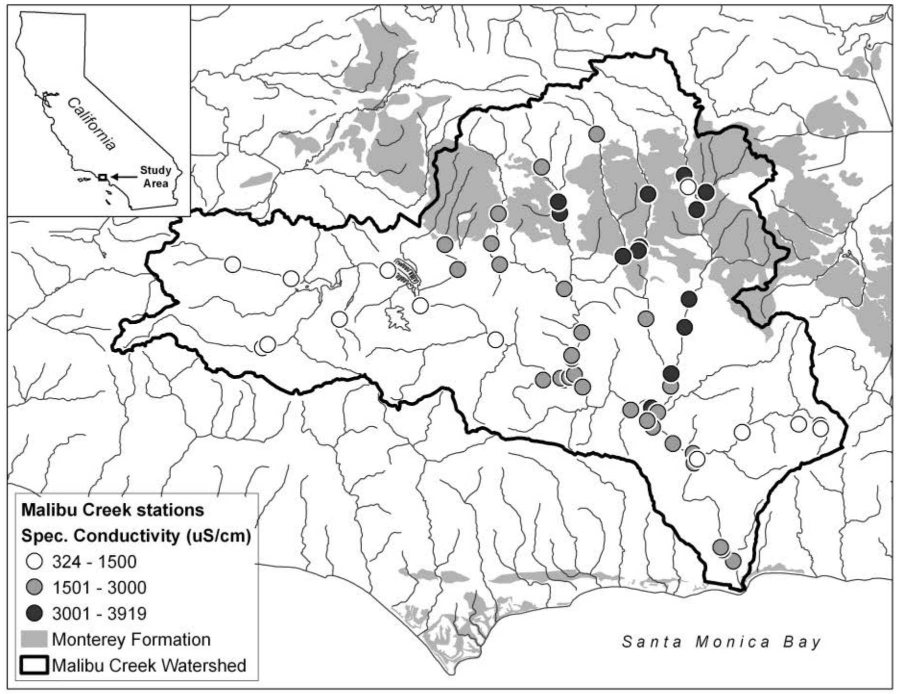


Specific Conductivity - µS/cm

Region	Reach	Land Use	Site	Annual Record: Median	Annual Record: 25th Percentile	Annual Record: 75th Percentile	Annual Record: Count	Median Wet	25th Percentile Wet	75th Percentile Wet	Count Wet	Median Dry	25th Percentile Dry	75th Percentile Dry	Count Dry	Median	25th Percentile	75th Percentile	Median wet >TMDL	Median DRY >TMDL	Is annual median > Water Quality Objective?
North	all sites combined			3060	2704	3504	1128	3000	2602	3463	488	3100	2774	3555	640	–	–	–	–	–	Yes
North	Cheeseboro	all sites combined		3473	3298	3681	36	3413	3259	3667	22	3533	3443	3681	14	–	–	–	–	–	Yes
North	Cheeseboro	Developed	6	3470	3300	3622	25	3330	3259	3486	14	3620	3469	3716	11	–	–	–	–	–	Yes
North	Cheeseboro	Developed	Ches	3382	2760	3541	6	3329			3	3435			3	–	–	–	–	–	Yes
North	Cheeseboro	Developed	MCW_9	3659			4	3659			4				0	–			–		Yes
North	Cheeseboro	Open Space	J_CHEESEBRO	3829			1	3829			1				0	–			–		Yes
North	Las_Virgenes	all sites combined		3486	3193	3750	394	3460	3158	3700	164	3508	3203	3800	230	–	–	–	–	–	Yes
North	Las_Virgenes	Developed	13	3630	3493	3785	67	3660	3490	3760	29	3610	3501	3804	38	–	–	–	–	–	Yes
North	Las_Virgenes	Developed	30	3825	3633	3958	22	3860	3698	3935	8	3825	3633	4050	14	–	–	–	–	–	Yes
North	Las_Virgenes	Developed	5	3380	3245	3500	89	3380	3157	3488	38	3400	3300	3545	51	–	–	–	–	–	Yes
North	Las_Virgenes	Developed	LV2	3200	3054	3400	38	3225	3000	3375	20	3200	3108	3400	18	–	–	–	–	–	Yes
North	Las_Virgenes	Developed	LVCreek_Form_LV3	3185	2907	3943	6	2879			1	3380	2990	4130	5	–	–	–	–	–	Yes
North	Las_Virgenes	Developed	LVCreek_WhiteOak_LV4	3255	2963	4020	6	2940			1	3480	3030	4200	5	–	–	–	–	–	Yes
North	Las_Virgenes	Developed	RSW_MC001F	3010	2768	3395	7	2918			2	3010	2840	3650	5	–	–	–	–	–	Yes
North	Las_Virgenes	Developed	RSW_MC002F	2760	2750	3650	7	2983			2	2760	2750	4020	5	–	–	–	–	–	Yes
North	Las_Virgenes	Developed	RSW_MC003F	3270	2963	3475	7	2963			2	3270	3270	3680	5	–	–	–	–	–	Yes
North	Las_Virgenes	Developed	RSW_MC007D	2960	2753	3525	6	2747			1	3150	2770	3650	5	–	–	–	–	–	Yes
North	Las_Virgenes	Developed	S_LLASVIR	3504	3431	3650	8	3505	3436	3573	2	3504	3458	3640	6	–	–	–	–	–	Yes
North	Las_Virgenes	Open Space	9	3208	3120	3540	30	3485	3194	3775	10	3190	3095	3360	20	–	–	–	–	–	Yes
North	Las_Virgenes	Open Space	J_EFLASVIR	3959	3795	4121	8	3730			3	4073	3999	4265	5	–	–	–	–	–	Yes
North	Las_Virgenes	Open Space	LV1	3584	3175	3900	34	3325	2750	3575	16	3850	3450	4129	18	–	–	–	–	–	Yes
North	Las_Virgenes	Open Space	MCW_8b	3717	3524	3831	51	3594	3493	3752	27	3823	3706	3978	24	–	–	–	–	–	Yes
North	Las_Virgenes	Open Space	S_ULASVIR	2854	2848	2892	8	2870			2	2853	2847	2890	6	–	–	–	–	–	Yes
North	Liberty Canyon	all sites combined		2667	1800	3267	45	2912	1893	3275	20	2600	1715	3098	25	–		–	–	–	Yes
North	Liberty Canyon	Developed	LC	2100	1693	2984	35	2300	1870	3267	17	1900	1638	2650	18			–			
North	Liberty Canyon	Developed	LibertyCanyonCrkatSewerXing	3710			3	2891			1	4170			2	–			–	–	Yes
North	Liberty Canyon	Developed	R1_LIBCYN	2974	2872	3062	5	3062			1	2923			4	–	–	–	–	–	Yes
North	Liberty Canyon	Developed	R3_LIBCYN	3803			2	3971			1	3634			1	–			–	–	Yes
North	Lindero_1	all sites combined		2400	2058	2900	35	2083	1250	2400	20	2967	2746	3084	15			–		–	
North	Lindero_1	Developed	LIN2	2400	2050	2900	33	2100	1250	2400	19	2984	2825	3092	14			–		–	
North	Lindero_1	Developed	R3_LADYFACE	2379			2	2066			1	2692			1					–	
North	Lindero_2	all sites combined		2852	2727	3000	152	2867	2688	3074	64	2834	2758	2979	88	–	–	–	–	–	Yes
North	Lindero_2	Developed	LIN1	3000	2885	3085	31	2975	2813	3125	16	3000	2925	3069	15	–	–	–	–	–	Yes
North	Lindero_2	Developed	LinderoCrk_LakeInlet_L2	2930			1				0	2930			1	–				–	Yes
North	Lindero_2	Developed	LinderoCrkatVenturaCoLine_L1	2650			1				0	2650			1	–				–	Yes
North	Lindero_2	Developed	LinderoGolf_SoEndSmallPond_L3	2920			1				0	2920			1	–				–	Yes
North	Lindero_2	Developed	MCW_14b	2826	2714	2971	118	2848	2569	3054	48	2804	2719	2922	70	–	–	–	–	–	Yes
North	Medea_1	all sites combined		2852	2650	3030	139	2701	2306	2871	58	2950	2770	3060	81	–	–	–	–	–	Yes
North	Medea_1	Developed	21	2723	2576	2965	32	2698	2286	2770	8	2755	2580	2985	24	–	–	–	–	–	Yes
North	Medea_1	Developed	7	2970	2860	3143	63	2860	2658	3080	27	3035	2958	3184	36	–	–	–	–	–	Yes
North	Medea_1	Developed	MED2	2700	2275	2837	36	2400	2050	2650	20	2850	2746	2950	16	–		–		–	Yes
North	Medea_1	Developed	S_LMEDCRK	2810	2724	2873	8	2730			3	2852	2768	2852	5	–	–	–	–	–	Yes
North	Medea_2	all sites combined		3486	3287	3600	163	3398	2939	3503	67	3553	3429	3652	96	–	–	–	–	–	Yes
North	Medea_2	Developed	MCW_12	3478	3301	3585	118	3392	2946	3489	48	3526	3430	3616	70	–	–	–	–	–	Yes
North	Medea_2	Developed	MED1	3550	3422	3713	32	3450	3213	3533	16	3675	3592	3767	16	–	–	–	–	–	Yes
North	Medea_2	Developed	MedeaCrk_atBayLaurelSch_M1	3580			1				0	3580			1	–				–	Yes
North	Medea_2	Developed	R1_MEDCRK	2987			4	2793			1	2989			3	–			–	–	Yes
North	Medea_2	Developed	S_UMEDCRK	3543	3218	3665	8	3340			2	3608	3320	3721	6	–	–	–	–	–	Yes
North	Palo_Comado	all sites combined		1789	1738	1995	15	1842	1759	2011	8	1763	1719	1923	7						
North	Palo_Comado	Open Space	8	1789	1738	1995	15	1842	1759	2011	8	1763	1719	1923	7						
North	Russell	all sites combined		2612	2320	2731	149	2638	2334	2749	65	2611	2315	2712	84	–		–	–	–	Yes
North	Russell	Developed	MCW_15b	2652	2462	2740	118	2658	2415	2746	48	2647	2491	2728	70	–		–	–	–	Yes
North	Russell	Developed	RUS	2300	2225	2400	31	2350	2250	2800	17	2300	2175	2400	14						
East	all sites combined			1005	720	1340	234	1000	721	1350	102	1017	720	1322	132						
East	Cold	all sites combined		990	720	1311	219	995	721	1333	97	983	719	1288	122						
East	Cold	Developed	11	1367	1332	1438	15	1438	1425	1525	6	1344	1329	1367	9						
East	Cold	Developed	2	1318	1201	1386	74	1337	1205	1400	36	1295	1201	1380	38						
East	Cold	Developed	J_LCOLDCRK	1304	1217	1371	6	1365			2	1304			4						
East	Cold	Developed	R3_COLDCRK	791			2	728			1	854	854	854	1						
East	Cold	Open Space	3	714	687	725	87	710	658	730	37	717	699	724	50						
East	Cold	Open Space	CC	997	981	1019	27	1000	987	1010	13	997	979	1019	14						
East	Cold	Open Space	J_UCOLDCRK	752	731	793	8	712			2	766	750	827	6						
East	Stokes	all sites combined		1607	1567	1627	15	1607	1562	1629	5	1609	1573	1623	10						
East	Stokes	Developed	16	1607	1567	1627	15	1607	1562	1629	5	1609	1573	1623	10						
West	all sites combined			783	560	929	76	785	559	899	51	722	562	977	25						
West	Carlisle	all sites combined		504	421	587	22	475	402	510	11	580	466	631	11						
West	Carlisle	Developed	10	504	421	582	18	477	407	518	9	562	425	595	9						
West	Carlisle	Developed	S_CARLISLE	515			4	401			2	651			2						
West	Eleanor	all sites combined		981			3	1285			2	981			1						
West	Eleanor	Developed	R1_ELEANOR	981			3	1285			2	981			1						
West	Hidden Valley	all sites combined		895	857	959	10	885	836	938	8	930			2						
West	Hidden Valley	Developed	HV	900	870	970	9	900	862	949	7	930			2						
West	Hidden Valley	Developed	MCW_18	324			1	324			1				0						
West	Potrero	all sites combined		846	748	977	41	812	726	897	30	977	883	1074	11						
West	Potrero	Developed	MCW_17	836	741	973	36	812	726	885	26	1000	905	1090	10						
West	Potrero	Developed	POT	875	750	1533	5	1142			4	875			1						
Central	all sites combined			1933	1449	2529	522	1608	1330	2109	223	2330	1563	2665	299			–			
Central	Malibou	all sites combined		2350	1770	2620	191	1736	1360	2125	46	2490	1970	2700	145			–		–	
Central	Malibou	Developed	22	2359	1955	2609	32	1860	1460	2164	8	2475	2239	2670	24			–			
Central	Malibou	Developed	23	2362	1786	2585	32	1793	1351	2053	8	2485	1934	2678	24			–		–	
Central	Malibou	Developed	24	2315	1731	2550	33	1724	1328	1976	8	2430	1890	2650	25			–			
Central	Malibou	Developed	26	2241	1632	2583	32	1735	1544	1978	8	2425	1725	2703	24			–			
Central	Malibou	Developed	27	2330	1766	2638	31	1703	1414	1975	7	2530	1955	2715	24			–		–	
Central	Malibou	Developed	28	2525	2170	2653	31	1732	1408	2175	7	2555	2296	2750	24	–		–		–	Yes
Central	Malibu	all sites combined		2070	1630	2540	209	1824	1493	2360	125	2395	2035	2753	84			–			
Central	Malibu	Developed	12	2080	1645	2402	67	1812	1338	2087	28	2335	1935	2515	39						
Central	Malibu	Developed	4	2410	1726	2740	33	1724	1495	2305	14	2710	2393	2895	19			–		–	
Central	Malibu	Developed	J_MALICRKU	2052	1972	2208	7	2318			2	2052	2039	2143	5						
Central	Malibu	Developed	R1_MALICRK	2568	2447	2717	5	2972			1	2508			4	–		–	–	–	Yes
Central	Malibu	Developed	R3_CRAGSRD	2329			2	1884			1	2773			1					–	
Central	Malibu	Developed	R3_MALICRKSP	2231			1				0	2231			1						
Central	Malibu	Developed	RSW_MC001U	2360	1825	2868	34	2320	1758	2700	27	3070	2555	3120	7			–		–	
Central	Malibu	Developed	RSW_MC002D	1645	1489	2338	34	1589	1485	1949	28	2585	2233	2795	6					–	
Central	Malibu	Developed	RSW_MC009U	1814	1374	2078	26	1814	1401	2155	24	1526			2						
Central	Triunfo_1	all sites combined		1391	1117	1576	87	1217	1012	1455	32	1446	1239	1708	55						
Central	Triunfo_1	Developed	17	1331	1034	1465	54	1135	992	1416	24	1370	1166	1483	30						
Central	Triunfo_1	Developed	25	1607	1328	2410	33	1349	1134	1660	8	1782	1430	2490	25						
Central	Triunfo_2	all sites combined		1300	957	1500	35	990	881	1400	20	1470	1320	1512	15						
Central	Triunfo_2	Developed	TRI	1300	957	1500	35	990	881	1400	20	1470	1320	1512	15						
Lower	all sites combined			1830	1577	2256	259	1670	1500	1878	157	2239	1886	2418	102						
Lower	Malibu	all sites combined		1830	1577	2256	259	1670	1500	1878	157	2239	1886	2418	102						
Lower	Malibu	Developed	1	1798	1620	2215	88	1620	1475	1717	38	2105	1841	2315	50						
Lower	Malibu	Developed	15	2390	1560	2700	23	1560	1377	1662	11	2700	2503	2835	12			–		–	
Lower	Malibu	Developed	J_MALICRKL	2086	1912	2219	6	1741			2	2199			4						
Lower	Malibu	Developed	MAL	1815	1662	2100	34	1650	1510	1808	16	2050	1827	2275	18						
Lower	Malibu	Developed	MalibuCreekatGage	2389	2389	2389	1				0	2389			1						
Lower	Malibu	Developed	R3_CROSSCRK	1217	1217	1217	1	1217			1				0						
Lower	Malibu	Developed	RSW_MC003D	1843	1616	2228	34	1765	1601	1987	28	2235	2223	2300	6						
Lower	Malibu	Developed	RSW_MC004D	1750	1560	2000	29	1765	1621	2003	28	1360			1						
Lower	Malibu	Developed	RSW_MC013D	1785	1499	2310	34	1675	1485	2145	28	2550	2250	2783	6					–	
Lower	Malibu	Developed	S02	1940	1430	2790	9	1430	1320	1930	5	2945			4			–		–	
Lower	Lagoon	all sites combined		7440	3325	17333	30	6680	3395	15450	24	15230	5413	19865	6	–	–	–	–	–	NA
Lower	Lagoon	Developed	RSW_MC011D	7440	3325	17333	30	6680	3395	15450	24	15230	5413	19865	6	–	–	–	–	–	NA

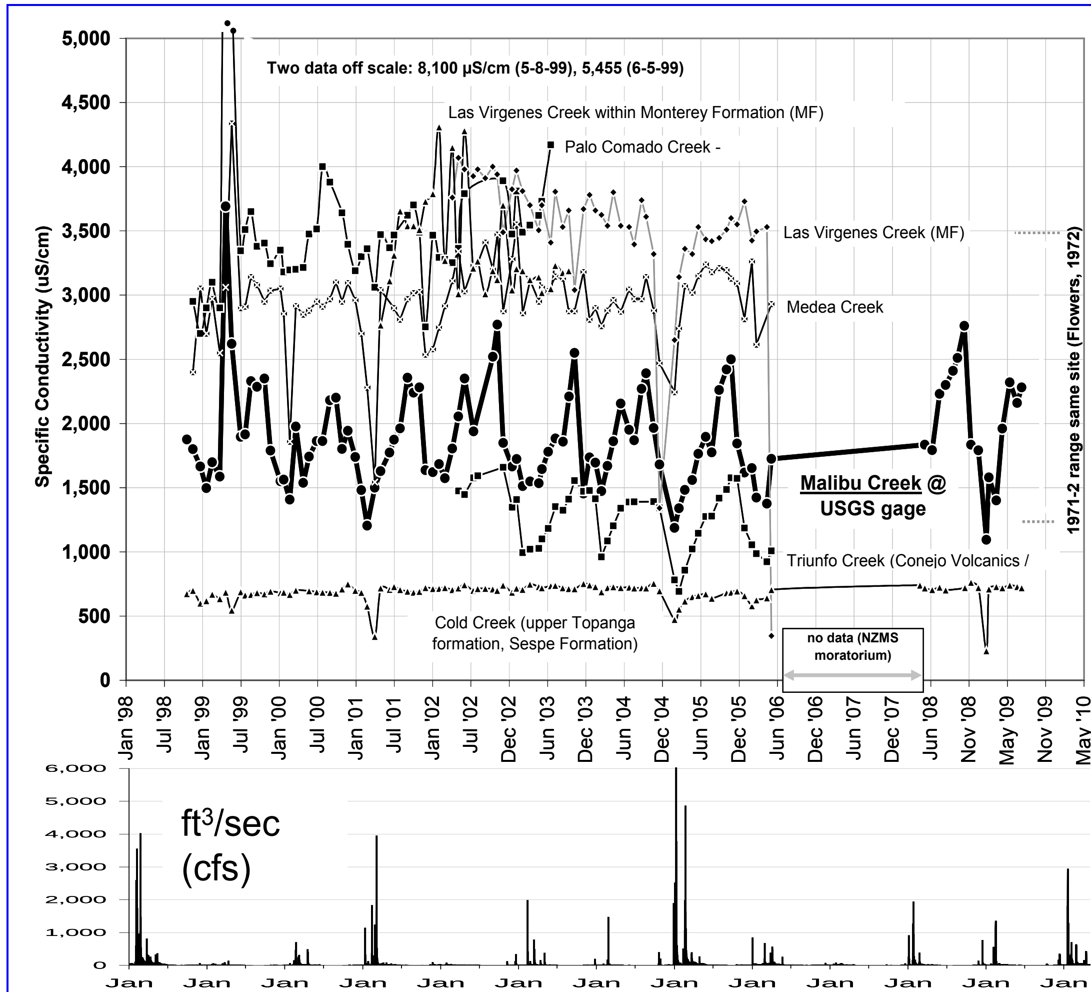
Specific Conductance

Average Specific Conductivity (µS/cm) in Malibu Creek and major tributaries in relation to MF rock, 1998 - 2009. Note low SC in east and west subdrainages (= Cold Creek and Carlise Creek, respectively) with minimal MF rock. See Fig. 1 for station ID's



Extraordinarily high Specific Conductance in Malibu Creek's northern tributaries results in brackish water the length of Malibu Creek, a condition unique among coastal streams that drain to Santa Monica Bay.

Water quality: Specific conductance (SC) measures the ability of water to pass an electrical current. SC in water increases as the levels of inorganic dissolved solids increase such as chloride, sulfate, magnesium and calcium, all of which are unusually high in Malibu Creek, and extraordinarily high in its northern tributaries draining Monterey / Modelo Formation rock (see ternary diagram - Sulfate page). SC is also tightly correlated with Total Dissolved Solids (TDS) in Malibu Creek with linear regression R^2=0.87 or better once possible erroneous outliers are removed, and resulting in a conversion of the TDS WQO to 2,465 µS/cm. Except for Malibu Creek's western and eastern tributaries, even *minimum SC* levels exceed the US EPA drinking water standards year-round, and is why TDS commonly exceeds the Los Angeles Basin Plan objective as well. Malibu Creek specific conductivity was the highest of any measured among Santa Monica Mountain (SMM) coastal streams. It is brackish year-round (SC > 1,500 µS/cm; Masters and Ela, 2007) over the 1998 – 2009 period of record from its highest northern tributaries in the foothills north of the 101 freeway to its lower reaches in the City of Malibu, except during large rain events, when SC fell to ~1,200 µS/cm (see figure, left). *Average* SC ranged from 3,053 µS/cm in the northern headwaters region to 1,916 µS/cm for sites in the lower Malibu Creek region. *Average* values at northern creek sites varied from high values of 3,960 for J_EFLASVIR and 3,829 at J_CHEESEBORO to lower values of 1,860 and 2,923 at Heal the Bay sites 8 and 7 respectively. Of 520 samples from Malibu Creek, only 18 were less than 1,200 µS/cm, all during or immediately following wet weather. **Annual & Seasonal variation:** There is a strong seasonal component to SC in Malibu Creek, peaking at the end of the dry season in any given year. SC in the lower reaches below Rindge Dam peaked in Sept – early November between 2,200 to 2,700 µS/cm, depending on the year (graph lower left). Late summer SC levels in the upper creek and its northern tributaries were significantly higher than SC in non-M Fm. tributaries (t-test, 0.05 rejection criteria), with peak values >3,500 µS/cm. Seasonal oscillations in SC in Malibu Creek reflect winter dilution of high conductivity groundwater base flow with more dilute surface and shallow groundwater flow from winter precipitation.



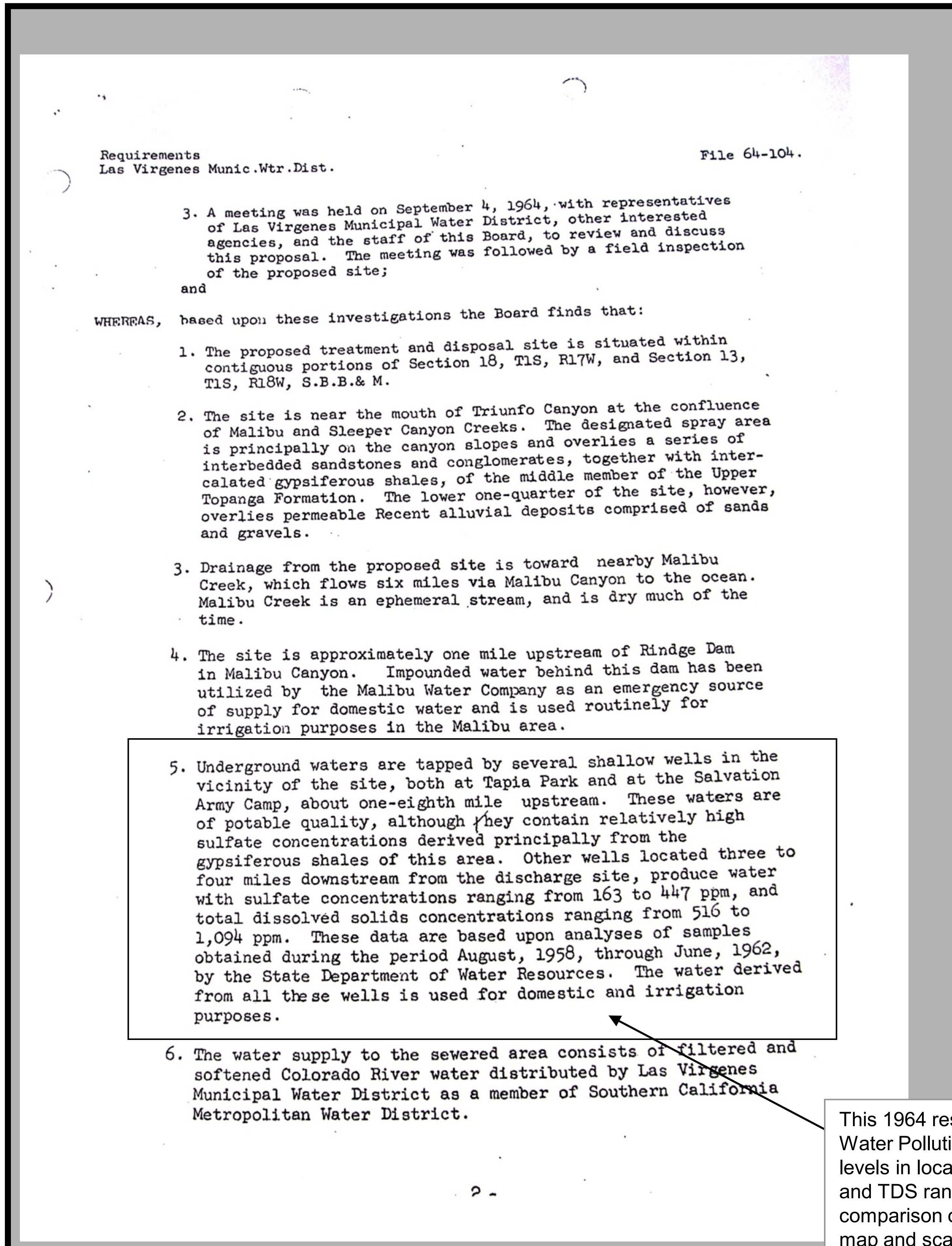
Source assessment: A geologic source is indicated by the magnitude of SC observed in Malibu Creek (nearly 4x higher than levels found in either potable or recycled water), by its close geographic association with a geologic formation enriched in sulfate, magnesium and calcium (all found in high concentrations in Malibu Creek), and by the fact that the highest levels occur within this formation upstream from any urban development. Also, the primary constituent responsible for high SC in Malibu Creek is sulfate, present at levels an order of magnitude higher than that found in imported State Water Project water. (See the Natural Source Assessment section.) **Historical Trends:** Consistent with a natural source, there are no apparent long-term trends in SC levels in the watershed. **Exceptions:** An exception to the seasonal trend of lower SC immediately following rain events was observed in the winter of 1999, when SC rose abruptly to very high levels at three stations in Medea, Palo Comado and upper Las Virgenes Creeks following a very small rain event (see figure, left). This counter-intuitive rise in SC immediately following a small rain event that should have diluted SC was also recorded in 2009 in a small eastern tributary to Las Virgenes Creek following the Oct. 9th, rain event during "first rain event" testing. We speculate that this rise was caused by hydraulic forcing of high SC groundwater by rain falling at higher elevations (testable with isotopic analysis) or by flushing solutes precipitated on surfaces. **Potential impacts on aquatic life:** As for sulfate, SC is a known predictive indicator of diatom composition and abundance in freshwater streams (Potapova and Charles, 2003). In Malibu Creek, high SC levels favor benthic diatoms such as *Pleurosira laevis,* a cosmopolitan species that favors brackish waters (El-Awamri, 2008) and the dominant diatom in "Malibu muck" (see Natural Source Assessment). Macroinvertebrates are also sensitive to SC and high TDS (reviewed by Goodfellow *et al*., 2000), with significant impacts on aquatic macroinvertebrates recorded in watersheds draining petroleum source rocks or coal (Pond *et al*. 2008). In Malibu Creek, Luce (2003) found SC (closely linked with sulfate levels – see figure next page) was negatively correlated to all benthic macroinvertebrate (BMI) index metrics, except percent dominant species (significant positive relationship) and percent filterers (no significant relationship). She also noted that her natural reference sites R6 and R9 (both located in the M Fm.) had higher SC than her other reference sites, slightly higher diatom cover, and lower values of taxa richness, EPT richness, EPT index, sensitive EPT index, percent intolerant species and percent shredders, especially at site R9. Very poor BMI metrics in the Malibu Creek watershed were also associated with all high SC sites in macroinvertebrate bioassessments performed by the Aquatic Bioassay and Consulting Laboratories (2007).

Specific Conductivity (µS/cm) in Malibu Creek and major tributaries (upper graph) vs. rain events (lower). Rain events = spikes in gauged stream flow (F130-R, lower graph). Lower Malibu Creek has intermediate values of SC reflecting mixing of higher SC water from M Fm.-fed northern tributaries and lower SC from Cold Creek (no known M Fm. exposures). Note drop in Cold Creek SC following three large rain events in 2001, 2004 and 2008, and increase in SC in Malibu Creek & M Fm.-fed tributaries following very small rain events in the dry winter of 1999.

Old Tools: Historical Records document high sulfate and TDS in 1964

Los Angeles Regional Water Pollution Control Board (the predecessor of the LARWQB) Resolution 64-55 documents historical water quality (sulfate and TDS) at a specific location, attributed to "gypsiferous shales of this area." These data can be compared with recent data (2002-08) from the same area to determine if historical values fall within modern-day levels. In this case, the 1964 levels superimposed on a simple scatter-plot of recent data shows nearly perfect overlap with the range of constituents measured 45 years ago.

A cross-reference of the resolution's date with residential parcel data reveals that the bulk of the watershed's development occurred *after* these measurements were reported in 1964. The early date and the apparently stable sulfate and TDS levels over 50 years since suggests a natural background source for sulfate and TDS, as do their extraordinarily high levels both locally and nationally (see Natural Source Assessment and Sulfate sections).



Requirements
Las Virgenes Munic.Wtr.Dist.

File 64-104.

3. A meeting was held on September 4, 1964, with representatives of Las Virgenes Municipal Water District, other interested agencies, and the staff of this Board, to review and discuss this proposal. The meeting was followed by a field inspection of the proposed site;

and

WHEREAS, based upon these investigations the Board finds that:

1. The proposed treatment and disposal site is situated within contiguous portions of Section 18, T1S, R17W, and Section 13, T1S, R18W, S.B.B.& M.

2. The site is near the mouth of Triunfo Canyon at the confluence of Malibu and Sleeper Canyon Creeks. The designated spray area is principally on the canyon slopes and overlies a series of interbedded sandstones and conglomerates, together with intercalated gypsiferous shales, of the middle member of the Upper Topanga Formation. The lower one-quarter of the site, however, overlies permeable Recent alluvial deposits comprised of sands and gravels.

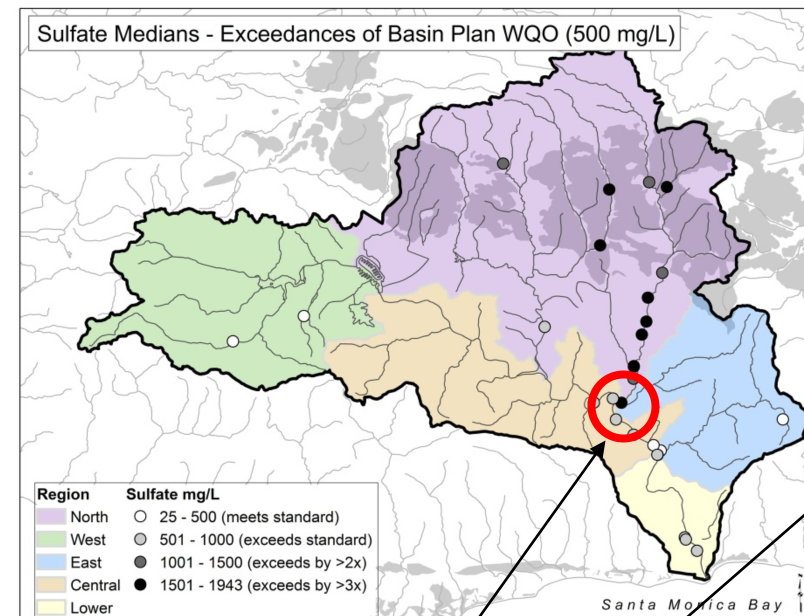
3. Drainage from the proposed site is toward nearby Malibu Creek, which flows six miles via Malibu Canyon to the ocean. Malibu Creek is an ephemeral stream, and is dry much of the time.

4. The site is approximately one mile upstream of Rindge Dam in Malibu Canyon. Impounded water behind this dam has been utilized by the Malibu Water Company as an emergency source of supply for domestic water and is used routinely for irrigation purposes in the Malibu area.

5. Underground waters are tapped by several shallow wells in the vicinity of the site, both at Tapia Park and at the Salvation Army Camp, about one-eighth mile upstream. These waters are of potable quality, although they contain relatively high sulfate concentrations derived principally from the gypsiferous shales of this area. Other wells located three to four miles downstream from the discharge site, produce water with sulfate concentrations ranging from 163 to 447 ppm, and total dissolved solids concentrations ranging from 516 to 1,094 ppm. These data are based upon analyses of samples obtained during the period August, 1958, through June, 1962, by the State Department of Water Resources. The water derived from all these wells is used for domestic and irrigation purposes.

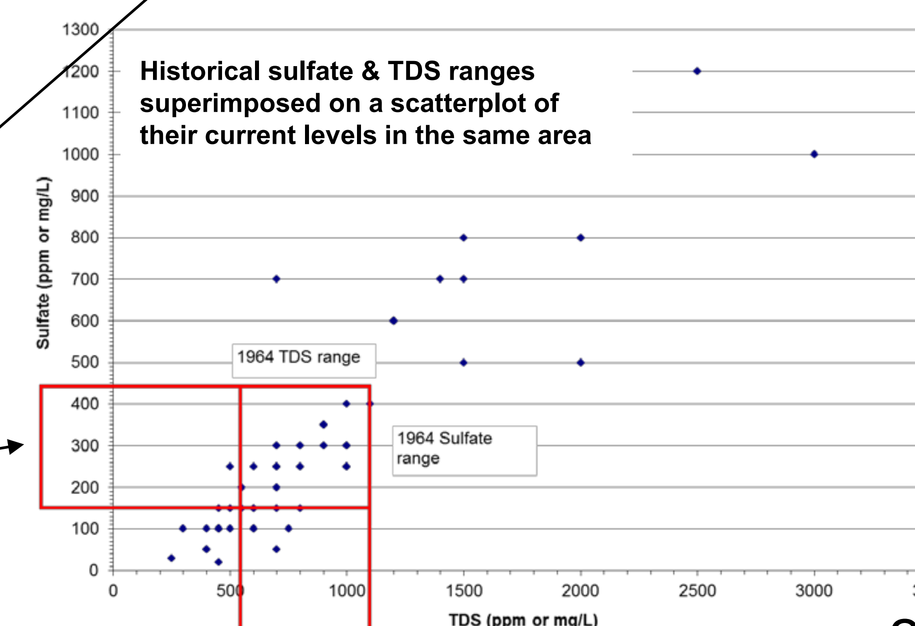
6. The water supply to the sewered area consists of filtered and softened Colorado River water distributed by Las Virgenes Municipal Water District as a member of Southern California Metropolitan Water District.

- 2 -



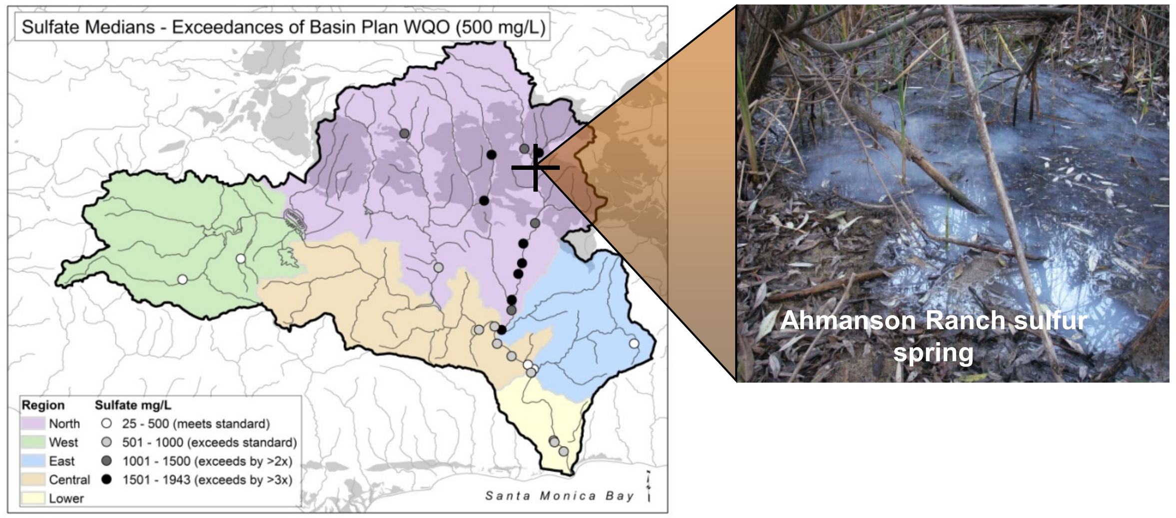
"Consistent with a natural source, there are no apparent long-term trends in sulfate levels in the watershed beyond slight decreases following wet winters, based on the recent period of record (2002-08) and earlier measurements by the LARWQCB in 1974."

- from page 1 of the Sulfate section of this report, "Historical Trends"



This 1964 resolution from the Los Angeles Regional Water Pollution Control Board staff documents sulfate levels in local well-water ranging from 163 to 447 ppm and TDS ranging from 516 to 1,094 ppm. A comparison of current levels at the same location (spot map and scatterplot) and early data on sulfate and TDS in Malibu Creek at this location nearly 50 years ago (red brackets) shows that levels have not changed.

Sulfate



Sulfur seeps and springs occur in various locations and times in the watershed, particularly within the Monterey Formation and immediately downstream of it. They support active sulfur-reducing microbial communities, which metabolically reduce sulfate to **hydrogen sulfide gas (H_2S),** which is toxic to most forms of aquatic life. The "rotten egg" odor of H_2S is common around these seeps, which can and do occur within the creek itself. The white color of this particular seep is due to groundwater minerals precipitating out of solution upon exposure to water of different pH, in this case rainwater collecting in the seep during a small rain event (Photo by R. Orton 10/9/09)

High sulfate levels in Malibu Creek are explained as the result of blending of very high sulfate levels in its northern tributaries with lower sulfate levels more typical of other Santa Monica Mountain coastal streams.

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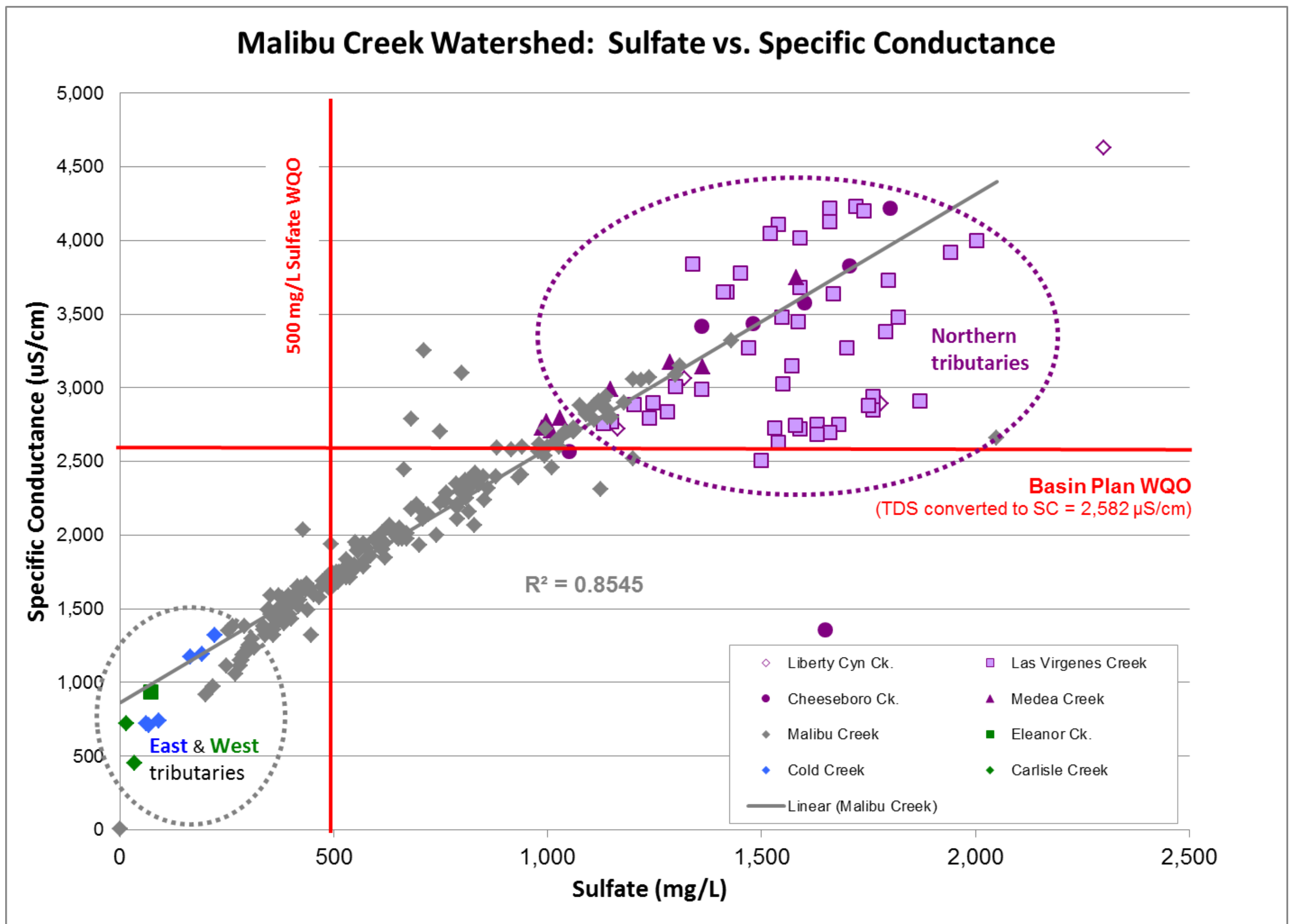


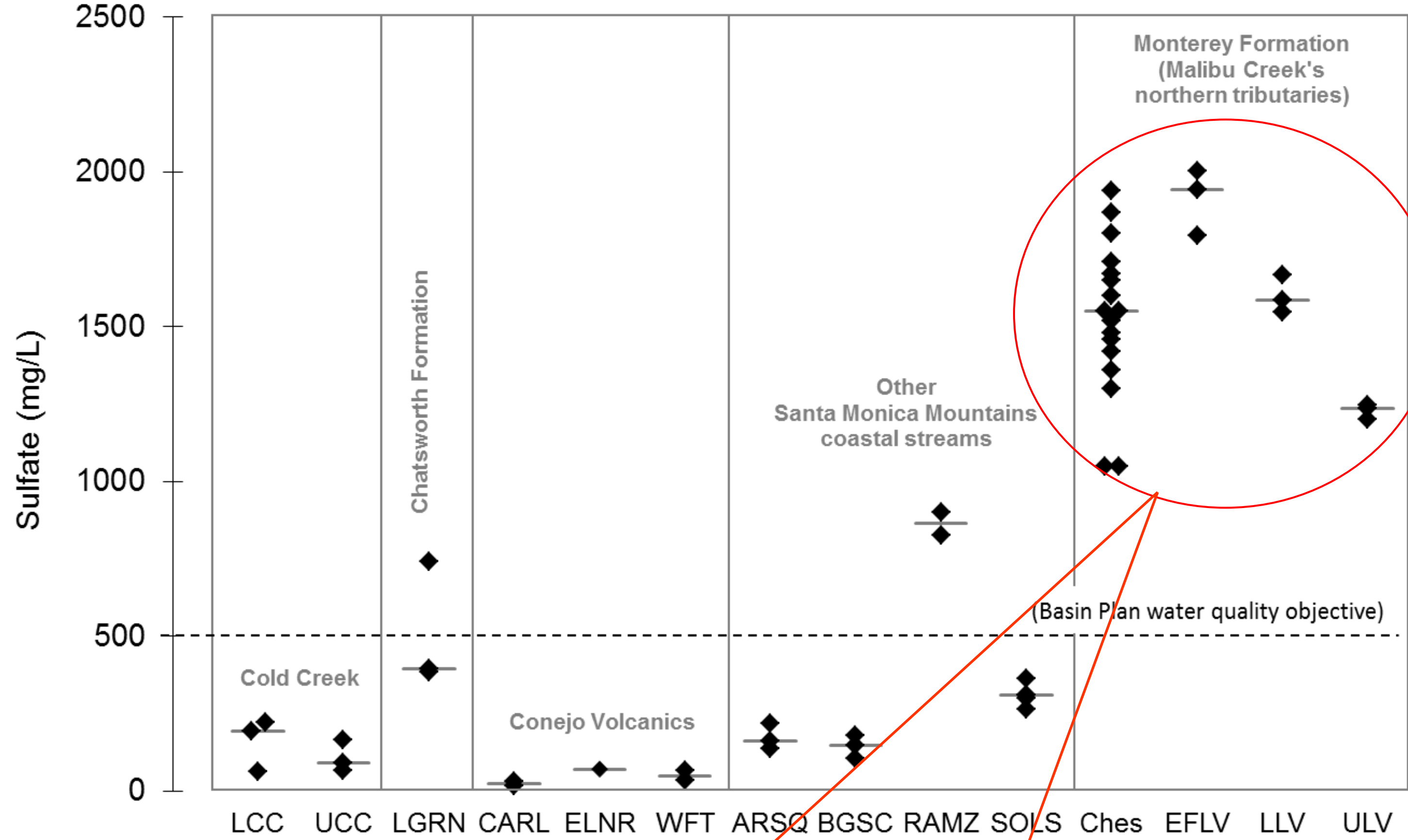
Sulfate is a major component of Specific Conductance (SC), and is tightly correlated with SC in Malibu Creek (R^2=0.85).

Like SC, **sulfate levels in Malibu Creek are a blend** of high sulfate levels from the creek's northern tributaries and lower sulfate water from is western and eastern tributaries (see figure, left).

Sulfate mg/L

Sulfate mg/L					Annual Record				Seasonal Record and Exceedance Details																
Is annual median > Water Quality Objective?	Region	Reach	Land Use	Site	Median	25th Percentile	75th Percentile	Count	Median Wet	25th Percentile Wet	75th Percentile Wet	Count Wet	Median Dry	25th Percentile Dry	75th Percentile Dry	Count Dry	Median > TMDL	25th Percentile > TMDL	75th Percentile > TMDL	Median Wet >TMDL	25th %ile Wet >TMDL	75th %ile Wet >TMDL	Median Dry >TMDL	25th %ile Dry > TMDL	75th %ile Dry >TMDL
Yes	North	all sites combined			1560	1400	1690	123	1560	1420	1670	57	1560	1395	1690	66	!	!	!	!	!	!	!	!	!
Yes	North	Cheeseboro	all sites combined		1550	1460	1705	17	1650	1520	1705	9	1515	1238	1668	8	!	!	!	!	!	!	!	!	!
Yes	North	Cheeseboro	Developed	Ches	1550	1450	1680	16	1600	1505	1680	8	1515	1238	1668	8	!	!	!	!	!	!	!	!	!
Yes	North	Cheeseboro	Open Space	J_CHEESEBRO	1705			1	1705			1				0	!			!					
Yes	North	Las_Virgenes	all sites combined		1582	1463	1688	90	1560	1460	1655	39	1590	1465	1695	51	!	!	!	!	!	!	!	!	!
Yes	North	Las_Virgenes	Developed	LVCreek_Farm_LV3	1680	1653	1748	14	1680	1613	1733	6	1680	1660	1760	8	!	!	!	!	!	!	!	!	!
Yes	North	Las_Virgenes	Developed	LVCreek_WhiteOak_LV4	1745	1698	1760	14	1750	1203	1758	6	1740	1713	1830	8	!	!	!	!	!	!	!	!	!
Yes	North	Las_Virgenes	Developed	RSW_MC001F	1450	1390	1500	13	1480	1450	1495	6	1410	1345	1495	7	!	!	!	!	!	!	!	!	!
Yes	North	Las_Virgenes	Developed	RSW_MC002F	1630	1560	1630	13	1625	1575	1630	6	1630	1555	1660	7	!	!	!	!	!	!	!	!	!
Yes	North	Las_Virgenes	Developed	RSW_MC003F	1530	1470	1560	13	1520	1135	1538	6	1540	1485	1590	7	!	!	!	!	!	!	!	!	!
Yes	North	Las_Virgenes	Developed	RSW_MC007D	1540	1440	1578	14	1565	1513	1588	6	1520	1400	1548	8	!	!	!	!	!	!	!	!	!
Yes	North	Las_Virgenes	Developed	S_LLASVIR	1585			3	1668			1	1566			2	!			!			!		
Yes	North	Las_Virgenes	Open Space	J_EFLASVIR	1943			3	1796			1	1973			2	!			!			!		
Yes	North	Las_Virgenes	Open Space	S_ULASVIR	1238			3	1203			1	1243			2	!			!			!		
Yes	North	Liberty Canyon	all sites combined		1705	1281	1900	8	1705	1397	1795	6	1733			2	!	!	!	!	!	!	!		
Yes	North	Liberty Canyon	Developed	LibertyCanyonCrkatSewerXing	1790	1668	2100	6	1780	1630	1800	5	2300			1	!	!	!	!	!	!	!		
Yes	North	Liberty Canyon	Developed	R1_LIBCYN	1242			2	1319			1	1165			1	!			!			!		
Yes	North	Medea_1	all sites combined		998			3	987			1	1003			2	!			!			!		
Yes	North	Medea_1	Developed	S_LMEDCRK	998			3	987			1	1003			2	!			!			!		
Yes	North	Medea_2	all sites combined		1287	1147	1362	5	1158			2	1362			3	!	!	!	!			!		
Yes	North	Medea_2	Developed	R1_MEDCRK	1088			2	1029			1	1147			1	!			!			!		
Yes	North	Medea_2	Developed	S_UMEDCRK	1362			3	1287			1	1472			2	!			!			!		
	East	all sites combined			128	74	186	6	142			2	117			4									
	East	Cold	all sites combined		128	74	186	6	142			2	117			4									
	East	Cold	Developed	J_LCOLDCRK	193			3	193			1	142			2									
	East	Cold	Open Space	J_UCOLDCRK	90			3	90			1	117			2									
	West	all sites combined			34			3	53			2	16			1									
	West	Carlisle	all sites combined		25			2	34			1	16			1									
	West	Carlisle	Developed	S_CARLISLE	25			2	34			1	16			1									
	West	Eleanor	all sites combined		72			1	72			1				0									
	West	Eleanor	Developed	R1_ELEANOR	72			1	72			1				0									
Yes	Central	all sites combined			670	414	1020	117	530	378	834	84	1030	722	1110	33	!		!	!		!	!	!	!
Yes	Central	Malibu	all sites combined		670	414	1020	117	530	378	834	84	1030	722	1110	33	!		!	!		!	!	!	!
Yes	Central	Malibu	Developed	J_MALICRKU	654			3				0	654			3	!						!		
Yes	Central	Malibu	Developed	R1_MALICRK	822			2				0	822			2	!						!		
Yes	Central	Malibu	Developed	RSW_MC001U	989	656	1107	46	803	519	1056	30	1094	1053	1303	16	!	!	!	!	!	!	!	!	!
	Central	Malibu	Developed	RSW_MC002D	456	360	978	40	397	356	561	30	1005	864	1093	10			!			!	!	!	!
Yes	Central	Malibu	Developed	RSW_MC009U	530	348	727	26	530	363	770	24	428			2	!		!	!		!			
Yes	Lower	all sites combined			544	405	759	108	512	395	660	89	761	703	836	19	!		!	!		!	!	!	!
Yes	Lower	Malibu	all sites combined		544	405	759	108	512	395	660	89	761	703	836	19	!		!	!		!	!	!	!
Yes	Lower	Malibu	Developed	J_MALICRKL	835	826	844	2				0	835	826	844	2	!	!	!				!	!	!
Yes	Lower	Malibu	Developed	RSW_MC003D	544	421	756	34	513	416	624	28	760	752	805	6	!		!	!		!	!	!	!
Yes	Lower	Malibu	Developed	RSW_MC004D	530	418	671	29	535	423	680	28	360			1	!		!	!		!			
Yes	Lower	Malibu	Developed	RSW_MC013D	550	374	806	34	462	368	728	28	934	722	1083	6	!		!			!	!	!	!
Yes	Lower	Malibu	Developed	S02	682	448	712	9	448	401	494	5	731			4	!		!				!		
Yes	Lower	Lagoon	all sites combined		932	655	1285	30	853	638	1218	24	1178	806	1383	6	!	!	!	!	!	!	!	!	!
Yes	Lower	Lagoon	Developed	RSW_MC011D	932	655	1285	30	853	638	1218	24	1178	806	1383	6	!	!	!	!	!	!	!	!	!

Sulfate in Malibu Creek's northern tributaries in relation to its east and west tributaries and other nearby Santa Monica Mountains coastal streams – undeveloped sites only.



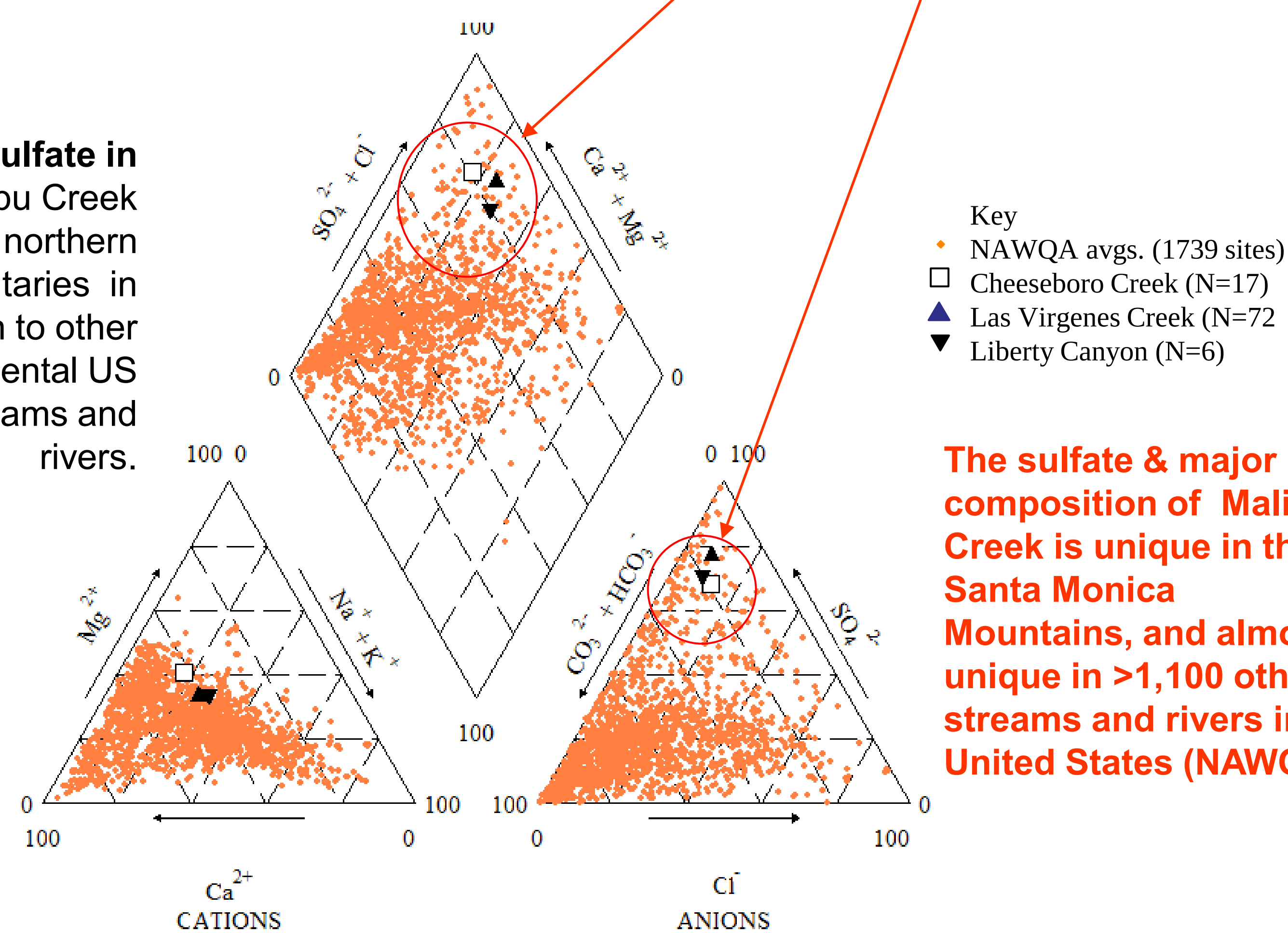
Sulfate

Extraordinarily high natural levels of sulfate render Malibu Creek and its northern tributaries unfit for human consumption

Water quality: Except for western and eastern tributaries, even *minimum* sulfate levels exceed the US EPA secondary drinking water standard year-round, and usually exceed the Los Angeles Basin Plan objective as well. **Annual & Seasonal variation:** Sulfate levels fell following the 2004-05 wet winter, but have since risen to their earlier levels in excess of 1,500 mg/L. Sulfate levels vary slightly seasonally, peaking in dry weather. **Source assessment:** Aside from the lagoon (which receives ~885 mg sulfate per liter of seawater), Malibu Creek's northern tributaries are clearly the major source of sulfate in the watershed. These tributaries drain the Monterey Formation, which contains high levels of sulfur in comparison to other geologic formations in the watershed (See Natural Source Assessment). **No known human sources (aside from coal and shale mining, neither of which occur in the watershed) are capable of yielding sulfate levels equivalent to those recorded.** Sulfate levels in northern tributaries are particularly high, constituting 68% - 72% of the total major anions and 43% - 55% of the TDS, which ranges from 2127 - 4048 mg/L. For comparison, these sulfate levels are over an order of magnitude higher than those found in imported State Water Project water (SWP). The major ions in SWP are sodium and chloride, which attain levels of less than 8% of TDS in Malibu Creek's northern tributaries. **Historical Trends:** Consistent with a natural source, there are no apparent long-term trends in sulfate levels in the watershed beyond slight decreases following wet winters, based on the recent period of record (2002-08) and earlier measurements by the LARWQCB in 1974.

Potential impacts on aquatic life: Sulfate is a known predictive indicator of diatom species composition and abundance in freshwater streams (Potapova and Charles, 2003). As noted earlier in this report, high sulfate levels support brackish water benthic diatoms such as *Pleurosira laevis* (El-Awamri , 2008) - the dominant diatom in "Malibu muck" (see Natural Source Assessment). Anaerobic condition within dense *Pleurosira*-dominated algal mats can be a source of hydrogen disulfide gas when sulfate-reducing bacteria decompose organic detritus from these algal mats. Elevated sulfate levels will also affect macroinvertebrate community assemblages (Goodfellow *et al.*, 2000). Pond *et al.* (2008) found statistically-significant negative correlations between all eight indices of macroinvertebrate community health and concentrations of sulfate (mean 696, max 1520 mg/L) in West Virginia streams affected by coal mining, levels equal-to or less than those measured in the Malibu Creek watershed.

Sulfate in Malibu Creek and northern tributaries in relation to other continental US streams and rivers.



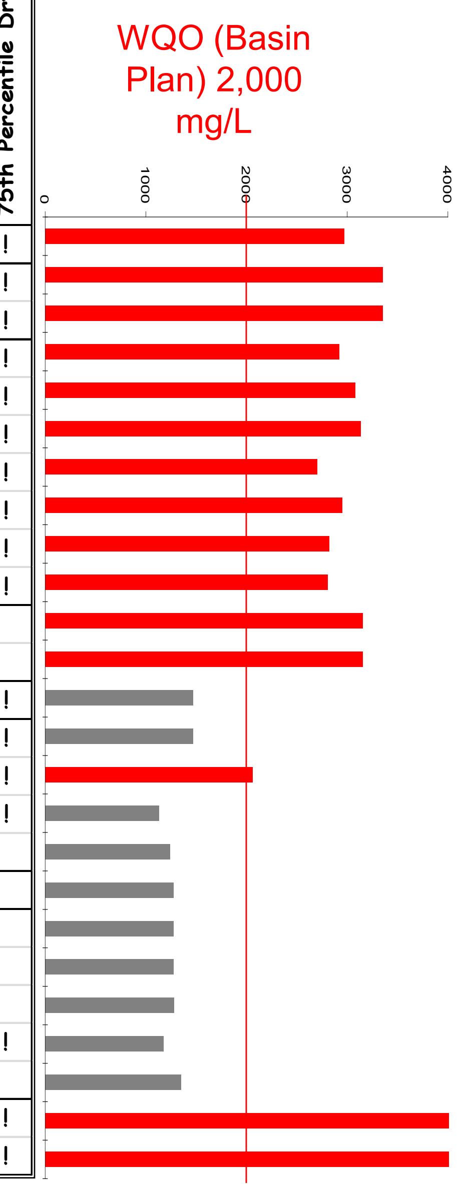
The sulfate & major ion composition of Malibu Creek is unique in the Santa Monica Mountains, and almost unique in >1,100 other streams and rivers in the United States (NAWQA).

Comparisons with other streams. To the left we have superimposed the U.S. Geological Survey National Water Quality Assessment (NAWQA) Program dataset for over 1,100 US streams and rivers with our results for two northern tributaries of Malibu Creek. The overlay shows how exceptionally high in sulfate, magnesium and calcium Malibu Creek watershed streams are in comparison with other US streams and rivers.

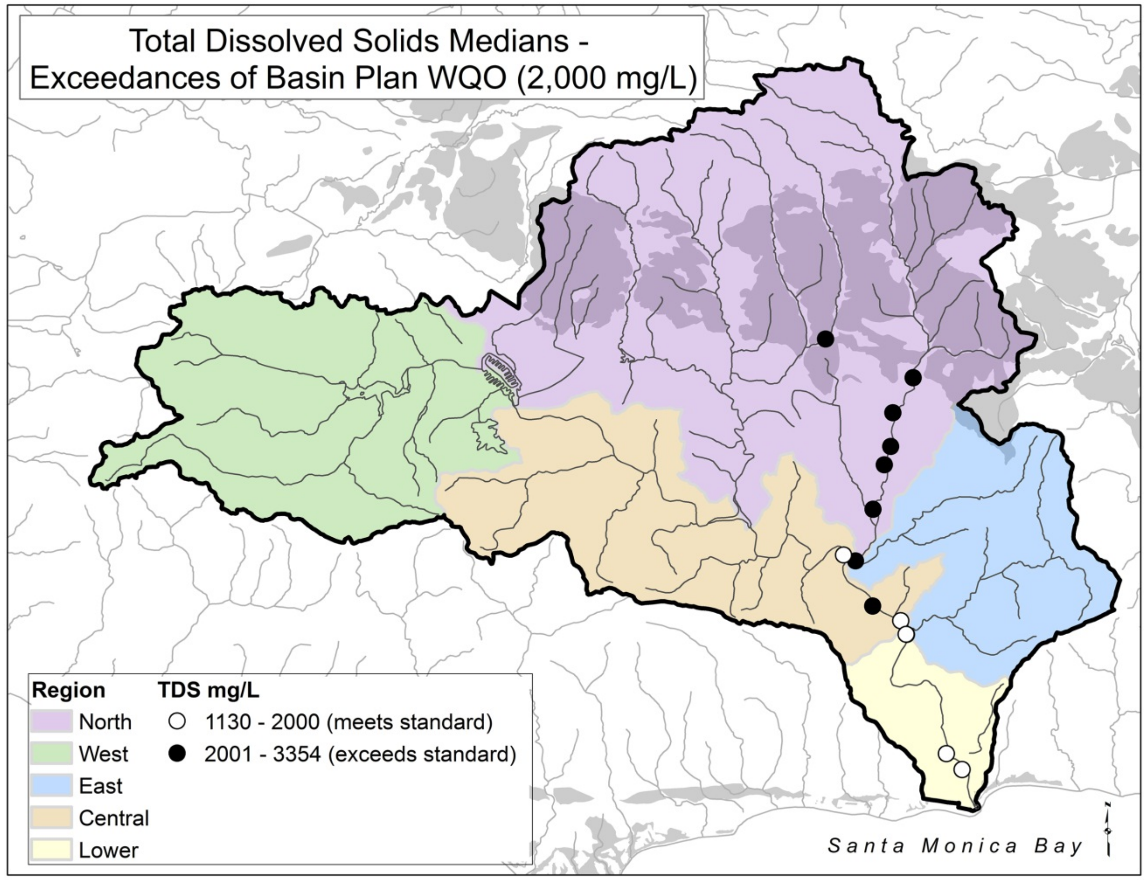
Regulatory implications: The only stream or reach listed in the current 303(d) list for sulfate is Malibu Creek, which sometimes meets the Basin Plan objective of 500 mg/L. Water at northern headwaters streams with no upstream development rarely or never meet the standard. The Basin Plan standard for the Malibu Creek watershed should be revised – sulfate concentrations in the watershed are clearly elevated due to a natural geologic source.

Total Dissolved Solids (TDS) mg/L

Total Dissolved Solids (mg/L)					Annual Record				Seasonal Record								Exceedance details								
Is annual median > Water Quality Objective?	Region	Reach	Land Use	Site	Median	25th Percentile	75th Percentile	Count	Median Wet	25th Percentile Wet	75th Percentile Wet	Count Wet	Median Dry	25th Percentile Dry	75th Percentile Dry	Count Dry	Median	25th Percentile	75th Percentile	Median wet >TMDL	25th Percentile Wet	75th Percentile Wet	Median DRY >TMDL	25th Percentile Dry > TMDL	75th Percentile Dry >TMDL
Yes	North	all sites combined			2970	2770	3155	103	2970	2770	3120	49	2982	2775	3198	54	!	!	!	!	!	!	!	!	!
Yes	North	Cheeseboro	all sites combined		3354	3017	3429	16	3365	3225	3414	8	3354	2806	3505	8	!	!	!	!	!	!	!	!	!
Yes	North	Cheeseboro	Developed	Ches	3354	3017	3429	16	3365	3225	3414	8	3354	2806	3505	8	!	!	!	!	!	!	!	!	!
Yes	North	Las_Virgenes	all sites combined		2920	2770	3100	81	2895	2758	3015	36	2940	2770	3140	45	!	!	!	!	!	!	!	!	!
Yes	North	Las_Virgenes	Developed	LVCreek_Farm_LV3	3080	2970	3158	14	3075	3035	3123	6	3110	2943	3243	8	!	!	!	!	!	!	!	!	!
Yes	North	Las_Virgenes	Developed	LVCreek_WhiteOak_LV4	3135	3093	3175	14	3105	3000	3150	6	3145	3123	3345	8	!	!	!	!	!	!	!	!	!
Yes	North	Las_Virgenes	Developed	RSW_MC001F	2700	2550	2860	13	2710	2655	2825	6	2620	2525	2875	7	!	!	!	!	!	!	!	!	!
Yes	North	Las_Virgenes	Developed	RSW_MC002F	2950	2910	3010	13	2965	2920	2995	6	2920	2850	3090	7	!	!	!	!	!	!	!	!	!
Yes	North	Las_Virgenes	Developed	RSW_MC003F	2820	2790	2880	13	2815	2780	2828	6	2820	2795	2940	7	!	!	!	!	!	!	!	!	!
Yes	North	Las_Virgenes	Developed	RSW_MC007D	2805	2503	2953	14	2865	2788	2898	6	2665	2455	3010	8	!	!	!	!	!	!	!	!	!
Yes	North	Liberty Canyon	all sites combined		3155	3038	3783	6	3120	3010	3190	5	3980			1	!	!	!	!	!	!	!		
Yes	North	Liberty Canyon	Developed	LibertyCanyonCrkatSewerXing	3155	3038	3783	6	3120	3010	3190	5	3980			1	!	!	!	!	!	!	!		
	Central	all sites combined			1470	1053	2193	106	1260	1030	1840	83	2300	1790	2330	23			!				!		!
	Central	Malibu	all sites combined		1470	1053	2193	106	1260	1030	1840	83	2300	1790	2330	23			!				!		!
Yes	Central	Malibu	Developed	RSW_MC001U	2060	1430	2300	41	1700	1280	2250	29	2300	2265	2560	12	!		!			!	!	!	!
	Central	Malibu	Developed	RSW_MC002D	1130	991	2000	39	1062	976	1358	30	2200	1830	2320	9							!		!
	Central	Malibu	Developed	RSW_MC009U	1242	906	1650	26	1242	919	1703	24	1085			2									
	Lower	all sites combined			1275	1035	1690	106	1240	1050	1470	89	1750	976	1870	17									
	Lower	Malibu	all sites combined		1275	1035	1690	106	1240	1050	1470	89	1750	976	1870	17									
	Lower	Malibu	Developed	RSW_MC003D	1275	1061	1643	34	1245	1074	1463	28	1715	1141	1808	6									
	Lower	Malibu	Developed	RSW_MC004D	1280	1084	1490	29	1300	1089	1505	28	976			1									
	Lower	Malibu	Developed	RSW_MC013D	1176	989	1733	34	1115	1003	1510	28	1995	1155	2300	6									!
	Lower	Malibu	Developed	S02	1350	970	1790	9	970	922	1340	5	1830			4									
Yes		Lagoon	all sites combined		7525	3095	11325	30	6695	3105	10575	24	10230	3758	14700	6	!	!	!	!	!	!	!	!	!
Yes		Lagoon	Developed	RSW_MC011D	7525	3095	11325	30	6695	3105	10575	24	10230	3758	14700	6	!	!	!	!	!	!	!	!	!



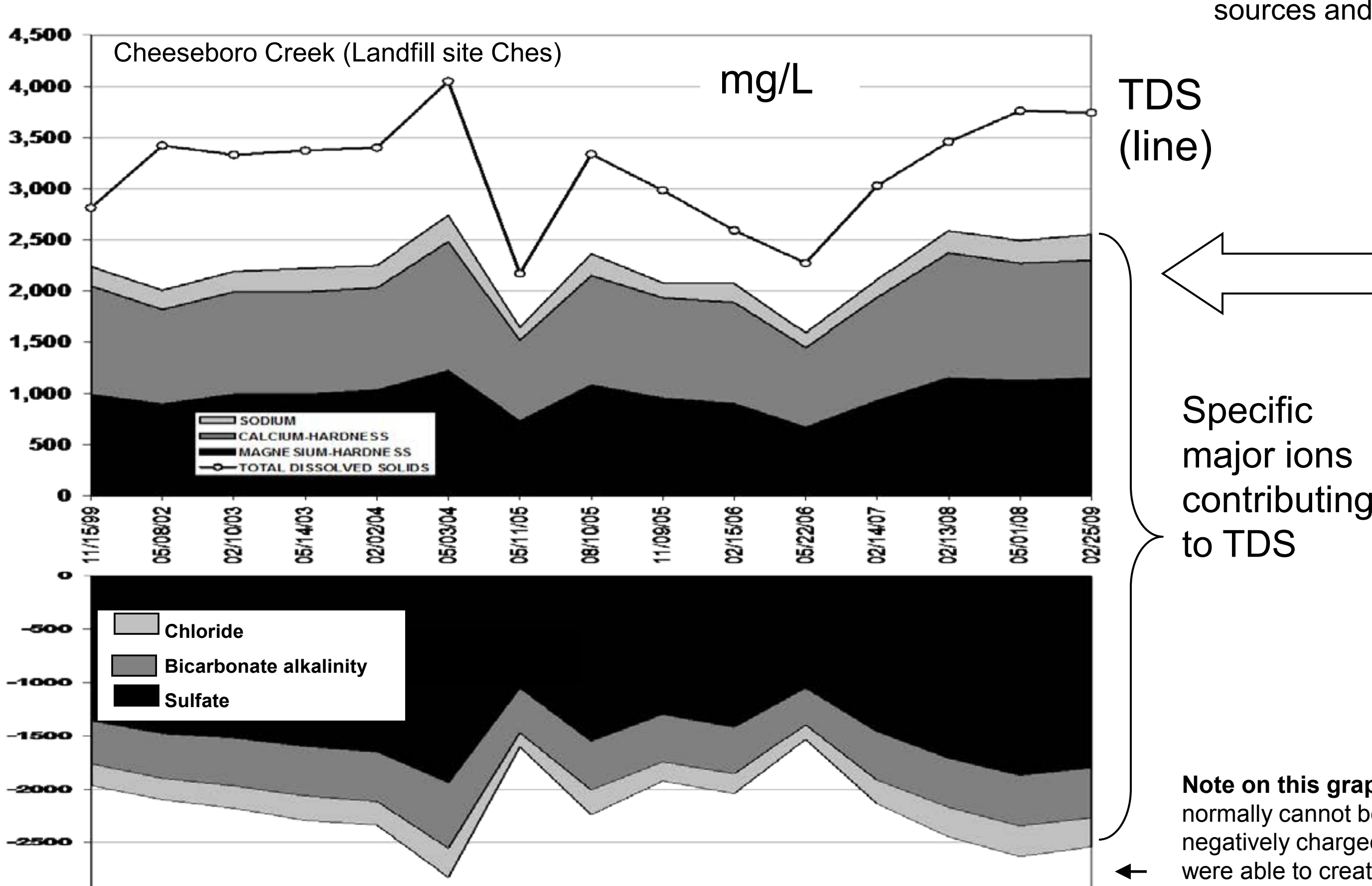
Note no data for Western & Eastern tributaries. However, see page on Specific Conductance for these tributaries, which is highly correlated to TDS



Total Dissolved Solids (TDS)

Unusually high natural TDS in Malibu Creek and its northern tributaries exceed the Basin Plan Water Quality Objective for drinking water (MCL)

Water quality: Specific conductance (SC) measures the ability of water to pass an electrical current. SC in water increases as the levels of inorganic dissolved solids increase such as chloride, sulfate, magnesium and calcium, the first three of which are exceptionally high in Malibu Creek, and extraordinarily high in its northern tributaries draining the Monterey / Modelo Formation (see Piper diagram - Sulfate page). The Basin Plan water quality objective for TDS is exceeded by median, 25th and 75th percentile at upper watershed sites. Of note, the WQO is more frequently exceeded at RSW-MC001U, upstream of Tapia WRF, than it is at RSW-MC002D, which is downstream. SC is also tightly correlated with Total Dissolved Solids (TDS) in Malibu Creek. Except for Malibu Creek's western and eastern tributaries, *minimum SC* levels exceed the US EPA secondary drinking water standard of 500 mg/L year-round. **Annual & Seasonal variation:** Total dissolved solids concentrations appear to decrease after years of heavy rain, such as in 2005. Seasonal fluctuation in TDS reflects variation in ionic concentrations, which peak in dry weather. **Source assessment:** Previous pages on the mineral composition of water in Malibu Creek watershed describe high concentrations of chloride, sulfate and selenium. While the piper diagram in the earlier section on sulfate shows that Malibu Creek watershed water is unusual in its ionic composition, the diagram does not indicate concentration. This water has unique composition at high concentration. To repeat one finding, sulfate concentrations in northern headwaters are over an order of magnitude higher than that found in imported State Water Project water. **Historical Trends:** Consistent with a natural source, there are no apparent long-term trends in TDS levels in the watershed beyond slight decreases following wet winters. Note the drop in TDS below Malibu Creek's confluence with Cold Creek, which has fresher water. **Regulatory implications:** The Basin Plan standard of 2,000 mg/L TDS may be unattainable due to natural geologic sources and should be revised. **Potential impacts on aquatic life:** See Specific Conductance and Sulfate pages.



Why are TDS and SC so high in Malibu Creek? Both TDS and SC are composite measures of all the solutes in a given water sample. To determine which solutes are responsible for high TDS or SC, one must further analyze the ionic composition of the sample, which is rarely done. The figure at left shows TDS (line in upper portion of graph), major cations (above) and major anions (below and shown with negative value to reflect charge) variation at one of Malibu Creek's northern tributaries (Cheeseboro Creek) over the last decade, revealing very high levels of sulfate (major anion) and calcium and magnesium (major cations). Recent tests by the US Geological Survey found similar percentages of these elements in lower Malibu Creek, with TDS and SC levels virtually identical to those measured by other agencies sampling the same location at the same time. Note also the decrease in major ions over the very wet winter of 2005-06.

Note on this graph's negative Y axis. The use of a negative scale for a parameter that normally cannot be negative simply connotes that these ions, measured in mg/L, are negatively charged (anions). By the simple expedient of multiplying the anion data by (-1), we were able to create this figure that graphically illustrates the general mirroring of cation and anion levels expected under electrical neutrality for all ions combined.

Aquatic Life

An analysis of water quality parameters based on aquatic life or known to affect aquatic life

Parameters analyzed:

1. Ammonia – compiled but not presented (no exceedances any sample, any site)

2. Benthic Macroinvertebrate Assessments – Analysis of JPA southern California IBI scores (7 sites) from 2006–10. See also our discussion of benthic macroinvertebrate surveys by Luce (2003) in the Natural Source Assessment section

3. Eutrophication - Includes long-term data on biostimulatory substances (phosphorus, nitrogen), algal cover, pH, dissolved oxygen

4. Metals except mercury and lead (covered in the Human Health section) are treated under the Mineral Quality section under CTR test results. See also Natural Source Assessment section and cross-agency results for metals in the Organic Compounds section

5. Sulfate, SC, TDS, selenium – Covered in the section on Mineral Quality and Natural Source Assessment sections

Parameters not analyzed: Total organic carbon, Malibu Lagoon Benthic Community Effects (no data), New Zealand mudsnail surveys (well-covered in other cited reports by Aquatic Bioassay and Consulting Laboratories and the Santa Monica Bay Restoration Commission (M. Abramson)).

Major findings: (1) Ammonia. No exceedances detected at any station by any program over four decades. **(2) Benthic Macroinvertebrates**: 35 benthic macroinvertebrate bioassessments were conducted at seven sites in Malibu Creek from 2006-10 using the southern California Index of Biotic Integrity (IBI) scoring system. IBI scores were rarely better than “poor” at any monitored location. A review of the scientific literature found that benthic macroinvertebrate bioassessment scores are sensitive to high levels of sulfate, specific conductance and total dissolved solids (TDS) at concentrations regularly exceeded in Malibu Creek. **(3) Eutrophication and biostimulatory substances (nutrients):** Compilation of nutrient data from upstream reference sites located in undeveloped areas north of the 101 freeway found naturally high background levels of phosphate and nitrate, higher than current water quality standards and well-above those necessary to sustain high algal growth. We also identified a natural geological source in these areas consistent with these exceedances (Section 3). However, the data also show that pH and dissolved oxygen (DO) levels, key measures of the *intensity* of eutrophication, were within regulatory limits at all stations except the east fork of upper Las Virgenes creek (two DO exceedances) and Liberty Canyon creek (two DO exceedances). *High algal growth in Malibu Creek is probably a natural phenomenon caused by the presence of high levels of biostimulatory substances in upstream marine Tertiary shales and siltstone in Malibu Creek’s northern headwaters.* **(4) pH**: No exceedances any station, any program. **(5) Dissolved Oxygen (DO)**: Wet season DO levels never exceeded regulatory standards in 523 samples measured at 84 sites. Dry season DO levels met standards in 632 of 636 tests (99.4%), except for 2 exceedances in Liberty Canyon Creek and 2 exceedances in Las Virgenes Creek (east fork), as discussed in (3) above. There is also a strong seasonal component to DO, with higher values in winter. **(6) Metals known to affect aquatic life**: The concentration of 23 metals were tested in surface runoff and local creeks immediately following a small rain event in 2009. With the exception of selenium (highest in upper Las Virgenes Creek), the highest levels for all metals tested occurred in surface runoff from both freshly graded and weathered exposures of the Monterey / Modelo Formation (M Fm) north of the 101 freeway in open space areas above all development. These levels were consistently higher than those measured in both urban runoff and in creeks outside of the Monterey / Modelo Formation. See “First Rain Event” results in Section 3. Their relative abundances and concentrations measured further downstream in Malibu Creek at station RSW-MC001 were also consistent with this natural source (i.e. lower than undiluted M Fm runoff but higher than those measured in urban runoff). Their relative abundances in M Fm runoff were also consistent with those measured in algae, crayfish and fish from the CTR test site. **(7) Selenium (Se)**: Moderate to high Se levels in water and fish tissue samples are consistent with selenium and minor element levels in native rock and runoff within the Monterey / Modelo Formation north of the 101 freeway. We found no evidence of any human Se source in the watershed consistent with those measured.

Eutrophication defined for this report: Eutrophication refers to the process whereby high levels of nutrients favor algal growth in amounts that adversely affect water quality and aquatic life.

Some definitions of eutrophication on the Web:

“Excessive nutrients in a lake or other body of water, usually caused by runoff of nutrients (animal waste, fertilizers, sewage) from the land, which causes a dense growth of plant life; the decomposition of the plants depletes the supply of oxygen, leading to the death of animal life.” wordnetweb.princeton.edu/perl/webwn

“Eutrophication: The slow aging process during which a lake, estuary, or bay evolves into a bog or marsh and eventually disappears. During the later stages of eutrophication the water body is choked by abundant plant life due to higher levels of nutritive compounds such as nitrogen and phosphorus. Human activities can accelerate the process.” *water.epa.gov/scitect/swguidance/waterquality/standards/criteria/aqlife/pollutants*

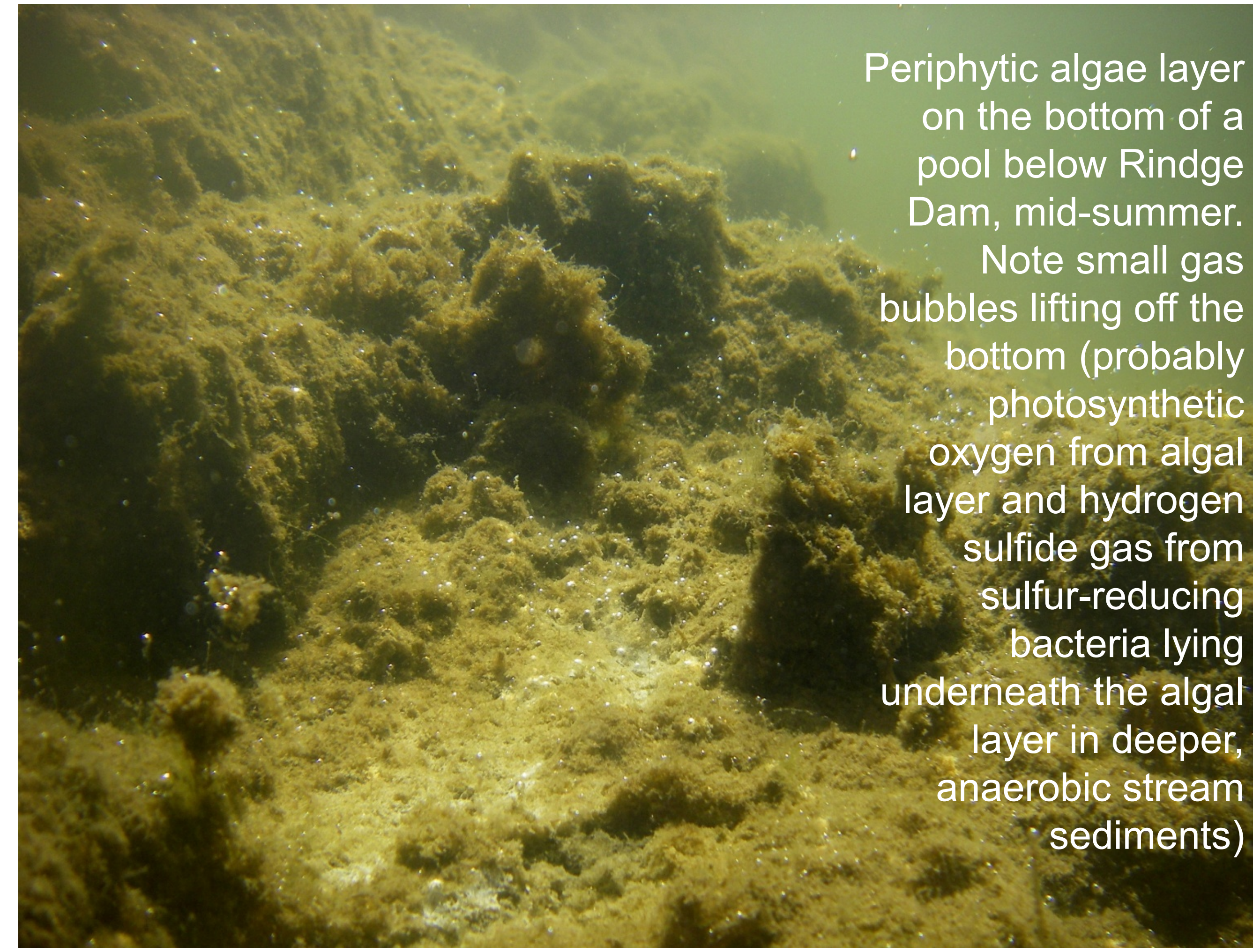
“Eutrophication is an increase in the concentration of chemical nutrients in an ecosystem to an extent that increases the primary productivity of the ecosystem.” wikipedia.org/wiki/Eutrophication

“Eutrophication reduces the oxygen dissolved within a body of water, producing an environment that does not readily support aquatic life.” ww.dnr.state.md.us/criticalarea/glossary.html

“The natural or artificial process of nutrient enrichment whereby a water body becomes filled with aquatic plants and low oxygen content. The low oxygen level is detrimental to fish.” www.mnr.gov.on.ca/en/Business/Water/2ColumnSubPage/STEL02_163778.html

“Addition of excessive nutrients (usually nitrates or phosphates) to a body of water, leading to overgrowth of aquatic plants.” tycho.knowlton.ohio-state.edu/gloss.html

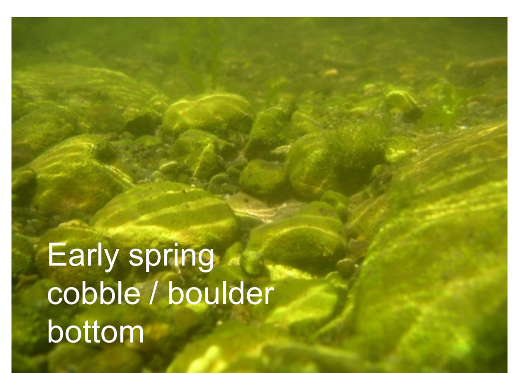
Some examples of algal growth in Malibu Creek



Periphytic algae layer on the bottom of a pool below Rindge Dam, mid-summer. Note small gas bubbles lifting off the bottom (probably photosynthetic oxygen from algal layer and hydrogen sulfide gas from sulfur-reducing bacteria lying underneath the algal layer in deeper, anaerobic stream sediments)

Examples of benthic algal diatoms, floating macroalgae mats & late summer drying in Malibu Creek. Note dried algae and white precipitated minerals covering streambed in last photo

(photos R. Orton except where noted)



Early spring cobble / boulder bottom

Summer boulder habitat

Summer pool (courtesy ABC Labs)

Late summer drying above Malibu civic center

Eutrophication

Eutrophication is a process or chain of events that begins with unusually high levels of biostimulatory substances – typically nitrogen and phosphorus – that can trigger algal blooms, which in turn can affect water quality in ways inimical to aquatic life. Key water quality parameters used to detect potential eutrophication problems are wide swings in pH and low levels of dissolved oxygen (DO) in the water, particularly at night when algae become net oxygen users rather than producers. If persistent either in time or area, sub-standard DO can kill via suffocation those aquatic species that cannot tolerate it.

In Malibu Creek, there is ample evidence for both nutrient enrichment and abundant algal growth (particularly in the dry season months). But pH and DO generally meet applicable Basin Plan standards at all stations tested by the reporting agencies in our dataset. Seasonality in algal abundance is due at least in part to winter storm events that scour and mobilize algal mats, and by lower winter temperatures and lower light levels that reduce re-growth rates by half in comparison with summer rates. Riparian shading and water depth also reduce algal growth, especially in the mat-forming *Cladophora* and *Rhizoclonium* algal species that favor full sunlight. Growth in these species can also be limited in mid-summer by high temperatures, and a mid-summer dip in their abundance is evident in the data coincident with peak temperatures. However, while these moderating factors help explain areas where algal abundance is low despite high nutrient levels, in general Malibu Creek has more algae than other coastal streams draining to Santa Monica Bay (Luce and Abramson, 2005). This is probably due to nutrient levels in excess of those needed to sustain maximum algal growth in Malibu Creek. Nor is this a new phenomenon; excessive algal growth in Malibu Creek was noted as early as 1947 in a state Department of Fish and Game report, when urbanization of the watershed consisted of fewer than 500 homes and over a decade before the arrival of imported potable and recycled water.

These observations argue for a nutrient source that predates urban development, consistent with the presence of phosphatic rock in the upper watershed, as detailed in the Natural Source Assessment section. **Our analysis:** Following a brief description of eutrophication, we review the data on those water quality parameters commonly linked to eutrophication, including nutrients (phosphorus and nitrogen), dissolved oxygen and pH.

Biostimulatory substances (Phosphorus, Nitrogen), Algal growth (% cover over time), pH and Dissolved Oxygen

Our findings: The data show that Malibu Creek and most of its northern and some of its western tributary streams are eutrophic, exceeding the nutrient TMDL phosphorus and nitrogen targets for summer, but not winter. Exceedances occur even at sites located in undeveloped open space within the Monterey Formation, a natural geologic source enriched in phosphorus, nitrogen, and TOC (see Natural Source Assessment section). **Exceptions:** Eastern tributaries outside of the Monterey Formation generally meet all nutrient standards (e.g. Cold Creek). The data also show algal growth commonly exceeds the numerical guidance on percent cover commonly used by state regulators based on **Biggs (2000)** to define excessive or nuisance algal growth (though usually absent his caveats on natural eutrophication in watersheds with exposures of phosphatic rock, such as Malibu Creek – see next page). In the summer, algal growth results in widespread floating mats of the cosmopolitan (world-wide) *Cladophora* and *Rhizoclonium* species which reach maximum biomass in high conductivity waters such as Malibu Creek. In both summer and winter, benthic diatoms (a group of single-celled algae) grow as thick films adhering to rocks and other hard substrates. Taxonomic surveys of diatoms in Malibu Creek (Chapman, 1979) are dominated by species identified as high conductivity favoring (Potapova and Charles, 2003). High sulfate levels in summer favor dense films of *Pleurosira laevis,* referred to locally as "Malibu muck" (Dagit *et al.,* 2009) along with colonies of sulfur-reducing bacteria at various locations in the creek. These colonies produce hydrogen sulfide gas (H_2S) as a metabolic by-product, which can impact aquatic life at relatively low concentrations.

Overall, the data and natural source assessment strongly suggest that elevated nutrients and algal growth are a **natural phenomena** in Malibu Creek and those tributaries that drain the Monterey Formation. While probably the most controversial finding of our analysis, it is well-documented in other areas where similar, nutrient-enriched formations occur, as described in the Natural Source Assessment section.

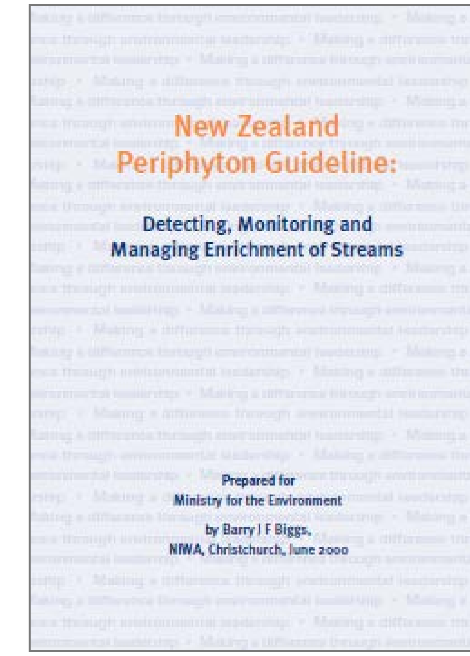
Regardless of their cause, high nutrient and algae levels in Malibu Creek have generally not resulted in widespread low dissolved oxygen and pH - two parameters usually affected by eutrophication via excessive algal growth and commonly used to gauge its severity and extent. DO and pH standards are consistently met at nearly all sample sites in both Malibu Creek and its tributaries. This may reflect the time of day these parameters are measured (DO and pH typically reach their minimum values at night); continuously-recording instruments have shown sub-standard DO levels in at least one pool in lower Malibu Creek in the summer of 2010 (Resource Conservation District of the Santa Monica Mountains, unpublished).

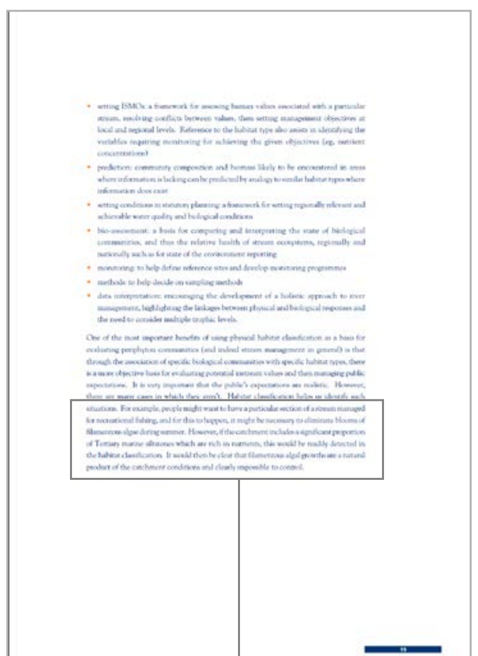
Chain of causality – Classic eutrophication in relation to eutrophication in Malibu Creek

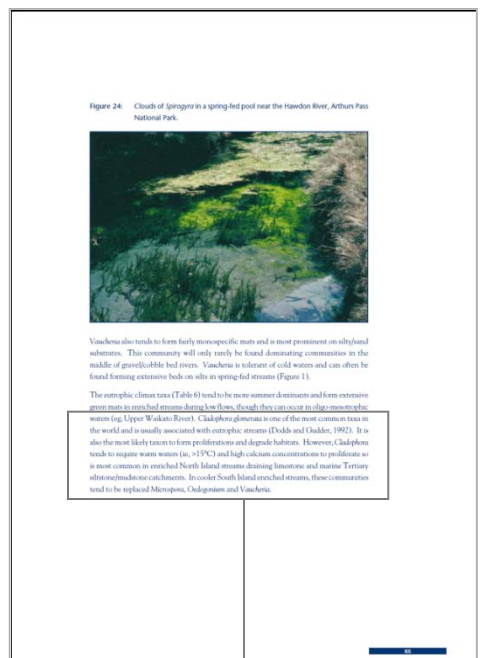
Enrichment of water with potential biostimulatory substances (phosphorus, nitrogen nutrients)	→	Algal growth	→	Potential secondary impacts of high algal growth on water quality (pH, dissolved oxygen)	→	Potential ultimate impacts of poor water quality on other aquatic life (fish, aquatic invertebrates)
Malibu Creek is unusual among Santa Monica Mountain coastal streams for natural levels of phosphorus and nitrogen higher than those necessary to support max. growth in both benthic and floating mat algal species in the creek. See Natural Source Assessment.		Malibu Creek has unusually high levels of the same algal species found elsewhere in the world in high conductivity watersheds draining nutrient-enriched marine Tertiary siltstones (e.g. *Cladophora glomerata, Rhizoclonium).* See following page.		Low pH and DO typical of extreme eutrophication are unusual in Malibu Creek, especially in the wetter winter months. See data pages and summaries for these parameters below.		Malibu Creek typically has not experienced the kinds of large, annual die-offs of fish and other aquatic life typical of highly eutrophic systems. An early fish kill in the l970's was shown to be due to high chlorine levels. More recent die-offs of steelhead trout in 2006 and 2009 could not be linked to any specific eutrophic condition, and remain unresolved as to their cause(s). See Dagit *et al*. (2009).

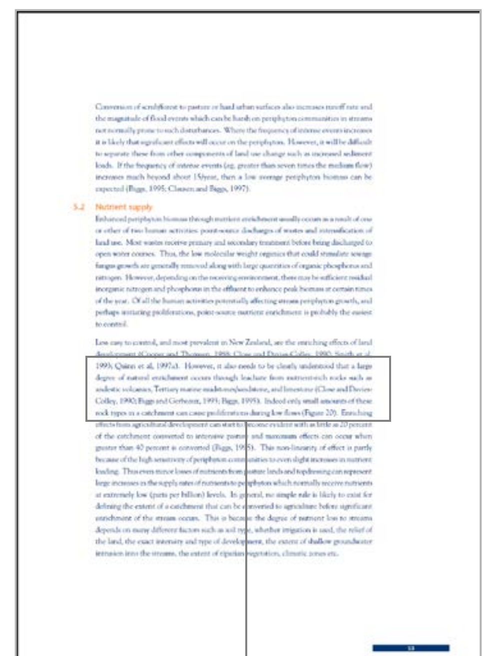
Why Tertiary marine siltstone in the Malibu Creek watershed is important for understanding its eutrophic condition

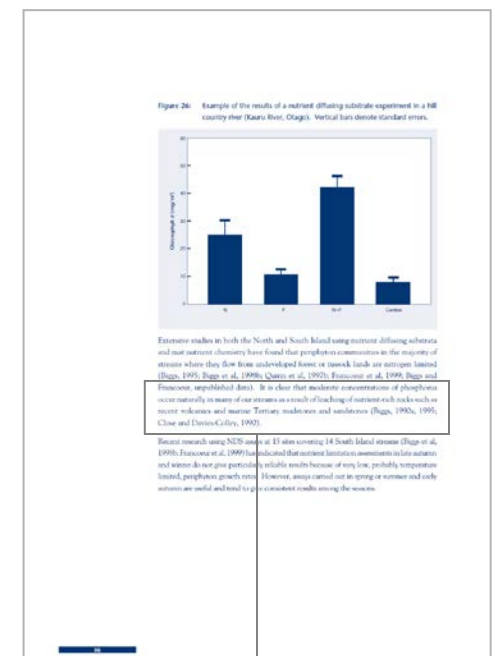
Biggs (2000) warns of natural eutrophication associated with nutrient-enriched marine Tertiary siltstones and andesitic volcanic rock ***5 times*** in his seminal work on periphyton algae control. However, neither the US EPA nutrient TMDL - intended to control nuisance algae - nor any of the three local studies of algae in Malibu Creek mentions or discusses the presence of the Monterey Formation, a marine Tertiary age sedimentary rock exposed throughout the creek's northern tributaries and areas adjacent to Malibu Lagoon, or the presence of volcanic andesitic rock, despite the availability of detailed geologic maps for the watershed and a US Geological Survey website warning of the environmental hazards associated with the Monterey Formation. Unusually high nutrient levels in undeveloped areas were noted in two studies (Luce, 2003; Luce & Abramson, 2005), but both studies attributed it to unidentified human sources such as historical nurseries (Ahmanson Ranch) and landfill leachate (Cheeseboro Creek).

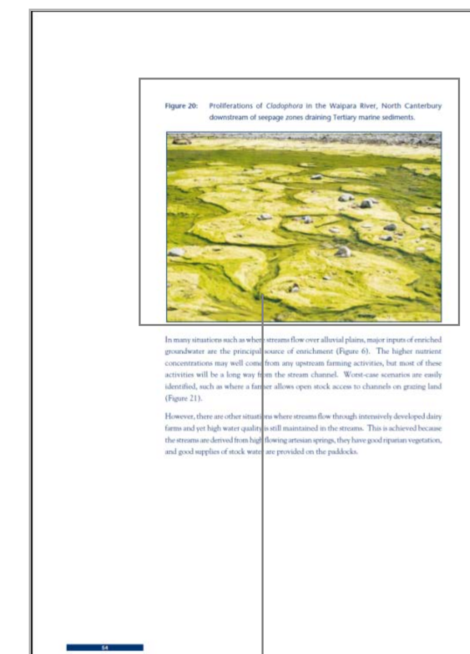












situations. For example, people might want to have a particular section of a stream managed for recreational fishing, and for this to happen, it might be necessary to eliminate blooms of filamentous algae during summer. However, if the catchment includes a significant proportion of Tertiary marine siltstones which are rich in nutrients, this would be readily detected in the habitat classification. It would then be clear that filamentous algal growths are a natural product of the catchment conditions and clearly impossible to control.

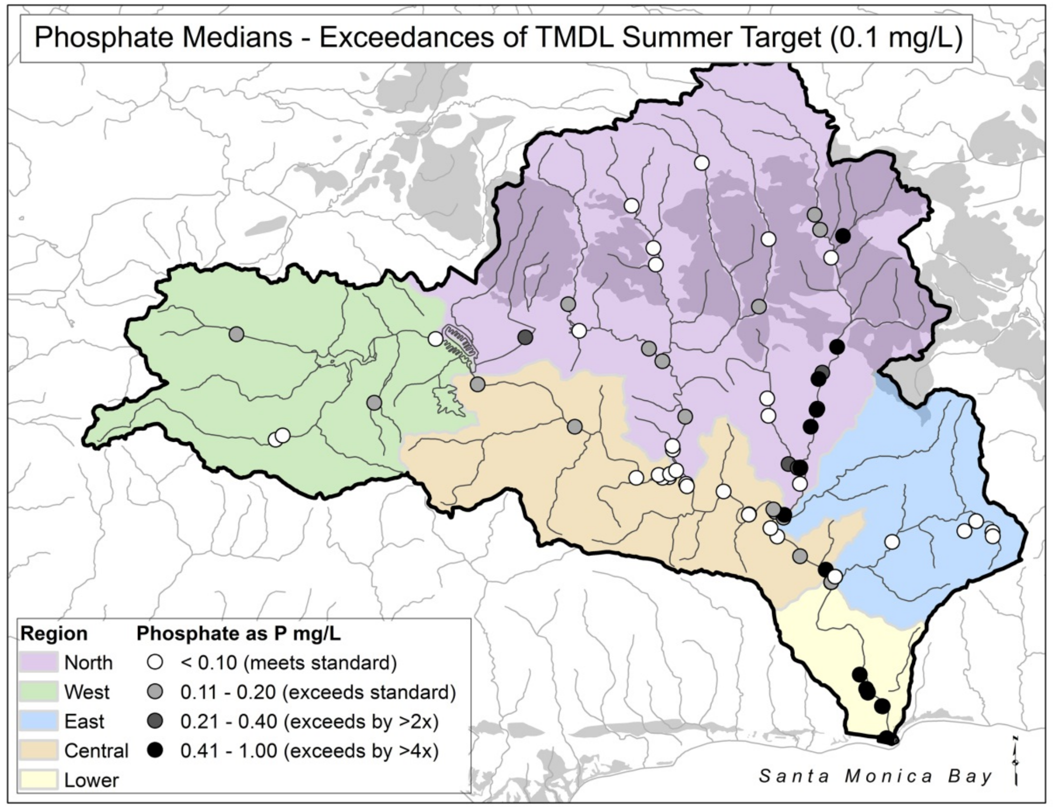
waters (eg, Upper Waikato River). *Cladophora glomerata* is one of the most common taxa in the world and is usually associated with eutrophic streams (Dodds and Gudder, 1992). It is also the most likely taxon to form proliferations and degrade habitats. However, *Cladophora* tends to require warm waters (ie, >15°C) and high calcium concentrations to proliferate so is most common in enriched North Island streams draining limestone and marine Tertiary siltstone/mudstone catchments. In cooler South Island enriched streams, these communities tend to be replaced *Microspora*, *Oedogonium* and *Vaucheria*.

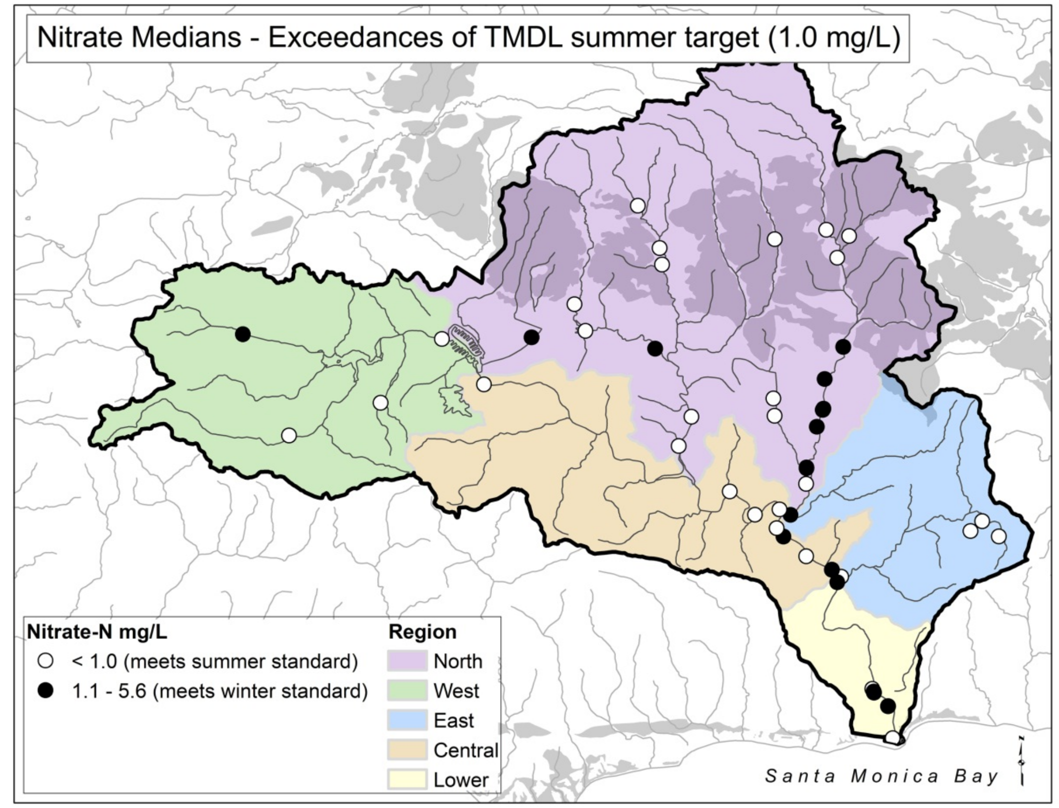
1993; Quinn et al, 1997a). However, it also needs to be clearly understood that a large degree of natural enrichment occurs through leachate from nutrient-rich rocks such as andestic volcanics, Tertiary marine mudstones/sandstone, and limestone (Close and Davies-Colley, 1990; Biggs and Gerbeaux, 1993; Biggs, 1995). Indeed only small amounts of these rock types in a catchment can cause proliferations during low flows (Figure 20). Enriching

Francoeur, unpublished data). It is clear that moderate concentrations of phosphorus occur naturally in many of our streams as a result of leaching of nutrient-rich rocks such as recent volcanics and marine Tertiary mudstones and sandstones (Biggs, 1990a, 1995; Close and Davies-Colley, 1990).

Figure 20: Proliferations of *Cladophora* in the Waipara River, North Canterbury downstream of seepage zones draining Tertiary marine sediments.

What the data show: Phosphate, Nitrate, pH, Dissolved Oxygen exceedance locations at a glance

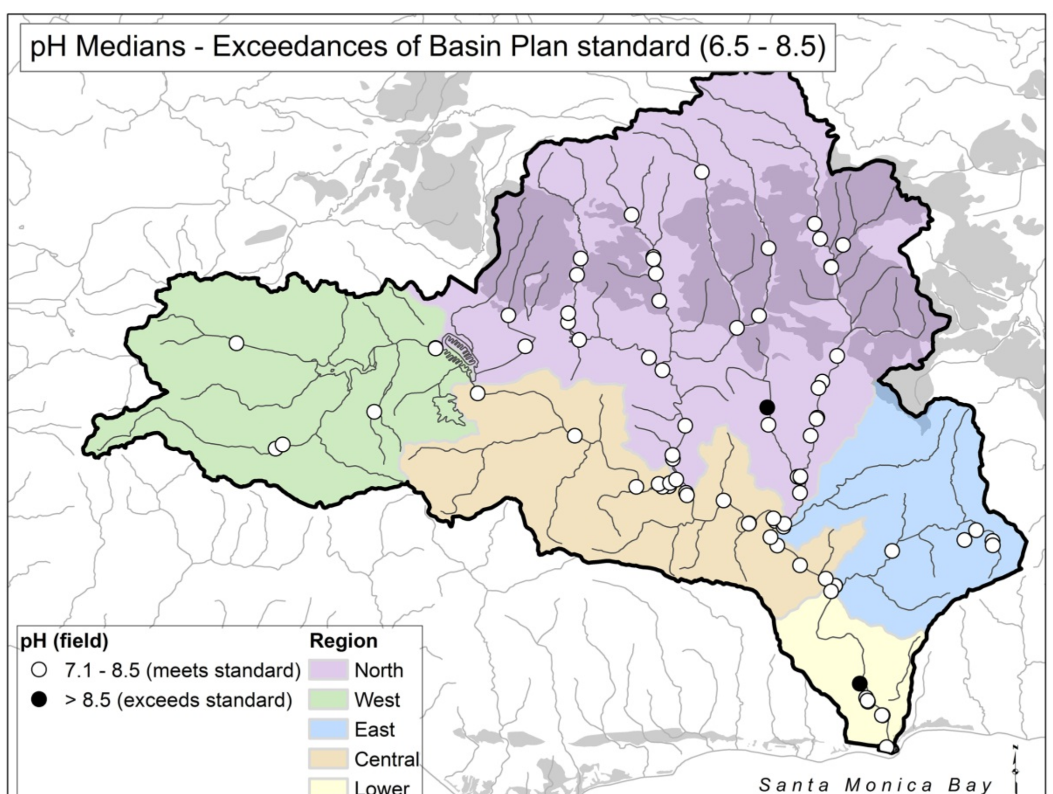


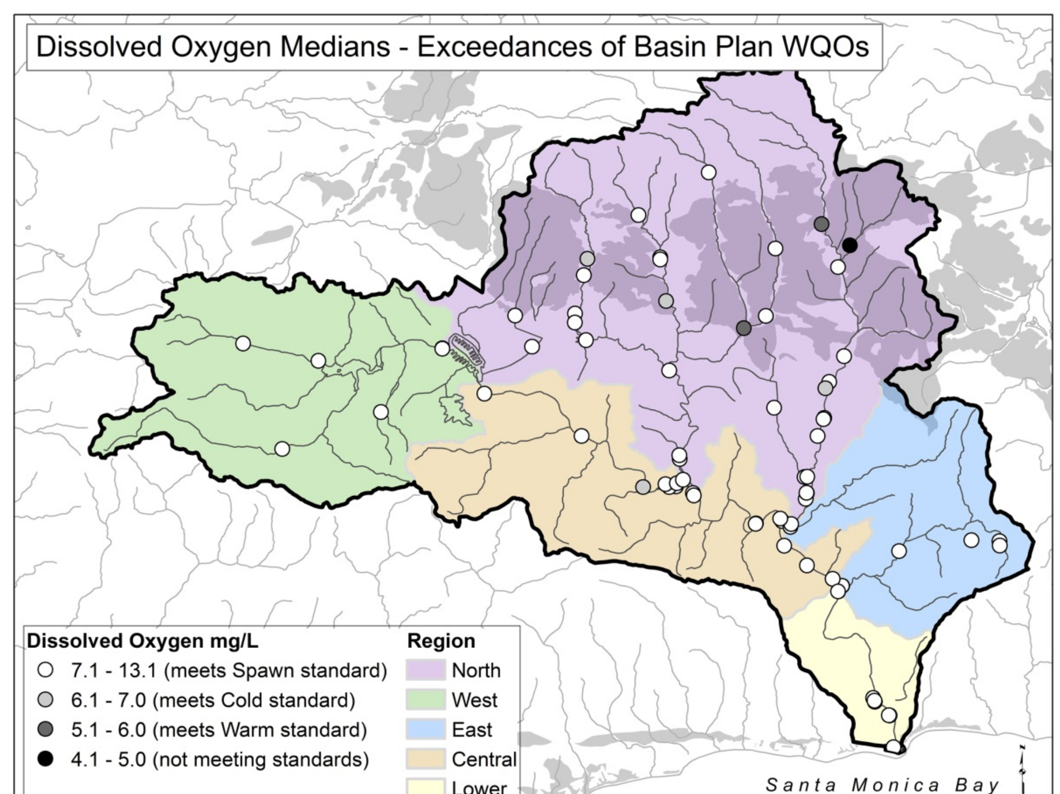


The US EPA Nutrient TMDL for Malibu Creek established seasonal targets for total nitrogen of 1 mg/L (summer) and 8 mg/L (winter) and for total phosphorus of 0.1 mg/L (summer). The figures to the left show where these targets are exceeded in the watershed.

The watershed is currently meeting its TMDL winter nitrogen targets at all stations. However, nitrate and phosphate exceed the more stringent summer targets at most stations in Malibu Creek,Las Virgenes Creek (beginning just above the 101 freeway for nitrate and within undeveloped M Fm for phosphate), at stations along the 101 corridor at the southern and downstream extent of the Monterey Formation, and at stations in the watershed's western region in Hidden Valley and Eleanor Creeks (neither of which are currently listed as impaired for nutrients).

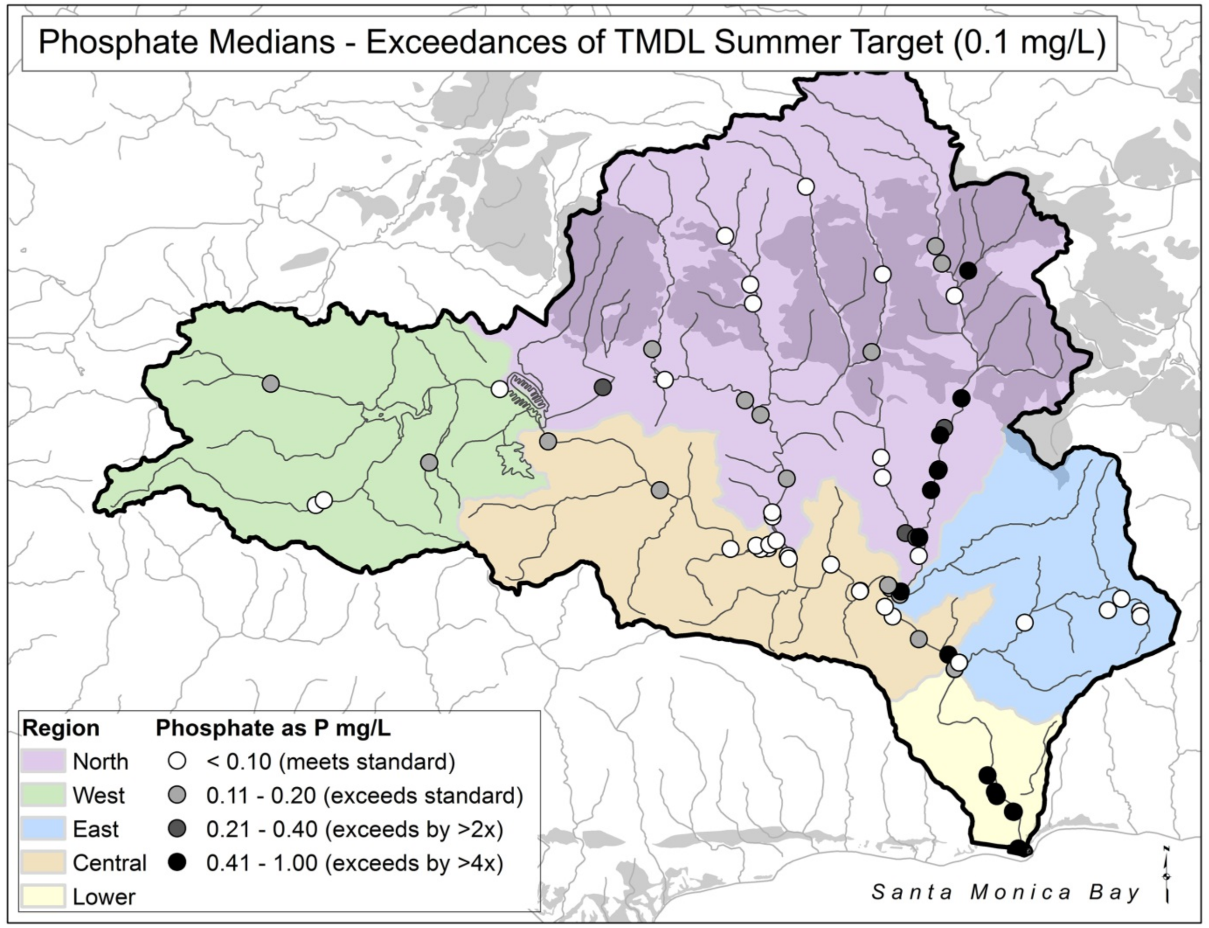
While not obvious from these figures, the summary statistics and bar graphs in following pages show that Malibu Creek's western tributaries, which drain Conejo Volcanic rock, are generally lower in phosphate than the northern tributaries that drain the phosphorus-rich Monterey Formation (see Natural Sources Assessment).

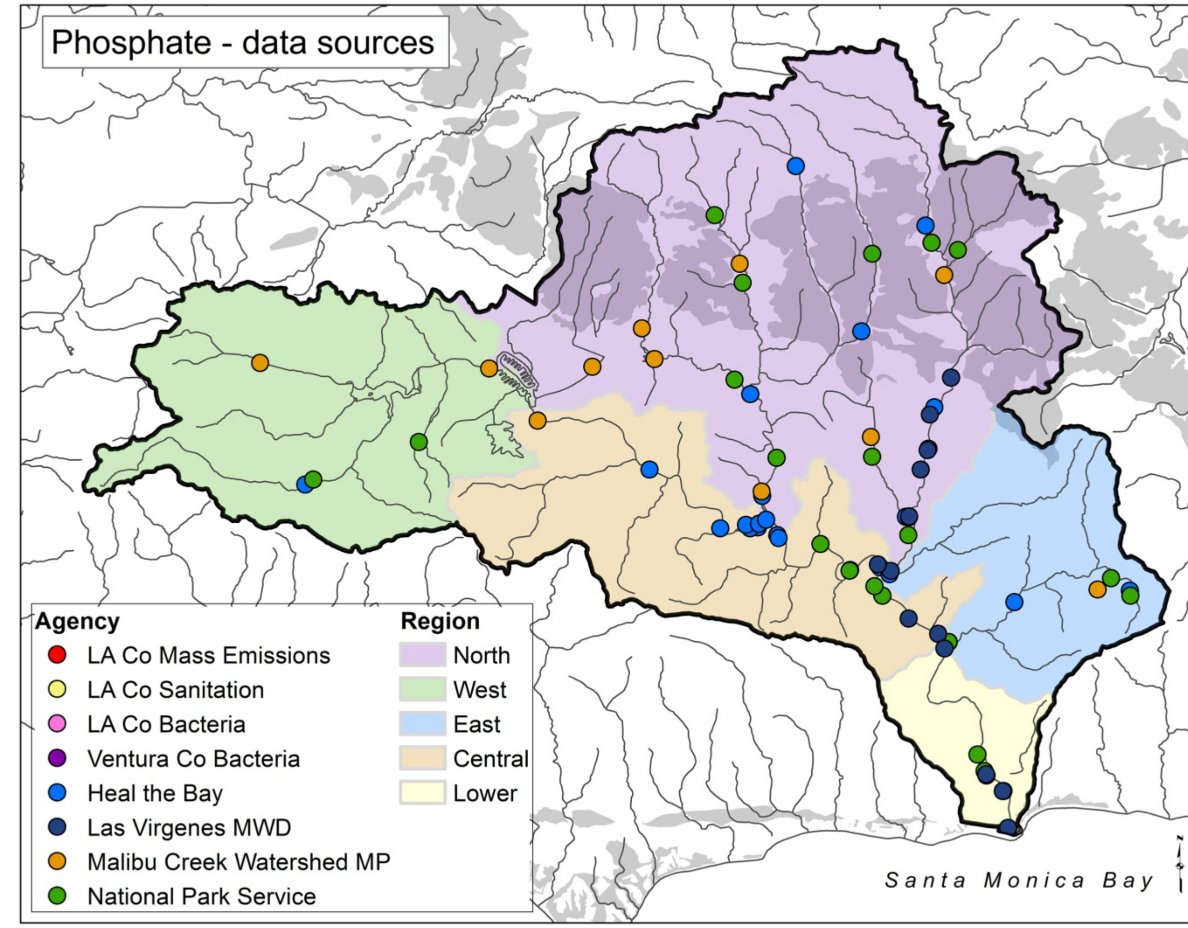




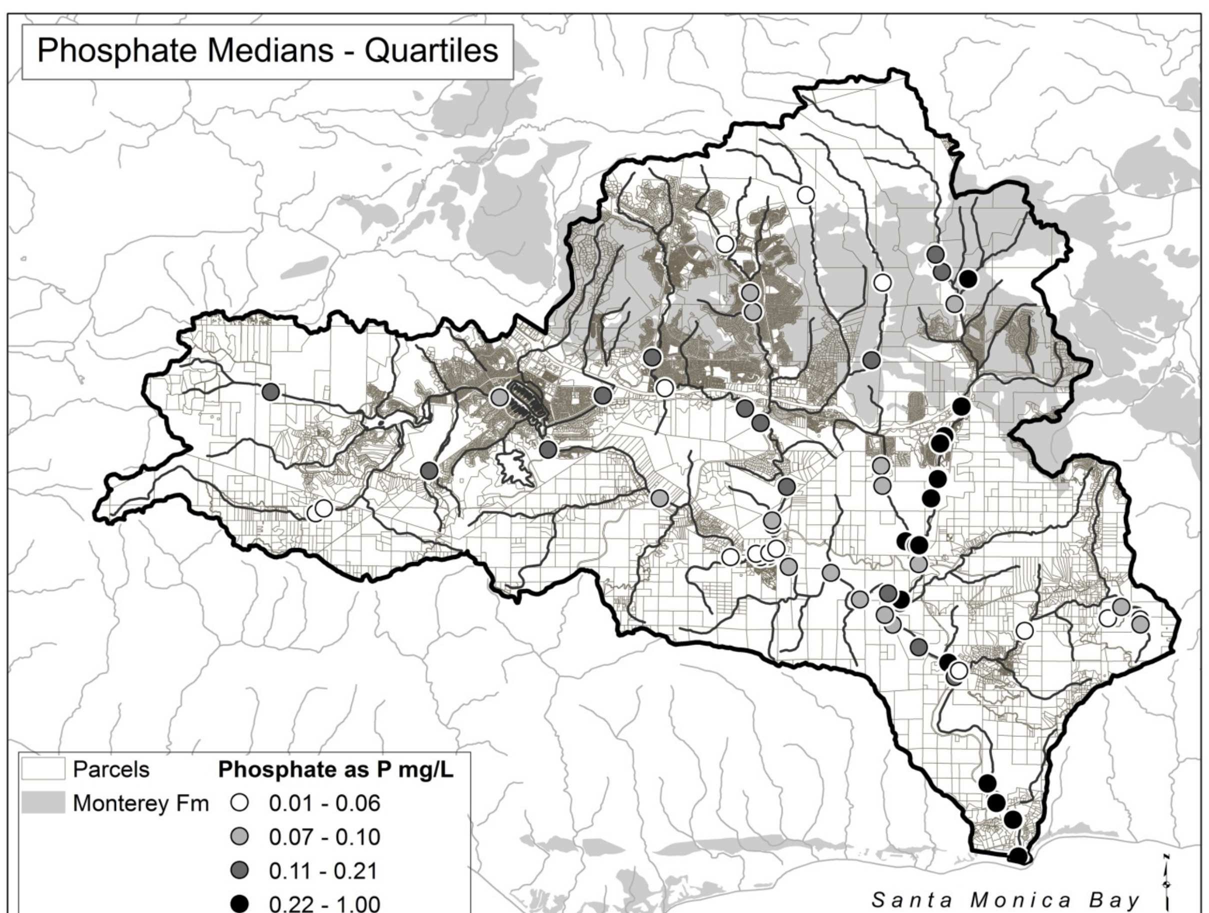
Two important parameters used to evaluate eutrophication are pH and Dissolved Oxygen (DO). The current 303(d) list reports no pH impairments in the watershed other than in Malibu Lagoon, but reports low DO in Las Virgenes Creek and three upper watershed artificial lakes. Listings for pH are consistent with our results except: no exceedances were found in Malibu Lagoon other than the dry season 75th percentile; Liberty Canyon site LC exceeded standards; and the single sample taken at R3_CrossCrk exceeded standards. Dissolved oxygen listings are also consistent with our results except: our analysis indicates that median values from Malibou Lake meet all standards in both seasons; and one station in upper Las Virgenes Creek (J_EFLasVir) that is not meeting the applicable DO objective (WARM). Inspection of the sample counts for this station show this result is based on 3 samples collected during the dry season. Our results are also consistent with the nutrient TMDL's findings on DO, which found little evidence of low DO in the winter, but recommended additional data might be useful. Our additional data corroborate the original finding by EPA.

This plot of phosphate exceedances shows that Malibu Creek and most of its tributaries exceed the summer TMDL phosphate limit of 0.1 mg/L, except for Cold Creek, which lies outside of both the Monterey Formation and most urban development. This plot also highlights the role of Las Virgenes Creek as a significant contributor of phosphate to Malibu Creek. The Monterey Formation in general has higher phosphate concentrations throughout than other formations, but also is known to have areas of phosphate accumulation. It appears the eastern tributaries of the northern region have such accumulations, which was also recognized by Hibbs (2011). See Geological setting and Natural Source Assessment sections for further information.





This plot of phosphate median quartiles against parcels and the Monterey Formation helps illustrate potential sources of phosphate in creeks. While all of the northern tributaries draining the Monterey Formation tend to be higher in phosphate (see summary statistics and associated bar graph in following pages on phosphorus), Las Virgenes Creek has unusually high phosphate levels from its east fork in Ahmanson Ranch (undeveloped) to its confluence with Malibu Creek. Undeveloped Cheeseboro Creek also increases in concentration through the Monterey Formation. Increases along Medea and Lindero Creeks could be from the Monterey Formation but are confounded by potential inputs from development.

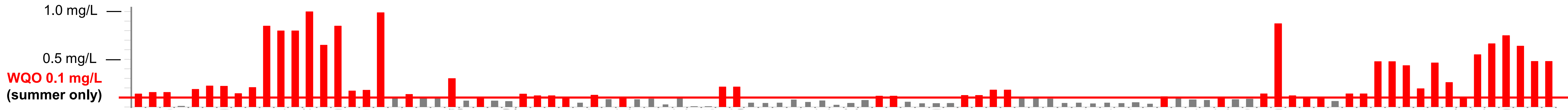


Data sources. Phosphate is measured by most agencies monitoring water quality in the Malibu Creek watershed, although sample sizes tend to be small for recent programs (see summary statistics table in following pages on phosphate.)

Phosphate versus Total Phosphorus: The bulk of phosphorus in local streams is in the form of phosphate, and this is the form commonly measured and reported for most agencies contributing to the dataset. However, the Malibu Creek TMDL phosphorus target is for Total Phosphorus, which is rarely measured. The use of phosphate – a subset of total phosphorus – for our analysis of exceedances is conservative for sites identified as exceeding the TMDL target, especially since these sites constitute the bulk of the watershed by area. It is less conservative for drainages such as Cold Creek, where phosphate alone rarely exceeds the TMDL target. Future sampling using total phosphorus is recommended for those drainages currently meeting the TMDL target on the basis of phosphate data alone.

Phosphate – additional detail

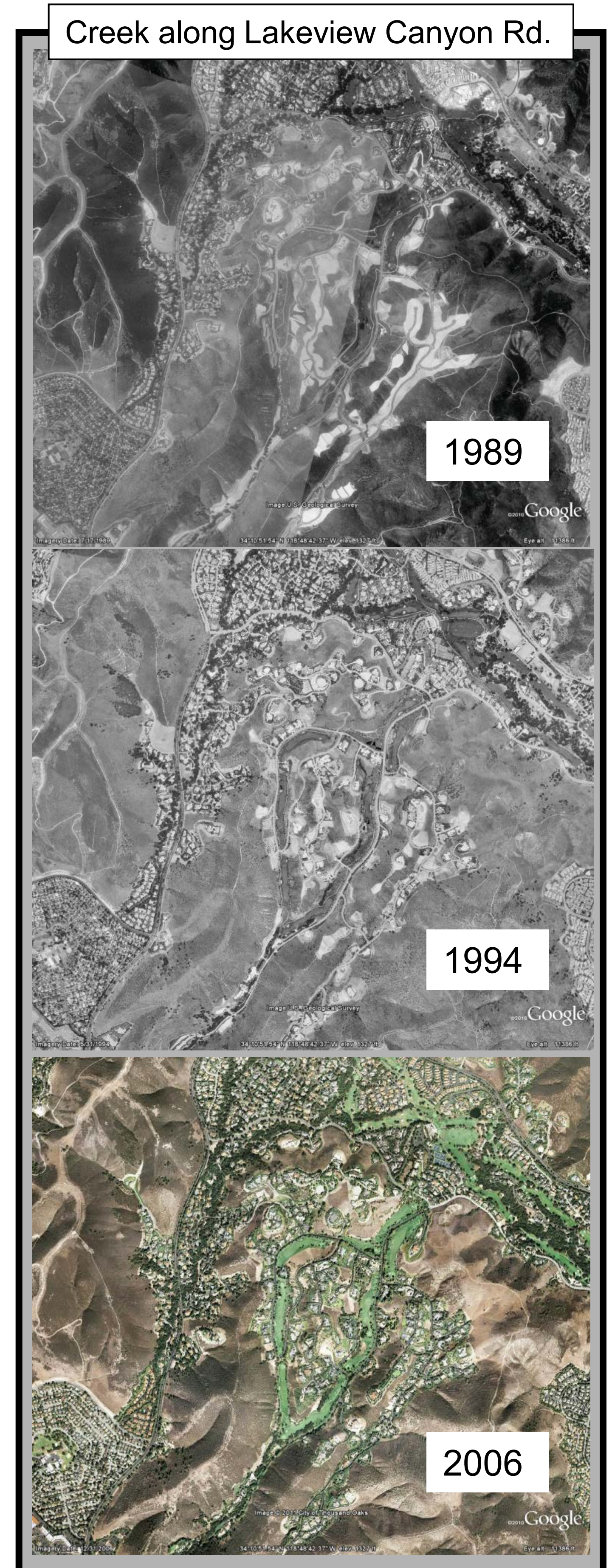
Phosphate as P – mg/L



Phosphate as P - mg/L

NOTE: P data from Heal the Bay sites converted from phosphate as orthophosphate

Region	Reach	Land Use	Site	Median	25th Percentile	75th Percentile	Count	Median Wet	25th Percentile Wet	75th Percentile Wet	Count Wet	Median Dry	25th Percentile Dry	75th Percentile Dry	Count Dry	Median wet >TMDL	Median DRY >TMDL	Is annual median > Summer Water Quality Objective?
North	all sites combined			0.14	0.07	0.21	722	0.14	0.08	0.20	322	0.14	0.07	0.22	400	!	!	
North	Cheeseboro	all sites combined		0.15	0.11	0.17	32	0.17	0.14	0.17	15	0.15	0.00	0.17	17	!	!	
North	Cheeseboro	Developed	6	0.15	0.12	0.17	31	0.17	0.14	0.17	14	0.15	0.00	0.17	17	!	!	
North	Cheeseboro	Open Space	J_CHEESEBRO	0.01			1	0.01			1				0			YES
North	Las_Virgenes	all sites combined		0.19	0.13	0.25	335	0.19	0.14	0.23	142	0.18	0.12	0.25	193	!	!	
North	Las_Virgenes	Developed	13	0.22	0.20	0.27	69	0.21	0.19	0.22	29	0.25	0.22	0.28	40	!	!	
North	Las_Virgenes	Developed	30	0.22	0.19	0.25	25	0.22	0.20	0.23	10	0.22	0.19	0.25	15	!	!	
North	Las_Virgenes	Developed	5	0.14	0.11	0.16	91	0.15	0.13	0.19	38	0.13	0.11	0.16	53	!	!	
North	Las_Virgenes	Developed	LV2	0.21	0.12	0.25	38	0.19	0.14	0.23	20	0.22	0.05	0.27	18	!	!	
North	Las_Virgenes	Developed	LVCreek_Farm_LV3	0.85			4	1.60			2	0.85			2	!	!	
North	Las_Virgenes	Developed	LVCreek_WhiteOak_LV4	0.80			4	1.65			2	0.80			2	!	!	
North	Las_Virgenes	Developed	RSW_MC001F	0.80			4	1.40			2	0.80			2	!	!	
North	Las_Virgenes	Developed	RSW_MC002F	1.00			4	1.70			2	1.00			2	!	!	
North	Las_Virgenes	Developed	RSW_MC003F	0.65			4	1.55			2	0.60			2	!	!	
North	Las_Virgenes	Developed	RSW_MC007D	0.85			4	1.60			2	0.85			2	!	!	
North	Las_Virgenes	Developed	S_LLASVIR	0.17	0.13	0.24	8	0.23			2	0.17	0.14	0.20	6	!	!	
North	Las_Virgenes	Open Space	9	0.18	0.15	0.21	30	0.17	0.15	0.20	10	0.19	0.16	0.22	20	!	!	
North	Las_Virgenes	Open Space	J_EFLASVIR	0.99	0.83	1.27	8	0.90			3	1.24	1.03	1.37	5	!	!	
North	Las_Virgenes	Open Space	LV1	0.09	0.05	0.14	34	0.12	0.09	0.16	16	0.06	0.02	0.09	18	!		YES
North	Las_Virgenes	Open Space	S_ULASVIR	0.13	0.06	0.16	8	0.09			2	0.13	0.08	0.16	6		!	
North	Liberty Canyon	all sites combined		0.09	0.06	0.17	45	0.12	0.07	0.20	21	0.08	0.03	0.15	24	!		YES
North	Liberty Canyon	Developed	LC	0.09	0.06	0.16	35	0.11	0.07	0.15	17	0.09	0.03	0.16	18	!		YES
North	Liberty Canyon	Developed	LibertyCanyonCrkatSewerXing	0.30			3	1.40			2	0.30			1	!	!	
North	Liberty Canyon	Developed	R1_LIBCYN	0.07	0.01	0.07	5	0.01			1	0.07			4			YES
North	Liberty Canyon	Developed	R3_LIBCYN	0.10			2	0.12			1	0.07			1	!		YES
North	Lindero_1	all sites combined		0.06	0.02	0.17	35	0.06	0.03	0.16	20	0.07	0.02	0.17	15			YES
North	Lindero_1	Developed	LIN2	0.06	0.02	0.16	33	0.06	0.03	0.17	19	0.06	0.02	0.16	14			YES
North	Lindero_1	Developed	R3_LADYFACE	0.14			2	0.09			1	0.19			1		!	
North	Lindero_2	all sites combined		0.12	0.10	0.18	31	0.12	0.11	0.17	16	0.10	0.09	0.19	15	!	!	
North	Lindero_2	Developed	LIN1	0.12	0.10	0.18	31	0.12	0.11	0.17	16	0.10	0.09	0.19	15	!	!	
North	Medea_1	all sites combined		0.10	0.05	0.14	141	0.08	0.06	0.12	58	0.10	0.05	0.16	83		!	YES
North	Medea_1	Developed	21	0.05	0.03	0.09	32	0.05	0.03	0.09	8	0.04	0.03	0.09	24			YES
North	Medea_1	Developed	7	0.13	0.09	0.18	65	0.09	0.07	0.13	27	0.16	0.11	0.20	38		!	
North	Medea_1	Developed	MED2	0.08	0.06	0.11	36	0.08	0.06	0.12	20	0.08	0.05	0.11	16			YES
North	Medea_1	Developed	S_LMEDCRK	0.10	0.05	0.14	8	0.12			3	0.09	0.03	0.14	5	!		
North	Medea_2	all sites combined		0.08	0.04	0.12	44	0.09	0.06	0.11	19	0.08	0.04	0.13	25			YES
North	Medea_2	Developed	MED1	0.09	0.06	0.13	32	0.09	0.07	0.12	16	0.08	0.04	0.15	16			YES
North	Medea_2	Developed	R1_MEDCRK	0.03			4	0.01			1	0.04			3			YES
North	Medea_2	Developed	S_UMEDCRK	0.09	0.04	0.12	8	0.07			2	0.10	0.05	0.12	6			YES
North	Palo_Comado	all sites combined		0.01	0.00	0.04	28	0.01	0.00	0.04	14	0.01	0.00	0.04	14			YES
North	Palo_Comado	Open Space	8	0.01	0.00	0.04	28	0.01	0.00	0.04	14	0.01	0.00	0.04	14			YES
North	Russell	all sites combined		0.21	0.07	0.27	31	0.15	0.07	0.23	17	0.26	0.08	0.41	14	!	!	
North	Russell	Developed	RUS	0.21	0.07	0.27	31	0.15	0.07	0.23	17	0.26	0.08	0.41	14	!	!	
East	all sites combined	all sites combined		0.05	0.02	0.09	256	0.05	0.02	0.08	106	0.04	0.02	0.09	150			YES
East	Cold	all sites combined		0.04	0.02	0.08	237	0.05	0.02	0.08	100	0.04	0.02	0.08	137			YES
East	Cold	Developed	11	0.05	0.04	0.06	19	0.05	0.05	0.06	6	0.04	0.00	0.05	13			YES
East	Cold	Developed	2	0.08	0.05	0.10	86	0.08	0.06	0.10	38	0.08	0.05	0.12	48			YES
East	Cold	Developed	J_LCOLDCRK	0.05	0.02	0.08	6	0.07			2	0.05			4			YES
East	Cold	Developed	R3_COLDCRK	0.07			2	0.05			1	0.09			1			YES
East	Cold	Open Space	3	0.02	0.01	0.03	89	0.02	0.01	0.03	38	0.03	0.02	0.03	51			YES
East	Cold	Open Space	CC	0.04	0.02	0.07	27	0.04	0.02	0.07	13	0.04	0.02	0.08	14			YES
East	Cold	Open Space	J_UCOLDCRK	0.07	0.01	0.09	8	0.04			2	0.08	0.03	0.11	6			YES
East	Stokes	all sites combined		0.12	0.11	0.14	19	0.13	0.11	0.14	6	0.12	0.11	0.12	13	!	!	
East	Stokes	Developed	16	0.12	0.11	0.14	19	0.13	0.11	0.14	6	0.12	0.11	0.12	13	!	!	
West	all sites combined			0.05	0.04	0.13	41	0.06	0.04	0.17	24	0.04	0.03	0.06	17			YES
West	Carlisle	all sites combined		0.04	0.03	0.05	24	0.04	0.03	0.06	11	0.04	0.03	0.05	13			YES
West	Carlisle	Developed	10	0.04	0.03	0.05	20	0.04	0.04	0.05	9	0.04	0.03	0.05	11			YES
West	Carlisle	Developed	S_CARLISLE	0.04			4	0.04			2	0.05			2			YES
West	Eleanor	all sites combined		0.12			3	0.08			2	0.16			1		!	
West	Eleanor	Developed	R1_ELEANOR	0.12			3	0.08			2	0.16			1		!	
West	Hidden Valley	all sites combined		0.18	0.17	0.20	9	0.18	0.17	0.20	7	0.17			2	!	!	
West	Hidden Valley	Developed	HV	0.18	0.17	0.20	9	0.18	0.17	0.20	7	0.17			2	!	!	
West	Potrero	all sites combined		0.09	0.06	0.11	5	0.10			4	0.02			1	!		YES
West	Potrero	Developed	POT	0.09	0.06	0.11	5	0.10			4	0.02			1	!		YES
Central	all sites combined			0.09	0.04	0.13	534	0.09	0.05	0.14	224	0.08	0.03	0.12	310			YES
Central	Malibou	all sites combined		0.04	0.03	0.09	193	0.04	0.03	0.05	46	0.05	0.02	0.10	147			YES
Central	Malibou	Developed	22	0.05	0.03	0.09	33	0.05	0.03	0.06	8	0.05	0.03	0.10	25			YES
Central	Malibou	Developed	23	0.04	0.02	0.09	32	0.03	0.03	0.04	8	0.04	0.02	0.10	24			YES
Central	Malibou	Developed	24	0.05	0.03	0.09	33	0.04	0.04	0.05	8	0.05	0.03	0.10	25			YES
Central	Malibou	Developed	26	0.04	0.03	0.09	32	0.03	0.03	0.03	8	0.05	0.02	0.11	24			YES
Central	Malibou	Developed	27	0.05	0.02	0.11	31	0.04	0.03	0.08	7	0.06	0.01	0.11	24			YES
Central	Malibou	Developed	28	0.03	0.03	0.05	32	0.04	0.03	0.04	7	0.03	0.02	0.06	25			YES
Central	Malibu	all sites combined		0.11	0.08	0.17	212	0.11	0.08	0.20	126	0.10	0.08	0.14	86	!	!	
Central	Malibu	Developed	12	0.09	0.07	0.11	70	0.09	0.06	0.10	29	0.09	0.07	0.12	41			YES
Central	Malibu	Developed	4	0.08	0.03	0.18	33	0.03	0.02	0.05	14	0.17	0.08	0.19	19		!	YES
Central	Malibu	Developed	J_MALICRKU	0.07	0.05	0.10	7	0.10			2	0.05	0.04	0.08	5			YES
Central	Malibu	Developed	R1_MALICRK	0.10	0.03	0.13	5	0.13			1	0.06			4	!		YES
Central	Malibu	Developed	R3_CRAGSRD	0.08			2	0.05			1	0.11			1		!	YES
Central	Malibu	Developed	R3_MALICRKSP	0.08			1				0	0.08			1			YES
Central	Malibu	Developed	RSW_MC001U	0.14	0.11	0.18	34	0.15	0.11	0.19	27	0.12	0.10	0.14	7	!	!	
Central	Malibu	Developed	RSW_MC002D	0.88	0.33	1.44	34	1.14	0.47	1.50	28	0.26	0.14	0.56	6	!	!	
Central	Malibu	Developed	RSW_MC009U	0.12	0.08	0.17	26	0.12	0.08	0.17	24	0.15			2	!	!	
Central	Triunfo_1	all sites combined		0.10	0.06	0.11	94	0.08	0.06	0.10	32	0.10	0.05	0.12	62		!	YES
Central	Triunfo_1	Developed	17	0.10	0.08	0.11	61	0.10	0.08	0.10	24	0.11	0.09	0.12	37		!	
Central	Triunfo_1	Developed	25	0.06	0.03	0.09	33	0.06	0.05	0.07	8	0.06	0.02	0.10	25			YES
Central	Triunfo_2	all sites combined		0.14	0.08	0.17	35	0.11	0.08	0.15	20	0.17	0.14	0.18	15	!	!	
Central	Triunfo_2	Developed	TRI	0.14	0.08	0.17	35	0.11	0.08	0.15	20	0.17	0.14	0.18	15	!	!	
Lower	all sites combined			0.48	0.26	0.91	255	0.87	0.47	1.13	152	0.29	0.17	0.42	103	!	!	
Lower	Malibu	all sites combined		0.48	0.26	0.91	255	0.87	0.47	1.13	152	0.29	0.17	0.42	103	!	!	
Lower	Malibu	Developed	1	0.44	0.30	0.88	91	0.92	0.58	1.11	38	0.36	0.26	0.45	53	!	!	
Lower	Malibu	Developed	15	0.19	0.11	0.98	25	1.02	0.29	1.14	11	0.14	0.10	0.19	14	!	!	
Lower	Malibu	Developed	J_MALICRKL	0.46	0.21	0.90	6	1.48			2	0.24			4	!	!	
Lower	Malibu	Developed	MAL	0.26	0.13	0.57	34	0.57	0.39	0.85	16	0.19	0.10	0.22	18	!	!	
Lower	Malibu	Developed	MalibuCreekatGage	0.10			1				0	0.10			1		!	
Lower	Malibu	Developed	R3_CROSSCRK	0.55			1	0.55			1				0	!		
Lower	Malibu	Developed	RSW_MC003D	0.67	0.48	1.00	34	0.85	0.50	1.12	28	0.42	0.38	0.52	6	!	!	
Lower	Malibu	Developed	RSW_MC004D	0.75	0.50	0.95	29	0.78	0.50	0.96	28	0.34			1	!	!	
Lower	Malibu	Developed	RSW_MC013D	0.64	0.27	1.30	34	0.79	0.28	1.32	28	0.45	0.30	0.72	6	!	!	
Lower	Lagoon	all sites combined		0.48	0.18	0.72	30	0.59	0.37	0.73	24	0.13	0.07	0.16	6	!	!	
Lower	Lagoon	Developed	RSW_MC011D	0.48	0.18	0.72	30	0.59	0.37	0.73	24	0.13	0.07	0.16	6	!	!	

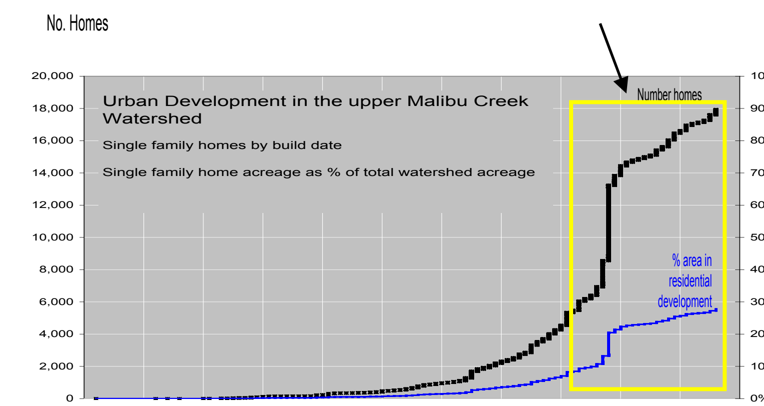


New Tools: Historical imagery on the web provides clues to anomalously high historical phosphate levels

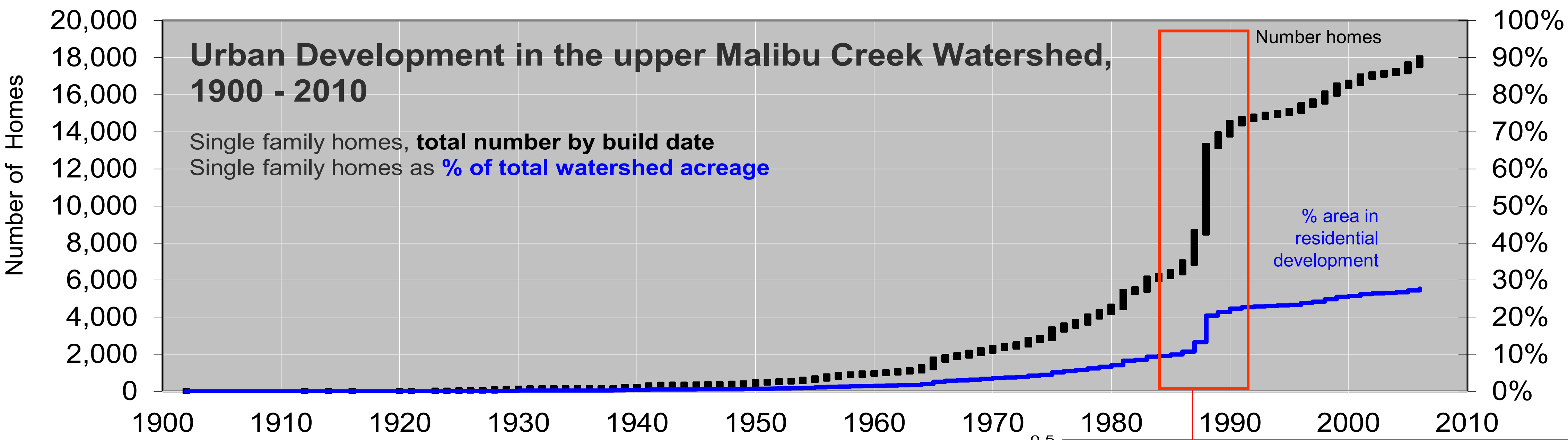
These images of the upper watershed show major changes in grading and housing development over a period of more than 20 years. (Google Earth 6.0.0.1735 (beta), Historical Imagery tool).

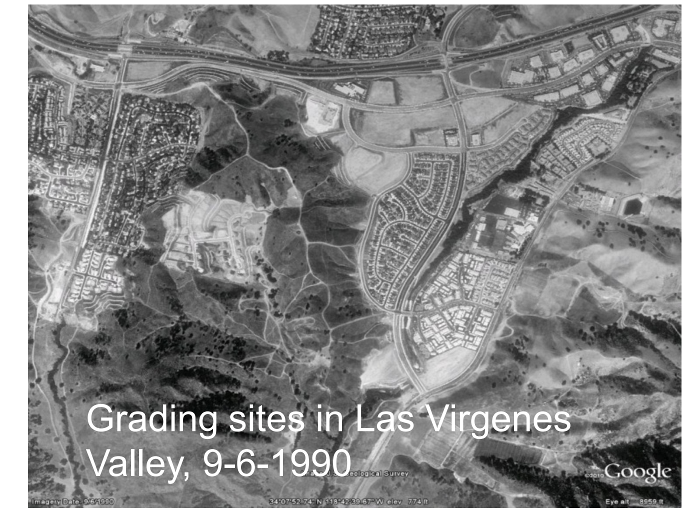
Rain falling on grading sites may leach soluble elements in exposed rock and soil, which may then drain to local storm drains and creeks.

Below: During the 20 year period from 1985 – 2005, over 11,000 new homes were built in the JPA service area, including the three areas shown to the left. During the same period, the percent developed residential land cover in the watershed tripled, increasing from 10 percent (which took 80 years to reach – see figure) to about 30 percent, where it stands today.

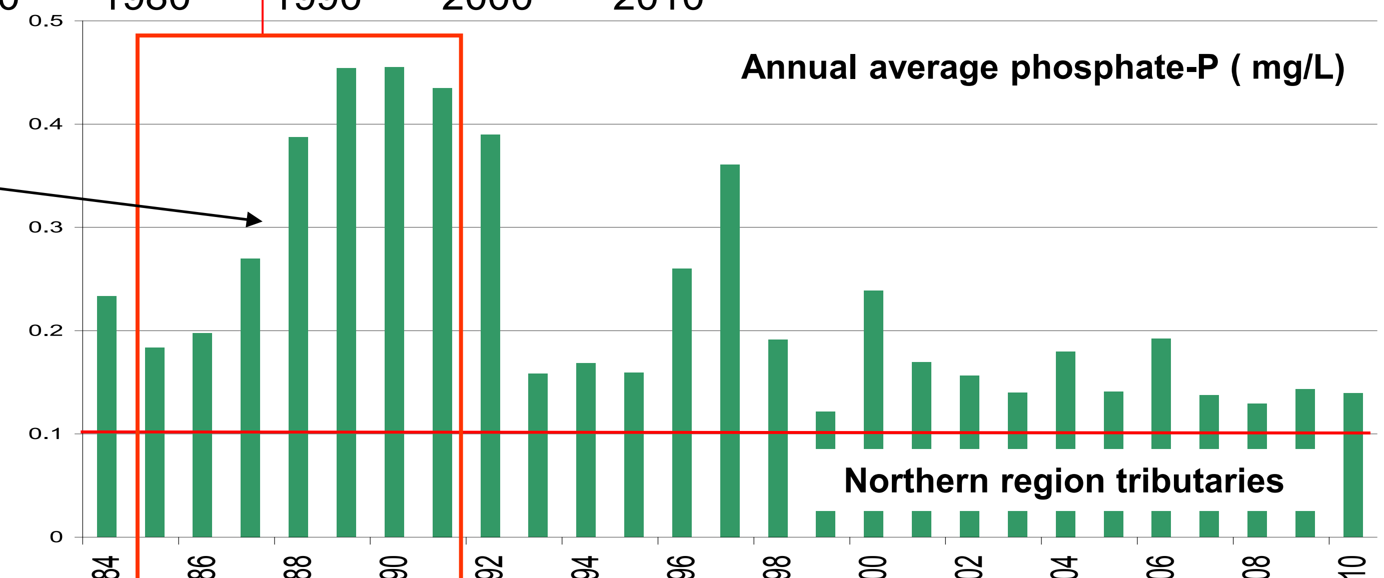


The combination of readily available historical imagery with historical time series water quality data can enable a quantitative look at potential causal linkages between historical land use and construction practices and water quality. Areas shown for Lindero and Westlake View lie within the Monterey Formation, which is enriched in metals, nutrients and salts (primarily sulfate, calcium and magnesium). The area shown for Las Virgenes Creek lies just downstream within the Miocene marine Calabasas Formation. Direct testing of rain water runoff from exposed, recently graded sites provide the means to estimate historical loads of these compounds to local creeks (See “First Rain” results in the Natural Source Assessment section).





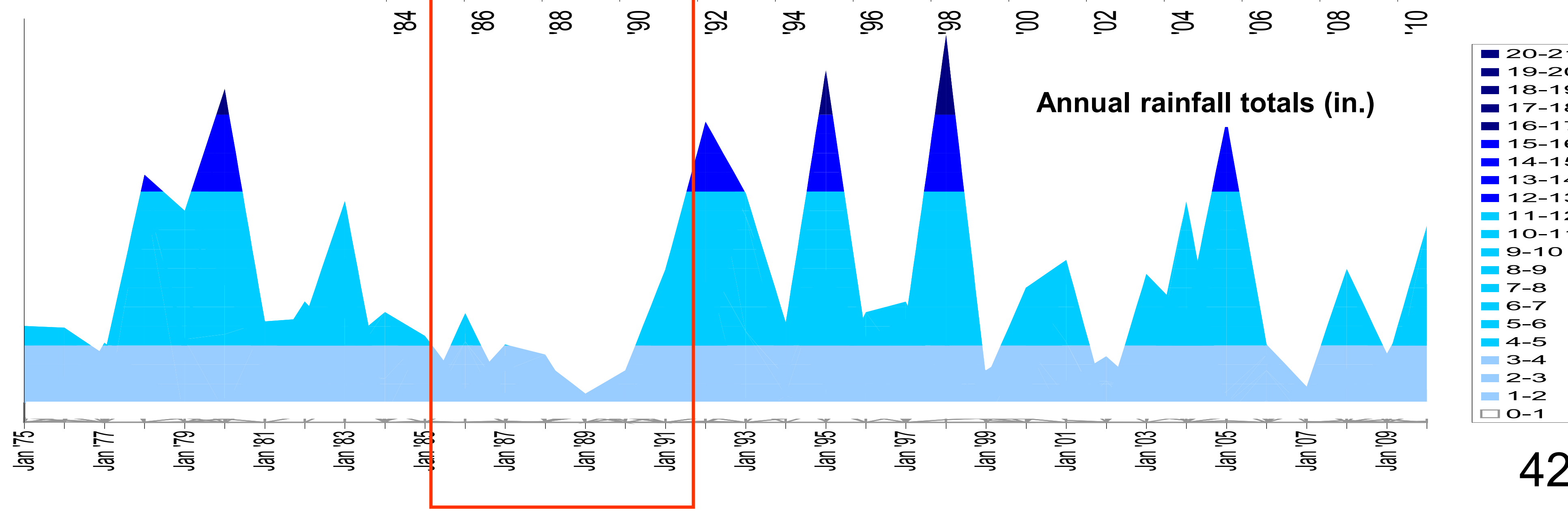
One water quality puzzle is **"what caused the rise in phosphate in Malibu Creek's northern tributaries from 1987 – 1992?"**

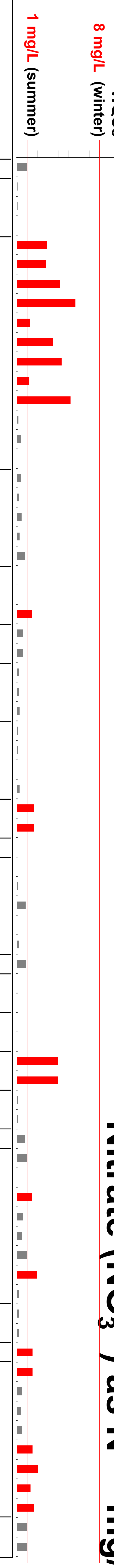


Comparison with weather records (lower graph) shows this period was unusually dry, suggesting greater evaporative concentration of dissolved phosphate in local streams. This idea finds support in the record following 1992 as well, when phosphate levels dropped coincident with wetter winters, suggesting a potential dilution effect.

However, inspection of residential parcel build dates (LA County parcel data, above) shows that the 1987 – 1992 rise in phosphate also coincided with a period of large residential development grading, when about 40% of the upper watershed's homes were built. Historical photos show large areas of grading during this period, exposing bedrock and bare soil derived from high-phosphorus Monterey / Modelo Formation rock.

Separating these potential effects is challenging. Direct measurements of runoff from bare Monterey / Modelo Formation grading sites was conducted in 2009, and lends support to the grading hypothesis (see Natural Source Assessment). But the existing evidence is insufficient, in our view, to draw firm conclusions on why phosphate rose so abruptly in the late 1980's.



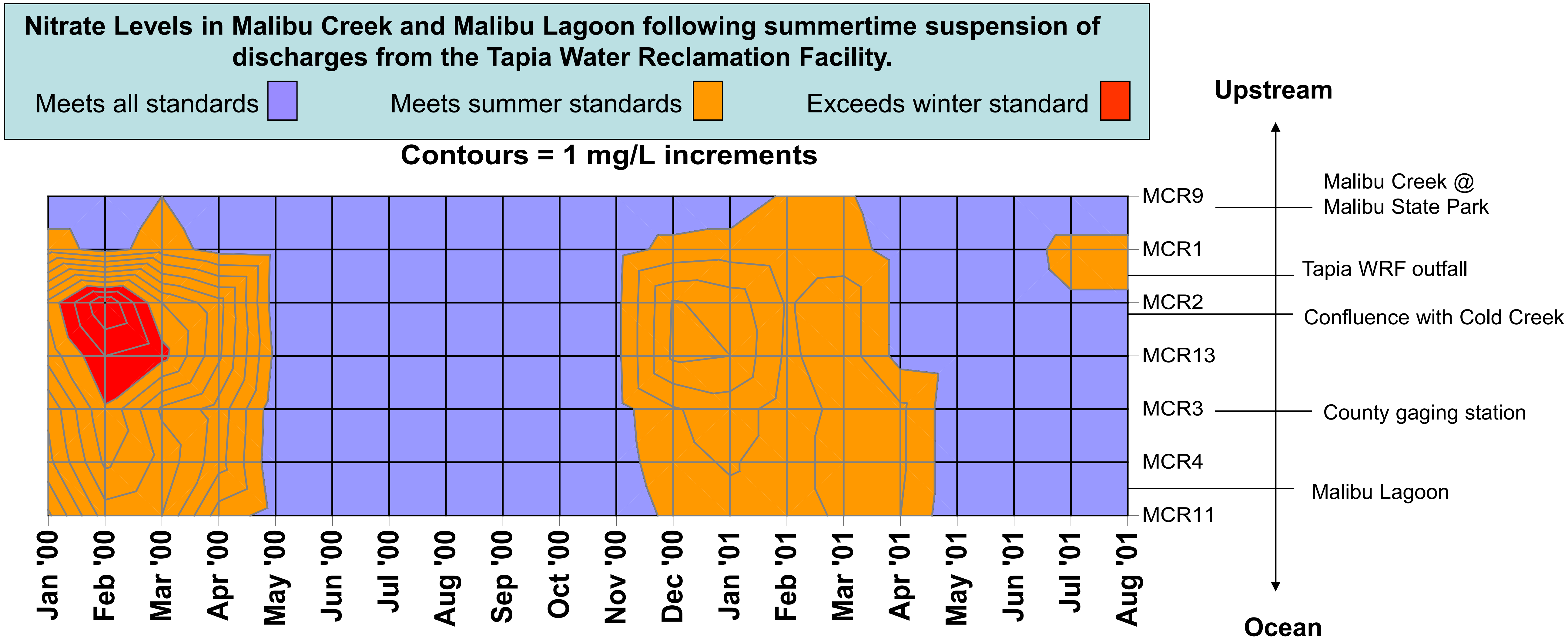


Nitrate (NO_3^{2-}) as N – mg/L

Is annual median > dry season Water Quality Objective?	Region	Reach	Land Use	Site	Median	25th Percentile	75th Percentile	Count	Median Wet	25th Percentile Wet	75th Percentile Wet	Count Wet	Median Dry	25th Percentile Dry	75th Percentile Dry	Count Dry	Median wet >TMDL	Median DRY >TMDL
					Annual Record				**Seasonal Record & Exceedances**									
Yes	North	all sites combined			0.94	0.14	3.14	548	1.12	0.34	3.28	284	0.61	0.06	3.12	264	!	!
	North	Cheeseboro	all sites combined		0.05	0.05	0.05	17	0.05	0.05	0.05	9	0.05	0.05	0.05	8		
	North	Cheeseboro	Developed	Ches	0.05	0.05	0.05	16	0.05	0.05	0.05	8	0.05	0.05	0.05	8		
	North	Cheeseboro	Open Space	J_CHEESEBRO	0.01			1	0.01			1				0		
Yes	North	Las_Virgenes	all sites combined		2.88	1.10	4.15	302	2.84	1.32	4.09	160	2.89	0.89	4.19	142	!	!
Yes	North	Las_Virgenes	Developed	LV2	2.83	2.14	3.57	38	2.60	2.14	3.69	20	2.91	1.84	3.24	18	!	!
Yes	North	Las_Virgenes	Developed	LVCreek_Farm_LV3	4.16	3.56	5.12	20	4.07	3.50	4.74	8	4.42	3.64	5.41	12	!	!
Yes	North	Las_Virgenes	Developed	LVCreek_WhiteOak_LV4	5.63	4.66	6.21	20	5.02	4.40	5.98	8	5.80	5.39	6.45	12	!	!
Yes	North	Las_Virgenes	Developed	RSW_MC001F	1.25	0.99	1.89	48	1.32	1.00	1.90	32	1.10	0.57	1.82	16	!	!
Yes	North	Las_Virgenes	Developed	RSW_MC002F	3.50	2.89	4.14	51	3.45	2.77	3.78	32	3.60	3.13	4.39	19	!	!
Yes	North	Las_Virgenes	Developed	RSW_MC003F	4.29	3.53	5.18	50	4.42	3.68	5.25	32	4.05	3.36	4.90	18	!	!
Yes	North	Las_Virgenes	Developed	RSW_MC007D	1.19	1.11	1.44	20	1.39	1.11	1.57	8	1.18	1.08	1.30	12	!	!
Yes	North	Las_Virgenes	Developed	S_LLASVIR	5.16	3.38	6.08	7	5.16			1	4.75	3.04	6.40	6	!	!
	North	Las_Virgenes	Open Space	J_EFLASVIR	0.12	0.08	0.82	7	0.41			2	0.12	0.10	0.83	5	!	!
	North	Las_Virgenes	Open Space	LV1	0.35	0.16	0.69	34	0.33	0.16	0.88	16	0.41	0.14	0.64	18	!	!
	North	Las_Virgenes	Open Space	S_ULASVIR	0.02	0.01	0.20	7	0.02			1	0.09	0.01	0.22	6		
	North	Liberty Canyon	all sites combined		0.35	0.07	0.61	47	0.44	0.30	0.77	23	0.10	0.02	0.36	24	!	
	North	Liberty Canyon	Developed	LC	0.19	0.05	0.71	35	0.57	0.19	1.88	17	0.07	0.02	0.27	18	!	
	North	Liberty Canyon	Developed	LibertyCanyonCrkatSewerXing	0.44	0.44	0.44	6	0.44	0.44	0.44	5	0.44			1	!	!
	North	Liberty Canyon	Developed	R1_LIBCYN	0.24	0.01	0.40	5	0.77			1	0.13			4	!	!
	North	Liberty Canyon	Developed	R3_LIBCYN	0.73			1				0	0.73			1		!
	North	Lindero_1	all sites combined		0.02	0.02	0.09	34	0.02	0.02	0.12	19	0.02	0.02	0.06	15		
	North	Lindero_1	Developed	LIN2	0.02	0.02	0.08	33	0.02	0.02	0.12	19	0.02	0.02	0.04	14		
	North	Lindero_1	Developed	R3_LADYFACE	1.40			1				0	1.40			1		!
	North	Lindero_2	all sites combined		0.59	0.42	0.74	31	0.69	0.43	0.88	16	0.55	0.34	0.63	15	!	!
	North	Lindero_2	Developed	LIN1	0.59	0.42	0.74	31	0.69	0.43	0.88	16	0.55	0.34	0.63	15	!	!
	North	Medea_1	all sites combined		0.17	0.05	0.41	43	0.37	0.21	0.52	22	0.08	0.02	0.14	21	!	
	North	Medea_1	Developed	MED2	0.16	0.03	0.38	36	0.34	0.19	0.65	20	0.05	0.02	0.11	16	!	
	North	Medea_1	Developed	S_LMEDCRK	0.23	0.12	0.45	7	0.45			2	0.14	0.10	0.23	5	!	!
	North	Medea_2	all sites combined		0.09	0.02	0.16	43	0.12	0.08	0.17	18	0.04	0.02	0.12	25	!	
	North	Medea_2	Developed	MED1	0.10	0.02	0.13	32	0.12	0.09	0.16	16	0.04	0.02	0.11	16	!	
	North	Medea_2	Developed	R1_MEDCRK	0.02			4	0.02			1	0.01			3		
	North	Medea_2	Developed	S_UMEDCRK	0.24	0.05	0.41	7	0.24			1	0.19	0.05	0.46	6	!	!
Yes	North	Russell	all sites combined		1.61	0.88	1.91	31	1.63	1.04	1.80	17	1.57	0.72	2.42	14	!	!
Yes	North	Russell	Developed	RUS	1.61	0.88	1.91	31	1.63	1.04	1.80	17	1.57	0.72	2.42	14	!	!
	East	all sites combined			0.02	0.02	0.06	40	0.02	0.02	0.04	15	0.02	0.02	0.08	25		
	East	Cold	all sites combined		0.02	0.02	0.06	40	0.02	0.02	0.04	15	0.02	0.02	0.08	25		
Yes	East	Cold	Developed	J_LCOLDCRK	0.07	0.01	0.14	5	4.30			1	0.04			4	!	
	East	Cold	Developed	R3_COLDCRK	0.83			1				0	0.83			1		!
	East	Cold	Open Space	CC	0.02	0.02	0.03	27	0.02	0.02	0.04	13	0.02	0.02	0.03	14		
	East	Cold	Open Space	J_UCOLDCRK	0.16	0.01	0.24	7	0.01			1	0.17	0.05	0.27	6		!
	West	all sites combined			0.84	0.02	2.76	20	0.88	0.10	2.24	14	0.06	0.01	8.95	6	!	
	West	Carlisle	all sites combined		0.01	0.01	0.06	3	0.01			1	0.06			2		
	West	Carlisle	Developed	S_CARLISLE	0.01	0.01	0.06	3	0.01			1	0.06			2		
	West	Eleanor	all sites combined		0.01	0.01	0.95	3	0.95			2	0.01			1	!	
	West	Eleanor	Developed	R1_ELEANOR	0.01	0.01	0.95	3	0.95			2	0.01			1	!	
Yes	West	Hidden Valley	all sites combined		3.97	1.19	11.90	9	2.36	1.03	6.70	7	12.70			2	!	!
Yes	West	Hidden Valley	Developed	HV	3.97	1.19	11.90	9	2.36	1.03	6.70	7	12.70			2	!	!
	West	Potrero	all sites combined		0.10	0.02	0.11	5	0.10			4	0.02			1	!	
	West	Potrero	Developed	POT	0.10	0.02	0.11	5	0.10			4	0.02			1	!	
	Central	all sites combined			0.80	0.20	1.40	303	1.00	0.23	1.85	167	0.50	0.20	1.00	136	!	!
	Central	Malibu	all sites combined		1.00	0.20	1.50	268	1.00	0.50	2.40	147	0.60	0.20	1.00	121	!	!
	Central	Malibu	Developed	J_MALICRKU	0.03	0.01	0.04	6	0.36	0.36	0.36	1	0.02	0.01	0.04	5	!	
Yes	Central	Malibu	Developed	R1_MALICRK	1.40	0.27	1.62	5	2.72	2.72	2.72	1	0.83			4	!	!
	Central	Malibu	Developed	R3_CRAGSRD	0.57			1				0	0.57			1		!
	Central	Malibu	Developed	R3_MALICRKSP	0.50			1				0	0.50			1		!
	Central	Malibu	Developed	RSW_MC001U	1.00	0.60	1.30	93	1.00	0.80	1.38	50	0.90	0.55	1.30	43	!	!
Yes	Central	Malibu	Developed	RSW_MC002D	1.90	0.70	5.15	91	4.60	2.30	7.50	49	0.70	0.30	1.08	42	!	!
	Central	Malibu	Developed	RSW_MC009U	0.20	0.20	1.00	71	0.20	0.20	1.00	46	0.20	0.20	0.20	25	!	!
	Central	Triunfo_2	all sites combined		0.18	0.08	0.34	35	0.21	0.07	0.35	20	0.17	0.09	0.31	15	!	!
	Central	Triunfo_2	Developed	TRI	0.18	0.08	0.34	35	0.21	0.07	0.35	20	0.17	0.09	0.31	15	!	!
Yes	Lower	all sites combined			1.50	0.30	3.44	310	2.88	1.90	4.90	173	0.20	0.20	0.60	137	!	!
Yes	Lower	Malibu	all sites combined		1.50	0.30	3.44	310	2.88	1.90	4.90	173	0.20	0.20	0.60	137	!	!
Yes	Lower	Malibu	Developed	J_MALICRKL	0.47	0.02	1.20	5	3.60	3.60	3.60	1	0.24			4	!	!
Yes	Lower	Malibu	Developed	MAL	0.39	0.04	2.33	34	2.50	1.57	3.26	16	0.04	0.02	0.13	18	!	
	Lower	Malibu	Developed	MalibuCreekatGage	0.50			1				0	0.50			1		!
Yes	Lower	Malibu	Developed	RSW_MC003D	1.50	0.20	3.30	91	2.80	1.90	4.80	50	0.20	0.20	0.50	41	!	!
Yes	Lower	Malibu	Developed	RSW_MC004D	2.00	0.30	3.40	77	2.69	2.00	4.15	50	0.20	0.20	0.35	27	!	!
Yes	Lower	Malibu	Developed	RSW_MC013D	1.30	0.60	5.20	93	4.60	1.65	7.20	51	0.55	0.20	1.00	42	!	!
Yes	Lower	Malibu	Developed	S02	1.61	0.95	2.27	9	2.27	1.61	2.72	5	0.64			4	!	!
Yes		Lagoon	all sites combined		1.00	0.20	1.80	88	1.50	1.12	2.37	46	0.20	0.20	0.30	42	!	!
Yes		Lagoon	Developed	RSW_MC011D	1.00	0.20	1.80	88	1.50	1.12	2.37	46	0.20	0.20	0.30	42	!	!

Nitrate as N - mg/L

Nitrate as N



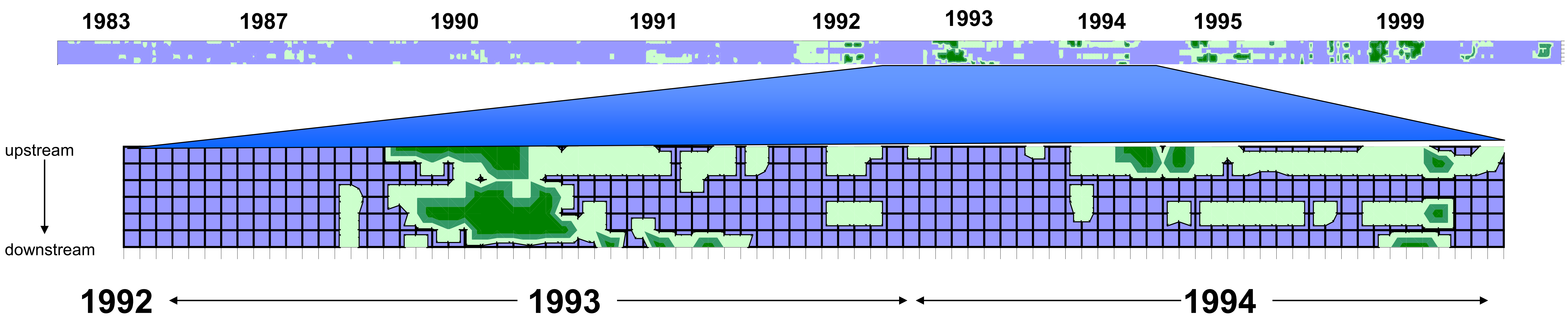
Shown are nitrate levels in Malibu Creek from Station RSW-MC009U (R-9) to and including Malibu Lagoon at station RSW-MC011D (R-11) in the first two years following the suspension of dry season discharges from Tapia WRF from April 15th to November 15th each year. The winter nitrate objective (8 mg/L) was attained in 2001, and is now consistently met in the lower creek even immediately below the Tapia discharge due to treatment upgrades and operational changes completed in recent years at the Tapia WRF. **However, as these data show, the winter receiving water target was usually met even prior to these upgrades except for the short section of creek between the discharge and station R13 at the county gaging station.**

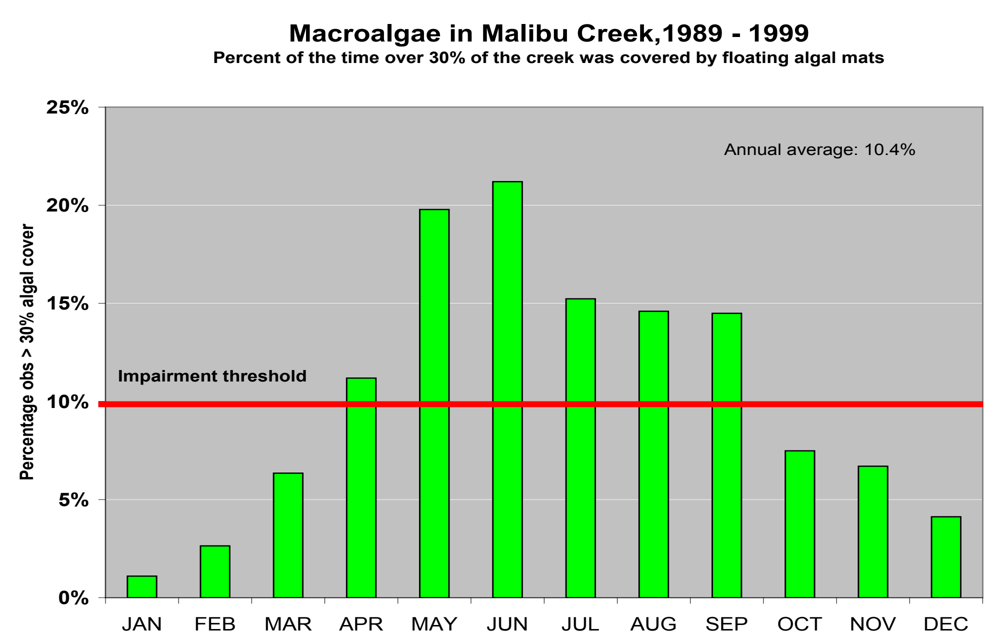
Algae

Seasonality and annual variation in floating algae in Malibu Creek

The long term record based on visual observations at the time of water quality sampling

Shown below is a strip chart showing the long term record of floating algal mats in Malibu Creek based on visual observation and quantitative scoring of percent algal cover at seven sites in Malibu Creek. Note both the seasonality of floating mats (highest in summer) and years of high overall abundance from 1992 – 1999. Green shading shows extent of algal cover, with darkest green showing highest algal cover.



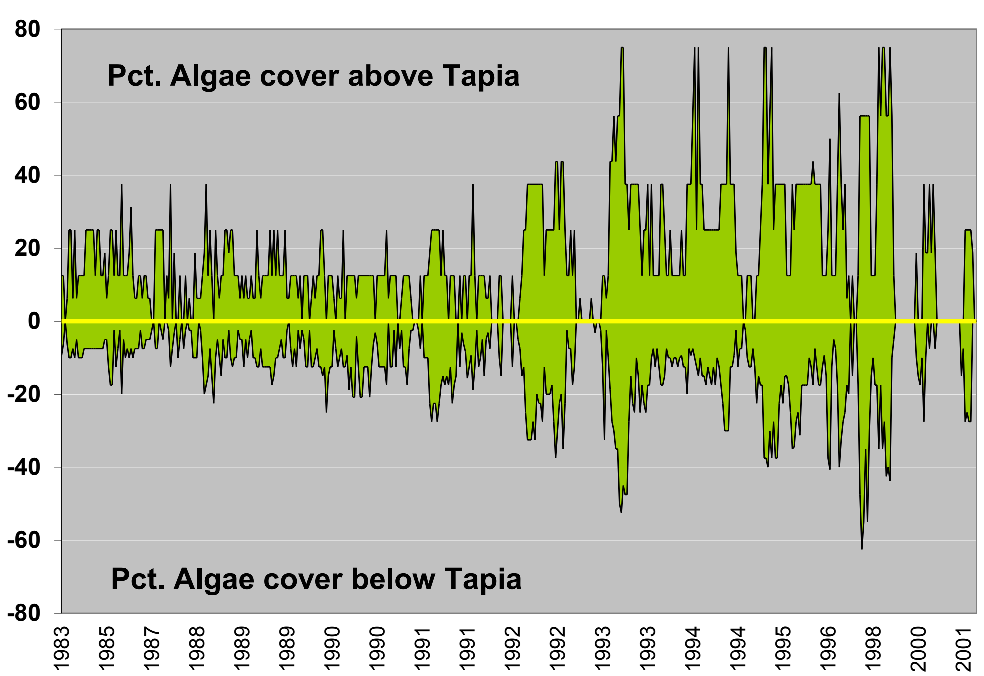


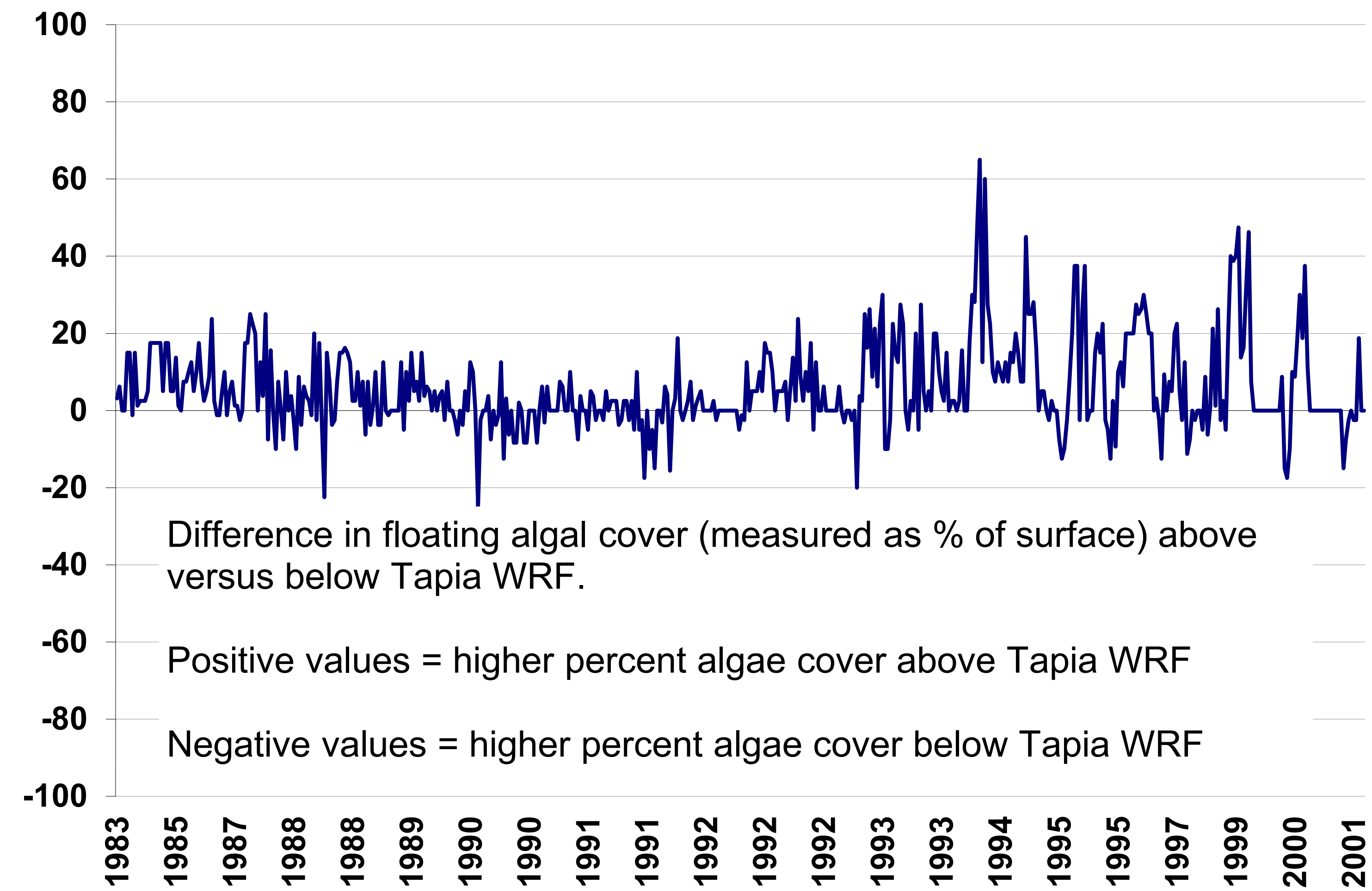
Percent algal cover - mean percent of the creek surface covered by floating algae over 1989 – 1999, by month, in relation to the 30% impairment threshold commonly used by regulatory agencies to identify nuisance levels for body contact recreation and aesthetics. This figure is based on the same data as the one above (JPA RSW stations R6, R9, R1, R2, R13, R3 and R4).

Geographic variation in algal growth above and below the Tapia Water Reclamation Facility (WRF).

Long term record based on visual observations at the time of water quality sampling

The green area graph to the left (below) shows the record of percent algal cover from sites above and below Tapia WRF. The dark blue line graph to the right is the difference in upstream versus downstream algal biomass between sites located above versus below Tapia WRF. Positive values in the right figure indicate a larger percent algae cover above, negative values indicate more algae below the Tapia WRF outlet. In general, the percentage of the water surface covered by floating algal mats is equal to or higher above the treatment plant as below, especially in the more recent record.

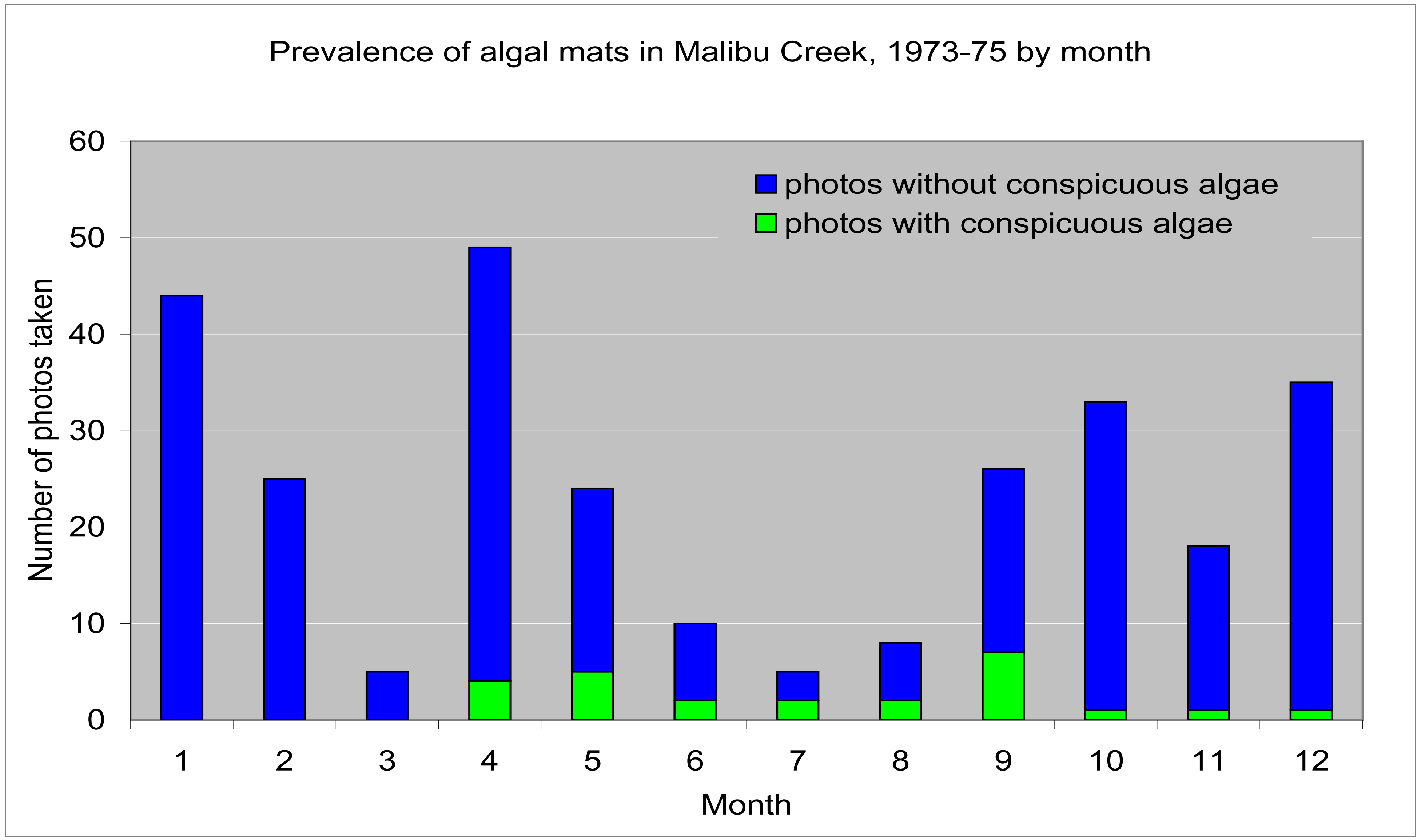




Difference in floating algal cover (measured as % of surface) above versus below Tapia WRF.

Positive values = higher percent algae cover above Tapia WRF

Negative values = higher percent algae cover below Tapia WRF

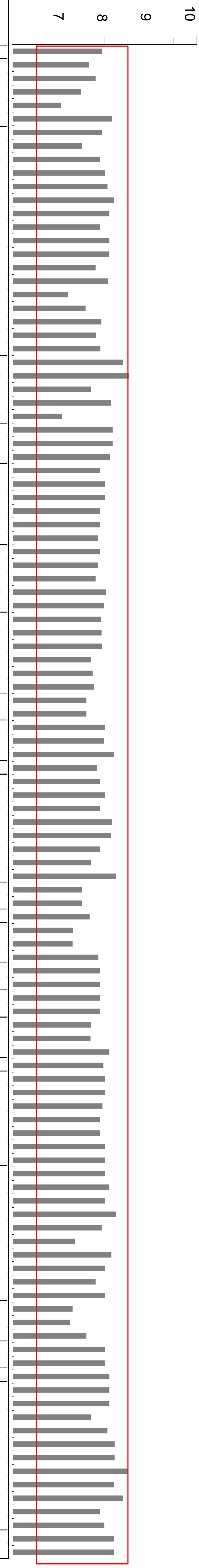


Floating Algae – another historical record of algae cover based on scoring of historical photographs taken at the time of water quality sampling

Two-year historical record of floating algal mats in Malibu Creek from 1973-75 based on an examination of over 270 color photographs, taken by field personnel while collecting water quality samples.

As for the later record based on on-site visual estimates, the analysis of these historical photos shows the seasonality of floating mats (highest in summer, but also seen in late fall photographs as well, albeit at lower levels).

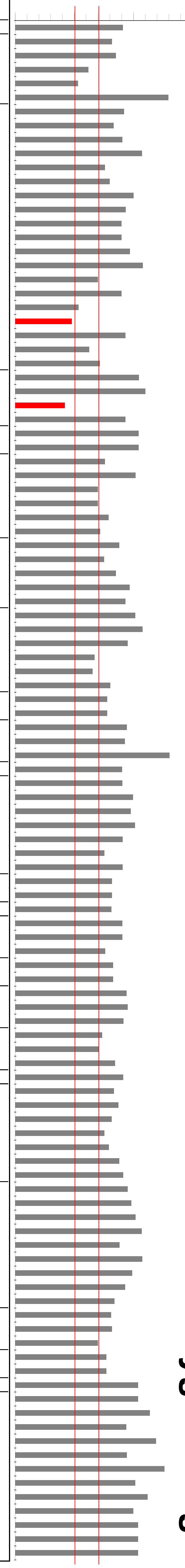
pH – No exceedances



pH (Field)				Annual Record				Seasonal Record								
Region	Reach	Land Use	Site	Median	25th Percentile	75th Percentile	Count	Median Wet	25th Percentile Wet	75th Percentile Wet	Count Wet	Median Dry	25th Percentile Dry	75th Percentile Dry	Count Dry	Median DRY <> WQO / Median wet <> WQO
	all sites combined			7.9	7.8	8.1	1247	8.0	7.8	8.1	585	7.9	7.8	8.0	662	
North	Cheeseboro	all sites combined		7.7	7.5	7.8	36	7.6	7.5	7.8	23	7.8	7.5	7.9	13	
		Developed	6	7.8	7.6	7.8	24	7.7	7.6	7.8	14	7.8	7.7	7.9	10	
		Developed	Ches	7.5	7.1	7.6	8	7.5	7.5	7.6	5	7.3			3	
		Developed	MCW_9	7.1			3	7.1			3				0	
		Open Space	J_CHEESEBRO	8.2			1	8.2			1				0	
	Las_Virgenes	all sites combined		7.9	7.7	8.1	518	8.0	7.8	8.1	265	7.9	7.6	8.0	253	
		Developed	13	7.5	7.3	7.6	66	7.5	7.4	7.7	29	7.5	7.3	7.6	37	
		Developed	30	7.9	7.8	8.0	22	8.0	7.8	8.0	8	7.9	7.8	8.0	14	
		Developed	5	8.0	7.9	8.1	88	8.1	7.9	8.1	37	8.0	7.9	8.1	51	
		Developed	LV2	8.1	8.0	8.1	38	8.1	8.0	8.2	20	8.0	8.0	8.1	18	
		Developed	LVCreek_Farm_LV3	8.2	8.0	8.3	13	8.2	8.2	8.3	7	8.0	8.0	8.2	6	
		Developed	LVCreek_WhiteOak_LV4	8.1	8.1	8.2	13	8.1	8.1	8.2	7	8.2	8.0	8.2	6	
		Developed	RSW_MC001F	7.9	7.6	8.1	43	8.0	7.8	8.2	31	7.5	7.4	7.7	12	
		Developed	RSW_MC002F	8.1	8.0	8.1	43	8.1	8.0	8.2	31	8.0	7.9	8.1	12	
		Developed	RSW_MC003F	8.1	8.0	8.2	43	8.1	8.0	8.2	31	8.1	8.0	8.1	12	
		Developed	RSW_MC007D	7.8	7.7	7.9	13	7.9	7.8	7.9	7	7.8	7.7	7.8	6	
		Developed	S_LLASVIR	8.1	8.0	8.1	8	8.1			2	8.1	8.0	8.1	6	
		Open Space	9	7.2	7.1	7.5	30	7.2	7.1	7.4	10	7.4	7.1	7.5	20	
		Open Space	J_EFLASVIR	7.6	7.5	7.7	8	7.8			3	7.6	7.5	7.6	5	
		Open Space	LV1	7.9	7.9	8.0	34	8.0	7.9	8.1	16	7.9	7.9	8.0	18	
		Open Space	MCW_8b	7.8	7.7	7.9	48	7.8	7.8	7.9	24	7.8	7.7	7.9	24	
		Open Space	S_ULASVIR	7.9	7.8	8.0	8	8.1			2	7.9	7.8	7.9	6	
	Liberty Canyon	all sites combined		8.4	8.1	8.7	49	8.4	8.1	8.6	24	8.5	8.2	8.7	25	
		Developed	LC	8.5	8.4	8.8	35	8.5	8.4	8.8	17	8.6	8.4	8.8	18	
		Developed	LibertyCanyonCrkatSewerXing	7.7	7.4	8.0	7	8.0	7.7	8.0	5	7.4			2	
		Developed	R1_LIBCYN	8.1	8.1	8.2	5	8.1			1	8.2			4	
		Developed	R3_LIBCYN	7.1			2	6.9			1	7.2			1	
	Lindero_1	all sites combined		8.2	8.0	8.3	35	8.2	8.0	8.5	20	8.1	8.0	8.2	15	
		Developed	LIN2	8.2	8.0	8.3	33	8.2	8.0	8.5	19	8.1	8.0	8.2	14	
		Developed	R3_LADYFACE	8.1			2	8.2			1	8.0			1	
	Lindero_2	all sites combined		7.9	7.8	8.0	149	8.0	7.9	8.0	61	7.9	7.8	7.9	88	
		Developed	LIN1	8.0	8.0	8.1	31	8.0	7.9	8.1	16	8.0	8.0	8.1	15	
		Developed	LinderoCrk_LakeInlet_L2	8.0			1				0	8.0			1	
		Developed	LinderoCrkatVenturaCoLine_L1	7.9			1				0	7.9			1	
		Developed	LinderoGolf_SoEndSmallPond_L3	7.9			1				0	7.9			1	
		Developed	MCW_14b	7.9	7.8	7.9	115	7.9	7.8	8.0	45	7.8	7.8	7.9	70	
	Medea_1	all sites combined		7.9	7.7	8.0	140	8.0	7.8	8.1	58	7.9	7.7	8.0	82	
		Developed	21	7.9	7.7	8.0	32	8.0	7.8	8.0	8	7.8	7.6	8.0	24	
		Developed	7	7.8	7.7	7.9	64	7.8	7.7	8.0	27	7.8	7.6	7.9	37	
		Developed	MED2	8.0	8.0	8.1	36	8.1	8.0	8.1	20	8.0	8.0	8.1	16	
		Developed	S_LMEDCRK	8.0	7.8	8.0	8	8.1			3	8.0	7.8	8.0	5	
	Medea_2	all sites combined		7.9	7.8	8.1	160	8.1	7.9	8.1	64	7.9	7.8	8.0	96	
		Developed	MCW_12	7.9	7.8	8.1	115	8.1	8.0	8.2	45	7.9	7.8	8.0	70	
		Developed	MED1	7.9	7.9	8.1	32	8.0	7.9	8.1	16	7.9	7.9	8.0	16	
		Developed	MedeaCrk_atBayLaurelSch_M1	7.7			1				0	7.7			1	
		Developed	R1_MEDCRK	7.7			4	7.9			1	7.7			3	
		Developed	S_UMEDCRK	7.8	7.7	7.8	8	7.8			2	7.8	7.6	7.8	6	
	Palo_Comado	all sites combined		7.6	7.3	7.8	15	7.5	7.1	7.6	8	7.8	7.5	7.8	7	
		Open Space	8	7.6	7.3	7.8	15	7.5	7.1	7.6	8	7.8	7.5	7.8	7	
	Russell	all sites combined		8.0	7.9	8.0	145	8.0	8.0	8.1	62	8.0	7.9	8.0	83	
		Developed	MCW_15b	8.0	7.9	8.0	115	8.0	8.0	8.0	45	8.0	7.9	8.0	70	
		Developed	RUS	8.2	8.1	8.5	30	8.2	8.1	8.3	17	8.3	8.2	8.5	13	
	all sites combined			7.8	7.6	8.1	236	7.9	7.7	8.1	103	7.8	7.6	8.0	133	
East	Cold	all sites combined		7.9	7.7	8.1	221	7.9	7.7	8.1	98	7.8	7.7	8.0	123	
		Developed	11	8.0	7.8	8.1	15	8.1	8.0	8.2	6	7.8	7.7	8.0	9	
		Developed	2	7.9	7.7	8.0	76	7.9	7.7	8.1	37	7.8	7.7	8.0	39	
		Developed	J_LCOLDCRK	8.2	8.1	8.2	6	7.9			2	8.2			4	
		Developed	R3_COLDCRK	8.1			2	8.1			1	8.2			1	
		Open Space	3	7.9	7.7	8.1	87	8.0	7.7	8.1	37	7.8	7.7	8.0	50	
		Open Space	CC	7.7	7.5	7.8	27	7.7	7.6	7.8	13	7.6	7.5	7.8	14	
		Open Space	J_UCOLDCRK	8.2	8.2	8.3	8	8.3			2	8.2	8.2	8.2	6	
	Stokes	all sites combined		7.5	7.5	7.7	15	7.6	7.5	7.7	5	7.5	7.4	7.6	10	
		Developed	16	7.5	7.5	7.7	15	7.6	7.5	7.7	5	7.5	7.4	7.6	10	
	all sites combined			7.7	7.4	7.9	72	7.8	7.5	7.9	47	7.5	7.3	7.7	25	
West	Carlisle	all sites combined		7.3	7.2	7.5	22	7.4	7.3	7.7	11	7.3	7.2	7.4	11	
		Developed	10	7.3	7.2	7.4	18	7.3	7.2	7.5	9	7.2	7.2	7.4	9	
		Developed	S_CARLISLE	7.9			4	8.2			2	7.4			2	
	Eleanor	all sites combined		7.9			3	7.8			2	7.9			1	
		Developed	R1_ELEANOR	7.9			3	7.8			2	7.9			1	
	Hidden Valley	all sites combined		7.9	7.9	7.9	9	7.9	7.8	7.9	7	8.0			2	
		Developed	HV	7.9	7.9	7.9	9	7.9	7.8	7.9	7	8.0			2	
	Potrero	all sites combined		7.7	7.6	7.9	38	7.8	7.6	8.0	27	7.6	7.5	7.7	11	
		Developed	MCW_17	7.7	7.6	7.8	33	7.7	7.6	7.9	23	7.6	7.5	7.7	10	
		Developed	POT	8.1	7.6	8.1	5	8.1			4	7.4			1	
	all sites combined			8.0	7.7	8.1	991	8.0	7.7	8.1	477	7.9	7.7	8.1	514	
Central	Malibou	all sites combined		8.0	7.7	8.2	192	7.9	7.7	8.2	46	8.0	7.8	8.2	146	
		Developed	22	8.0	7.9	8.2	33	8.0	7.7	8.1	8	8.0	7.9	8.2	25	
		Developed	23	8.0	7.8	8.1	32	7.9	7.7	8.1	8	8.0	7.8	8.1	24	
		Developed	24	7.9	7.7	8.1	33	7.9	7.7	8.2	8	7.9	7.8	8.1	25	
		Developed	26	7.9	7.7	8.0	32	7.9	7.7	8.1	8	7.9	7.7	8.0	24	
		Developed	27	8.0	7.8	8.2	31	8.0	7.8	8.2	7	8.0	7.9	8.2	24	
		Developed	28	8.0	7.8	8.2	31	7.8	7.8	8.1	7	8.1	7.7	8.2	24	
	Malibu	all sites combined		8.0	7.8	8.1	677	8.0	7.8	8.1	379	8.0	7.8	8.1	298	
		Developed	12	8.1	7.9	8.2	68	8.1	7.9	8.3	29	8.1	7.9	8.2	39	
		Developed	4	8.0	8.0	8.1	32	8.1	7.8	8.2	13	8.0	8.0	8.1	19	
		Developed	J_MALICRKU	8.2	8.2	8.3	7	8.2			2	8.2	8.2	8.3	5	
		Developed	R1_MALICRK	7.9	7.9	8.0	5	7.8			1	8.0			4	
		Developed	R3_CRAGSRD	7.3			2	7.7			1	7.0			1	
		Developed	R3_MALICRKSP	8.1			1				0	8.1			1	
		Developed	RSW_MC001U	8.0	7.9	8.1	225	8.1	8.0	8.2	129	8.0	7.9	8.1	96	
		Developed	RSW_MC002D	7.8	7.5	8.0	208	7.6	7.4	7.8	126	7.9	7.8	8.1	82	
		Developed	RSW_MC009U	8.0	7.8	8.1	129	8.0	7.9	8.2	78	7.8	7.6	8.0	51	
	Triunfo_1	all sites combined		7.3	7.2	7.7	87	7.4	7.2	7.7	32	7.3	7.1	7.6	55	
		Developed	17	7.3	7.0	7.5	54	7.3	7.1	7.6	24	7.2	7.0	7.3	30	
		Developed	25	7.6	7.3	7.9	33	7.7	7.5	7.8	8	7.6	7.3	7.9	25	
	Triunfo_2	all sites combined		8.0	7.8	8.1	35	8.1	7.9	8.2	20	8.0	7.8	8.1	15	
		Developed	TRI	8.0	7.8	8.1	35	8.1	7.9	8.2	20	8.0	7.8	8.1	15	
	all sites combined			8.1	7.8	8.4	625	8.2	7.9	8.4	318	8.1	7.8	8.2	307	
Lower	Malibu	all sites combined		8.1	7.8	8.4	625	8.2	7.9	8.4	318	8.1	7.8	8.2	307	
		Developed	1	8.1	7.8	8.3	88	8.2	8.0	8.4	37	8.0	7.6	8.3	51	
		Developed	15	7.7	7.6	7.8	23	7.7	7.5	7.8	10	7.7	7.6	7.8	13	
		Developed	J_MALICRKL	8.1	7.9	8.1	6	7.9			2	8.1			4	
		Developed	MAL	8.2	8.1	8.4	32	8.4	8.2	8.4	15	8.1	8.0	8.3	17	
		Developed	MalibuCreekatGage	8.2			1				0	8.2			1	
		Developed	R3_CROSSCRK	8.5			1	8.5			1				0	
		Developed	RSW_MC003D	8.2	7.9	8.4	161	8.4	8.2	8.5	82	8.0	7.8	8.2	79	
		Developed	RSW_MC004D	8.4	8.2	8.5	138	8.4	8.3	8.6	82	8.2	8.1	8.4	56	
		Developed	RSW_MC013D	7.9	7.7	8.1	166	7.8	7.6	8.0	84	8.0	7.8	8.2	82	
		Developed	S02	8.0	7.7	8.1	9	8.0	7.7	8.1	5	7.9			4	
	Lagoon	all sites combined		8.2	8.0	8.5	160	8.2	8.0	8.3	78	8.4	8.1	8.8	82	
		Developed	RSW_MC011D	8.2	8.0	8.5	160	8.2	8.0	8.3	78	8.4	8.1	8.8	82	

Is annual median <> Water Quality Objective?

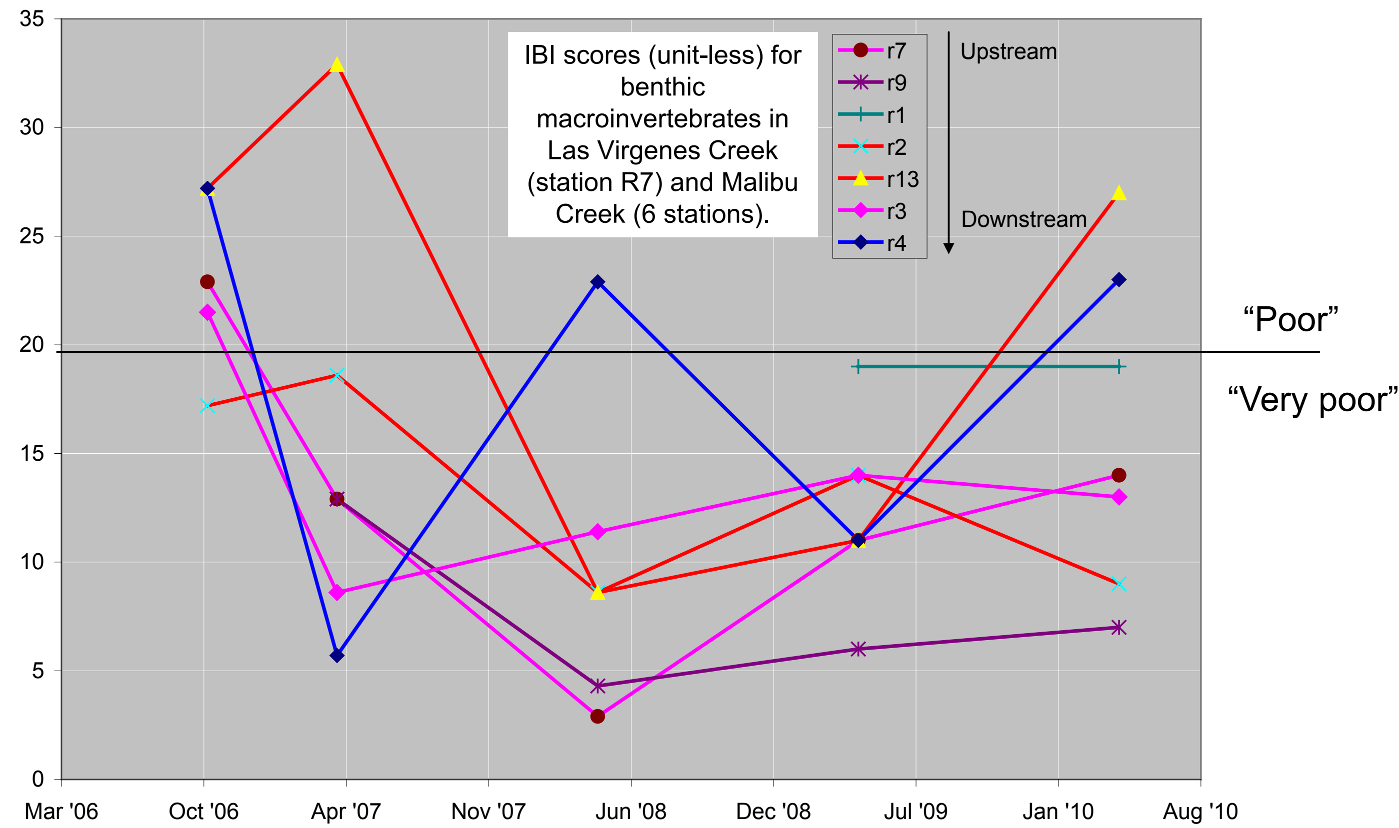
Dissolved Oxygen – mg/L



Is annual median < Water Quality Objective?	Region	Reach	Land Use	Site	Annual Record: Median	25th Percentile	75th Percentile	Count	Seasonal Record & Exceedances: Median Wet	25th Percentile Wet	75th Percentile Wet	Count Wet	Median Dry	25th Percentile Dry	75th Percentile Dry	Count Dry	Median Wet <TMDL	Median DRY < TMDL
	North	all sites combined			9.1	7.5	10.5	1159	10.0	8.8	11.1	523	8.3	6.8	9.6	636		
		Cheeseboro	all sites combined		8.2	6.6	9.1	35	8.9	7.6	9.5	22	7.2	6.3	8.3	13		
		Cheeseboro	Developed	6	8.5	7.8	9.4	24	9.2	8.3	9.6	14	7.6	7.1	8.3	10		
		Cheeseboro	Developed	Ches	6.2	5.8	6.3	6	6.3			3	5.7			3		
		Cheeseboro	Developed	MCW_9	5.3			4	5.3			4				0		
		Cheeseboro	Open Space	J_CHEESEBRO	12.9			1	12.9			1				0		
		Las_Virgenes	all sites combined		9.2	7.2	10.5	468	10.0	8.6	11.0	221	8.3	6.6	9.8	247		
		Las_Virgenes	Developed	13	8.3	7.3	9.4	65	9.3	8.7	10.0	27	7.6	7.0	8.8	38		
		Las_Virgenes	Developed	30	9.1	8.5	10.0	19	10.3	9.1	11.3	6	8.8	8.3	9.9	13		
		Las_Virgenes	Developed	5	10.7	9.9	11.8	87	11.2	10.3	12.2	38	10.3	9.6	11.0	49		
		Las_Virgenes	Developed	LV_atMulholland	7.6			1				0	7.6			1		
		Las_Virgenes	Developed	LV_belowLibertyCynCreek	8.0			1				0	8.0			1		
		Las_Virgenes	Developed	LV2	10.0	8.9	10.6	34	10.1	9.9	10.6	17	9.2	8.2	10.2	17		
		Las_Virgenes	Developed	LVCreek_Farm_LV3	9.4	9.2	10.0	8	10.8			1	9.2	9.1	9.7	7		
		Las_Virgenes	Developed	LVCreek_WhiteOak_LV4	9.0	8.7	9.3	7	9.0			1	9.0	8.6	9.4	6		
		Las_Virgenes	Developed	RSW_MC001F	9.0	6.4	10.3	37	10.0	9.0	11.2	25	6.3	5.2	6.7	12		
		Las_Virgenes	Developed	RSW_MC002F	9.7	8.7	10.6	37	10.2	9.3	10.7	25	8.7	8.0	9.2	12		
		Las_Virgenes	Developed	RSW_MC003F	10.8	9.7	11.2	38	10.8	10.0	11.2	25	10.1	8.9	11.2	13		
		Las_Virgenes	Developed	RSW_MC007D	7.0	6.2	7.4	7	7.6			1	6.7	6.0	7.2	6		
		Las_Virgenes	Developed	S_LLASVIR	9.0	8.6	9.2	5	10.5			1	8.8	8.3	9.0	4		
		Las_Virgenes	Open Space	9	5.4	4.4	6.5	30	5.3	4.8	7.2	10	5.4	4.1	5.9	20		
Yes		Las_Virgenes	Open Space	J_EFLASVIR	4.8	2.3	6.4	5	5.6			2	2.3			3		!
		Las_Virgenes	Open Space	LV1	9.3	7.5	10.0	31	9.8	9.4	10.5	14	7.6	7.0	9.4	17		
		Las_Virgenes	Open Space	MCW_8b	6.3	5.3	7.5	51	7.2	6.1	8.6	27	5.4	4.0	6.3	24		
		Las_Virgenes	Open Space	S_ULASVIR	7.2	6.9	7.8	5	9.7			1	7.1			4		
		Liberty Canyon	all sites combined		10.5	8.5	12.1	33	10.7	8.6	12.9	15	10.5	8.0	12.1	18		
		Liberty Canyon	Developed	LC	11.0	9.6	13.2	26	10.7	8.7	13.8	13	11.3	10.1	12.3	13		
Yes		Liberty Canyon	Developed	LibertyCanyonCrkatSewerXing	4.2			3	8.4			1	3.4			2		!
		Liberty Canyon	Developed	R1_LIBCYN	9.3			4	10.8			1	8.2			3		
		Lindero_1	all sites combined		10.4	7.7	12.1	31	11.2	10.1	12.9	17	7.5	6.4	10.5	14		
		Lindero_1	Developed	LIN2	10.4	7.7	12.1	31	11.2	10.1	12.9	17	7.5	6.4	10.5	14		
		Lindero_2	all sites combined		7.6	6.3	9.0	151	8.7	7.8	9.5	63	6.4	5.7	7.8	88		
		Lindero_2	Developed	LIN1	10.2	9.5	11.1	30	10.3	9.5	11.0	15	10.1	9.4	12.2	15		
		Lindero_2	Developed	LinderoCrk_LakeInlet_L2	7.0			1				0	7.0			1		
		Lindero_2	Developed	LinderoCrkatVenturaCoLine_L1	7.0			1				0	7.0			1		
		Lindero_2	Developed	LinderoGolf_SoEndSmallPond_L3	7.9			1				0	7.9			1		
		Lindero_2	Developed	MCW_14b	7.2	6.0	8.1	118	8.3	7.6	8.9	48	6.2	5.6	7.1	70		
		Medea_1	all sites combined		8.8	7.3	10.0	129	10.0	9.2	10.7	53	7.7	7.0	8.9	76		
		Medea_1	Developed	21	7.5	6.2	10.6	30	10.6	9.1	11.5	8	7.4	5.5	8.9	22		
		Medea_1	Developed	7	8.5	7.2	9.8	62	9.9	9.2	10.7	26	7.6	7.1	8.0	36		
		Medea_1	Developed	MED2	9.7	8.4	10.1	32	10.0	9.6	10.2	17	8.5	8.1	9.5	15		
		Medea_1	Developed	S_LMEDCRK	9.3	9.1	10.0	5	10.2			2	9.3			3		
		Medea_2	all sites combined		10.2	8.6	11.7	157	11.3	10.4	13.1	64	9.0	8.0	10.8	93		
		Medea_2	Developed	MCW_12	10.8	8.8	12.6	118	12.0	11.1	13.8	48	9.2	8.3	11.1	70		
		Medea_2	Developed	MED1	9.5	8.6	10.5	30	10.3	9.5	10.7	14	9.1	8.2	9.6	16		
		Medea_2	Developed	MedeaCrk_atBayLaurelSch_M1	6.7			1				0	6.7			1		
		Medea_2	Developed	R1_MEDCRK	6.6			3	8.4			1	6.5			2		
		Medea_2	Developed	S_UMEDCRK	8.0	5.8	9.0	5	9.0			1	6.9	5.6	8.4	4		
		Palo_Comado	all sites combined		7.8	6.9	8.4	10	8.1	7.1	8.5	5	7.5	6.8	8.3	5		
		Palo_Comado	Open Space	8	7.8	6.9	8.4	10	8.1	7.1	8.5	5	7.5	6.8	8.3	5		
		Russell	all sites combined		9.4	8.7	10.1	145	10.0	9.5	11.3	63	8.8	8.4	9.5	82		
		Russell	Developed	MCW_15b	9.3	8.7	9.9	118	9.9	9.5	10.3	48	8.8	8.4	9.3	70		
		Russell	Developed	RUS	13.1	9.4	15.0	27	13.8	11.8	15.6	15	9.8	8.7	13.2	12		
	East	all sites combined			9.0	7.8	10.1	224	10.0	9.0	10.7	96	8.4	7.6	9.3	128		
		Cold	all sites combined		9.1	7.8	10.2	209	10.1	9.1	10.8	91	8.5	7.5	9.3	118		
		Cold	Developed	11	10.0	8.0	10.7	15	10.7	10.2	11.2	6	8.4	7.9	10.0	9		
		Cold	Developed	2	9.8	8.5	10.6	74	10.3	9.7	11.1	35	8.8	7.6	10.1	39		
		Cold	Developed	J_LCOLDCRK	10.1	9.6	10.3	4	10.7			1	10.1			3		
		Cold	Open Space	3	9.1	8.2	9.9	84	10.2	9.5	10.4	35	8.4	7.7	9.1	49		
		Cold	Open Space	CC	7.5	6.8	8.2	27	8.0	7.2	8.3	13	7.5	6.5	7.6	14		
		Cold	Open Space	J_UCOLDCRK	9.1	9.0	9.3	5	10.6			1	9.0			4		
		Stokes	all sites combined		8.2	7.7	9.2	15	8.1	7.2	9.3	5	8.3	7.9	8.9	10		
		Stokes	Developed	16	8.2	7.7	9.2	15	8.1	7.2	9.3	5	8.3	7.9	8.9	10		
	West	all sites combined			8.1	5.6	9.5	72	9.1	6.6	9.9	50	5.4	3.1	8.1	22		
		Carlisle	all sites combined		9.1	6.6	10.4	19	10.4	9.4	11.3	10	6.7	4.8	8.2	9		
		Carlisle	Developed	10	9.1	6.7	10.4	17	10.4	9.3	10.5	9	6.8	6.1	8.4	8		
		Carlisle	Developed	S_CARLISLE	7.6			2	11.6			1	3.6			1		!
		Eleanor	all sites combined		8.3			2	8.3			2				0		
		Eleanor	Developed	R1_ELEANOR	8.3			2	8.3			2				0		
		Hidden Valley	all sites combined		9.4	6.8	10.2	10	9.2	5.9	9.6	8	10.6			2		
		Hidden Valley	Developed	HV	9.5	6.0	10.4	9	9.3	5.9	9.7	7	10.6			2		
		Hidden Valley	Developed	MCW_18	9.2			1	9.2			1	0.0	0.0	0.0	0		
		Potrero	all sites combined		7.3	3.7	9.3	41	8.4	6.4	9.5	30	2.9	1.6	5.3	11		!
		Potrero	Developed	MCW_17	7.1	3.5	9.2	36	8.4	6.6	9.4	26	2.6	1.5	4.5	10		!
		Potrero	Developed	POT	8.5	6.3	9.8	5	8.0			4	8.5			1		
	Central	all sites combined			9.1	7.8	10.4	947	9.7	8.6	10.7	468	8.5	6.7	9.9	479		
		Malibou	all sites combined		8.4	6.8	9.8	179	10.7	7.7	11.7	46	8.0	6.3	9.1	133		
		Malibou	Developed	22	8.7	6.3	10.3	31	11.3	8.7	12.0	8	8.6	5.6	9.7	23		
		Malibou	Developed	23	8.2	7.2	8.8	30	9.5	7.9	11.2	8	7.9	6.6	8.6	22		
		Malibou	Developed	24	7.5	6.1	8.6	31	8.6	7.8	10.8	8	6.8	5.9	8.3	23		
		Malibou	Developed	26	7.9	7.2	9.3	30	10.0	8.0	11.3	8	7.6	6.9	8.7	22		
		Malibou	Developed	27	8.8	7.2	9.9	29	10.7	8.2	12.0	7	8.6	7.2	9.1	22		
		Malibou	Developed	28	9.1	7.3	11.6	28	11.1	7.8	11.9	7	9.1	7.4	11.1	21		
		Malibu	all sites combined		9.5	8.4	10.7	651	9.8	8.8	10.7	372	9.0	7.6	10.6	279		
		Malibu	Developed	12	9.8	8.9	10.6	66	10.5	10.1	11.1	29	9.1	7.6	9.8	37		
		Malibu	Developed	4	10.2	9.3	11.2	32	10.9	10.5	11.5	13	9.5	8.9	10.3	19		
		Malibu	Developed	J_MALICRKU	10.7			4	11.3			1	10.1			3		
		Malibu	Developed	R1_MALICRK	8.8			4	8.3			1	9.1			3		
		Malibu	Developed	R3_MALICRKSP	10.7			1				0	10.7			1		
		Malibu	Developed	RSW_MC001U	9.9	8.9	11.0	207	10.3	9.5	11.2	124	8.9	8.1	10.2	83		
		Malibu	Developed	RSW_MC002D	9.3	8.4	10.6	208	9.2	8.4	10.0	126	10.0	8.3	11.9	82		
		Malibu	Developed	RSW_MC009U	8.4	6.2	9.9	129	9.3	8.3	10.2	78	6.0	4.8	8.1	51		
		Triunfo_1	all sites combined		8.1	5.5	9.4	82	9.0	8.1	9.9	30	6.7	4.9	8.7	52		
		Triunfo_1	Developed	17	8.2	6.1	9.4	51	8.8	8.1	9.8	22	6.9	4.9	8.4	29		
		Triunfo_1	Developed	25	7.0	5.2	9.6	31	10.1	7.8	10.6	8	6.7	4.9	8.8	23		
		Triunfo_2	all sites combined		7.7	5.1	9.0	35	8.9	7.5	9.8	20	5.1	4.1	6.2	15		
		Triunfo_2	Developed	TRI	7.7	5.1	9.0	35	8.9	7.5	9.8	20	5.1	4.1	6.2	15		
	Lower	all sites combined			10.4	9.0	12.0	618	10.8	10.0	12.2	315	9.5	7.6	12.0	303		
		Malibu	all sites combined		10.4	9.0	12.0	618	10.8	10.0	12.2	315	9.5	7.6	12.0	303		
		Malibu	Developed	1	11.4	9.6	13.8	86	11.7	10.7	13.7	36	11.0	8.4	14.0	50		
		Malibu	Developed	15	9.4	7.5	10.3	21	10.3	7.8	10.8	9	8.9	7.5	9.6	12		
		Malibu	Developed	J_MALICRKL	11.9			3	9.0			1	13.4			2		
		Malibu	Developed	MAL	9.4	7.8	10.7	32	10.4	10.1	11.1	16	7.7	5.6	8.7	16		
		Malibu	Developed	MalibuCreekatGage	12.6			1				0	12.6	12.6	12.6	1		
		Malibu	Developed	RSW_MC003D	10.2	8.1	11.4	162	10.8	10.1	12.0	82	8.2	6.4	10.2	80		
		Malibu	Developed	RSW_MC004D	11.2	9.5	12.8	138	11.8	10.3	13.0	82	9.8	8.2	12.2	56		
		Malibu	Developed	RSW_MC013D	10.0	9.0	11.7	166	10.0	9.4	11.1	84	10.1	8.5	12.6	82		
		Malibu	Developed	S02	10.4	9.8	11.7	9	11.7	11.7	11.8	5	9.9			4		
	Lagoon	Malibu_Lagoon	all sites combined		10.4	8.8	12.5	160	10.4	9.4	12.5	78	10.4	8.2	12.5	82		
		Malibu_Lagoon	Developed	RSW_MC011D	10.4	8.8	12.5	160	10.4	9.4	12.5	78	10.4	8.2	12.5	82		

Benthic Macroinvertebrate Bioassessments

The watershed's first biological indicator results for aquatic insect larvae closely tracks high sulfate and TDS levels in Malibu Creek



Station	Year	Season Sampled	Adjusted IBI Score	Rating
R-4	2006	Fall	24.3	Poor
R-4	2007	Spring	5.7	Very Poor
R-4	2008	Spring	22.9	Poor
R-4	2009	Spring	11.4	Very Poor
R-4	2010	Spring	23.0	Poor
R-3	2006	Fall	20.0	Poor
R-3	2007	Spring	8.6	Very Poor
R-3	2008	Spring	14.3	Very Poor
R-3	2009	Spring	14.3	Very Poor
R-3	2010	Spring	13.0	Very Poor
R-13	2006	Fall	25.7	Poor
R-13	2007	Spring	31.5	Poor
R-13	2008	Spring	11.4	Very Poor
R-13	2009	Spring	11.4	Very Poor
R-13	2010	Spring	27.0	Poor
R-2	2006	Fall	17.2	Very Poor
R-2	2007	Spring	15.7	Very Poor
R-2	2008	Spring	8.6	Very Poor
R-2	2009	Spring	14.3	Very Poor
R-2	2010	Spring	9.0	Very Poor
R-1	2006	Fall	22.9	Poor
R-1	2007	Spring	8.6	Very Poor
R-1	2008	Spring	1.4	Very Poor
R-1	2009	Spring	18.6	Very Poor
R-1	2010	Spring	19.0	Very Poor
R-9	2006	Fall	(not sampled)	(not sampled)
R-9	2007	Spring	12.9	Very Poor
R-9	2008	Spring	2.9	Very Poor
R-9	2009	Spring	5.7	Very Poor
R-9	2010	Spring	7.0	Very Poor
R-7	2006	Fall	24.3	Poor
R-7	2007	Spring	12.9	Very Poor
R-7	2008	Spring	2.9	Very Poor
R-7	2009	Spring	11.4	Very Poor
R-7	2010	Spring	14.0	Very Poor

Aquatic Bioassay and Consulting Laboratories, 2010

Water quality: Benthic Macroinvertebrate Bioassessment data in the database (JPA) cover the period from Fall 2006 to Spring 2010 and are uniformly poor (IBI 20-39) or very poor (IBI < 20) depending on the station and season.

Annual & Seasonal variation: Spring values may be higher than Fall, but sample sizes precluded meaningful statistical tests for seasonality.

Source assessment: Benthic Macroinvertebrate Bioassessments are an integrated measure of overall stream water quality, and poor to very poor scores indicate need for further investigation into specific water quality problems that collectively are responsible for low scores. Sulfate was the only water quality parameter in the compiled dataset that we could identify that (1) has documented impacts on benthic macroinvertebrates in the scientific literature, and (2) is present in Malibu Creek at levels equal to or greater than those in the literature. Macroinvertebrates are sensitive to sulfate levels (reviewed by Goodfellow *et al.*, 2000). Pond *et al.* (2008) documented poor benthic macroinvertebrate bioassessment scores in high sulfate streams in West Virginia at levels equal to or less than sulfate levels in Malibu Creek (especially its northern tributary streams). They also found correlations between low benthic macronivertebrate scores and high levels of selenium and metals at concentrations similar to those in Malibu Creek. As in their study streams below mined coal formations, high sulfate in Malibu Creek is due to the presence upstream of sulfate and metal enriched rock.

It should also be noted that Malibu Creek's major ion and mineral composition is very unusual in general (see Mineral Quality section), and its salinity as SC is brackish (SC>1,500 µS/cm) its entire length, and extremely brackish (SC>3,000 µS/cm) in those headwaters draining the Monterey / Modelo Formation. In Malibu Creek, Luce (2003) found SC was negatively correlated with all benthic macroinvertebrate index (BMI) metrics, except percent dominant species (significant positive relationship) and percent filterers (no significant relationship). (Note that SC is closely linked with sulfate levels – see pages on Specific Conductance in the Mineral Quality section.) She also noted that her natural reference sites R6 and R9 (both located in the M Fm.) had higher SC than her other reference sites, slightly higher diatom cover, and lower values of taxa richness, EPT richness, EPT index, sensitive EPT index, percent intolerant species and percent shredders, especially at site R9. Very poor BMI metrics in the Malibu Creek watershed were also associated with all high SC sites in macroinvertebrate bioassessments performed by the Aquatic Bioassay and Consulting Laboratories (2007). Macroinvertebrate species diversity in freshwater streams generally declines along a gradient of increasing brackishness, terminating in hypersaline lakes such as Mono Lake that may harbor but one or two abundant species (e.g. brine shrimp, brine fly larvae). See Natural Source Assessment section for references and details.

Historical Trends: In the upper left figure, IBI scores at all stations except R4 declined from 2006 to 2008, then increased through 2010.

Potential impacts on aquatic life: See Natural Source Assessment section for references and details. IBI scores themselves are a measure, or intended measure, of the collective effect of all pollutants and stressors on benthic macroinvertebrates. See Ode *et al.* (2005) for further details. Aside from waters naturally enriched in sulfate, TDS, metals or selenium, IBI scores may be affected by invasive species such as New Zealand mudsnails or non-native crayfish (both present in the Malibu Creek watershed, often in abundance) and stream gradient.

Sulfate levels and Macroinvertebrate IBI Scores in Malibu Creek watershed

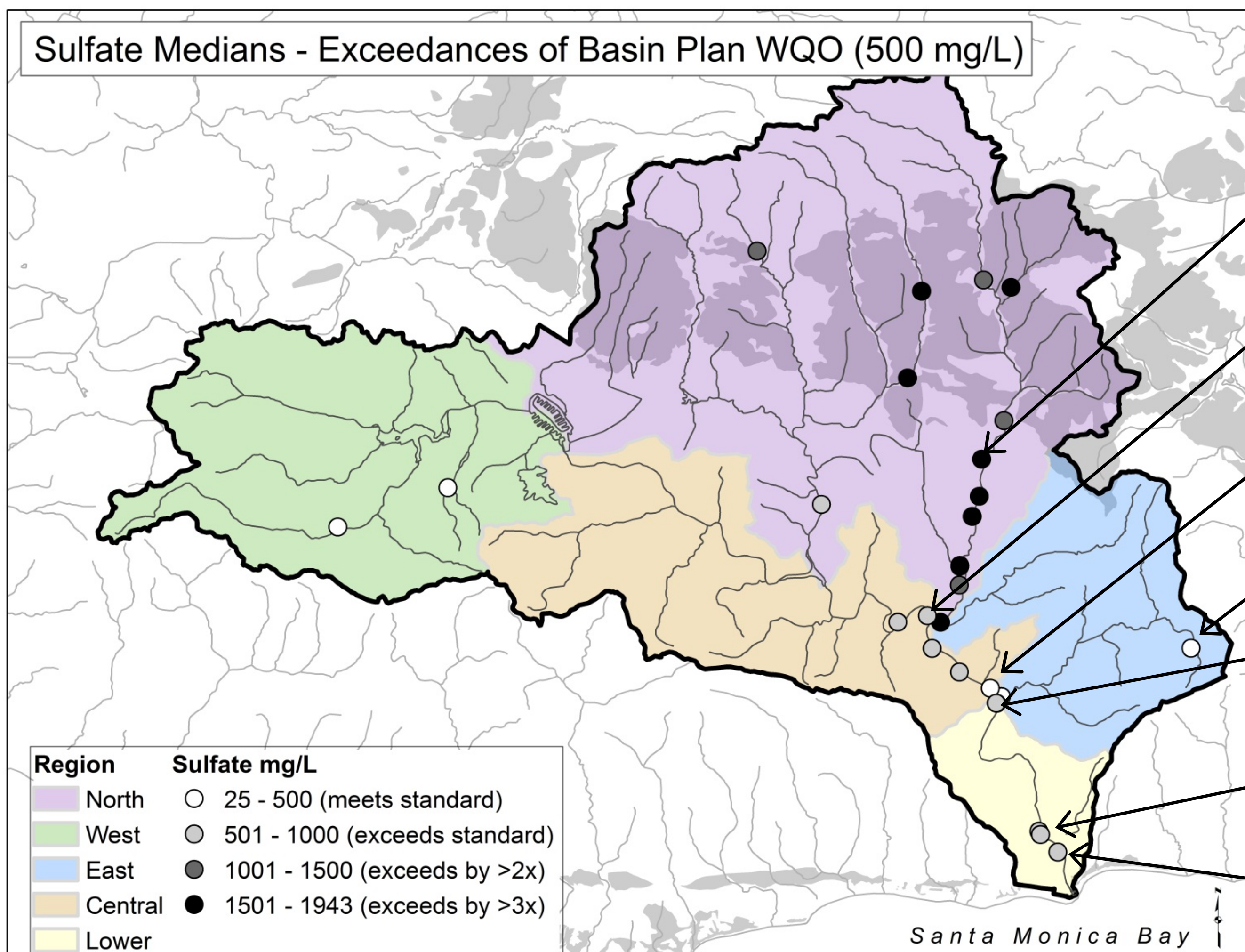
Macroinvertebrates are sensitive to sulfate levels

In US EPA sponsored research on the effects of mountaintop coal mining valley fill on downstream water quality and macroinvertebrates in West Virginia streams, Pond *et al.* (2008) found significant negative correlations between all eight measures of macroinvertebrate community health and sulfate concentrations at levels equal to or less than those measured in Malibu Creek (WV mined stream mean 696 mg/L, max 1520 mg/L; Malibu Creek mean 670 mg/L, max 1582 mg/L) or Las Virgenes Creek (mean 1540 mg/L, max 2003 mg/L). Malibu Creek watershed's best IBI scores, like those in Pond *et al.* (2008) are associated with the lowest sulfate levels. High sulfate levels originate from the Monterey/Modelo Formation (grey shaded region in map, below.)

Sulfate Exceedances

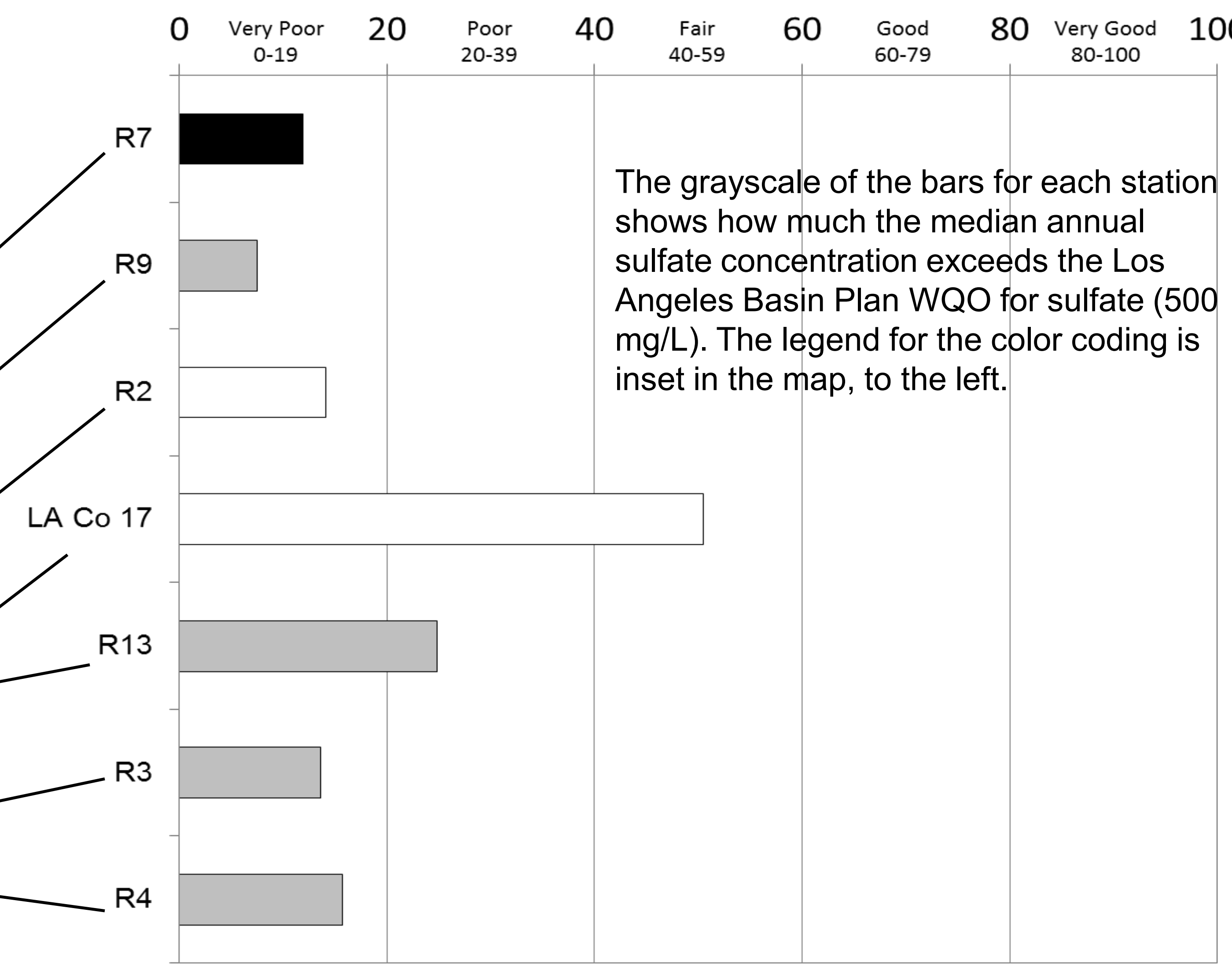
The coding in the spot map below shows how much the sulfate level at each station exceeds the Los Angeles Basin Plan sulfate water quality objective, ranging from white (median meets standard) to black (median is three times higher than the standard).

Seven JPA stations and one Los Angeles County station were classified here by their southern California macroinvertebrate IBI scores (Ode *et al.*, 2005), shown in the figure to the right. Sulfate medians exceeded the standard at all but two stations.



IBI Scores, 2006-2010 Averages

The bars below show average macroinvertebrate Index of Biotic Integrity (IBI) scores for assessments made from 2006-2010 for JPA sites and one Los Angeles County site in upper Cold Creek, which is often used for reference conditions. Bars are colored according to median annual sulfate average, according to the key in the map.



Las Virgenes Municipal Water District
Tapia Water Reclamation Facility

Bioassessment Monitoring Report 2009

Table 9. Southern California IBI scores and ratings for sites sampled in the Malibu Creek Watershed.

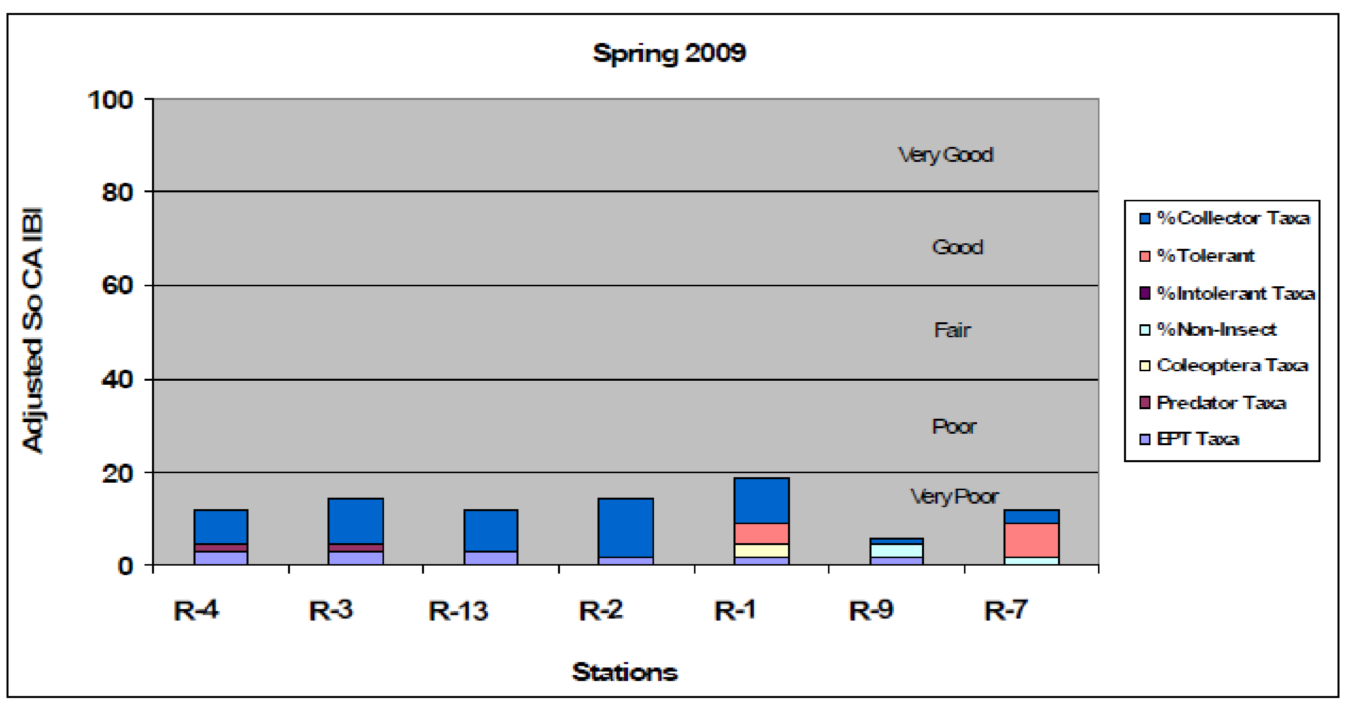
	Malibu Creek						Las Virgenes Creek
Metric	**R-4**	**R-3**	**R-13**	**R-2**	**R-1**	**R-9**	**R-7**
EPT Taxa	2	2	2	1	1	1	0
Predator Taxa	1	1	0	0	0	0	0
Coleoptera Taxa	0	0	0	0	2	0	0
% Non-Insect Taxa	0	0	0	0	0	2	1
% Intolerant Individuals	0	0	0	0	0	0	0
% Tolerant Taxa	0	0	0	0	3	0	5
% Collector Individuals	5	7	6	9	7	1	2
Total	**8**	**10**	**8**	**10**	**13**	**4**	**8**
Adjusted Total (1.43)	**11**	**14**	**11**	**14**	**19**	**6**	**11**
	Very Poor	**Very Poor**	**Very Poor**	**Very Poor**	**Very Poor**	**Very Poor**	**Very Poor**

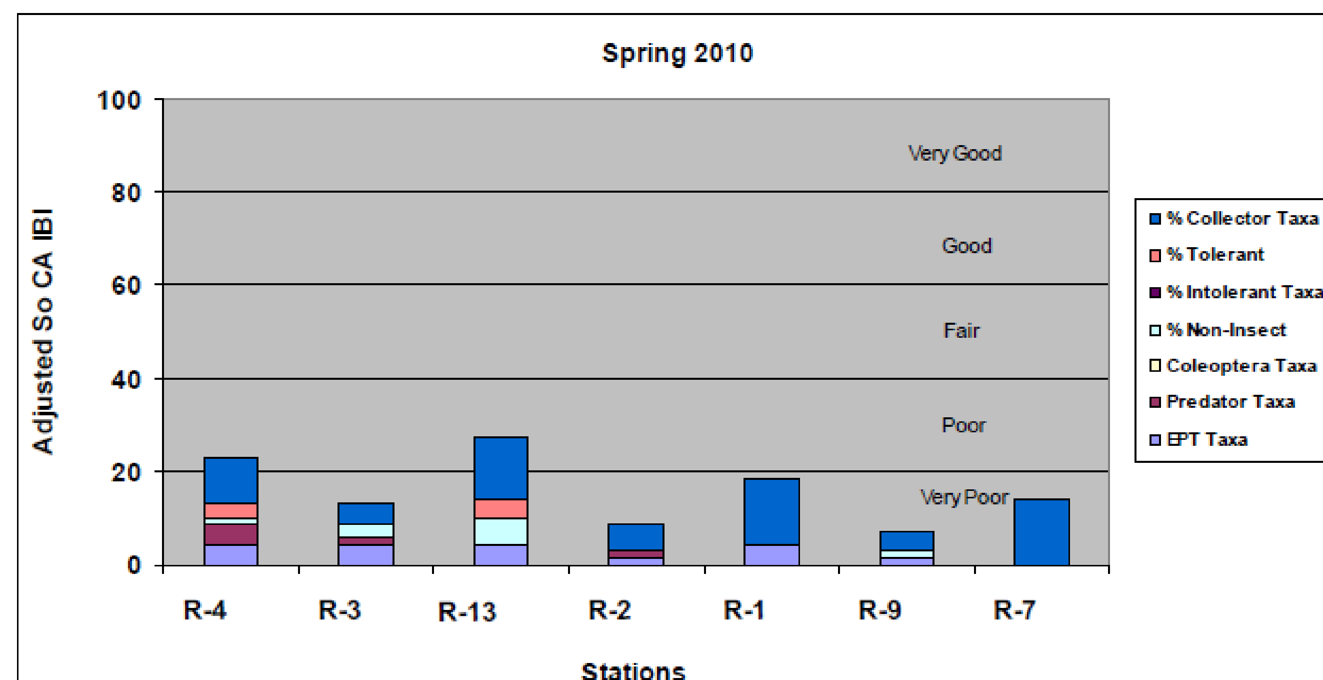
Las Virgenes Municipal Water District
Tapia Water Reclamation Facility

Bioassessment Monitoring Report 2010

Table 9. Southern California IBI scores and ratings for sites sampled in the Malibu Creek Watershed.

	Malibu Creek						Las Virgenes Creek
Metric	**R-4**	**R-3**	**R-13**	**R-2**	**R-1**	**R-9**	**R-7**
EPT Taxa	3	3	3	1	3	1	0
Predator Taxa	3	1	0	1	0	0	0
Coleoptera Taxa	0	0	0	0	0	0	0
% Non-Insect Taxa	1	2	4	0	0	1	0
% Intolerant Individuals	0	0	0	0	0	0	0
% Tolerant Taxa	2	0	3	0	0	0	0
% Collector Individuals	7	3	9	4	10	3	10
Total	**16**	**9**	**19**	**6**	**13**	**5**	**10**
Adjusted Total (1.43)	**23**	**13**	**27**	**9**	**19**	**7**	**14**
	Poor	**Very Poor**	**Poor**	**Very Poor**	**Very Poor**	**Very Poor**	**Very Poor**





Benthic Macroinvertebrate Bioassessments (additional detail)

Table 8. BMI metrics for each of the sample locations in Malibu Creek Watershed.

	Malibu Lagoon	Malibu Creek						Las Virgenes Creek
Biological Metric	**R-11**	**R-4**	**R-3**	**R-13**	**R-2**	**R-1**	**R-9**	**R-7**
Community Richness Measures								
Taxonomic Richness	6	15	17	13	13	12	10	11
EPT Taxa	1	4	4	4	2	3	2	1
Predator Taxa	1	4	4	3	2	2	1	3
Coleoptera Taxa	0	0	0	0	0	1	0	0
Community Composition Measures								
EPT Index (%)	2.2	14.4	15.2	37.6	3.2	13.2	18.2	13.4
Sensitive EPT Index (%)	0.0	0.2	0.0	0.2	0.2	0.0	0.0	0.0
Percent Non-Insect Taxa	33.3	53.3	47.1	53.8	69.2	50.0	40.0	45.5
Percent Non-Insect Individuals	73.9	37.6	64.0	34.0	65.6	49.8	53.8	43.6
Shannon Diversity	1.02	1.64	1.89	1.8	1.62	1.51	1.58	1.68
Community Tolerance Measures								
% Dominant Taxa	69.6	55.6	30.3	39.0	36.3	44.6	40.8	33.9
AverageTolerance Value	5.3	6.3	6.4	5.9	7.0	6.3	5.7	6.2
Percent Intolerant Individuals (0-2)	0.0	0.2	0.0	0.2	0.2	0.0	0.0	0.0
Percent Tolerant Individuals (8-10)	4.3	28.1	42.5	22.6	56.5	33.4	14.8	25.9
Percent Tolerant Taxa (8-10)	16.7	50.0	50.0	41.7	66.7	27.3	55.6	20.0
Percent Hydropsychidae	0.0	0.0	0.0	1.2	0.0	0.8	0.0	0.0
Percent Baetidae	2.2	13.6	14.2	31.8	3.0	12.0	17.6	13.4
Community Feeding Group Measures								
Percent Collectors and Filterers	97.7	77.6	68.6	74.8	61.6	68.8	92.8	91.4
Percent Collectors	97.7	73.8	67.6	70.8	60.8	60.2	90.0	79.4
Percent Filterers	0.0	3.8	1.0	4.0	0.8	8.6	2.8	12.0
Percent Grazers	0.0	18.2	29.4	18.4	37.4	29.4	6.4	8.0
Percent Predators	2.2	4.2	1.4	2.4	0.6	1.4	0.2	0.6
Percent Shredders	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Percent Chironomidae	15.2	43.8	19.8	25.8	30.6	29.0	24.0	30.2

Table 8. BMI metrics for each of the sample locations in Malibu Creek Watershed.

	Malibu Lagoon	Malibu Creek						Las Virgenes Creek
Biological Metric	**R-11**	**R-4**	**R-3**	**R-13**	**R-2**	**R-1**	**R-9**	**R-7**
Community Richness Measures								
Taxonomic Richness	5	20	17	12	17	13	16	10
EPT Taxa	0	6	5	5	3	5	3	1
Predator Taxa	1	6	4	0	4	2	1	2
Coleoptera Taxa	0	0	0	0	0	0	0	0
Community Composition Measures								
EPT Index (%)	0.0	26.2	47.8	30.0	20.2	16.2	16.2	11.2
Sensitive EPT Index (%)	0.0	0.0	0.2	0.2	0.0	0.2	0.0	0.0
Percent Non-Insect Taxa	40.0	45.0	41.2	33.3	52.9	53.8	43.8	60.0
Percent Non-Insect Individuals	94.6	56.6	37.8	55.2	43.2	76.2	38.8	66.4
Shannon Diversity	0.85	2.21	1.95	1.74	1.83	1.3	1.82	1.61
Community Tolerance Measures								
% Dominant Taxa	64.2	21.6	35.2	33.0	35.0	62.6	40.6	45.2
AverageTolerance Value	6.0	6.8	6.1	6.3	6.0	7.1	6.2	7.2
Percent Intolerant Individuals (0-2)	0.0	0.0	0.2	0.2	0.0	0.2	0.0	0.0
Percent Tolerant Individuals (8-10)	30.8	56.4	33.7	37.5	21.2	66.4	23.9	68.3
Percent Tolerant Taxa (8-10)	40.0	31.6	43.8	27.3	50.0	38.5	40.0	44.4
Percent Hydropsychidae	0.0	0.4	0.0	0.0	0.0	0.6	0.2	0.0
Percent Baetidae	0.0	20.4	37.4	24.6	14.8	13.2	14.8	11.2
Community Feeding Group Measures								
Percent Collectors and Filterers	99.6	69.4	84.8	62.4	81.6	33.8	86.8	54.4
Percent Collectors	99.6	66.6	84.4	60.6	80.6	33.2	85.4	42.2
Percent Filterers	0.0	2.8	0.4	1.8	1.0	0.6	1.4	12.2
Percent Grazers	0.0	22.4	4.4	33.4	12.2	63.2	11.6	45.2
Percent Predators	0.4	4.2	3.8	0.0	1.2	0.6	0.4	0.4
Percent Shredders	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Percent Chironomidae	1.8	12.6	13.4	12.4	35.0	7.6	40.6	10.0


R-11 facing upstream

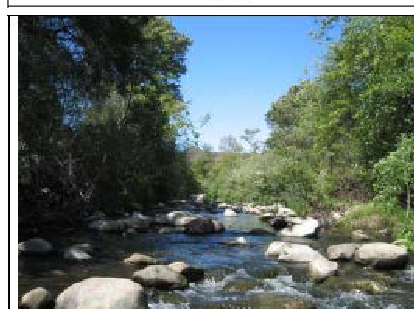

R-11 facing downstream


R-4 facing upstream


R-4 facing downstream


R-3 facing upstream


R-3 facing downstream


R-13 facing upstream


R-13 facing downstream


R-2 facing upstream


R-2 facing downstream

New Zealand mudsnail survey results (Aquatic Bioassay and Consulting Laboratories, 2010)

Table 7. Abundances of New Zealand mudsnails at sites in the Malibu Creek Watershed from 2007 to 2010.

Survey Year	Station	Abundance	Combined Annual Total
2007	R-4	52	680
	R-3	15	
	R-13	196	
	R-2	138	
	R-1	122	
	R-7	157	
2008	R-4	4	13
	R-3	0	
	R-13	0	
	R-2	7	
	R-1	0	
	R-7	2	
2009	R-4	42	445
	R-3	69	
	R-13	73	
	R-2	201	
	R-1	37	
	R-7	23	
2010	R-4	29	804
	R-3	14	
	R-13	165	
	R-2	57	
	R-1	313	
	R-7	226	

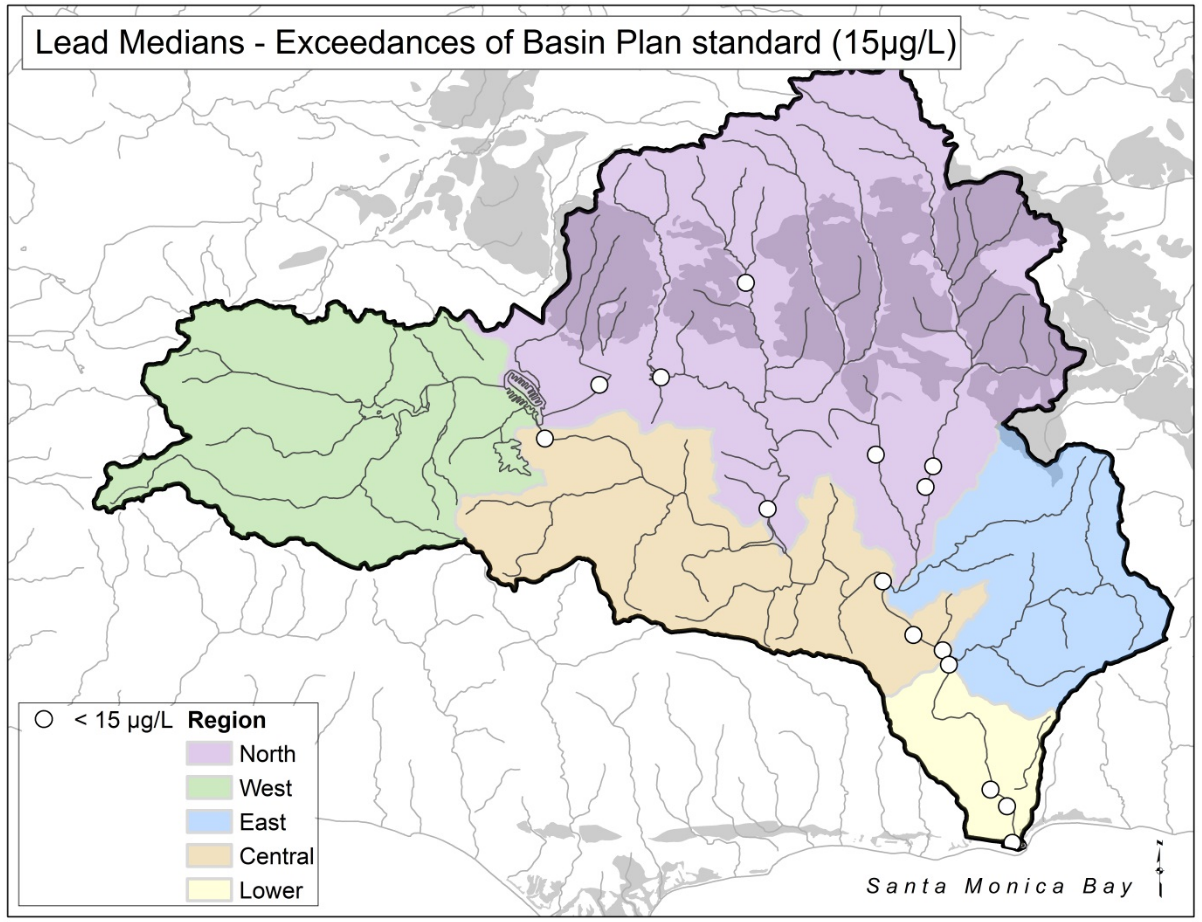
Human Health

Lead, mercury, bacterial indicators and body contact recreation, drinking water supply

Water quality: Each sheet in the this section summarizes the available data for a specific pollutant in the Malibu Creek watershed identified on the current state 303(d) list as responsible for impairing human health or body contact recreation. **Our main objective** was to identify where current water quality is not meeting Basin Plan water quality objectives or other applicable standards, but wherever we had sufficient data (most cases), we provide additional detail on annual and seasonal variation, historical trends, pollutant sources and impacts on human health and aquatic life.

Water quality parameters analyzed: Mercury, lead, *E. coli*, total coliform bacteria, fecal coliform bacteria, TDS and hardness (mineral quality section). **Not analyzed:** Recent DNA testing (Malibu Civic Center area), shoreline bacteria (outside geographic study scope).

Major findings: Lead only occasionally exceeds standards in wet weather. Mercury was never found to exceed standards. Bacteria levels regularly exceed body contact limits following storm events and also during the summer on occasion. Malibu Creek and its northern tributaries exceed state and federal secondary standards for drinking water for multiple parameters (SC, TDS, sulfate, hardness, alpha and beta emission) downstream from the Monterey Formation.



Lead

Historically high levels of lead have decreased

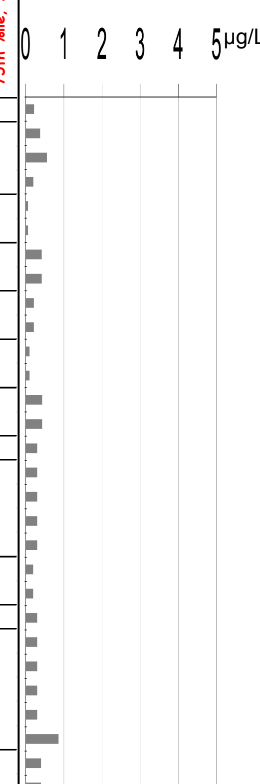
Water quality: Since 1980, data available on lead levels have only once, on January 18, 2006, exceeded the EPA drinking water Lead and Copper Rule Action Level for lead, 15 µg/L and the calculated 14.7 mg/L CTR criterion for lead using WER =1.0 and total hardness of 400 mg/L (the default hardness value when hardness exceeds 400 mg/L). Note that the CTR criterion is hardness dependent, so would vary according to sample hardness. Total hardness data for the watershed (N=311) averaged 1,021 mg/L (as $CaCO_3$). Only 6 values were less than 400 mg/L. Shown in the graph are all available data on lead levels in Malibu Creek and its tributary streams. Available data prior to 1980 are more sparse; there are only 19 samples from the dry season (April 16-Nov 14) and 2 from the wet season. An additional eight wet season samples were taken in 1980. The scarcity of early data may bias the apparent downward trend. No data were collected in the western or eastern regions. **Annual & Seasonal variation:** Lead levels can vary seasonally, with peaks in wet weather when all the single sample exceedances in the last decade occurred. **Source assessment:** The most historically significant source of lead in the watershed is likely leaded gasoline, available from the 1920s until its sale was banned in California in 1991. The use of leaded gasoline began to decline when new cars came out with catalytic converters in 1975. The sale of lead based paints was banned in 1977, before most development in the watershed occurred. **Historical Trends:** Lead levels have declined from 1970s and early 1980s. **303(d) listings:** The three listings for lead in the watershed are for Triunfo Canyon Reaches 1 and 2, and for Westlake Lake. The only data available for any of these sites were from the Malibu Creek Watershed Monitoring Project: three samples from site TRI in Triunfo Canyon Creek Reach 2 had values of 0.195, 0.25 and 0.1 (not detected). Decision IDs 7100 for Triunfo Creek Reach 1, 7130 for Reach 2, and 7027 for Westlake Lake say "303(d) listing decisions made prior to 2006 were not held in an assessment database." Additional sampling of these water bodies may be needed to determine whether listing is still appropriate.

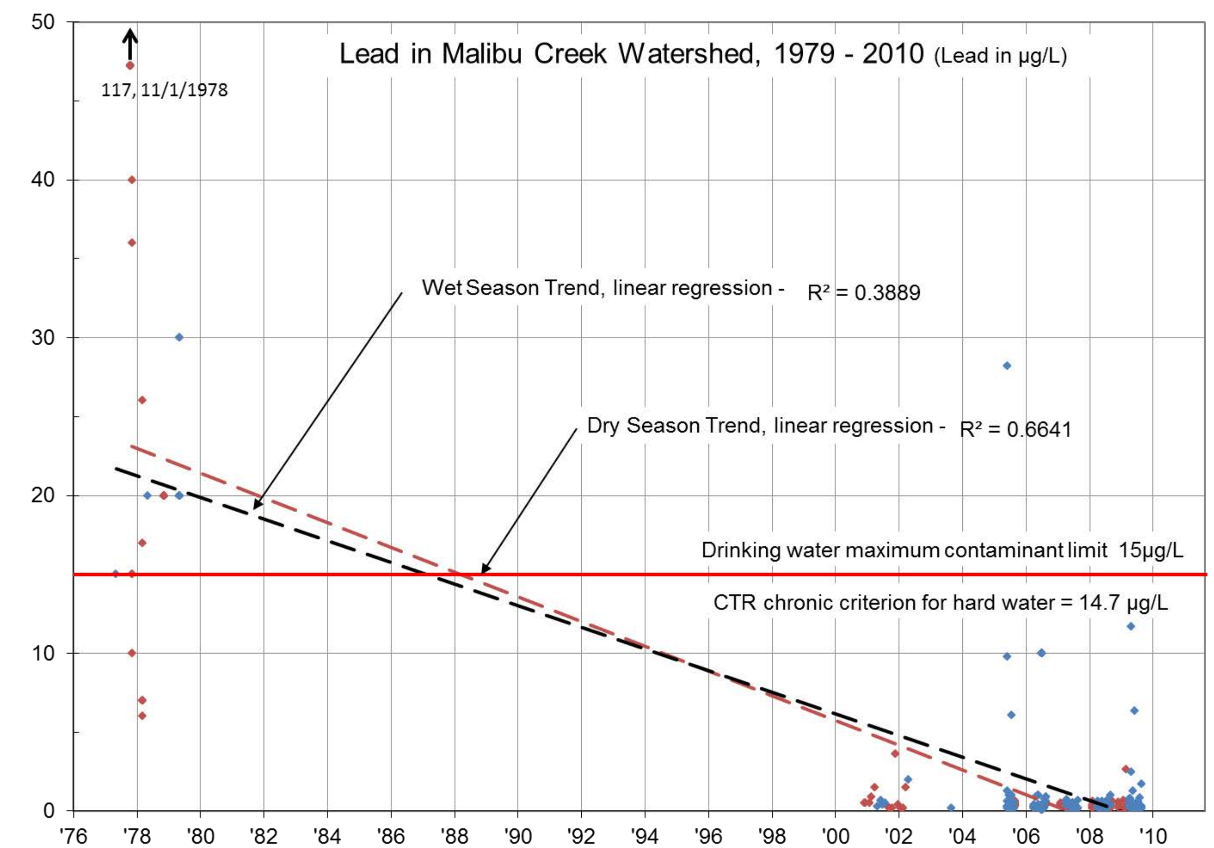
Potential impacts on aquatic life: Lead no longer appears to present a significant threat to human health or aquatic life in the watershed.

Lead - µg/L (Action Level fom EPA Lead and Copper Rule) = 15 µg/L

Is annual median > Water Quality Objective?	Region	Reach	Land Use	Site	Annual Record: Median	25th Percentile	75th Percentile	Count	Seasonal Record: Median Wet	25th Percentile Wet	75th Percentile Wet	Count Wet	Median Dry	25th Percentile Dry	75th Percentile Dry	Count Dry	Exceedances: Median, Annual >TMDL	25th %ile, Annual >TMDL	75th %ile, Annual >TMDL
	North	all sites combined			0.22	0.10	0.46	12	0.22	0.10	0.46	12				0			
	North	Las_Virgenes	all sites combined		0.38			4	0.38			4				0			
	North	Las_Virgenes	Developed	LV2	0.56			3	0.56			3				0			
	North	Las_Virgenes	Developed	LVCreek_Farm_LV3	0.20			1	0.20			1				0			
	North	Liberty Canyon	all sites combined		0.06			1	0.06			1				0			
	North	Liberty Canyon	Developed	LC	0.06			1	0.06			1				0			
	North	Lindero_1	all sites combined		0.42			3	0.42			3				0			
	North	Lindero_1	Developed	LIN2	0.42			3	0.42			3				0			
	North	Medea_1	all sites combined		0.21			2	0.21			2				0			
	North	Medea_1	Developed	MED2	0.21			2	0.21			2				0			
	North	Medea_2	all sites combined		0.10			1				0				0			
	North	Medea_2	Developed	MED1	0.10			1				0				0			
	North	Russell		all sites combined	0.43			1	0.43			1				0			
	North	Russell	Developed	RUS	0.43			1	0.43			1				0			
	Central	all sites combined			0.30	0.20	0.43	112	0.30	0.20	0.40	83	0.30	0.20	0.50	28			
	Central	Malibu	all sites combined		0.30	0.20	0.50	109	0.30	0.20	0.40	81	0.30	0.20	0.50	28			
	Central	Malibu	Developed	RSW_MC001U	0.30	0.20	0.50	51	0.40	0.20	0.40	31	0.30	0.20	0.53	20			
	Central	Malibu	Developed	RSW_MC002D	0.30	0.20	0.50	33	0.40	0.30	0.50	27	0.25	0.20	0.38	6			
	Central	Malibu	Developed	RSW_MC009U	0.30	0.20	0.40	25	0.30	0.20	0.40	23	0.25			2			
	Central	Triunfo_2	all sites combined		0.20			3	0.20			3				0			
	Central	Triunfo_2	Developed	TRI	0.20			3	0.20			3				0			
	Lower	all sites combined			0.30	0.20	0.51	103	0.30	0.20	0.50	86	0.40	0.30	0.59	17			
	Lower	Malibu	all sites combined		0.30	0.20	0.51	103	0.30	0.20	0.50	86	0.40	0.30	0.59	17			
	Lower	Malibu	Developed	RSW_MC003D	0.30	0.20	0.40	33	0.30	0.20	0.45	27	0.30	0.30	0.38	6			
	Lower	Malibu	Developed	RSW_MC004D	0.30	0.20	0.50	28	0.30	0.20	0.50	27	0.40	0.40	0.40	1			
	Lower	Malibu	Developed	RSW_MC013D	0.30	0.20	0.40	33	0.30	0.20	0.45	27	0.25	0.20	0.38	6			
	Lower	Malibu	Developed	S02	0.86	0.66	2.64	9	2.47	0.86	6.32	5	0.64	0.61	1.16	4			
		Lagoon	all sites combined		0.40	0.20	0.67	29	0.40	0.25	0.90	23	0.30	0.20	0.48	6			
		Lagoon	Developed	RSW_MC011D	0.40	0.20	0.67	29	0.40	0.25	0.90	23	0.30	0.20	0.48	6			

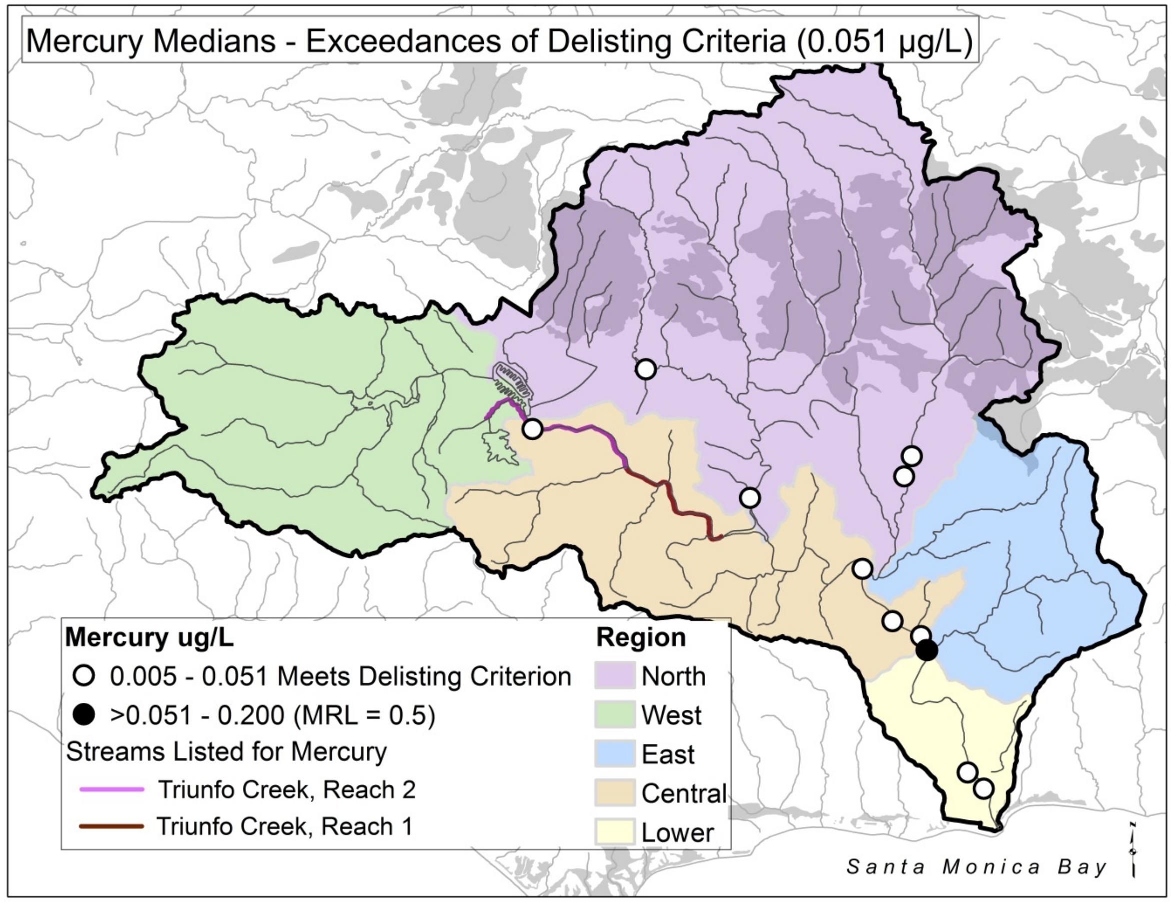
Lead WQO
= ~15 µg/L





Mercury

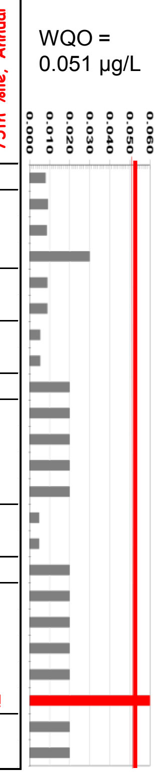
Mercury levels have declined from nearer limits to well below limits

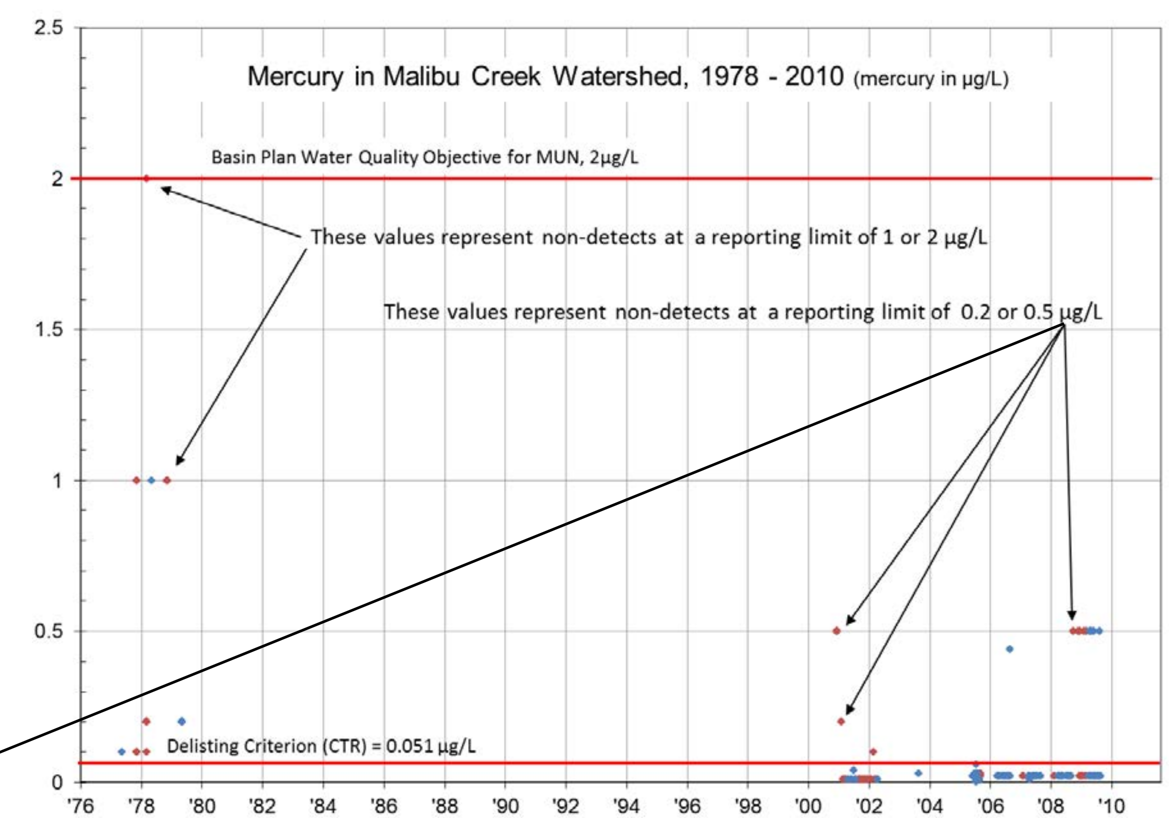


Water quality: All available data on mercury levels in Malibu Creek and its tributary streams are shown in the graph. The table shows median, 25th and 75th percentile values sorted by season and by geographic region (east, west, north, central, lower watershed, lagoon). No data were available for western and eastern tributaries. LVMWD collected 264 samples in the watershed, 264 of which were non-detects, but analyzed based on method reporting limits (MRL) ranging from 0.01 to 2 µg/L. The Los Angeles County Mass Emissions site collected nine samples: all nine were non-detects (MDL = 0.1 µg/L and MRL = 0.5 µg/L). The Malibu Creek Watershed Monitoring Program sampled mercury as part of their Hot Spot testing: eight samples from four sites were analyzed resulting in detectable values ranging from 0.0015 to 0.0092 µg/L. All detected values were below the MUN WQO and the CTR delisting criterion. **Annual & Seasonal variation:** There is no apparent seasonal variation in mercury concentration although patterns may be masked by the variation in method reporting limits. **Source assessment:** Source(s) unknown. The largest value detected (0.44 µg/L) was from site RWS_MC011 at Malibu Lagoon, which may indicate a local source there. However, mercury in excess of aquatic life objectives has also been recorded from Lake Sherwood in the upper watershed, with no known or obvious source. **Historical Trends:** Time series graphs show a significant decline, but this may be an artifact of improved laboratory methods. The 1 and 2 µg/L values early in the record are actually <1 and <2 µg/L – the method detection limit at the time. Trends may be confounded by the variation in method reporting limits over time and also between the three agencies collecting mercury data. **Regulatory implications:** The two listings for mercury in the watershed are for Triunfo Canyon Reaches 1 and 2. The only data available for any of these sites was from the Malibu Creek Watershed Monitoring Project: two samples from site TRI in Triunfo Canyon Creek Reach 2 had values of 0.0015 and 0.008. Decision IDs 7128 for Triunfo Creek Reach 1, 7131 for Reach 2 say "303(d) listing decisions made prior to 2006 were not held in an assessment database." Additional sampling of these water bodies may be needed to determine whether listing is still appropriate. **Potential impacts on aquatic life:** Mercury levels are well below the Basin Plan Water Quality Objective of 2 µg/L, so potentially adverse effects on human health and aquatic life are likely minimal except in Malibu Lagoon and Lake Sherwood.

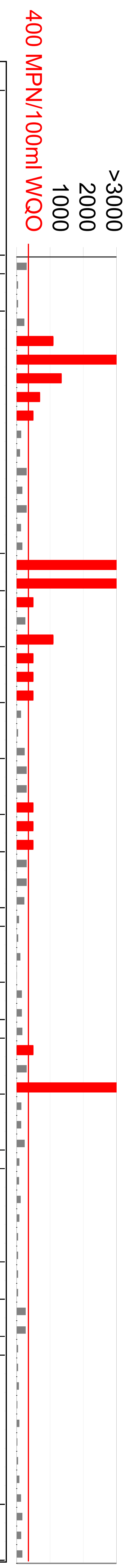
Mercury - µg/L; Delisting Criterion (CTR) = 0.051 µg/L

Is annual median > Water Quality Objective?	Region	Reach	Land Use	Site	Annual Record: Median	25th Percentile	75th Percentile	Count	Seasonal Record: Median Wet	25th Percentile Wet	75th Percentile Wet	Count Wet	Median Dry	25th Percentile Dry	75th Percentile Dry	Count Dry	Exceedances: Median, Annual >WQO	25th %ile, Annual >WQO	75th %ile, Annual >WQO
	North	all sites combined			0.008	0.006	0.011	7	0.008	0.006	0.011	7				0			
	North	Las_Virgenes	all sites combined		0.009			3	0.009			3				0			
	North	Las_Virgenes	Developed	LV2	0.009			2	0.009			2				0			
	North	Las_Virgenes	Developed	LVCreek_Farm_LV3	0.030			1	0.030			1				0			
	North	Lindero_1	all sites combined		0.009			2	0.009			2				0			
	North	Lindero_1	Developed	LIN2	0.009			2	0.009			2				0			
	North	Medea_1	all sites combined		0.005			2	0.005			2				0			
	North	Medea_1	Developed	MED2	0.005			2	0.005			2				0			
	Central	all sites combined			0.020	0.020	0.020	111	0.020	0.020	0.020	83	0.020	0.010	0.020	28			
	Central	Malibu	all sites combined		0.020	0.020	0.020	109	0.020	0.020	0.020	81	0.020	0.010	0.020	28			
	Central	Malibu	Developed	RSW_MC001U	0.020	0.015	0.020	51	0.020	0.020	0.020	31	0.020	0.010	0.020	20			
	Central	Malibu	Developed	RSW_MC002D	0.020	0.020	0.020	33	0.020	0.020	0.020	27	0.020	0.020	0.020	6			
	Central	Malibu	Developed	RSW_MC009U	0.020	0.020	0.020	25	0.020	0.020	0.020	23	0.025	0.023	0.028	2			
	Central	Triunfo_2	all sites combined		0.005			2	0.005			2				0			
	Central	Triunfo_2	Developed	TRI	0.005			2	0.005			2				0			
	Lower	all sites combined			0.020	0.020	0.020	103	0.020	0.020	0.020	86	0.020	0.020	0.030	17			
	Lower	Malibu	all sites combined		0.020	0.020	0.020	103	0.020	0.020	0.020	86	0.020	0.020	0.030	17			
	Lower	Malibu	Developed	RSW_MC003D	0.020	0.020	0.020	33	0.020	0.020	0.020	27	0.020	0.020	0.020	6			
	Lower	Malibu	Developed	RSW_MC004D	0.020	0.020	0.020	28	0.020	0.020	0.020	27	0.020	0.020	0.020	1			
	Lower	Malibu	Developed	RSW_MC013D	0.020	0.020	0.020	33	0.020	0.020	0.020	27	0.020	0.020	0.020	6			
Yes	Lower	Malibu	Developed	S02	0.500	0.500	0.500	9	0.500	0.500	0.500	5	0.500	0.500	0.500	4	!	!	!
	Lagoon		all sites combined		0.020	0.020	0.020	29	0.020	0.020	0.020	23	0.020	0.020	0.020	6			
	Lagoon		Developed	RSW_MC011D	0.020	0.020	0.020	29	0.020	0.020	0.020	23	0.020	0.020	0.020	6			





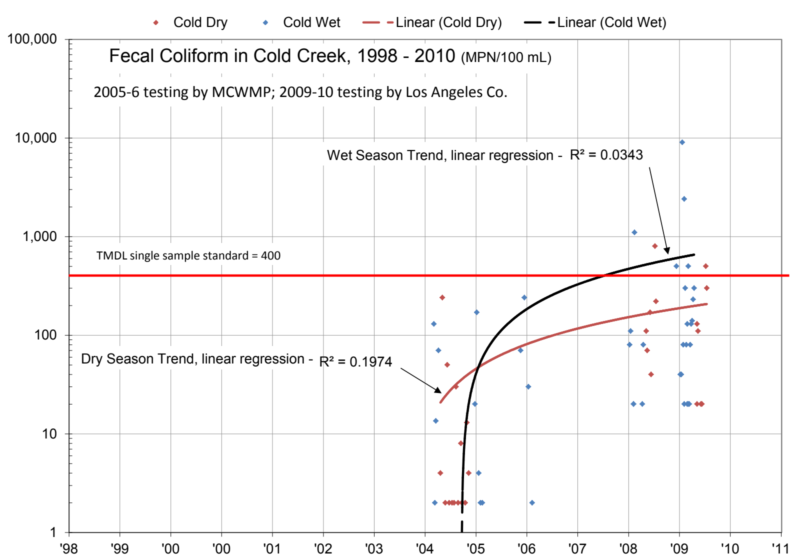
Fecal Coliform Bacteria MPN or CFU/100 ml

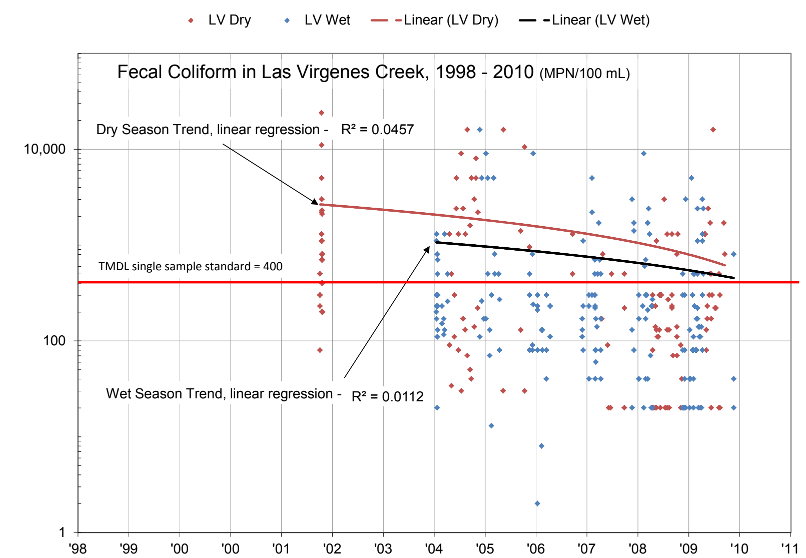


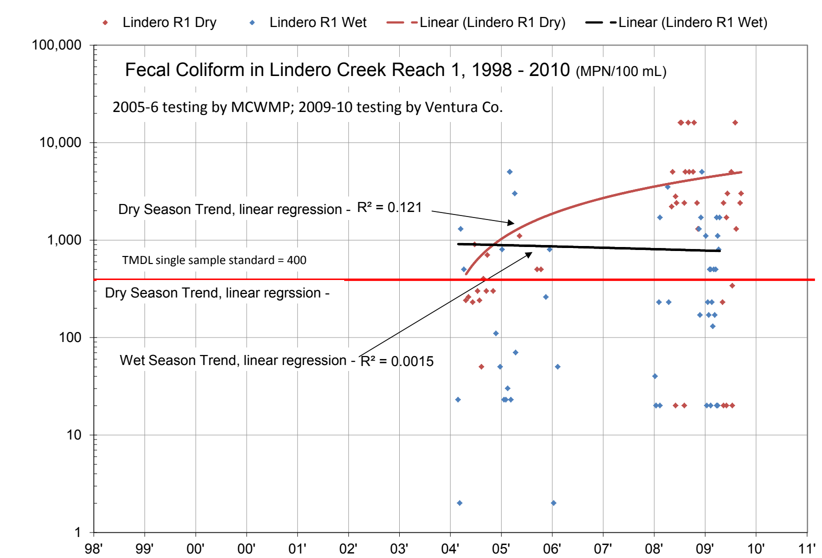
Fecal Coliform (MPN/100mL) TMDL single sample limit = 400

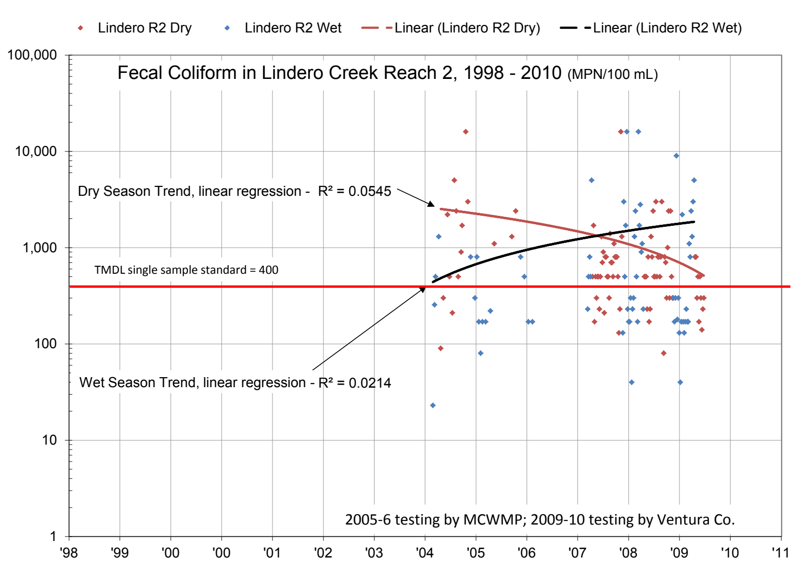
Is annual median > Water Quality Objective?	Region	Creek	LandUse	Site	Annual Record: Median	25th Percentile	75th Percentile	Count	Seasonal Record & Exceedances: Median Wet	25th Percentile Wet	75th Percentile Wet	Count Wet	Median Dry	25th Percentile Dry	75th Percentile Dry	Count Dry	Median Wet >WQO	Median Dry >WQO
	North	all sites combined			300	130	938	1142	230	90	800	569	500	200	1300	573		!
		Cheeseboro	all sites combined		40			4	40			4				0		
			Developed	MCW_9	40			4	40			4				0		
		Las_Virgenes	all sites combined		230	80	775	342	170	80	500	201	300	110	1300	141		
Yes			Developed	LV_atMulholland	1100	600	2600	7				0	1100	600	2600	7		!
Yes			Developed	LV_belowLibertyCynCreek	3550			4				0	3550			4		!
Yes			Developed	LV2	1350	350	5000	38	500	225	5000	20	2300	1300	7250	18	!	!
Yes			Developed	LVCreek_Farm_LV3	700	475	1150	8				0	700	475	1150	8		!
Yes			Developed	LVCreek_WhiteOak_LV4	500	282	875	16	500	300	800	14	765			2	!	!
			Developed	MCW_7	135	20	300	60	140	40	300	29	130	20	285	31		
			Developed	RSW_MC001F	100	40	230	30	120	40	230	24	80	35	185	6		
			Developed	RSW_MC002F	300	130	725	44	300	130	700	38	400	172	1100	6		
			Developed	RSW_MC003F	170	80	400	37	95	80	180	24	300	220	800	13		
			Developed	RSW_MC007D	300			1				0	300			1		
			Open Space	LV1	130	55	208	34	160	78	245	16	85	42	162	18		
			Open Space	MCW_8b	170	75	500	63	110	20	500	36	300	120	950	27		
Yes		Liberty Canyon	all sites combined		4000	1300	9000	34	3000	700	5000	17	9000	2400	16000	17	!	!
Yes			Developed	LC	4000	1300	9000	34	3000	700	5000	17	9000	2400	16000	17	!	!
Yes		Lindero_1	all sites combined		500	65	2250	92	230	23	1100	49	1300	280	3000	43		!
			Developed	LIN2	260	50	700	33	70	23	800	19	300	245	500	14		
Yes			Developed	MCW_13	1100	170	2600	59	230	62	1100	30	2400	1300	5000	29		!
Yes		Lindero_2	all sites combined		500	255	1100	185	300	170	1150	80	500	300	1100	105		!
Yes			Developed	LIN1	500	190	1300	31	238	170	575	16	1300	500	2400	15		!
Yes			Developed	MCW_14b	500	300	1100	154	500	178	1300	64	500	300	800	90	!	!
		Medea_1	all sites combined		130	36	300	88	130	40	300	45	130	20	300	43		
			Developed	MCW_11	40	20	230	52	40	20	130	25	40	20	300	27		
			Developed	MED2	240	130	500	36	235	125	575	20	270	130	350	16		
		Medea_2	all sites combined		300	170	800	186	300	130	800	80	500	180	800	106		!
			Developed	MCW_12	300	170	800	154	300	130	800	64	300	170	800	90		
Yes			Developed	MED1	500	228	950	32	300	160	575	16	800	500	1700	16		!
Yes		Palo_Comado	all sites combined		500	240	3000	54	500	235	1200	27	2400	250	9000	27	!	!
Yes			Developed	MCW_10	500	240	3000	54	500	235	1200	27	2400	250	9000	27	!	!
		Russell			300	170	800	157	220	90	500	66	300	220	1000	91		
			Developed	MCW_15b	300	170	800	126	230	110	700	49	300	210	800	77		
			Developed	RUS	230	130	1100	31	170	80	220	17	1050	400	2400	14		!
	East	all sites combined			70	20	230	92	70	20	270	59	50	4	170	33		
		Cold	all sites combined		45	15	138	66	80	20	155	39	20	3	120	27		
			Developed	MCW_5	110	30	265	39	80	25	282	26	110	40	220	13		
			Open Space	CC	4	2	40	27	20	2	70	13	3	2	12	14		
		Stokes	all sites combined		155	40	450	26	70	35	550	20	200	148	282	6		
			Developed	MCW_6	155	40	450	26	70	35	550	20	200	148	282	6		
	West	all sites combined			170	80	330	62	140	70	500	49	230	170	270	13		
Yes		Hidden Valley	all sites combined		500	265	1750	11	500	300	2400	9	265			2	!	
			Developed	HV	300	230	500	9	500	235	800	7	265			2	!	
Yes			Developed	MCW_18	5700			2	5700			2				0	!	
		Potrero	all sites combined		140	65	255	51	130	55	255	40	210	155	250	11		
			Developed	MCW_17	135	62	230	46	130	55	248	36	190	148	230	10		
			Developed	POT	240	80	300	5	160			4	500			1		!
	Central	all sites combined			80	20	200	569	70	20	170	315	80	40	200	254		
		Malibu	all sites combined		70	20	170	497	40	20	130	272	80	40	200	225		
			Developed	MCW_4	120	20	430	38	130	32	500	26	60	20	148	12		
			Developed	RSW_MC001U	80	40	200	165	40	20	170	83	110	45	215	82		
			Developed	RSW_MC002D	40	20	140	166	40	20	110	85	80	40	200	81		
			Developed	RSW_MC009U	40	20	115	128	40	20	110	78	40	20	138	50		
		Triunfo_1	all sites combined		40	20	170	37	40	20	195	23	20	20	75	14		
			Developed	MCW_16	40	20	170	37	40	20	195	23	20	20	75	14		
		Triunfo_2	all sites combined		270	150	800	35	235	200	800	20	500	65	800	15		!
			Developed	TRI	270	150	800	35	235	200	800	20	500	65	800	15		!
	Lower	all sites combined			40	20	140	602	40	20	130	318	40	20	170	284		
		Malibu	all sites combined		40	20	140	602	40	20	130	318	40	20	170	284		
			Developed	MAL	65	12	220	34	198	45	230	16	18	9	106	18		
			Developed	MCW_2	20	20	70	39	40	20	155	23	20	20	40	16		
			Developed	MCW_3	80	20	300	51	80	25	282	26	80	20	300	25		
			Developed	RSW_MC003D	20	20	75	163	20	20	78	82	20	20	70	81		
			Developed	RSW_MC004D	40	20	110	137	40	20	80	82	80	20	170	55		
			Developed	RSW_MC013D	80	40	200	169	70	35	140	84	80	40	200	85		
			Developed	S02	130	20	340	9	130	20	230	5	235			4		
		Lagoon	all sites combined		170	40	330	214	185	80	500	104	155	25	300	110		
			Developed	MCW_1	135	40	350	52	130	40	500	26	155	40	300	26		
			Developed	RSW_MC011D	170	70	330	162	220	95	330	78	155	20	325	84		

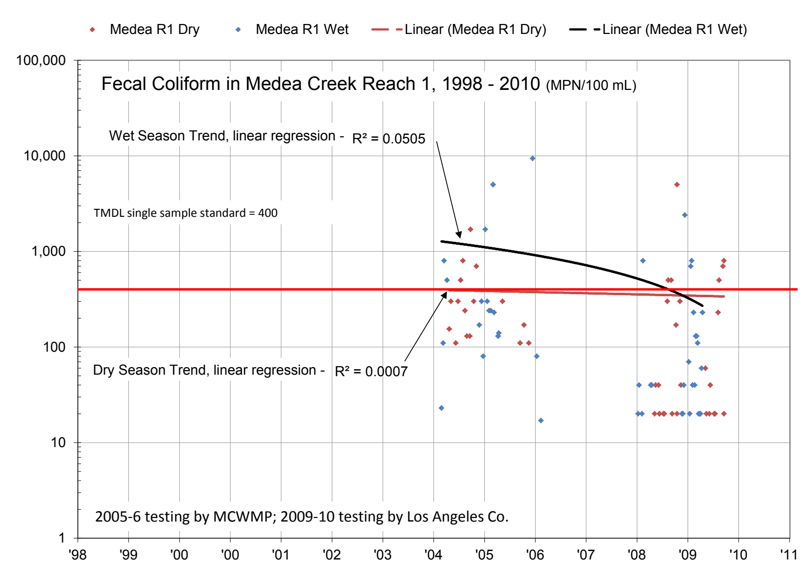
Fecal Coliform Bacteria CFU/100 ml

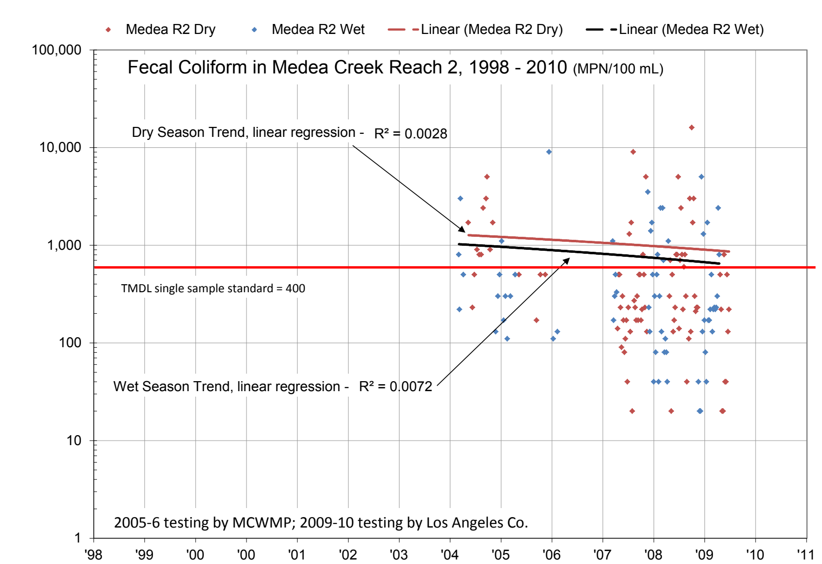


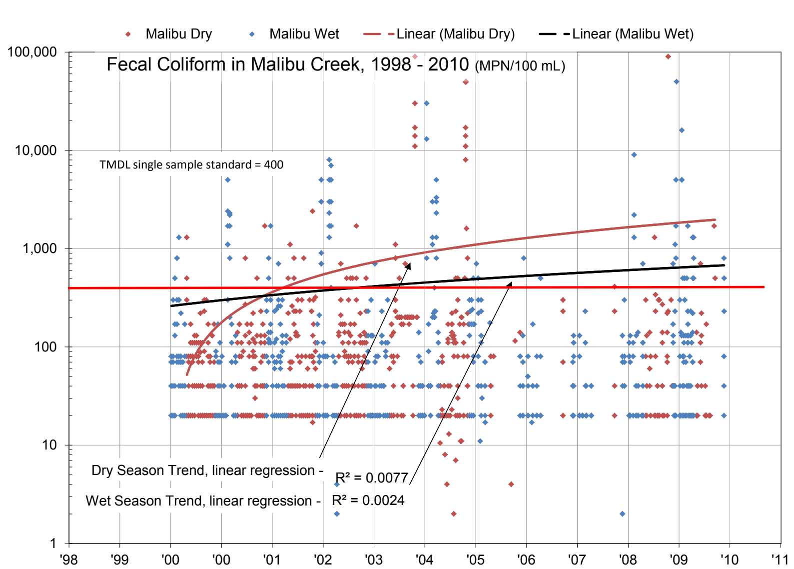


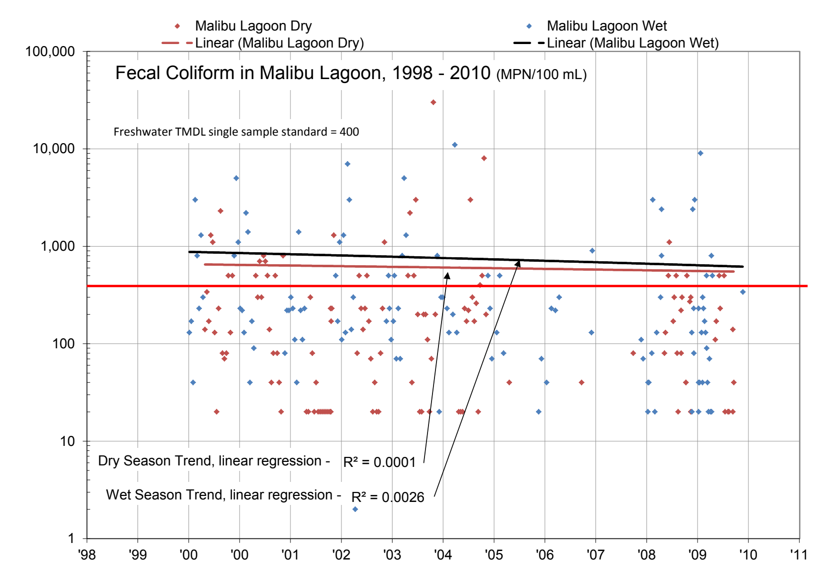


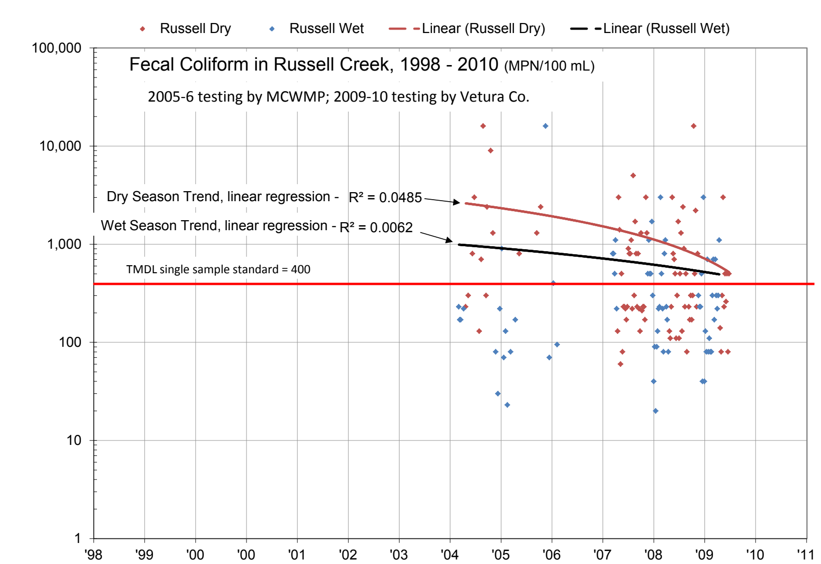






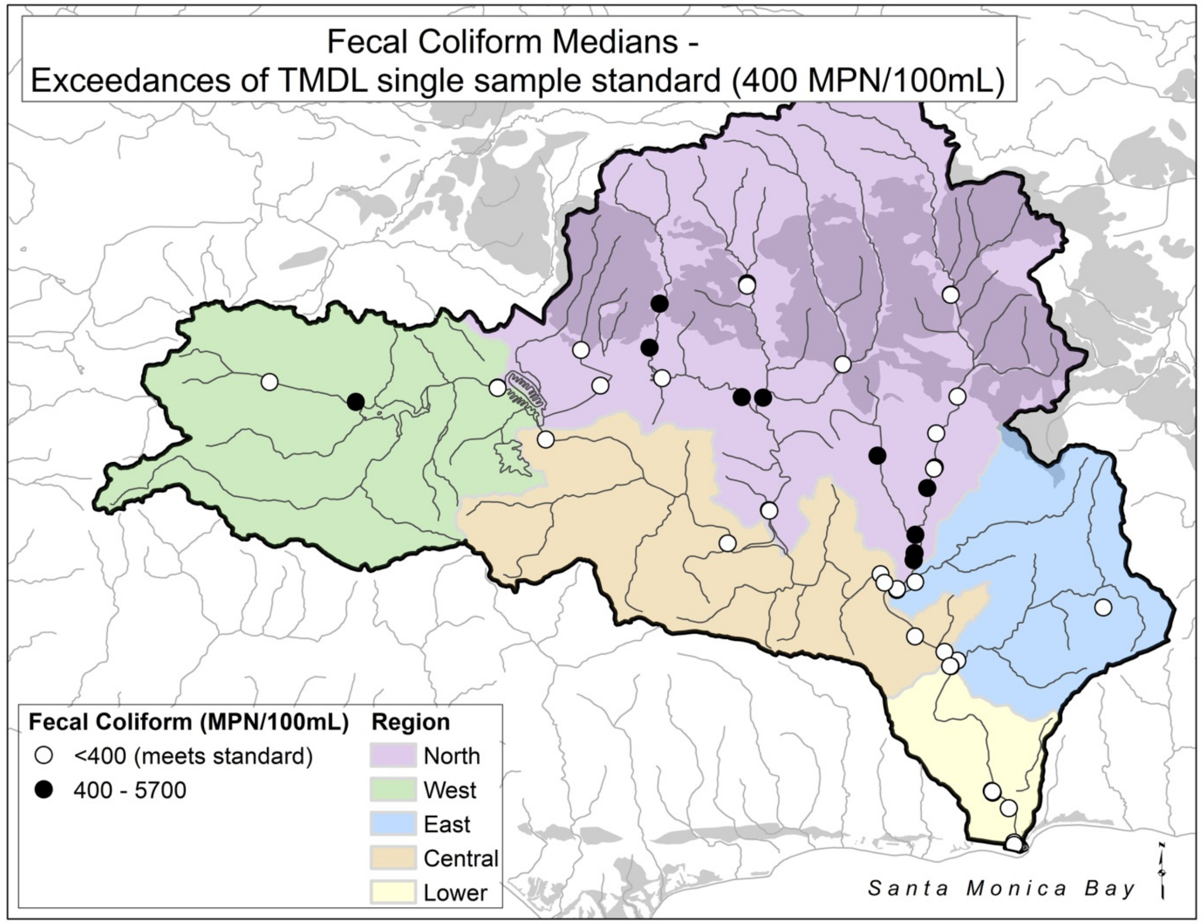




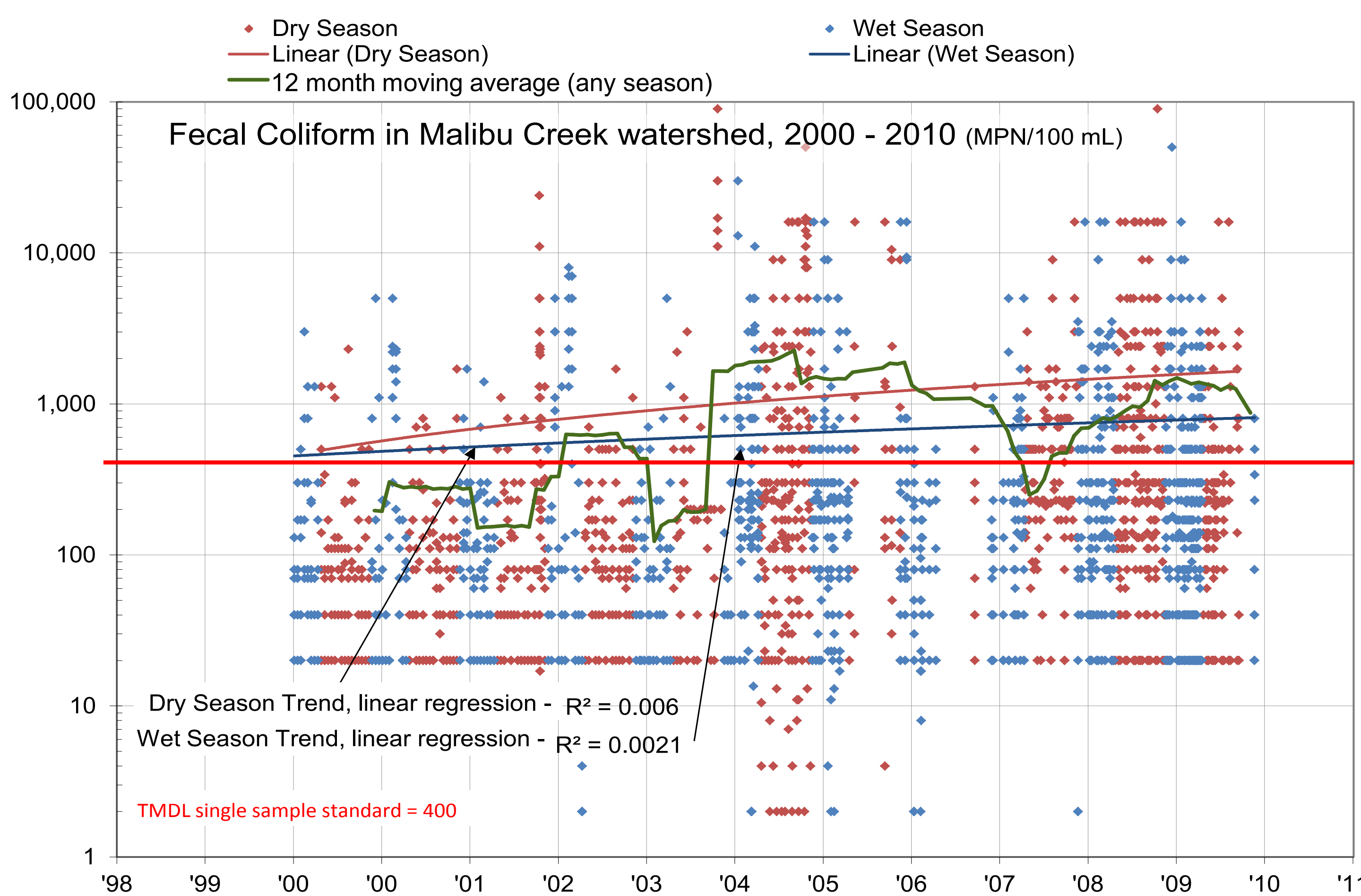


Fecal Coliform

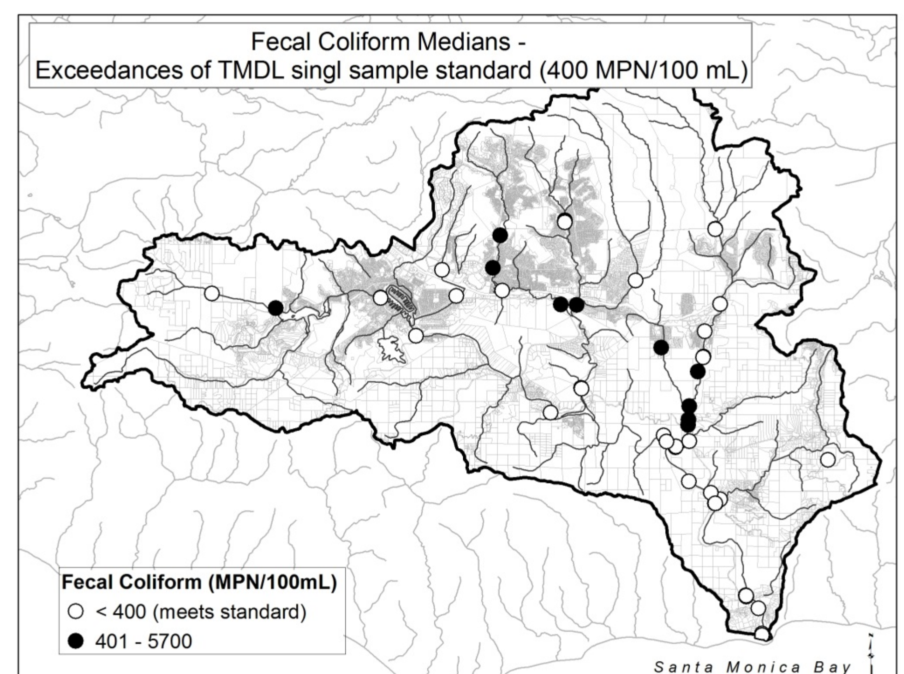
Single sample standard exceedances are increasing



Water quality: Shown on the graph are all available data on fecal coliform concentrations in Malibu Creek watershed. The table on a preceding page shows medians, 25th and 75th percentile value for Malibu Creek and its tributary streams, sorted by season and by geographic region (east, west, north, central, lower watershed, lagoon). It should be noted that sites LV_atMulholland, LV_belowLibertyCynCreek,and RSW_MC003F were used for surface water quality monitoring when a biosolids force main broke and was repaired during the period of October 14-22, 2002. **Historical Trends:** The twelve month moving average on the graph of all data, below left, shows a steep increase around 2004, which may correspond with the wetter winter that year. At this time the moving average changed from usually meeting the standard to usually exceeding it. The watershed-wide trends for both wet and dry weather are increasing, although this varies by reach. Time as an explanatory variable results in low R^2 values for all reaches. **Annual & Seasonal variation:** Fecal coliform varies only slightly by season. **Source assessment:** The Malibu Creek watershed Bacteria TMDL (2004) lists onsite wastewater treatment systems (OWTS), animal wastes and runoff from developed and undeveloped areas as potential sources of bacteria. Recent research by the US Geological Survey (Izbicki et al. 2010) at the Malibu Lagoon and Civic Center area found no indication that OWTS are a source of fecal bacteria in the lagoon; rather, sources there are primarily natural. Fecal coliform sources in the rest of the watershed could be similar with animal waste, both wild and domestic, being a primary source. The map below plots fecal coliform annual medians on parcels. Fecal coliform median values exceed standards at locations that are more densely populated and at Hidden Valley, which has agricultural land uses.

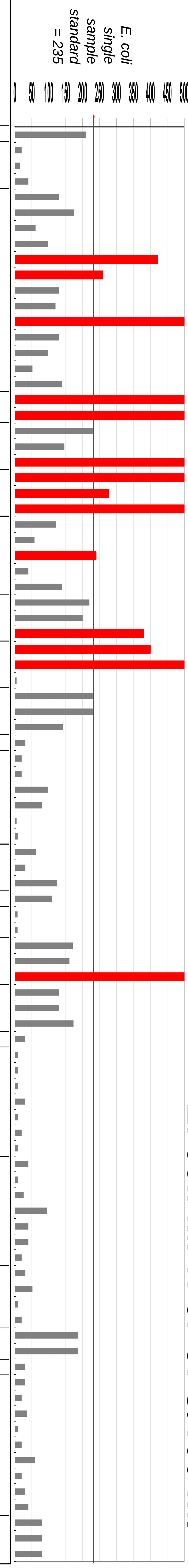


Potential impacts on human health: The impetus for the Malibu Creek watershed Bacteria TMDL was to improve water quality conditions for body contact recreation at Surfrider and other Santa Monica Bay beaches. The EPA recently (December 2010) approved the use of rapid assessment techniques at beaches, but not for TMDL and NPDES monitoring in streams that drain to those beaches. To the extent that pathogens are human-specific, rapid assessment techniques may be more appropriate. **Recommendations for further monitoring:** Reaches included on the 303(d) list of impaired water bodies are all currently monitored for fecal coliform. Median annual values at Hidden Valley and Liberty Canyon Creeks also exceed the 400 MPN/100 mL standard, and could be monitored for possible addition to the 303(d) list.



The absence of Bacteroidales in the lagoon and low fecal indicator bacteria (FIB)concentrations in shallow groundwater downgradient from treatment systems suggests that treated effluent was not the source of high FIB concentrations in the lagoon during the sample period.
– Izbicki, *et al.*, USGS, 2010

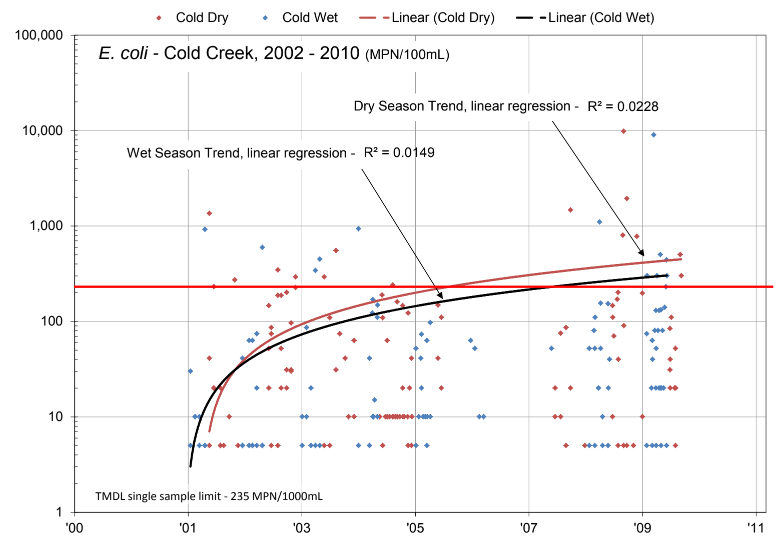
E. coli MPN or CFU/100 ml

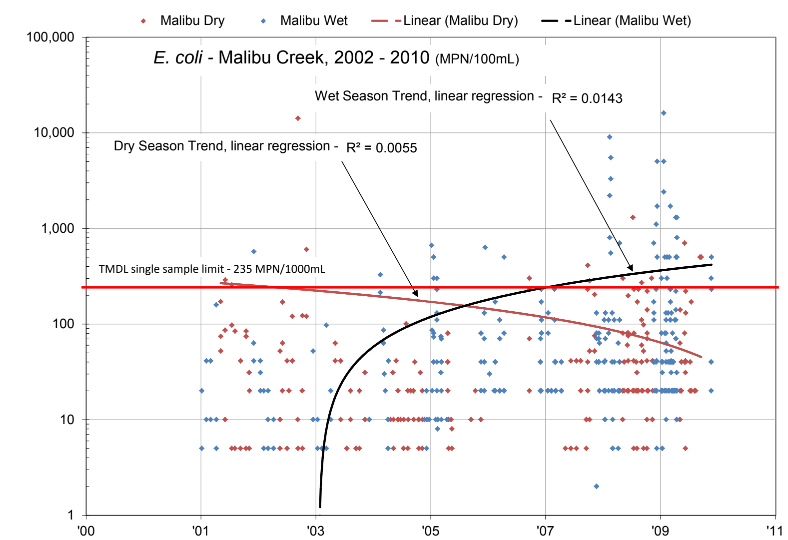


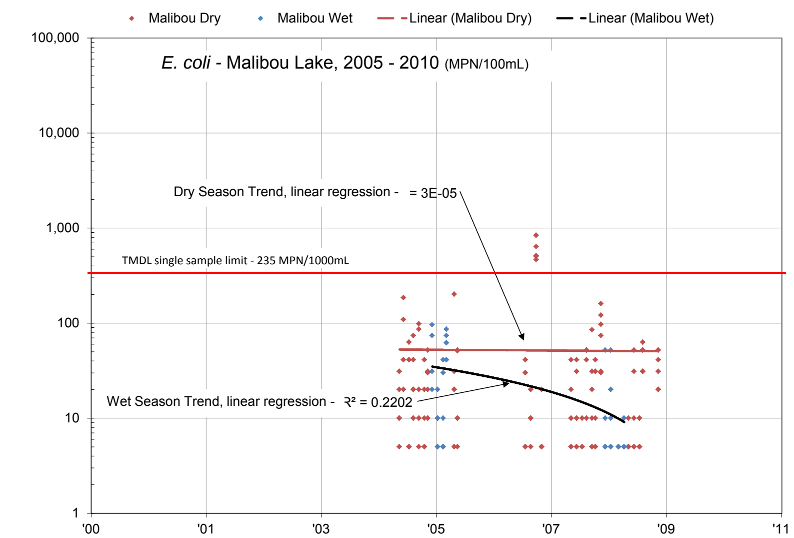
Is annual median > Water Quality Objective?	Region	Creek	LandUse	Site	Median	25th Percentile	75th Percentile	Count	Median Wet	25th Percentile Wet	75th Percentile Wet	Count Wet	Median Dry	25th Percentile Dry	75th Percentile Dry	Count Dry	Median wet >TMDL	Median Dry >TMDL
	North	all sites combined			210	75	500	1392	170	51	500	673	230	98	642	719		
		Cheeseboro	all sites combined		20	6	40	18	10	5	40	13	31	31	41	5		
		Cheeseboro	Developed	6	15	5	31	14	5	5	10	9	31	31	41	5		
		Cheeseboro	Developed	MCW_9	40			4	40			4				0		
		Las_Virgenes	all sites combined		130	52	300	484	109	40	300	259	170	73	389	225		
		Las_Virgenes	Developed	13	175	75	413	69	108	63	175	29	264	124	437	40		!
		Las_Virgenes	Developed	30	61	41	175	25	41	30	76	10	98	52	222	15		
		Las_Virgenes	Developed	5	98	52	191	79	63	52	146	33	127	62	213	46		
Yes		Las_Virgenes	Developed	LV2	422	167	1106	38	180	104	712	20	886	356	1439	18		!
Yes		Las_Virgenes	Developed	LVCreek_WhiteOak_LV4	260			4	260			4				0	!	
		Las_Virgenes	Developed	MCW_7	130	20	270	61	120	40	292	30	130	20	250	31		
		Las_Virgenes	Developed	RSW_MC001F	120	40	230	28	130	40	230	23	80	20	220	5		
Yes		Las_Virgenes	Developed	RSW_MC002F	500	130	1100	33	500	130	950	27	400	172	1100	6	!	!
		Las_Virgenes	Developed	RSW_MC003F	130	80	230	29	80	80	190	23	225	182	432	6		
		Las_Virgenes	Open Space	9	97	5	135	21	12	5	166	8	108	63	135	13		
		Las_Virgenes	Open Space	LV1	52	10	132	34	26	10	114	16	68	22	132	18		
		Las_Virgenes	Open Space	MCW_8b	140	55	400	63	80	20	300	36	300	120	650	27		!
Yes		Liberty Canyon	all sites combined		2844	731	4837	34	882	298	3076	17	3873	1464	6131	17	!	!
Yes		Liberty Canyon	Developed	LC	2844	731	4837	34	882	298	3076	17	3873	1464	6131	17	!	!
		Lindero_1	all sites combined		230	40	1300	93	184	23	982	50	500	138	1700	43		!
		Lindero_1	Developed	LIN2	146	31	368	33	74	20	706	19	158	112	226	14		
Yes		Lindero_1	Developed	MCW_13	500	108	1475	60	230	30	950	31	1300	340	2400	29		!
Yes		Lindero_2	all sites combined		500	199	800	185	300	170	800	80	500	300	800	105	!	!
Yes		Lindero_2	Developed	LIN1	278	164	504	31	176	148	271	16	504	399	738	15		!
Yes		Lindero_2	Developed	MCW_14b	500	230	800	154	300	170	1150	64	500	300	800	90	!	!
		Medea_1	all sites combined		121	40	282	173	130	40	312	75	120	40	277	98		
		Medea_1	Developed	21	58	10	127	32	20	10	167	8	68	10	112	24		
Yes		Medea_1	Developed	7	240	132	389	53	211	131	405	22	259	133	354	31		!
		Medea_1	Developed	MCW_11	40	20	220	52	40	20	130	25	40	20	225	27		
		Medea_1	Developed	MED2	140	82	325	36	166	74	608	20	133	86	282	16		
		Medea_2	all sites combined		220	90	500	186	219	80	500	80	225	106	599	106		
		Medea_2	Developed	MCW_12	200	80	500	154	215	80	500	64	180	90	500	90		
Yes		Medea_2	Developed	MED1	380	194	724	32	232	166	444	16	585	312	907	16		!
Yes		Palo_Comado	all sites combined		400	40	2400	62	300	20	700	33	800	70	5000	29	!	!
Yes		Palo_Comado	Developed	MCW_10	500	170	2400	54	500	235	1050	27	800	140	7000	27	!	!
		Palo_Comado	Open Space	8	5	5	10	8	5	5	5	6	20			2		
		Russell	all sites combined		230	122	500	157	202	80	479	66	230	142	500	91		
		Russell	Developed	MCW_15b	230	130	500	126	230	80	500	49	230	170	700	77		
		Russell	Developed	RUS	143	68	237	31	97	31	185	17	192	135	274	14		
	East	all sites combined			31	10	122	266	20	10	89	136	36	10	148	130		
		Cold	all sites combined		20	10	109	225	20	5	80	111	31	10	119	114		
		Cold	Developed	11	20	5	46	15	5	5	5	6	41	20	86	9		
		Cold	Developed	2	97	52	199	67	63	52	153	33	146	74	230	34		
		Cold	Developed	MCW_5	80	20	200	39	80	20	208	26	90	40	170	13		
		Cold	Open Space	3	5	5	10	77	5	5	5	33	10	5	23	44		
		Cold	Open Space	CC	10	10	18	27	10	10	52	13	10	10	10	14		
		Stokes	all sites combined		63	20	300	41	40	20	300	25	125	31	298	16		
		Stokes	Developed	16	31	10	150	15	10	5	10	5	47	31	283	10		
		Stokes	Developed	MCW_6	125	40	300	26	55	35	350	20	200	102	282	6		
	West	all sites combined			110	20	172	76	110	20	187	57	130	30	166	19		
		Carlisle	all sites combined		8	5	18	14	5	5	9	8	10	10	33	6		
		Carlisle	Developed	10	8	5	18	14	5	5	9	8	10	10	33	6		
		Hidden Valley	all sites combined		171	141	622	11	187	121	749	9	166			2		
		Hidden Valley	Developed	HV	161	121	187	9	161	86	341	7	166			2		
Yes		Hidden Valley	Developed	MCW_18	1650			2	1650			2				0	!	
		Potrero	all sites combined		130	40	196	51	120	40	187	40	130	120	195	11		
		Potrero	Developed	MCW_17	130	40	170	46	120	40	185	36	130	115	162	10		
		Potrero	Developed	POT	173	41	272	5	107			4	301			1		!
	Central	all sites combined			30	10	74	577	40	20	96	265	20	10	61	312		
		Malibou	all sites combined		10	5	41	192	10	5	31	46	20	5	41	146		
		Malibou	Developed	22	10	5	20	33	10	5	12	8	10	5	20	25		
		Malibou	Developed	23	10	5	31	32	5	5	26	8	15	9	31	24		
		Malibou	Developed	24	30	10	52	33	15	9	25	8	31	10	52	25		
		Malibou	Developed	26	10	5	31	32	5	5	15	8	10	5	31	24		
		Malibou	Developed	27	20	5	46	31	41	8	52	7	15	5	41	24		
		Malibou	Developed	28	10	5	30	31	5	5	18	7	15	5	34	24		
		Malibu	all sites combined		40	20	84	225	40	20	110	144	31	10	80	81		
		Malibu	Developed	12	10	5	38	70	10	5	31	29	10	5	41	41		
		Malibu	Developed	4	26	12	84	22	20	10	20	9	74	31	86	13		
		Malibu	Developed	MCW_4	95	20	430	38	110	20	500	26	60	20	148	12		
		Malibu	Developed	RSW_MC001U	40	40	140	33	40	40	132	26	40	30	130	7		
		Malibu	Developed	RSW_MC002D	40	20	80	37	40	20	75	31	65	45	122	6		
		Malibu	Developed	RSW_MC009U	20	20	80	25	20	20	90	23	50			2		
		Triunfo_1	all sites combined		31	20	75	125	40	20	63	55	30	10	79	70		
		Triunfo_1	Developed	17	52	20	103	55	41	20	63	24	63	30	126	31		
		Triunfo_1	Developed	25	10	5	25	33	5	5	21	8	10	5	31	25		
		Triunfo_1	Developed	MCW_16	20	20	80	37	40	20	150	23	20	20	55	14		
		Triunfo_2	all sites combined		187	74	395	35	238	148	405	20	74	26	232	15	!	
		Triunfo_2	Developed	TRI	187	74	395	35	238	148	405	20	74	26	232	15	!	
	Lower	all sites combined			30	20	74	319	40	20	80	189	20	10	49	130		
		Malibu	all sites combined		30	20	74	319	40	20	80	189	20	10	49	130		
		Malibu	Developed	1	20	5	44	76	15	10	63	32	20	5	41	44		
		Malibu	Developed	15	36	10	41	24	26	12	41	10	41	15	41	14		
		Malibu	Developed	MAL	10	10	31	34	20	10	46	16	10	10	28	18		
		Malibu	Developed	MCW_2	20	20	48	40	30	20	118	24	20	20	40	16		
		Malibu	Developed	MCW_3	60	20	250	51	40	20	282	26	70	20	230	25		
		Malibu	Developed	RSW_MC003D	20	20	70	33	20	20	95	27	20	20	20	6		
		Malibu	Developed	RSW_MC004D	30	20	50	28	40	20	60	27	20			1		
		Malibu	Developed	RSW_MC013D	40	20	110	33	40	20	95	27	80	50	192	6		
		Lagoon	all sites combined		80	40	230	81	130	40	300	49	40	20	185	32		
		Lagoon	Developed	MCW_1	80	20	278	52	130	40	450	26	80	20	230	26		
		Lagoon	Developed	RSW_MC011D	80	40	230	29	110	70	265	23	40	40	40	6		

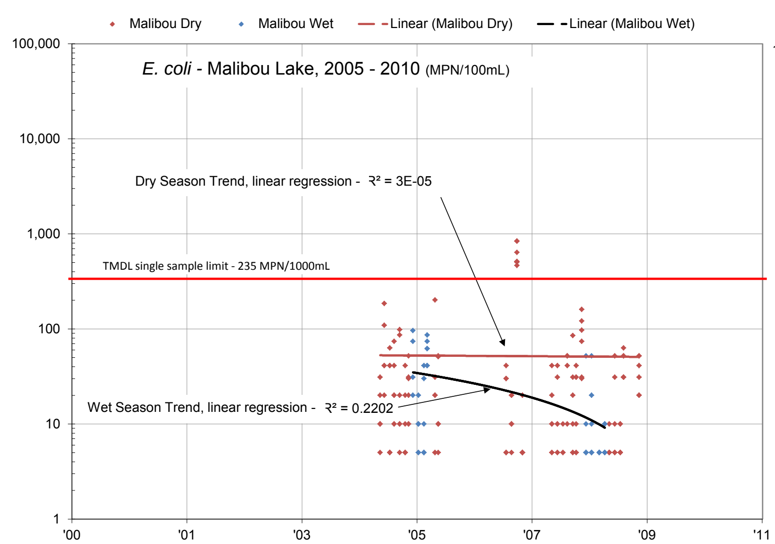
Table header: E. coli (MPN/100mL) TMDL single sample limit = 235 — Annual Record — Seasonal Record & Exceedances

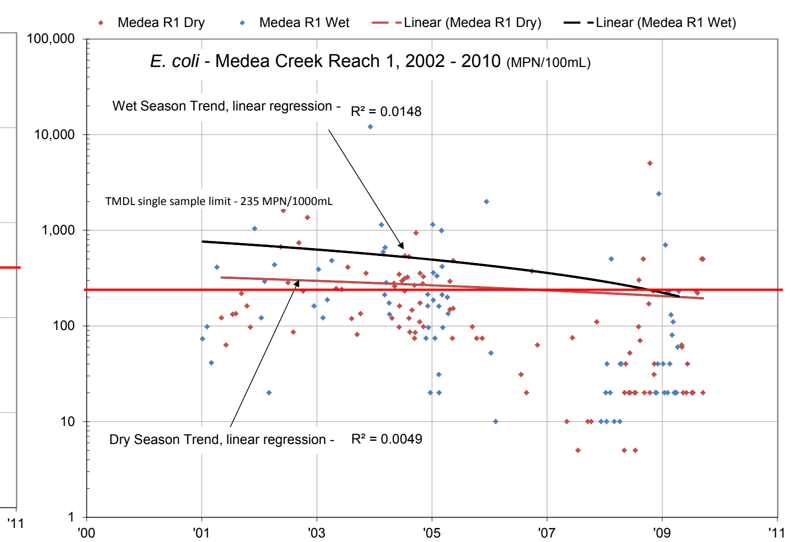
E. coli - MPN or CFU/100 ml

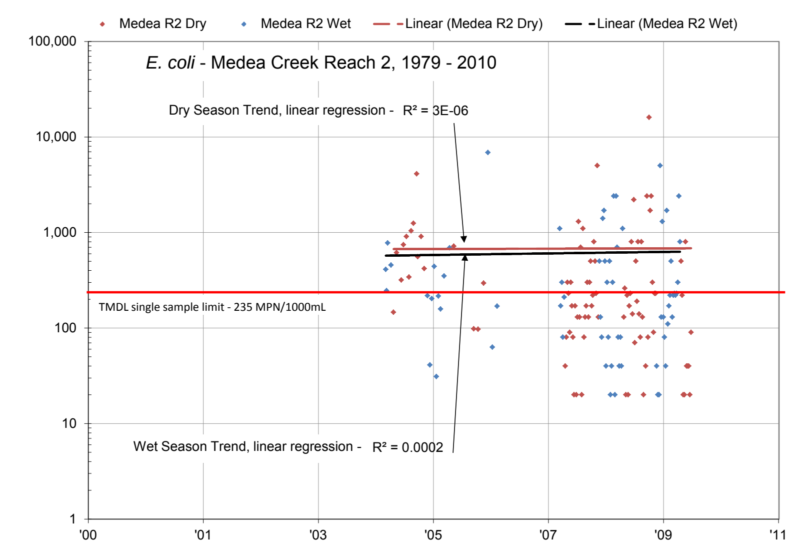


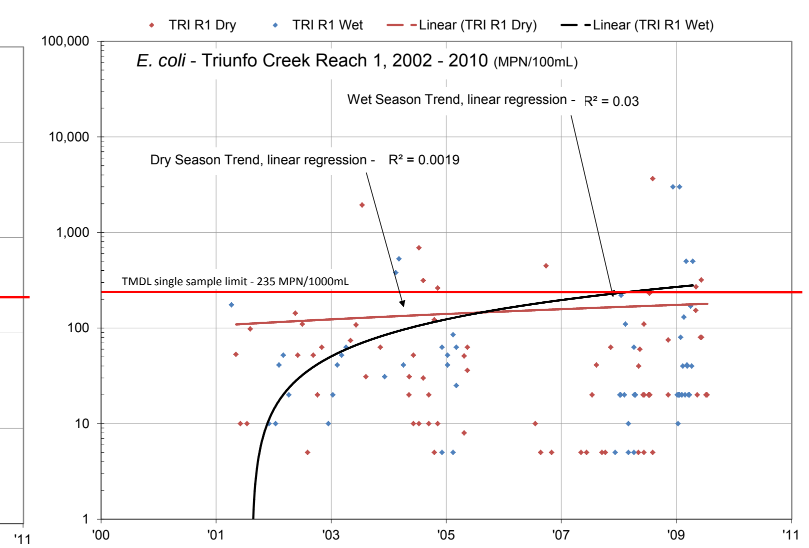


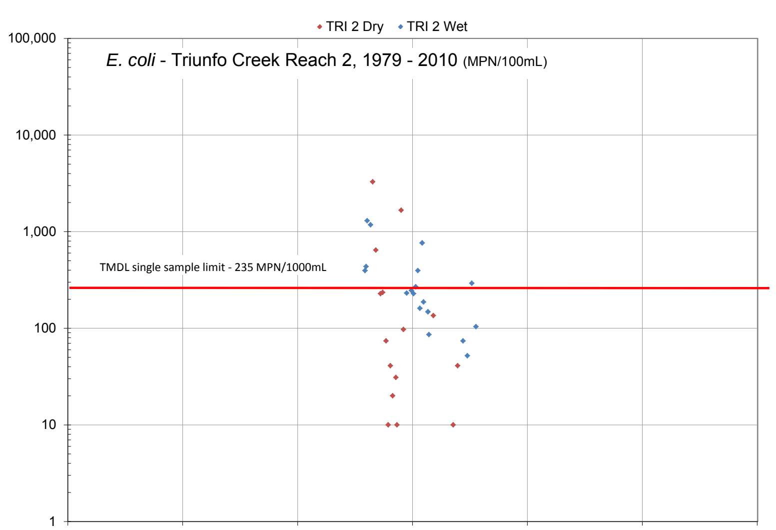


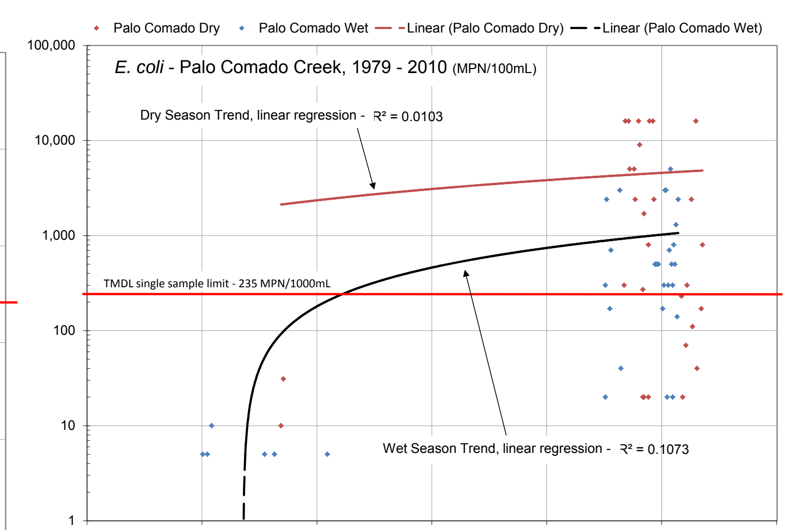


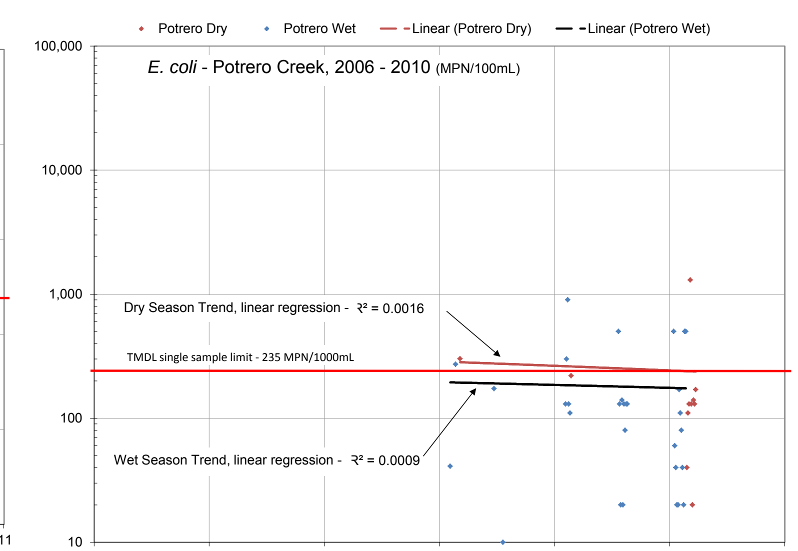


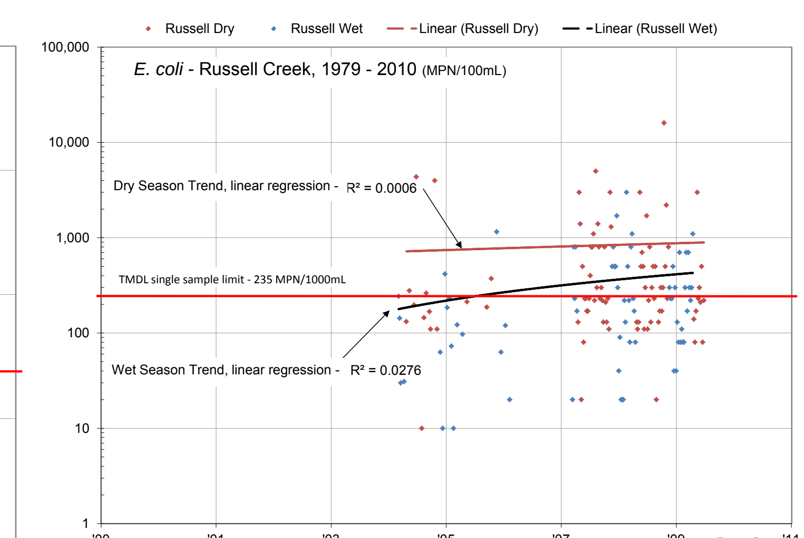






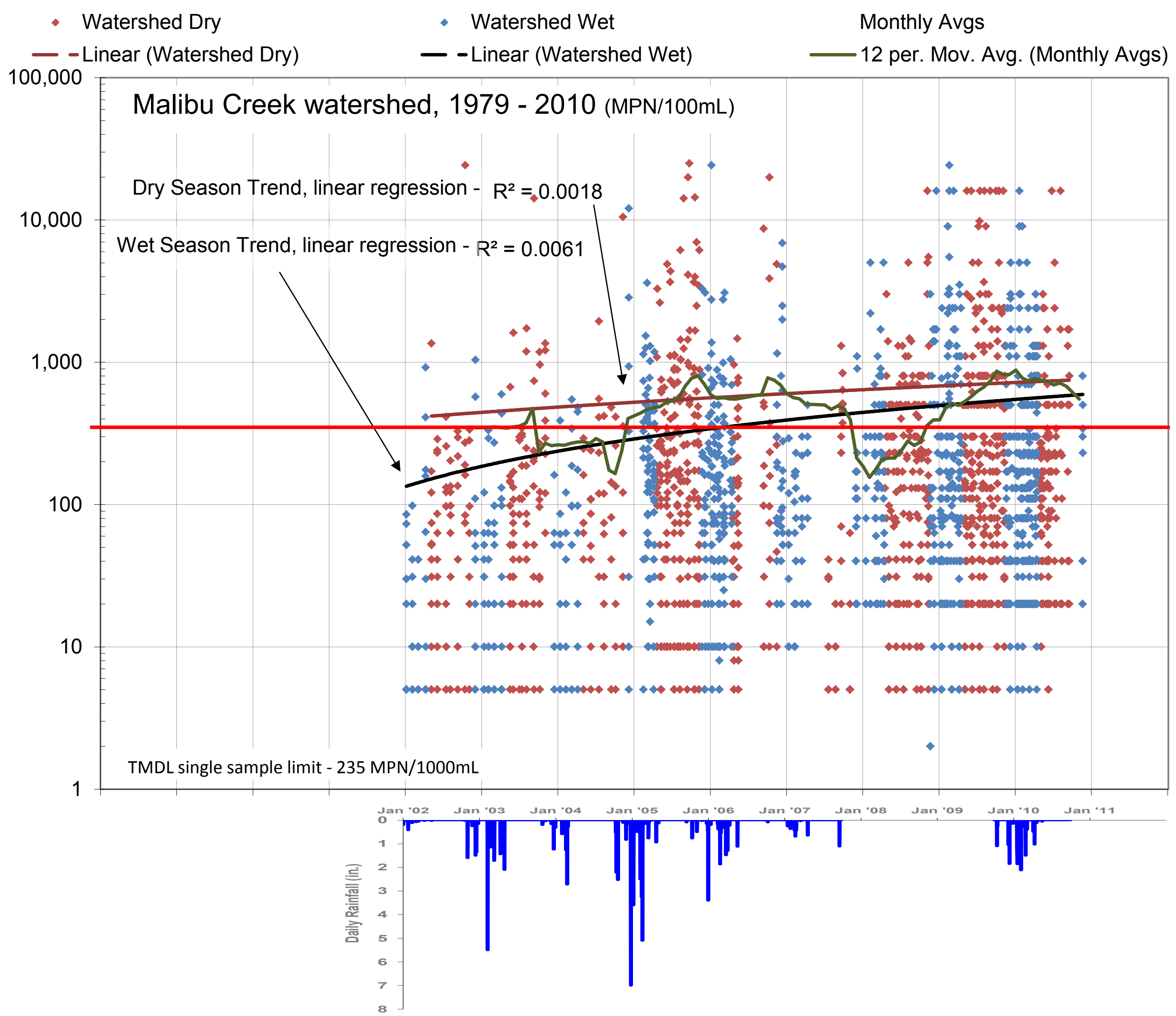




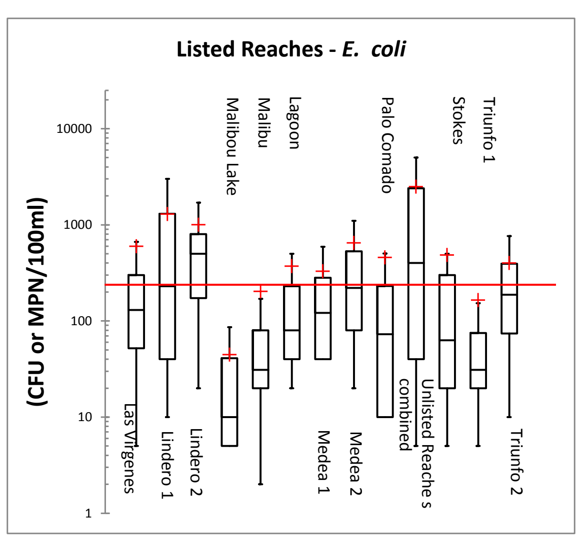


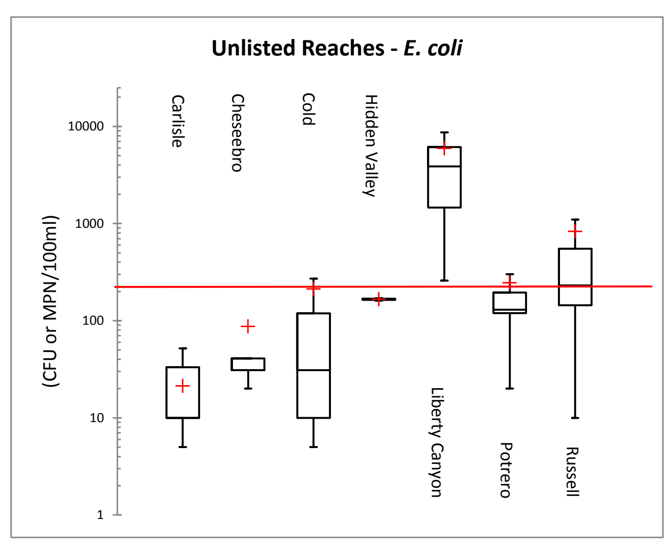
E. coli

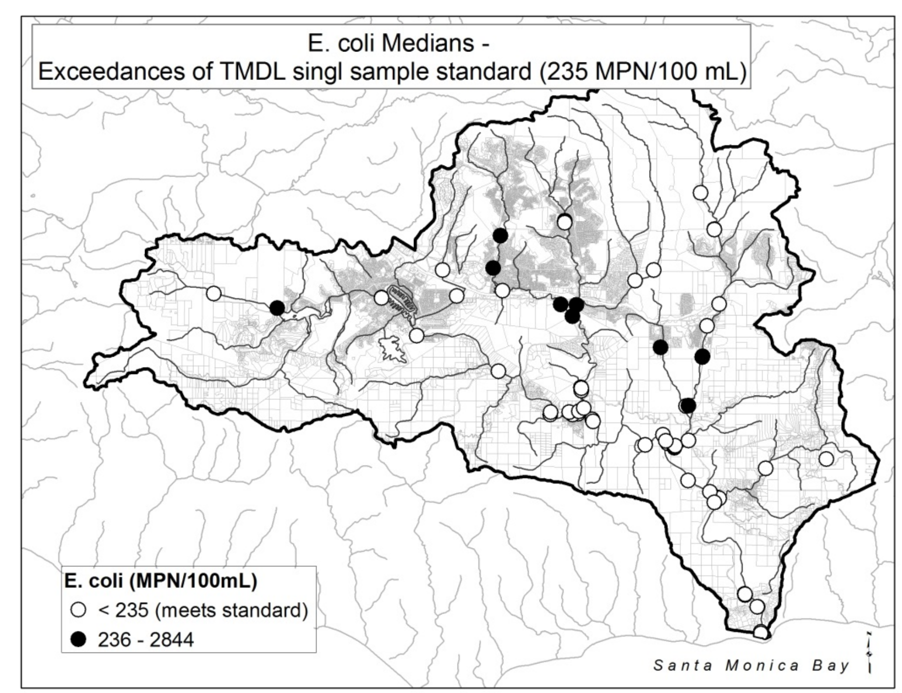
Single sample standard exceedances are increasing



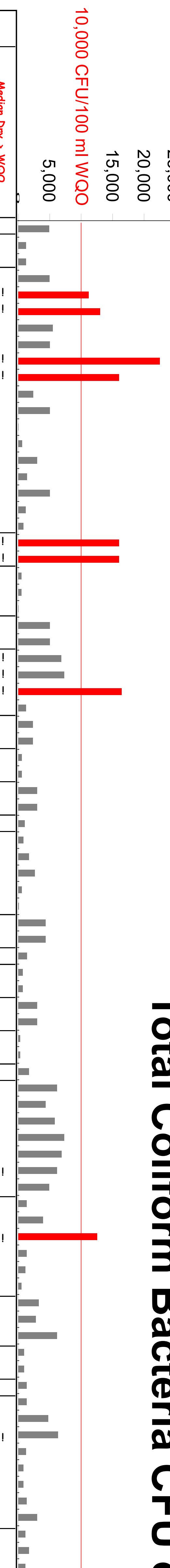
Water quality: Shown on the graph are all available data on *E. coli* concentrations in Malibu Creek watershed. The preceding table shows medians, 25th and 75th percentile values for Malibu Creek and its tributary streams, sorted by season and by geographic region (east, west, north, central, lower watershed, lagoon). It should be noted that sites LV_atMulholland, LV_belowLibertyCynCreek,and RSW_MC003F were used for surface water quality monitoring when a sludge main broke and was repaired during the period of October 14-22, 2002. *E. coli* median values exceed the TMDL single sample standard of 235 MPN/100mL at locations that are more densely populated and at Hidden Valley, which has agricultural land uses. Median values on Malibu Creek did not exceed the standard, nor did the 75th percentile values except at sites MCW-3 (at Los Angeles County gage F130-R) and MCW_4 (in a heavily used area at Malibu Creek State Park). Exceedances are plotted with parcel maps to show spatial correlation with development. **Historical Trends:** The twelve month moving average shows a steep increase around 2005, which may correspond with the wetter winter that year or it may relate to the start of the Malibu Creek Watershed Monitoring Program, which increased the number of sampling sites and frequency of sampling. At this time the moving average changed from usually meeting the standard to usually exceeding it until the dry winter of 2008. The watershed-wide trends in *E. coli* concentration for both wet and dry weather are increasing, although this varies by reach. Time as an explanatory variable results in low R^2 values for all reaches. **Annual & Seasonal variation:** *E. coli* varies only slightly by season. **Source assessment:** The source assessment is the same as for fecal coliform: The Malibu Creek watershed Bacteria TMDL (2004) lists onsite wastewater treatment systems (OWTS), animal wastes and runoff from developed and undeveloped areas as potential sources of bacteria. Recent research by the US Geological Survey (2010) at the Malibu Lagoon and Civic Center area found no indication that OWTS are a source of fecal bacteria in the lagoon; rather, sources there are primarily natural. Comparison of exceedance locations with parcel density (below) indicates wild and domestic fecal matter in runoff could be contributing factors. **Potential impacts on human health:** The impetus for the Malibu Creek watershed Bacteria TMDL was to improve water quality conditions for body contact recreation at Surfrider and other Santa Monica Bay beaches. The EPA recently (December 2010) approved the use of rapid assessment techniques at beaches, but not for TMDL and NPDES monitoring in streams that drain to those beaches. To the extent that pathogens are human-specific, rapid assessment techniques may be more appropriate.







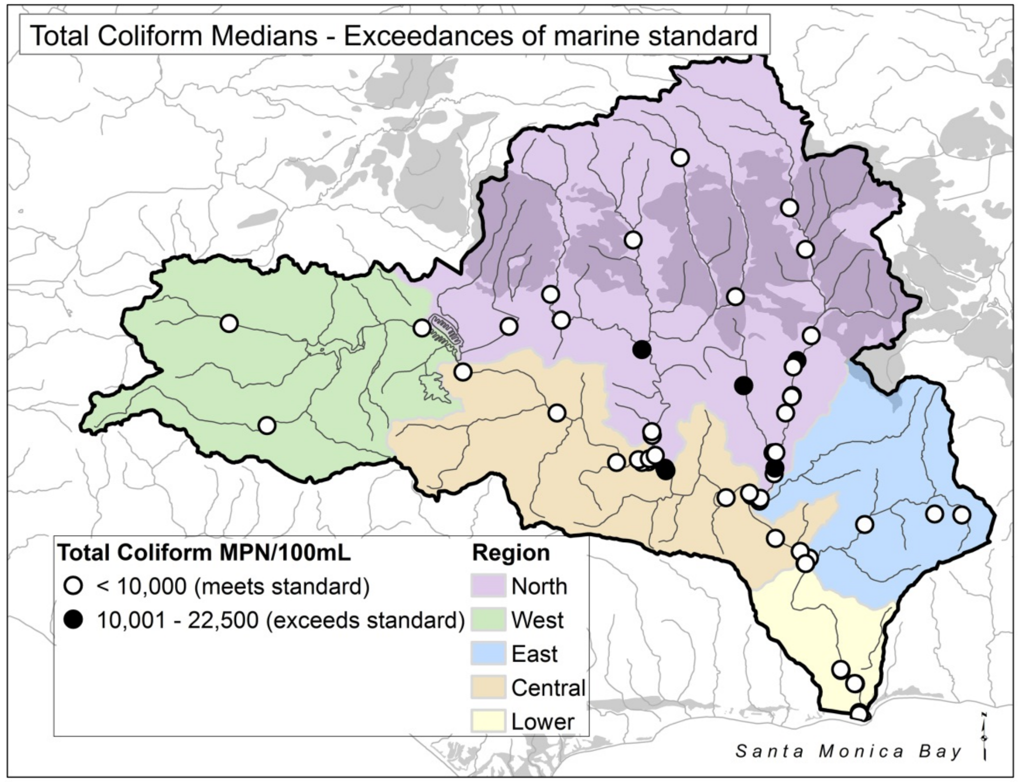
Total Coliform Bacteria CFU or MPN/100 ml

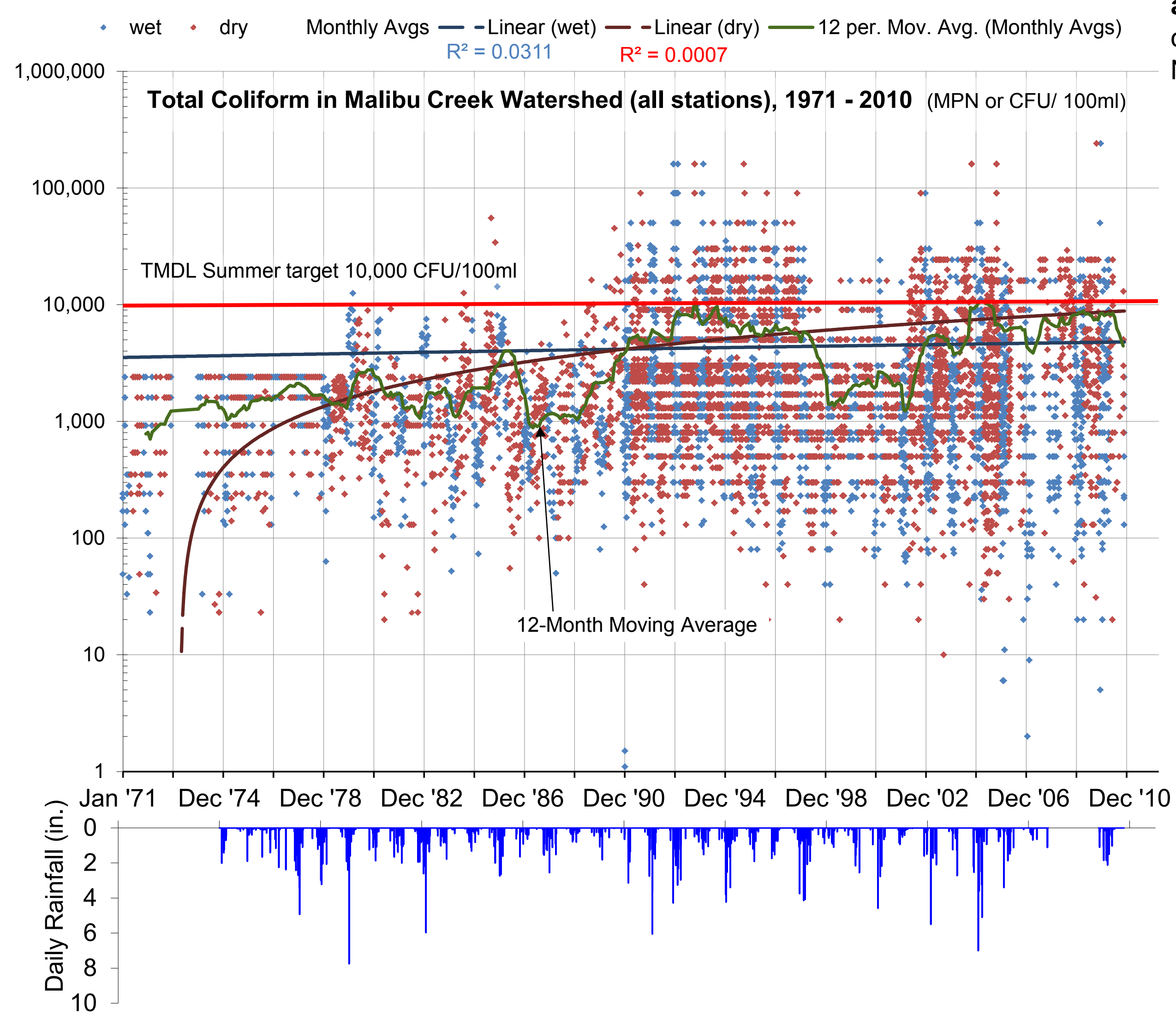


Is annual median > Water Quality Objective?	Region	Reach	Land Use	Site	Median	25th Percentile	75th Percentile	Count	Median Wet	25th Percentile Wet	75th Percentile Wet	Count Wet	Median Dry	25th Percentile Dry	75th Percentile Dry	Count Dry	Median wet > WQO	Median Dry > WQO
	North	all sites combined			4884	1300	13000	717	2948	900	9000	364	7270	2143	16000	353		
	North	Cheeseboro	all sites combined		1198	857	2014	13	882	761	999	8	2098	2014	2187	5		
	North	Cheeseboro	Developed	6	1198	857	2014	13	882	761	999	8	2098	2014	2187	5		
	North	Las_Virgenes	all sites combined		4942	1598	12997	414	2994	1081	8289	216	8164	2420	15531	198		
Yes	North	Las_Virgenes	Developed	13	11198	4552	17962	68	4748	2755	6907	28	14834	11014	24192	40		!
Yes	North	Las_Virgenes	Developed	30	12997	7701	17329	25	10099	5501	13851	10	14136	8984	24196	15	!	!
	North	Las_Virgenes	Developed	5	5475	3032	9804	79	4352	2359	6488	33	7270	4106	10034	46		
	North	Las_Virgenes	Developed	LV_atMulholland	5000	2450	21500	7				0	5000	2450	21500	7		
Yes	North	Las_Virgenes	Developed	LV_belowLibertyCynCreek	22500			4				0	22500			4		!
Yes	North	Las_Virgenes	Developed	LV2	16000	7501	16000	38	16000	8500	16000	20	16000	6000	16000	18	!	!
	North	Las_Virgenes	Developed	LVCreek_Farm_LV3	2350	1700	5000	8				0	2350	1700	5000	8		
	North	Las_Virgenes	Developed	LVCreek_WhiteOak_LV4	5000	3000	9000	16	5000	3000	9000	14	7000			2		
	North	Las_Virgenes	Developed	MCW_7	20			1	20			1				0		
	North	Las_Virgenes	Developed	RSW_MC001F	600	500	1200	31	500	300	1100	24	800	650	3350	7		
	North	Las_Virgenes	Developed	RSW_MC002F	3000	2075	9000	44	3000	1700	9000	38	5000	3500	13250	6		
	North	Las_Virgenes	Developed	RSW_MC003F	1400	800	3000	37	1200	650	3000	24	2200	1400	3000	13		
	North	Las_Virgenes	Developed	RSW_MC007D	5000			1				0	5000			1		
	North	Las_Virgenes	Open Space	9	1178	699	1616	21	882	570	1105	8	1354	988	1918	13		
	North	Las_Virgenes	Open Space	LV1	801	350	2950	34	801	700	1900	16	900	300	3933	18		
Yes	North	Liberty Canyon	all sites combined		16000	9000	16000	34	16000	9000	16000	17	16000	9000	16000	17	!	!
Yes	North	Liberty Canyon	Developed	LC	16000	9000	16000	34	16000	9000	16000	17	16000	9000	16000	17	!	!
	North	Lindero_1	all sites combined		500	300	1675	34	500	240	4000	19	500	350	1000	15		
	North	Lindero_1	Developed	LIN2	500	300	1700	33	500	240	4000	19	600	425	1050	14		
	North	Lindero_1	Developed	MCW_13	20			1				0	20			1		
	North	Lindero_2	all sites combined		5000	2400	9000	31	3000	2350	6000	16	5000	2700	9000	15		
	North	Lindero_2	Developed	LIN1	5000	2400	9000	31	3000	2350	6000	16	5000	2700	9000	15		
	North	Medea_1	all sites combined		6821	2312	19863	120	5000	1467	15531	49	11198	3128	24193	71		!
	North	Medea_1	Developed	21	7284	4210	20945	32	1964	1659	8963	8	13767	5669	24192	24		!
Yes	North	Medea_1	Developed	7	16430	7398	24193	52	12033	5475	17329	21	19863	10830	24193	31	!	!
	North	Medea_1	Developed	MED2	1200	500	3000	36	1300	500	5000	20	900	650	1600	16		
	North	Medea_2	all sites combined		2300	1300	5000	32	1450	575	3500	16	3000	1600	5000	16		
	North	Medea_2	Developed	MED1	2300	1300	5000	32	1450	575	3500	16	3000	1600	5000	16		
	North	Palo_Comado	all sites combined		556	413	711	8	448	407	593	6	1959			2		
	North	Palo_Comado	Open Space	8	556	413	711	8	448	407	593	6	1959			2		
	North	Russell	all sites combined		3000	1350	9000	31	2200	1100	5000	17	7000	1875	16000	14		
	North	Russell	Developed	RUS	3000	1350	9000	31	2200	1100	5000	17	7000	1875	16000	14		
	East	all sites combined			1016	331	2809	198	465	233	1694	87	1793	625	3654	111		
	East	Cold	all sites combined		816	311	2485	183	455	222	1633	82	1723	591	3076	101		
	East	Cold	Developed	11	1694	482	3012	14	428	317	435	5	2282	1872	3654	9		
	East	Cold	Developed	2	2608	1762	4048	66	2265	1282	3554	32	3076	2256	5259	34		
	East	Cold	Open Space	3	546	303	1015	76	309	213	444	32	780	556	1620	44		
	East	Cold	Open Space	CC	80	43	225	27	70	11	210	13	95	50	215	14		
	East	Stokes	all sites combined		4352	2523	6701	15	1236	933	3448	5	6131	4557	8316	10		
	East	Stokes	Developed	16	4352	2523	6701	15	1236	933	3448	5	6131	4557	8316	10		
	West	all sites combined			1400	281	3000	27	419	138	2650	18	2143	1789	3654	9		
	West	Carlisle	all sites combined		689	161	2143	13	161	86	400	7	2899	1878	4372	6		
	West	Carlisle	Developed	10	689	161	2143	13	161	86	400	7	2899	1878	4372	6		
	West	Hidden Valley	all sites combined		3000	1300	3000	9	3000	1650	4000	7	2150			2		
	West	Hidden Valley	Developed	HV	3000	1300	3000	9	3000	1650	4000	7	2150			2		
	West	Potrero	all sites combined		300	300	1400	5	300			4	1400			1		
	West	Potrero	Developed	POT	300	300	1400	5	300			4	1400			1		
	Central	all sites combined			1700	700	5475	869	883	414	2187	382	3000	1300	10462	487		
	Central	Malibou	all sites combined		6131	1932	15764	192	1645	909	3448	46	8414	3303	24192	146		
	Central	Malibou	Developed	22	4352	1259	12033	33	1355	647	3426	8	6488	2909	14136	25		
	Central	Malibou	Developed	23	5803	2376	15981	32	2371	849	3488	8	9835	4427	24191	24		
	Central	Malibou	Developed	24	7270	2909	19863	33	2548	1660	3303	8	9804	4884	24192	25		
	Central	Malibou	Developed	26	6867	2089	14718	32	1991	880	3962	8	9082	5194	24192	24		
	Central	Malibou	Developed	27	6131	2429	16430	31	2046	924	3150	7	10462	4741	20945	24		!
	Central	Malibou	Developed	28	4884	1154	17697	31	1187	926	2381	7	7148	2425	19863	24		
	Central	Malibu	all sites combined		1300	500	3000	554	800	300	1700	284	2200	800	5000	270		
	Central	Malibu	Developed	12	3945	1310	8664	70	1259	706	2481	29	7701	4352	12996	41		
Yes	Central	Malibu	Developed	4	12515	4352	19230	22	1553	624	12033	9	17329	8664	24192	13		!
	Central	Malibu	Developed	RSW_MC001U	1300	700	2400	166	1100	500	2300	83	1700	800	2900	83		
	Central	Malibu	Developed	RSW_MC002D	1100	500	2400	167	500	300	1300	85	1700	875	3000	82		
	Central	Malibu	Developed	RSW_MC009U	500	230	1400	129	315	220	875	78	800	500	2200	51		
	Central	Triunfo_1	all sites combined		3255	1708	7817	88	1553	1051	2187	32	6131	3255	11648	56		
	Central	Triunfo_1	Developed	17	2755	1609	5483	55	1609	946	2187	24	5172	3082	8414	31		
	Central	Triunfo_1	Developed	25	6131	2613	17359	33	1534	1411	1694	8	8664	5475	24192	25		
	Central	Triunfo_2	all sites combined		900	500	1700	35	900	450	1825	20	1300	900	1650	15		
	Central	Triunfo_2	Developed	TRI	900	500	1700	35	900	450	1825	20	1300	900	1650	15		
	Lower	all sites combined			1300	500	3000	614	1100	500	2358	310	1700	800	4611	304		
	Lower	Malibu	all sites combined		1300	500	3000	614	1100	500	2358	310	1700	800	4611	304		
	Lower	Malibu	Developed	1	4762	2371	10830	75	2755	1932	4557	31	7933	4291	15981	44		
	Lower	Malibu	Developed	15	6290	2929	24196	24	2871	2419	3818	10	18596	7292	24196	14		!
	Lower	Malibu	Developed	MAL	1200	500	2350	34	1750	775	3000	16	850	388	1700	18		
	Lower	Malibu	Developed	RSW_MC003D	800	300	2200	164	700	433	1625	82	1150	300	2400	82		
	Lower	Malibu	Developed	RSW_MC004D	800	300	1700	138	800	300	1700	82	1100	493	2400	56		
	Lower	Malibu	Developed	RSW_MC013D	1300	700	3000	170	1100	500	1700	84	2200	1100	3000	86		
	Lower	Malibu	Developed	S02	3000	1300	50000	9	24000	1300	50000	5	2700			4	!	
	Lower	Lagoon	all sites combined		1100	300	3000	213	1700	500	3000	104	800	300	2400	109		
	Lower	Lagoon	Developed	MCW_1	1700	500	3000	50	2400	925	3000	26	950	500	1875	24		
	Lower	Lagoon	Developed	RSW_MC011D	1100	300	3000	163	1300	500	3000	78	800	270	2400	85		

Note: The Malibu Creek Watershed Bacteria TMDL has no WQO for Total Coliform. The Department of Public Health's marine water single sample standard of 10,000 CFU/100ml is applied as guidance.

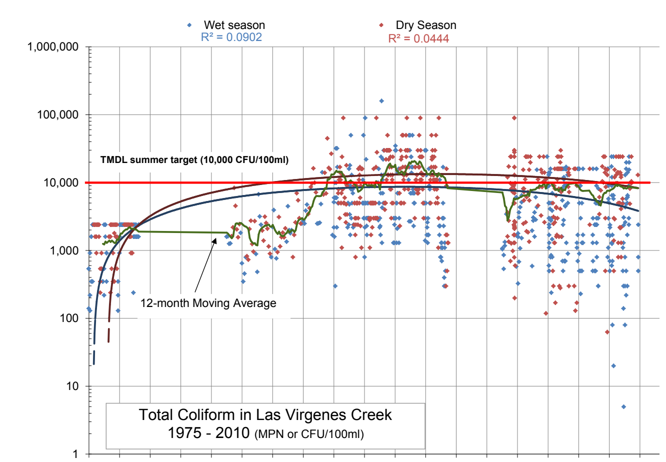
Total Coliform

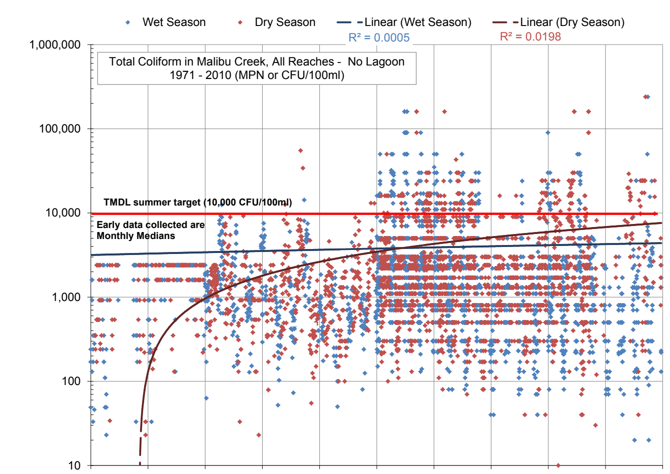


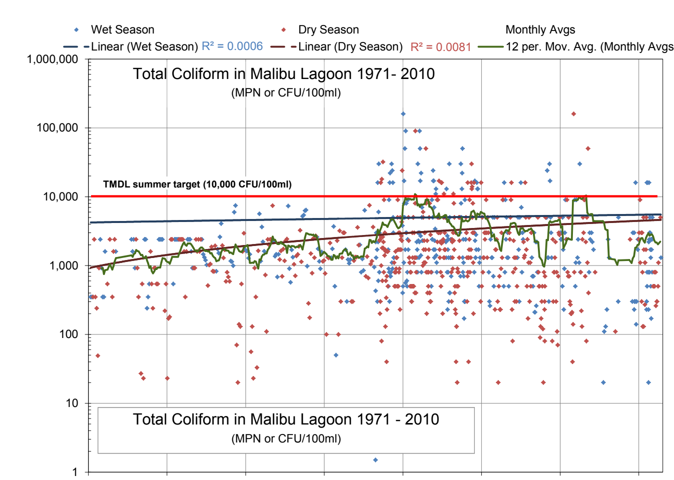


Single sample standard exceedances are increasing

Note: The Malibu Creek Bacteria TMDL (EPA 2004) was updated to be consistent with EPA guidance criteria for bacteria by eliminating total coliform standards and applying fecal coliform and *E. coli* standards. The EPA does not recommend the use of total coliform as an indicator of health risk from water contact in recreational waters and instead recommends *E.* coli and enterococci as better indicators in fresh water (http://water.epa.gov/type/rsl/monitoring/vms511.cfm). However, there is a longer record for total coliform in the watershed than for other bacterial indicators, so total coliform data was analyzed. The Department of Health Services recommends posting of freshwater beaches when total coliform exceeds 10,000 per 100 ml in a single sample. Although this is not a regulatory criteria for streams, the criteria is applied here as guidance. **Water quality:** Shown on the graph are all available data on total coliform concentrations in Malibu Creek and its tributary streams. The table on the preceding page shows all data sorted by season and by geographic region (east, west, north, central, lower watershed, and lagoon). It should be noted that sites LV_atMulholland, LV_belowLibertyCynCreek, and RSW_MC003F were used for surface water quality monitoring when a sludge main broke and was repaired during the period of October 14-22, 2002. Total coliform median values exceed the guidance criteria of 10,000 CFU or MPN/100mL at some sites on Las Virgenes and Liberty Canyon Creeks and at one site on Malibu Creek. **Historical Trends:** Overall trends are increasing with time, although some of this may be only apparent due to changes in maximum numbers reported. The apparent watershed-wide trends in total coliform concentration for both wet and dry weather are increasing, although this varies by reach. Time as an explanatory variable results in low R^2 values for all reaches. **Annual & Seasonal variation:** Graphical comparisons with rain events revealed increases with rain events, but also showed spikes in total coliform concentration unassociated with rain. **Source assessment:** Unknown. **Potential impacts on human health:** None. Again, the EPA does not recommend the use of total coliform as an indicator of health risk from water contact in recreational waters. **Recommendations for further monitoring:** None. The use of total coliform as an indicator of water quality is no longer recommended.





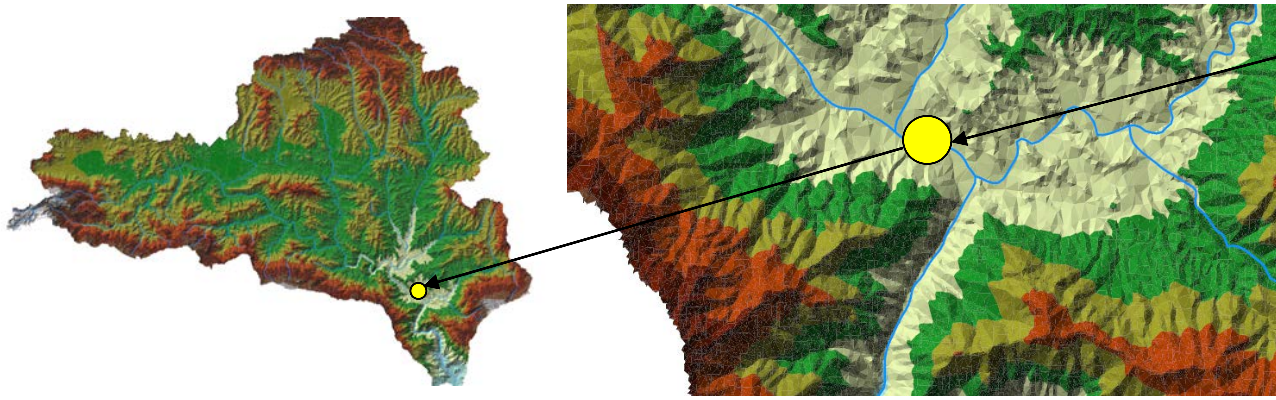


Organic Compounds

DDT, PCBs, EPA priority organic compounds – oil and grease, pesticides and metals were also tested during testing for organics.

Water quality parameters analyzed: 12 metals (see table below), 24 volatile organic compounds, 57 semi-volatile organic compounds, and 25 pesticides.

Major findings: (1) Non-detects except for metals. During the 18 month CTR test period, aside from bis(2-ethylhexyl) phthalate (detected once), the only compounds detected of 131 tested in upper Malibu Creek were 12 metals at concentrations shown in the following tables. (Note: For a comparison of these results with metals testing by other agencies, see following page) **(2) Metal sources.** Aside from silver and lead, all of the detected metals are found in high concentrations in groundwater and surface runoff from the Monterey / Modelo Formation, which is enriched in these elements. Aside from selenium and arsenic, all of these metals are also derived from urban runoff in other urbanized watersheds (e.g. Ballona Creek), although at much lower levels than those measured in storm water runoff from the Monterey / Modelo Formation. See Natural Source Assessment section for further information



All of the data shown here are from Station RSW-MC001U, located in upper Malibu Creek below its confluence with Triunfo Creek and Las Virgenes Creek and all upper watershed tributaries. Any pollution from point or non-point sources in the upper watershed must pass this station.

Metals and Organic Compounds

California Toxics Rule (CTR) test results upper Malibu Creek in Malibu Creek State Park (metals also shown)

Detected | Not Detected

Volatile organic compounds | Semi-volatile organic compounds | Metals (details next page) | Pesticides

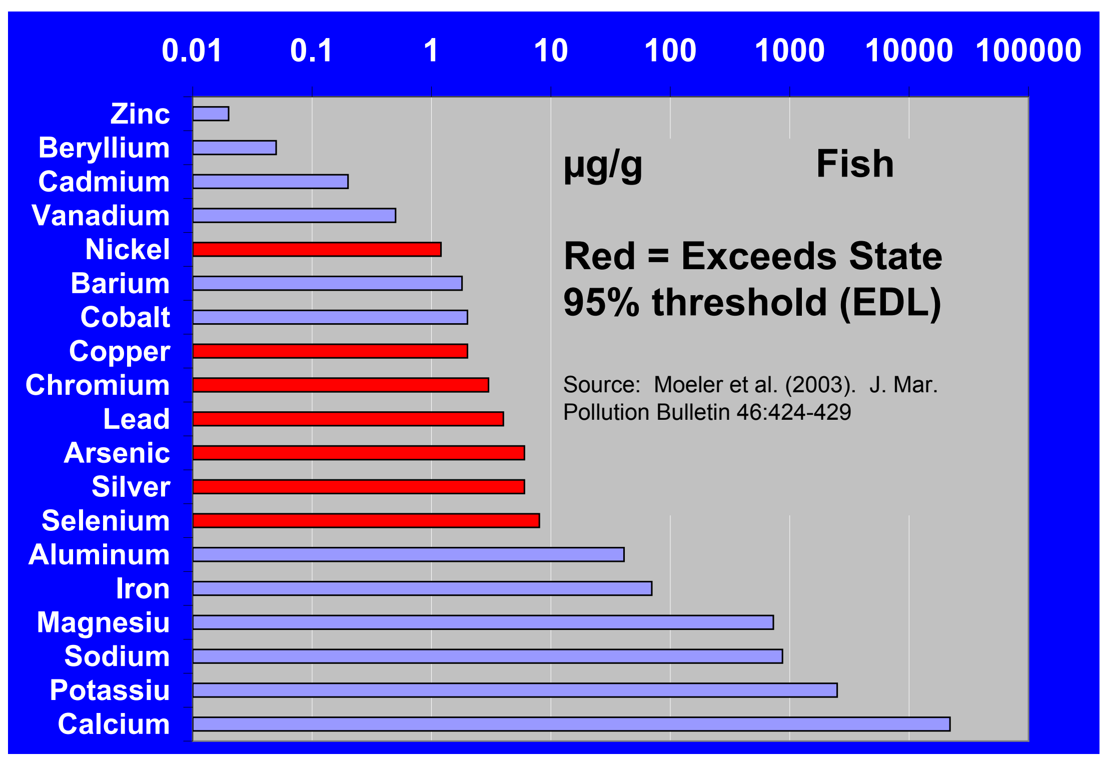
Pollutant ID	Constituent	US EPA Method Used	MDL (µg/L)	12-03-02	11-05-02	10-08-02	09-10-02	08-07-02	07-09-02	06-04-02	05-07-02	04-16-02	03-12-02	02-12-02	01-22-02	12-11-01	11-13-01	10-09-01	09-20-01	08-02-01	07-19-01
VOLATILE POLLUTANTS			Season →																		
34496	1,1 Dichloroethane	8260B	0.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34501	1,1 Dichloroethylene	8260B	0.28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34506	1,1,1 Trichloroethane	8260B	0.26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34511	1,1,2 Trichloroethane	8260B	0.14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34516	1,1,2,2 Tetrachloroethane	8260B	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34536	1,2 Dichlorobenzene	8260B	0.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32103	1,2 Dichloroethane	8260B	0.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34541	1,2 Dichloropropane	8260B	0.06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34566	1,3 Dichlorobenzene	8260B	0.23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34561	1,3 Dichloropropylene	8260B	0.09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34571	1,4 Dichlorobenzene	8260B	0.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34210	Acrolein	8260B	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34215	Acrylonitrile	8260B	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34030	Benzene	8260B	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32104	Bromoform	8260B	0.41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34413	Methyl Bromide	8260B	0.32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32102	Carbon Tetrachloride	8260B	0.38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34301	Chlorobenzene	8260B	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34306	Chlorodibromo-methane	8260B	0.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85811	Chloroethane	8260B	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32106	Chloroform	8260B	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32101	Dichlorobromo-methane	8260B	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34418	Methylene Chloride	8260B	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78113	Ethylbenzene	8260B	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34475	Tetrachloroethylene	8260B	0.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34010	Toluene	8260B	0.12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34549	1,2-Trans Dichloroethylene	8260B	0.21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39180	Trichloroethylene	8260B	0.13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39175	Vinyl Chloride	8260B	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SEMI – VOLATILE POLLUTANTS																					
34526	Benzo (a) Anthracene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34536	1,2 Dichlorobenzene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34346	1,2 Diphenylhydrazine	8270C	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34551	1,2,4 Trichlorobenzene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34566	1,3 Dichlorobenzene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34571	1,4 Dichlorobenzene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34586	2 Chlorophenol	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34601	2,4 Dichlorophenol	8270C	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34606	2,4 Dimethylphenol	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34616	2,4 Dinitrophenol	8270C	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34611	2,4 Dinitrotoluene	8270C	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34624	2,4,6 Trichlorophenol	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34626	2,6 Dinitrotoluene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34591	2-Nitrophenol	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34576	2-Chloroethylvinyl ether	8270C	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34581	2-Chloronaphthalene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34631	3,3' Dichlorobenzidine	8270C	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34230	Benzo (b) Fluoranthene	8270C	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3-Methyl-4-Chlorophenol	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3615	2-Methyl-4,6-Dinitrophenol	8270C	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34646	4-Nitrophenol	8270C	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34636	4-Bromophenyl phenyl ether	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34641	4-Chlorophenyl phenyl ether	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34205	Acenaphthene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34200	Acenaphthylene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34220	Anthracene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39120	Benzidine	8270C	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34247	Benzo (a) Pyrene	8270C	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34521	Benzo (g,h,i) Perylene	8270C	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34242	Benzo (k) Fluoranthene	8270C	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34278	Bis (2-Chloroethoxyl) methane	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34273	Bis(2-Chloroethyl) ether	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34283	Bis(2-Chloroisopropyl) ether	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39100	Bis(2-Ethylhexyl) phthalate	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
34292	Butyl benzyl phthalate	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34320	Chrysene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39110	di-n-Butyl phthalate	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34596	di-n-Octyl phthalate	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34556	Dibenzo(a,h)-anthracene	8270C	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34336	Diethyl phthalate	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34341	Dimethyl phthalate	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34376	Fluoranthene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34381	Fluorene	8270C	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34386	Hexachlorocyclopentadiene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39700	Hexachlorobenzene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39702	Hexachlorobutadiene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34396	Hexachloroethane	8270C	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34403	Indeno(1,2,3,cd)-pyrene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34408	Isophorone	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34433	N-Nitrosodiphenyl amine	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34438	N-Nitrosodimethyl amine	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34428	N-Nitroso-di-n-propyl amine	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34696	Naphthalene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34447	Nitrobenzene	8270C	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39032	Pentachlorophenol	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34461	Phenanthrene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34694	Phenol	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34469	Pyrene	8270C	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INORGANICS																					
948	Asbestos	100.1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1097	Antimony (Sb)	200.8	0.43	0.8	0	0.8	0	0.6	0	0.7	0.6	0	0.7	0.6	0.8	0.6	0.8	0.9	0	0	0
1000	Arsenic (As-III)	200.8	0.05	0	3	0	2	0	2	2	0	0	0	0	0	0	2	3	0	2	2.1
1012	Beryllium (Be)	200.8	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1027	Cadmium (Cd)	200.8	0.04	0.4	0.2	0.3	0.2	0	0.5	0	0.3	0	0.3	0.4	0.2	0.3	0.8	0.7	0.2	0	0
1033	Chromium-III (Cr-III)	200.8	0.14	1	3	0	1	2	0	1	0	2	3	1	1	1	3	2	1.2	0	0
1119	Copper (Cu)	200.8	0.08	14	21	13	4	4	6	4	5	5	7	4	5	4	11	4	1.2	11.1	2.7
1051	Lead	200.8	0.03	2	1.5	0	0.2	0.4	3.6	0	0.2	0.3	0.5	0.4	0.7	0.3	1.5	0.9	0	0	0
1067	Nickel(Ni)	200.8	0.04	8	10	8	7	7	5	5	5	9	11	6	5	6	10	8	0	7.3	6.8
1147	Selenium(Se)	200.8	0.13	6	12	10	10	7	7	11	8	6	10	10	0	10	7	13	0	11	11
1077	Silver(Ag)	200.8	0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.62	0.9	0	0
1059	Thallium(Tl)	200.8	0.01	0.4	0	0	0	0	0	0	0	0	0	0	0.2	0	0	0.4	0	0	0
1092	Zinc(Zn)	200.8	0.4	20	60	20	10	0	10	0	10	20	20	10	40	20	30	39	2.8	22	3.6
1032	Chromium VI (Cr-VI)	218.6	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
71900	Mercury	245.1	0.05	0	0	0.1	0	0.01	0.01	0	0	0	0.01	0.04	0	0	0.01	0	0	0	0
720	Cyanide(CN)	335.2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PESTICIDES																					
39310	4,4'-DDD	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39320	4,4'-DDE	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39300	4,4'-DDT	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
78428	Alpha-Endosulfan	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39336	Alpha-BHC	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39330	Aldrin	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34356	Beta-Endosulfan	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39338	beta-BHC	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39350	Chlordane	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34198	delta-BHC	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39380	Dieldrin	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34351	Endosulfan Sulfate	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39390	Endrin	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34366	Endrin Aldehyde	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39410	Heptachlor	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39420	Heptachlor Epoxide	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39340	gamma-BHC	8081A	0.002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4166	PCB 1016	8081A	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4166	PCB 1221	8081A	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4166	PCB 1232	8081A	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4166	PCB 1242	8081A	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4166	PCB 1248	8081A	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4166	PCB 1254	8081A	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4166	PCB 1260	8081A	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39400	Toxaphene	8081A	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
82698	TCDD	8280A																			

CTR and fish tissue data - Metals

California Toxics Rule (CTR) results for metals in comparison to fish tissue metals results, Upper Malibu Creek in Malibu Creek State Park

Station location and upstream land use: Station RSW-MC001U is located in upper Malibu Creek below confluences with Triunfo and Las Virgenes Creeks and all upper watershed tributaries, thus serving a sentinel location for pollutants commonly found in urban runoff. **Water quality parameters analyzed:** 12 metals (see table below), 24 volatile organic compounds, 57 semi-volatile organic compounds, and 25 pesticides. **Major findings: (1)** During the 18 month test period, aside from bis(2-ethylhexyl) phthalate (detected once), the only compounds detected of 131 parameters tested in upper Malibu Creek were the 12 metals at the concentrations shown below. (Note: For a comparison of these results with metals testing by other agencies, see following page) **(2)** Aside from silver and lead, all of the detected metals are found in high concentrations in groundwater and surface runoff from Monterey / Modelo Formation rock, which is enriched in these elements locally. **(3)** Aside from selenium and arsenic, all of these metals are also known to be present in urban runoff in other urbanized watersheds (e.g. Ballona Creek), although **(4)** at much lower levels than those measured in storm water runoff from the Monterey / Modelo Formation. See Natural Source Assessment section for further information.

Good agreement between results of metals in local fish tissues and their respective concentrations in local surface waters. Most metals tested in both mediums exceeded human consumption standards (shown in **RED** in the figure and two tables)



Metals in fish collected at CTR sample sites. **Red** indicates this metal exceeded fish tissue objective

Constituent	Average concentration in micrograms per Liter (ppb)
Zinc(Zn)	19.9
Selenium(Se)	**8.5**
Copper (Cu)	**7.0**
Nickel(Ni)	**7.0**
Arsenic (As-III)	**2.0**
Chromium-III (Cr-III)	**1.5**
Lead	**0.8**
Antimony (Sb)	0.6
Thallium(Ti)	0.4
Cadmium (Cd)	0.3
Silver(Ag)	**0.3**
Mercury	0.1

Metals in surface water at CTR sample sites sorted by average concentration (ppb). **Red** indicates that particular metal was found in fish tissues at levels exceeding human consumption standards.

Chemical & units	Landfill (11/15/1999 - 2/25/2009)			LA Co ME (5/11/2009 - 4/11/2010)			LVMWD (dates vary by period - see database)		
	No. of tests	No. Detects	MDL/PQL	No. of tests	No. Detects	MDL or RL	No. of tests	No. Detects	max/MDL
1,1,1,2-Tetrachloroethane_ugL	19	0	0.5-1	Not tested			Not tested		
1,1,1-Trichloroethane_ugL	18	0	0.5-1	Not tested			100	0	0.5
1,1,2,2-Tetrachloroethane_ugL	19	0	0.5-1	Not tested			100	0	0.5
1,1,2-Trichloroethane_ugL	19	0	0.5-1	Not tested			100	0	0.5
1,1-Dichloroethane_ugL	19	0	0.5-1	Not tested			100	0	0.5
1,1-Dichloroethene_ugL	19	0	0.5-1	Not tested			Not tested		
1,1-Dichloroethylene_ugL	Not tested			Not tested			103	0	0.5
1,2,3,4,6,7,8_-_HpCDD_ngL	Not tested			Not tested			12	0	0.048
1,2,3,4,6,7,8_-_HpCDF_ngL	Not tested			Not tested			12	0	0.048
1,2,3,4,7,8,9_-_HpCDF_ngL	Not tested			Not tested			12	0	0.045
1,2,3,4,7,8_-_HxCDD_ngL	Not tested			Not tested			12	0	0.048
1,2,3,4,7,8_-_HxCDF_ngL	Not tested			Not tested			12	0	0.042
1,2,3,6,7,8_-_HxCDD_ngL	Not tested			Not tested			12	0	0.048
1,2,3,6,7,8_-_HxCDF_ngL	Not tested			Not tested			12	0	0.03
1,2,3,7,8,9_-_HxCDD_ngL	Not tested			Not tested			12	0	0.048
1,2,3,7,8,9_-_HxCDF_ngL	Not tested			Not tested			12	0	0.02
1,2,3,7,8_-_PeCDD_ngL	Not tested			Not tested			12	0	0.035
1,2,3,7,8_-_PeCDF_ngL	Not tested			Not tested			12	0	0.048
1,2,3-Trichloropropane_ugL	19	0	1.0-2.5	Not tested			58	1	0.005
1,2,4-Trichlorobenzene_ugL	Not tested			10	0	1 (RL)	67	0	0.5
1,2-Benzanthracene_ugL	Not tested			10	0	0.1-5 (RL)	Not tested		
1,2-Dibromo-3-chloropropane_ugL	19	0	0.01	Not tested			Not tested		
1,2-Dibromoethane_ugL	19	0	0.01	Not tested			Not tested		
1,2_Dichlorobenzene_ugL	Not tested			10	0	0.5-1 (RL)	103	0	0.5
1,2-Dichloroethane_ugL	19	0	0.25-1	Not tested			100	0	0.5
1,2-Dichloropropane_ugL	19	0	0.5-1	Not tested			100	0	0.5
1,2-Diphenylhydrazine_ugL	Not tested			10	0	1 (RL)	Not tested		
1,3_Dichlorobenzene_ugL	Not tested			10	0	0.5-1 (RL)	103	0	0.5
1,3-Dichloropropene_ugL	Not tested			Not tested			57	0	0.5
1,4_Dichlorobenzene_ugL	Not tested			10	0	0.5-1 (RL)	275	0	0.32
1,4-Dioxane_ugL	Not tested			Not tested			58	16	0.5
2,3,4,6,7,8_-_HxCDF_ngL	Not tested			Not tested			12	0	0.037
2,3,4,7,8_-_PeCDF_ngL	Not tested			Not tested			12	0	0.048
2,3,7,8_-_TCDD_ngL	Not tested			Not tested			23	0	0.001
2,3,7,8_-_TCDF_ngL	Not tested			Not tested			12	0	0.0095
2,4,5_-_TP_Silvex_ugL	Not tested			10	0	0.2 (RL)	68	0	1
2,4,6-Trichlorophenol_ugL	Not tested			13	0	1-10 (RL)	104	0	10
2,4_-_D_ugL	Not tested			10	0	0.02 (RL)	64	0	1
2,4-DDD_ugL	Not tested			3	0	0.01 (RL)	7	0	0.05
2,4-DDE_ugL	Not tested			3	0	0.004 (RL)	7	0	0.05
2,4-DDT_ugL	Not tested			3	0	0.01 (RL)	7	0	0.05
2,4-Dichlorophenol_ugL	Not tested			12	0	1-2 (RL)	104	0	5
2,4-Dimethylphenol_ugL	Not tested			12	0	2 (RL)	104	0	2
2,4-Dinitrophenol_ugL	Not tested			12	0	3-5 (RL)	104	0	5
2,4-Dinitrotoluene_ugL	Not tested			10	0	5 (RL)	104	0	5
2,6-Dinitrotoluene_ugL	Not tested			10	0	5 (RL)	104	0	5
2-Butanone_(MEK)_ugL	19	0	0.5-1	Not tested			31	0	10
2-Chloroethylvinyl_ether_ugL	Not tested			16	0	1-2.5 (RL)	96	0	1
2-Chloronaphthalene_ugL	Not tested			10	0	10 (RL)	104	0	5
2-Chlororphenol_ugL	Not tested			10	0	2 (RL)	104	0	5
2-Hexanone_ugL	19	0	2.0-5	Not tested			Not tested		
2-Nitrophenol_ugL	Not tested			12	0	2-10 (RL)	104	0	10
3,3'-Dichlorobenzidine_ugL	Not tested			10	0	5 (RL)	104	0	1
4,4_-_DDD_ugL	Not tested			9	0	0.05 (RL)	96	0	0.01
4,4_-_DDE_ugL	Not tested			9	0	0.05 (RL)	96	0	0.01
4,4_-_DDT_ugL	Not tested			9	0	0.01 (RL)	96	0	0.01
4,6-Dinitro-o-cresol_ugL	Not tested			10	0	5 (RL)	104	0	5
4-Bromophenylphenylether_ugL	Not tested			10	0	1-5 (RL)	104	0	5
4-Chloro-3-methylphenol	Not tested			12	0	1-3 (RL)	Not tested		
4-Chlorophenylphenylether_ugL	Not tested			10	0	0.1-5 (RL)	104	0	5
4-methyl-2-pentatone_ugL	19	0	5.0-10	Not tested			Not tested		
4-Nitrophenol_ugL	Not tested			12	0	3-5 (RL)	104	0	10

Organic Compounds and other chemicals

A comparison of test results across programs

Not tested | Tested but not detected | Tested and detected

There are many valid reasons why different programs may yield different results for the same test parameter. Obvious differences in test dates or locations, different test methods, and different reporting limits are all common reasons for differences in results across programs for the same parameter.

A comparison of test results across programs is a basic first step in identifying any anomalies between different monitoring programs. A valid reason for most anomalies is often identified upon inspection of the data; other anomalies may warrant further investigation, especially in cases where one program consistently returns non-detects where others do not (or vice-versa).

Accordingly, to the left and on the subsequent page, we have lined up the results of the three programs that conducted testing in the Malibu Creek watershed for organic compounds and other US EPA priority pollutants. Data errors in the Hotspot database from Malibu Creek Watershed Monitoring Program precluded its inclusion in this investigation. Much of the detail behind these data was necessarily omitted in these tables due to space limitations (e.g. specific test dates and sites, reporting limits for specific test dates, etc.).

In this example, 1,2,3-trichloropropane was not detected in 19 Calabasas landfill tests, but was detected once by the Las Virgenes Municipal Water District in 58 samples. The non-detects might therefore be due to sampling error, or it may reflect a true difference in water quality between sites. Inspection of the raw data reveals that the sample sites were located in different sub-drainages; the Landfill site is on Cheeseboro Creek in the northern headwaters and has no development other than older landfill cells, while Los Angeles County Mass Emissions site S02 is on lower Malibu Creek at the County gauge.

Chemical & units	Landfill (11/15/1999 - 2/25/2009)			LA Co ME (5/11/2009 - 4/11/2010)			LVMWD (dates vary by period - see database)		
Acenaphthene_ugL	Not tested			10	0	1 (RL)	104	0	1
Acenaphthylene_ugL	Not tested			10	0	2 (RL)	104	0	5
Acetone_ugL	19	0	5.0-20	Not tested			Not tested		
Acetonitrile_ugL	2	0	10	Not tested			Not tested		
Acrolein_ugL	Not tested			Not tested			100	0	2
Acrylonitrile_ugL	19	0	5.0-10	Not tested			272	0	2
Aldrin_ugL	Not tested			10	0	0.005 (RL)	96	0	0.005
Alpha_BHC_ugL	Not tested			10	0	0.01 (RL)	96	0	0.005
alpha-chlordane	Not tested			10	0	0.1 (RL)	Not tested		
Anthracene_ugL	Not tested			10	0	2 (RL)	104	0	5
Atrazine_ugL	Not tested			10	0	2 (RL)	Not tested		
Azobenzene_ugL	Not tested			Not tested			104	0	1
Benzene_ugL	19	0	0.25-1	Not tested			100	0	0.5
Benzidine_ugL	Not tested			10	0	5 (RL)	104	0	5
Benzo(a)_anthracene_ugL	Not tested			Not tested			104	0	5
Benzo(a)_pyrene_ugL	Not tested			10	0	2 (RL)	106	0	5
Benzo(b)_fluoranthene_ugL	Not tested			10	0	0.1-10 (RL)	106	0	5
Benzo(g,h,i)_perylene_ugL	Not tested			10	0	0.5-5 (RL)	104	0	5
Benzo(k)_fluoranthene_ugL	Not tested			10	0	2 (RL)	106	0	5
Beta_BHC_ugL	Not tested			10	0	0.005 (RL)	96	0	0.005
bis(2-Chlorethoxy)_methane_ugL	Not tested			10	0	5 (RL)	104	0	5
bis(2-Chloroethyl)_ether_ugL	Not tested			10	0	1 (RL)	104	0	1
bis(2-Chloroisopropyl)_ether_ugL	Not tested			10	0	2 (RL)	104	0	2
bis(2-Ethylhexyl)_phthalate_ugL	Not tested			10	0	5 (RL)	275	22	2.6 - 100
Bromide_mgL	Not tested			Not tested			Not tested		
Bromochloromethane_ugL	19	0	0.5-1	Not tested			Not tested		
Bromodichloromethane_ugL	19	0	0.5-1	Not tested			See Dichlorobromomethane_ugL		
Bromoform_ugL	19	0	0.5-1	Not tested			103	18	0.5-2
Bromomethane_ugL	19	0	0.5-1	Not tested			100	0	0.5
Butylbenzylphthalate_ugL	Not tested			10	1	0.3-10 (RL)	104	0	5
Carbon_Disulfide_ugL	19	0	1.0-5	Not tested			31	0	1.0-5
Carbon_Tetrachloride_ugL	18	0	0.25-1	Not tested			103	0	0.5-1
Chlordane_ugL	Not tested			10	0	0.05 (RL)	96	0	0.01-.5
Chlorobenzene_ugL	Not tested			Not tested			100	0	0.5-1
Chloroethane_ugL	19	0	0.5-1	Not tested			100	0	0.5-1
Chloroform_ugL	18	0	0.5-1	Not tested			103	24	0.5-1
Chloromethane_ugL	19	0	0.5-1	Not tested			96	0	0.5
Chlorophyll-a__Algal_Biomass_ugL	Not tested			Not tested			236	160	2
Chlorpyrifos_ugL	Not tested			10	0	0.05 (RL)	Not tested		
Chrysene_ugL	Not tested			10	0	5 (RL)	104	0	5.0-50
cis-1,2-Dichloroethylene_ugL	19	0	0.5-1	Not tested			33	0	0.5-1
cis-1,3-Dichloropropene_ugL	19	0	0.25-1	Not tested			Not tested		
CTAS_mgL	Not tested			Not tested			237	4	0.1-0.2
Cyanazine_ugL	Not tested			10	0	2 (RL)	Not tested		
Cyanide_mgL	Not tested			9	1	0.005 (RL)	278	18	0.004 - 0.2
Delta_BHC_ugL	Not tested			10	0	0.005 (RL)	96	1	0.005 - 0.05
Demethon_ugL	Not tested			Not tested			58	0	2
Diazinon_ugL	Not tested			10	0	0.01 (RL)	70	0	2
Dibenzo(a,h)anthracene_ugL	Not tested			10	0	0.1 (RL)	106	0	5-100
Dibromochloromethane_ugL	19	0	0.5-1	Not tested			103	23	0.5 - 2
Dichlorobromomethane_ugL	Not tested			Not tested			272	75	0.05 - 1
Dieldrin_ugL	Not tested			10	0	0.01 (RL)	96	0	0.01 - 0.1
Diethylphthalate_ugL	Not tested			10	0	2 (RL)	104	1	2.0 - 20
Dimethylphthalate_ugL	Not tested			10	0	2 (RL)	104	0	2.0 - 20
Di-n-butylphthalate_ugL	Not tested			3	0	10 (RL)	104	0	5.0 - 50
Di-n-octylphthalate_ugL	Not tested			3	0	10 (RL)	104	0	5.0 - 50
Endosulfan I (alpha)	Not tested			10	0	0.01-0.02 (RL)	96	0	0.01 - 0.1
Endosulfan II (beta)	Not tested			10	0	0.01 (RL)	96	0	0.01 - 0.05
Endosulfan sulfate	Not tested			10	0	0.05 (RL)	96	0	0.01 - 0.05
Endrin	Not tested			10	0	0.01 (RL)	96	0	0.01 - 0.05
Endrin aldehyde	Not tested			10	0	0.01 (RL)	96	1	0.01 - 0.05
Endrin ketone	Not tested			2	0	1 (RL)	Not tested		
Ethyl_Benzene_ugL	19	0	0.5-1	Not tested			100	0	0.5 - 1

Chemical & units	Landfill (11/15/1999 - 2/25/2009)			LA Co ME (5/11/2009 - 4/11/2010)			LVMWD (dates vary by period - see database)		
Fluoranthene_ugL	Not tested			10	0	0.05 (RL)	104	0	1 - 10
Fluorene_ugL	Not tested			10	0	0.1 (RL)	104	0	5 - 50
Freon 11 (CCL3F)	19	0	1.0-5.0	Not tested			Not tested		
Freon 12 (CCL2F2)	17	0	1.0-2	Not tested			Not tested		
gamma-BHC (lindane)	Not tested			10	0	0.02 (RL)	Not tested		
gamma-chlordane	Not tested			10	0	0.1 (RL)	Not tested		
Guthion_ugL	Not tested			10	10		58	0	2
Heptachlor_Epoxide_ugL	Not tested			10	0	0.01 (RL)	96	0	0.01 - 0.05
Heptachlor_ugL	Not tested			10	0	0.01 (RL)	96	0	0.01 - 0.05
Hexachlorobenzene_ugL	Not tested			10	0	1 (RL)	104	0	1.0 - 10
Hexachlorobutadiene_ugL	Not tested			10	0	1 (RL)	104	0	1.0 - 10
Hexachlorocyclopentadiene_ugL	Not tested			10	0	5 (RL)	104	0	5.0 - 10
Hexachloroethane_ugL	Not tested			10	0	5 (RL)	104	0	1.0 - 10
indo(1,2,3-c,d)_pyrene_ugL	Not tested			10	0	1 (RL)	104	0	5.0 - 10
Isophorone_ugL	Not tested			10	0	1 (RL)	104	2	1.0 - 10
Lindane_ugL	Not tested			Not tested			275	4	0.005 - 0.1
Malathion_ugL	Not tested			9	0	1-2 (RL)	58	0	2
MBAS_mgL	Not tested			10	0	0.5 (RL)	2014	1164	various
Methoxychlor_ugL	Not tested			10	0	0.5 (RL)	92	0	0.01 - 1
Methylene_Chloride_ugL	18	0	0.5-1	Not tested			103	0	0.5 - 2
Mirex_ugL	Not tested			Not tested			58	0	0.01 - 0.1
MTBE_ugL	Not tested			9	0	1 (RL)	64	0	0.5 - 5
Naphthalene_ugL	Not tested			10	0	0.2 (RL)	104	1	1.0 - 10
Nitrobenzene_ugL	Not tested			10	0	1 (RL)	104	0	1.0 - 10
N-Nitrosodimethylamine_ugL	Not tested			12	0	5 (RL)	275	0	0.23 - 100
N-Nitrosodi-N-propylamine_ugL	Not tested			10	0	5 (RL)	104	0	5.0 - 50
N-Nitrosodiphenylamine_ugL	Not tested			12		1 (RL)	104	0	1.0 - 10
OCDD_ngL	Not tested			Not tested			12	0	0.0095
OCDF_ngL	Not tested			Not tested			12	0	0.0095
Oil_&_Grease,_Total_mgL	Not tested			9	0	5 (RL)	1940	0	various
o,p_-_DDD_ugL	Not tested			Not tested			3	0	0.05
o,p_-_DDE_ugL	Not tested			Not tested			3	0	0.05
o,p_-_DDT_ugL	Not tested			Not tested			3	0	0.05
Parathion_ugL	Not tested			Not tested			58	0	2
PCB_1016_ugL	Not tested			10	0	0.5 (RL)	95	0	0.5 - 50
PCB_1221_ugL	Not tested			12	0	0.5 (RL)	95	0	0.5 - 50
PCB_1232_ugL	Not tested			10	0	0.5 (RL)	95	0	0.5 - 50
PCB_1242_ugL	Not tested			10	0	0.5 (RL)	95	0	0.5 - 50
PCB_1248_ugL	Not tested			10	0	0.5 (RL)	95	0	0.5
PCB_1254_ugL	Not tested			10	0	0.5 (RL)	95	0	0.5
PCB_1260_ugL	Not tested			10	0	0.5 (RL)	95	0	0.5
p-Chloro-m-cresol_ugL	19	0	0.5-1	Not tested			104	0	1.0 - 20
Pentachlorophenol_ugL	Not tested			10	0	2 (RL)	104	0	5
Perchlorate_ugL	Not tested			Not tested			58	0	5.0 - 50
Pesticides_ugL	Not tested			Not tested			58	0	0.02 - 2
Phenanthrene_ugL	Not tested			10	0	0.05 (RL)	104	0	5.0 - 50
Phenol_ugL	Not tested			10	0	1 (RL)	133	24	0.1 - 10
Pyrene_ugL	Not tested			10	0	0.05 (RL)	104	0	5.0-50
Pyridine_ugL	Not tested			Not tested			4	0	10
TCDD_Equivalent_ngL	Not tested			Not tested			12	0	
Tetrachloroethylene_ugL	19	0	0.5-1	Not tested			272	0	0.05 - 1
Toluene_ugL	19	0	0.5-1	Not tested			100	0	0.5 - 1
trans-1,2-Dichloroethylene_ugL	19	0	0.5-1	Not tested			100	0	0.5 - 1
trans-1,3-Dichloropropene_ugL	19	0	0.5-1	Not tested			31	0	1.0 - 2
Trichloroethylene_ugL	19	0	0.5-1	Not tested			100	0	0.5 - 1
Vinyl_Chloride_ugL	19	0	0.25-1	Not tested			100	0	0.5 - 1