Section 4 - Opportunities for consolidated monitoring

Geographically coincident stations and some ideas for more efficient water quality monitoring

Recommendations for more efficient testing

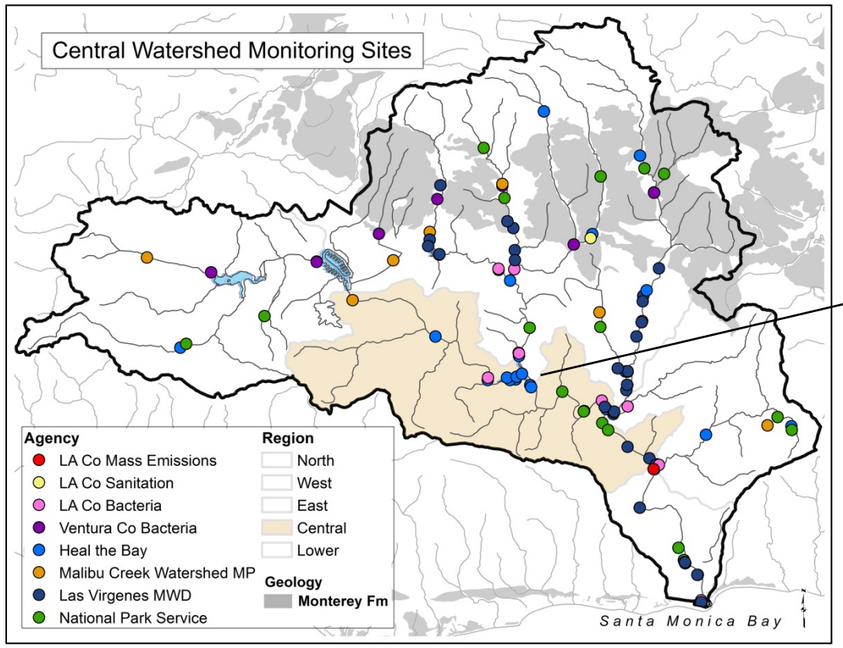
Some observations noted during our analysis

There are many valid reasons why different programs may yield different results for the same test parameter - even at the same site. But in general, our analysis results showed substantial overlap across agencies for station sites and test results, even at regional sub-drainage scales. Indeed, the association of nutrient, mineral and metal parameters in Malibu Creek with one particular sub-drainage within the Monterey Formation prompted our analysis of water quality in different geologic provinces within the watershed, revealing a major natural source of sulfate, selenium, phosphate, nitrogen and several metals, some of which we were able to track with reasonable fidelity from rocks to groundwater to streams to algae to macroinvertebrates to fish. One difficulty in this regard worth noting when consolidating monitoring efforts was inconsistency of units, as testing moved from solid to aqueous to gaseous phases (and, in fish tissues, back to solid phase), with units changing from mg/kg in rocks to mg/L and mEq/L in water, to ppb in local algae measured in ash-free dry weight samples, and finally ppb in fishes – in both dry and wet-weight units, depending on the source. But the exercise provided one of the report's most important findings with respect to future monitoring efforts, for we found that the geologic composition of Malibu Creek's various headwaters is, by far, the best single predictor of multiple parameters across all three of Malibu Creek's major sub-drainages.

Do we need to keep testing? We found several parameters that were tightly correlated with each other (e.g. TDS, SC, sulfate, magnesium, chloride, phosphate, nitrate), including several that vary in synchrony across years and seasons across multiple sites and regions. Correlations between these parameters were found at multiple geographic scales, ranging from correlation between parameters at single sites to along entire stream reaches to throughout entire sub-drainages. Monitoring any of these parameters provides approximate information on the others that may be sufficient to meet at least some general program objectives, many of which are shared across programs. In this regard, the statistical tables provided in the Water Quality section were intentionally designed to enable the identification of parameters whose median and percentile ranges may overlap at any of four spatial scales (site, reach, stream, region). We hope these results guide agencies interested in exploring consolidated testing in cooperation with other monitoring organizations in the watershed.

Data gaps – many filled, and a few new ones. Several earlier data gaps identified in single programs or regulatory documents are filled when the data is viewed in its entirety across programs. For example, the addition of post-2002 data on nutrients and dissolved oxygen at new sites in the upper watershed directly addresses the recommendation of the Malibu Creek Nutrient TMDL (US EPA 2002) for additional data for these parameters in the upper watershed and the wet season, respectively. Likewise, while no agency monitored weekly for nutrients, the fact that different agencies sampled for nutrients each month on different days at multiple sites in both the upper and lower watershed confirms that nutrient levels do not change appreciably over weekly timescales except for sites immediately below the Tapia WRF two days each year in mid-April and mid-November, when Tapia suspends and continues discharging, respectively. This result obviates the need for more frequent nutrient testing as described in the TMDL. Unfortunately, most of the DO data are from daytime samples, which are less-likely to reveal low DO than nighttime samples. This is a gap best filled by deploying automated instruments that do not entail field personnel walking in the creek or its banks each week at multiple sites, at night. Another gap is our currently very limited data on major ion composition of surface waters (two locations, one of which was a US Geological Survey project site for the City of Malibu, discontinued upon completion of their study). Normally, composite measures of major ions such as TDS or SC are sufficient for most regulatory purposes. Where the ionic composition is as unusual as it in Malibu Creek (especially in its northern tributaries), it is important to identify the specific ions responsible for brackish water the length of the creek, particularly because different ions have different consequences for human health and aquatic life beneficial uses. Sulfate levels in particular are known to affect benthic community index scores, but moderates the toxicity of selenium (See Natural Source Assessment discussion and Pond *et al.*, 2008). This testing need not occur *in perpetuity*; using what we know from existing major ion data, it should be sufficient for most purposes to determine major ions through one cycle of wet and dry years, with twice-annual sampling once in the dry season (preferably fall, when solute levels generally peak) and once late in the wet season when solute levels at most stations reach their annual minima. Annual wet season sampling should *not* occur during or immediately following storm events, as SC at some stations actually spikes during these times, possibly from groundwater being hydraulically forced to the surface by rainfall falling at higher elevations (testable with the addition of stable isotope testing in one or two storm events at the anomalous stations) or possibly because of a "first flush" of dissolved solutes that had precipitated on soil surfaces. Important locations for this testing (both seasons) include: Malibu Creek at station R13 (below confluence with Cold Creek), anywhere along Cold Creek, station R2 below Tapia WRF, station R1 above Tapia, station R9 above the confluence with Las Virgenes Creek and anywhere in the western tributary region. These data can be used to better refine the sources of very high levels of sulfate, magnesium and calcium observed in the already-sampled northern tributaries (Cheeseboro Creek) and lower Malibu Creek (USGS study), which thereafter can be monitored collectively via simpler TDS and SC tests.

What if water quality changes over time in the future? A common justification for continued monitoring in virtually all regulatory programs is to identify water quality trends over time, both to establish natural background conditions and to determine if efforts to improve water quality are working. In the absence of long-term data, historical baselines and trends must look to proxy measures if they can be established by reference to recent data. Even recent trends are difficult to establish in areas never monitored before without additional testing at least on a seasonal interval. But at this time there are few areas in the watershed that have *not* been monitored for most commonly-measured parameters for less than ten years. With respect to long-term, historical trends and baselines, over half a dozen sites in the lower watershed have been continuously monitored for nearly 40 years, with multiple agencies monitoring many of these sites in the last decade. What does the record tell us? Aside from declines in lead and mercury and a brief period of elevated phosphorus from 1988 – 92, the most conspicuous feature of the long-term record for most parameters at these locations is the absence of any statistically meaningful trend, as indicated by the generally-low correlation coefficients in the linear regression lines shown in time series graphs in this report (see Water Quality section). This is consistent with expectations for both native and non-native sources, the former because native sources lie primarily in undeveloped areas, the latter because the watershed is already within 10-20 percent of its expected build-out given current land use zoning and residential parcel data. In this regard, the majority of urban development occurred over a remarkably short interval in the 1980's and early 1990's (see urban development time series graph in the Introduction under Land Use and Weather Impacts on Water Quality). Overall, about a third of the parameters now measured monthly by multiple agencies at multiple sites can probably be reduced to a quarterly or even a biannual (twice a year) sampling frequency at perhaps a half dozen intelligently-located sites to periodically check current baselines, reserving more frequent testing for parameters known to vary more frequently, possibly sampling more frequently at each station on a rotating, multi-year schedule similar to that used by the National Park Service program.



Agency	Agency's Site Name	Creek	Region	Subwatershed	Below Tapia WRF?	Latitude	Longitude	Site Overlap*
MCWMP	TRI	Triunfo	Central	Triunfo Creek	No	34.132444	-118.82175	Different
HtB	17	Triunfo	Central	Triunfo Creek	No	34.120689	-118.788785	Different
HtB	21	Medea	Central	Lower Medea Creek	No	34.114515	-118.755687	Different
HtB	28	Malibou Lake	Central	Triunfo Creek	No	34.10865	-118.754512	Different
HtB	27	Malibou Lake	Central	Triunfo Creek	No	34.107685	-118.75661	Different
HtB	26	Malibou Lake	Central	Triunfo Creek	No	34.107416	-118.760366	Different
LA_Bact	MCW_16	Triunfo	Central	Triunfo Creek	No	34.1073	-118.767883	Different
HtB	23	Malibou Lake	Central	Triunfo Creek	No	34.106695	-118.756909	Different
HtB	24	Malibou Lake	Central	Triunfo Creek	No	34.106526	-118.759126	Different
HtB	25	Triunfo	Central	Triunfo Creek	No	34.10647	-118.767986	Different
HtB	22	Malibou Lake	Central	Triunfo Creek	No	34.104943	-118.751166	Same
HtB	4	Malibu	Central	Upper Malibu Creek	No	34.104274	-118.750762	Same
NPS	R3_CRAGSRD	Malibu	Central	Upper Malibu Creek	No	34.102865	-118.738448	Different
LA_Bact	MCW_4	Malibu	Central	Upper Malibu Creek	No	34.10001667	-118.722733	Different
LVMWD	RSW_MC009U	Malibu	Central	Upper Malibu Creek	No	34.09795	-118.721572	Different
HtB	12	Malibu	Central	Upper Malibu Creek	No	34.096612	-118.729656	Same
NPS	J_MALICRKU	Malibu	Central	Upper Malibu Creek	No	34.096386	-118.729839	Same
NPS	R3_MALICRKSP	Malibu	Central	Middle Malibu Creek	No	34.092648	-118.722501	Different
NPS	R1_MALICRK	Malibu	Central	Middle Malibu Creek	No	34.090345	-118.720157	Different
LVMWD	RSW_MC001U	Malibu	Central	Middle Malibu Creek	No	34.084832	-118.712406	Different
LVMWD	RSW_MC002D	Malibu	Central	Middle Malibu Creek	Yes	34.081139	-118.703731	Different

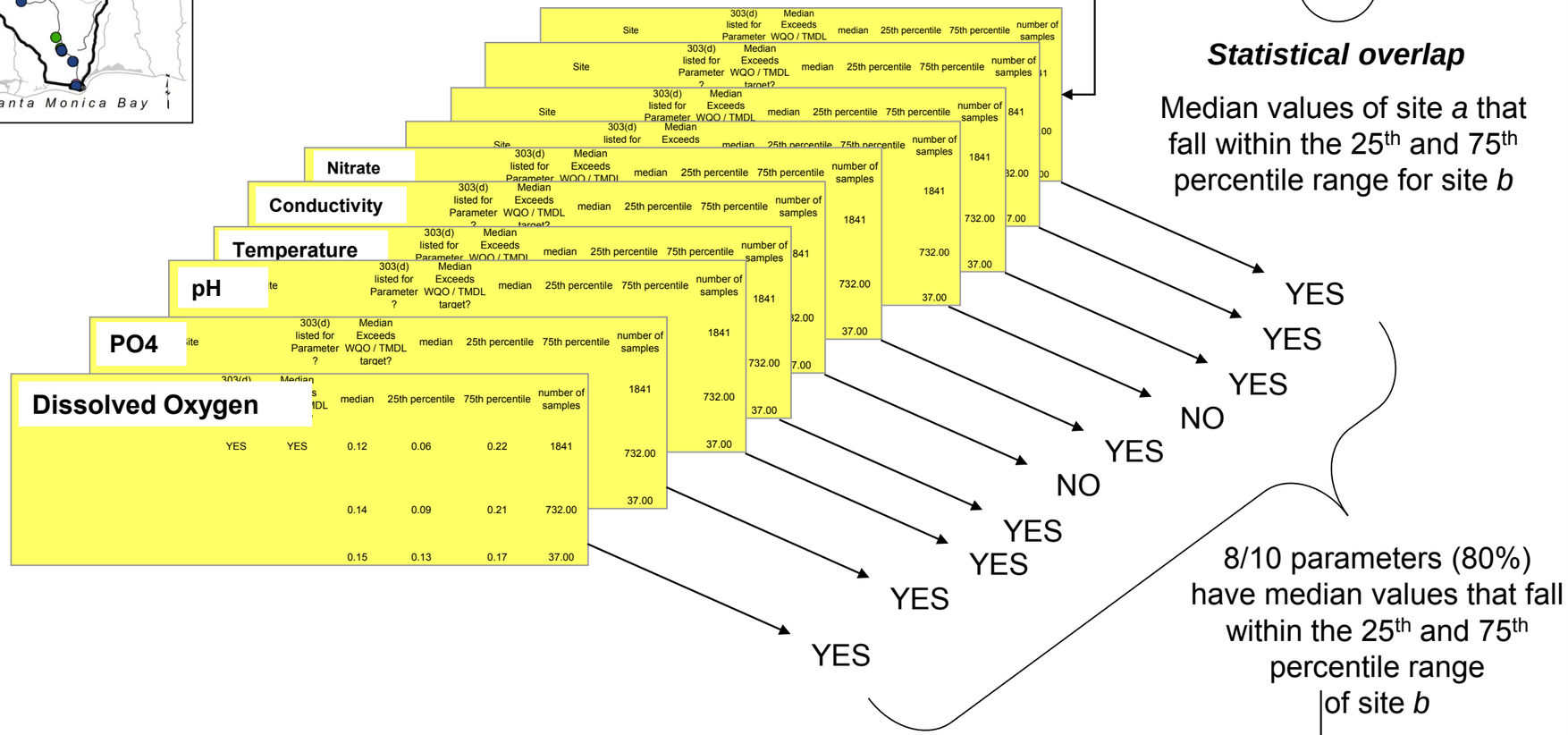
1

Geographic overlap: *Sites highlighted in YELLOW differ by less than 0.002 degrees latitude & longitude (about 200 meters)*

2

Statistical overlap

Median values of site *a* that fall within the 25th and 75th percentile range for site *b*



3

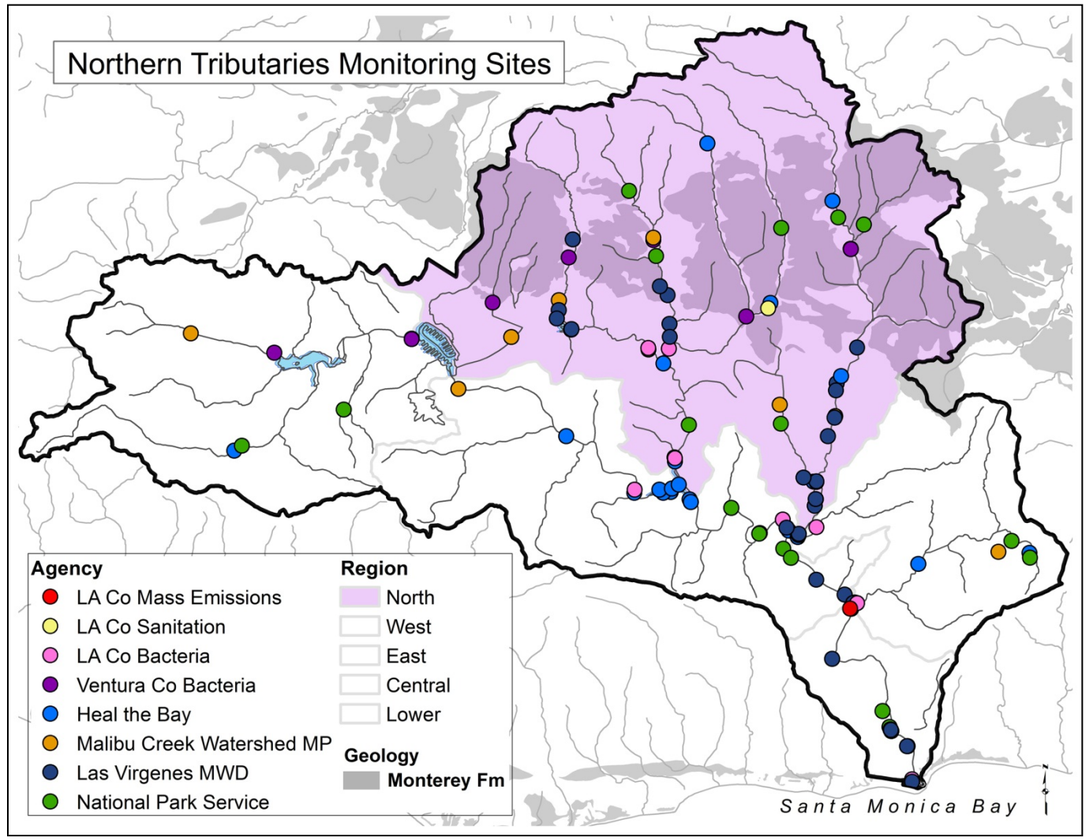
Redundancy Index: 80%

Site redundancy and duplicative monitoring analysis - General schematic.

The site redundancy analysis is basically a 3-step process. Step 1: Potentially redundant sites are first identified by geographic proximity (0.002 degrees separation or less). Step 2: All parameters measured at both sites are then compared statistically for overlapping median values (median of one site falling within the 25th & 75th percentiles of the other site) one parameter at a time. Step 3: The Redundancy Index is calculated as the percentage of overlapping median values for all measured parameters. Step1 has been completed and the results are provided in the following pages. The analysis of coincident test results in Steps 2 and 3 are provided for discussion – it is just one of many ways to quantify redundancy across stations using the information provided in the report.

North

Agency	Agency's Site Name	Creek	Region	Subwatershed	Below Tapia WRF?	Latitude	Longitude	Site Overlap*
NPS	S_LLASVIR	Las Virgenes	North	Lower Las Virgenes Creek	No	34.210254	-118.80267	Different
NPS	S_LMEDCRK	Medea	North	Lower Medea Creek	No	34.201948	-118.849441	Different
HtB	8	Palo Comado	North	Palo Comado Creek	No	34.195117	-118.746504	Different
NPS	R1_MEDCRK	Medea	North	Upper Medea Creek	No	34.182908	-118.770221	Different
HtB	9	Las Virgenes	North	Upper Las Virgenes Creek	No	34.180809	-118.708307	Different
NPS	S_ULASVIR	Las Virgenes	North	Upper Las Virgenes Creek	No	34.17658	-118.706468	Different
NPS	J_EFLASVIR	Las Virgenes	North	Upper Las Virgenes Creek	No	34.174839	-118.698708	Different
NPS	J_CHEESEBRO	Cheeseboro	North	Cheeseboro Creek	No	34.173815	-118.723893	Different
MCWMP	MED1	Medea	North	Upper Medea Creek	No	34.171121	-118.762739	Different
LVMWD	LinderoCrkatVenturaCoLine_L1	Lindero	North	Upper Lindero Creek	No	34.170525	-118.787319	Different
Ventura	MCW_12	Medea	North	Upper Medea Creek	No	34.1705	-118.76275	Different
MCWMP	LV1	Las Virgenes	North	Upper Las Virgenes Creek	No	34.168704	-118.702656	Same
Ventura	MCW_8b	Las Virgenes	North	Upper Las Virgenes Creek	No	34.168582	-118.702597	Same
NPS	S_UMEDCRK	Medea	North	Upper Medea Creek	No	34.166473	-118.76186	Different
Ventura	MCW_14b	Lindero	North	Upper Lindero Creek	No	34.165914	-118.78851	Different
LVMWD	MedeaCrk_atBayLaurelSch_M1	Medea	North	Upper Medea Creek	No	34.158839	-118.760644	Different
LVMWD	MedeaCrk_atTOBlvdaboveRalphs_M2	Medea	North	Upper Medea Creek	No	34.156619	-118.758283	Different
MCWMP	LIN1	Lindero	North	Upper Lindero Creek	No	34.155139	-118.791361	Different
HtB	6	Cheeseboro	North	Cheeseboro Creek	No	34.154764	-118.72697	Different
Ventura	MCW_15b	Russell	North	Westlake	No	34.154383	-118.81155	Different
LACSD	Ches	Cheeseboro	North	Cheeseboro Creek	No	34.153345	-118.727528	Different
LVMWD	LinderoGolf_SoEndSmallPond_L3	Lindero	North	Upper Lindero Creek	No	34.152594	-118.791411	Different
Ventura	MCW_9	Cheeseboro	North	Cheeseboro Creek	No	34.151367	-118.7343	Different
LVMWD	LinderoCrk_LakeInlet_L2	Lindero	North	Upper Lindero Creek	No	34.150453	-118.791969	Different
LVMWD	MedeaCrk_atAgouraHillsHS	Medea	North	Upper Medea Creek	No	34.149336	-118.757639	Different
LVMWD	LinderoLake_ouflow_L4	Lindero	North	Lower Lindero Creek	No	34.147808	-118.787486	Same
MCWMP	LIN2	Lindero	North	Lower Lindero Creek	No	34.147713	-118.787572	Same
LVMWD	MedeaCrk_atCanwoodand101_M3	Medea	North	Upper Medea Creek	No	34.146044	-118.757506	Different
MCWMP	RUS	Russell	North	Westlake	No	34.145694	-118.805817	Different
LVMWD	RSW_MC001F	Las Virgenes	North	Lower Las Virgenes Creek	No	34.143706	-118.700454	Different
LA_Bact	MCW_13	Lindero	North	Lower Lindero Creek	No	34.1432	-118.764033	Different
LA_Bact	MCW_10	Palo Comado	North	Palo Comado Creek	No	34.14308333	-118.7578	Different
NPS	R3_LADYFACE	Lindero	North	Lower Lindero Creek	No	34.142835	-118.764005	Different
HtB	7	Medea	North	Lower Medea Creek	No	34.139306	-118.75936	Different
HtB	13	Las Virgenes	North	Lower Las Virgenes Creek	No	34.136428	-118.705324	Same
LVMWD	RSW_MC008D	Las Virgenes	North	Lower Las Virgenes Creek	No	34.134616	-118.706624	Same
LVMWD	RSW_MC007D	Las Virgenes	North	Lower Las Virgenes Creek	No	34.134616	-118.706624	Same
MCWMP	LC	Liberty Canyon	North	Lower Las Virgenes Creek	No	34.129083	-118.7239	Different
MCWMP	LV2	Las Virgenes	North	Lower Las Virgenes Creek	No	34.126296	-118.706944	Same
LVMWD	RSW_MC002F	Las Virgenes	North	Lower Las Virgenes Creek	No	34.125933	-118.707178	Same
NPS	R3_LIBCYN	Liberty Canyon	North	Lower Las Virgenes Creek	No	34.124249	-118.7235	Different
LVMWD	LVCreek_Farm_LV3	Las Virgenes	North	Lower Las Virgenes Creek	No	34.121219	-118.709186	Different
MCWMP	MED2	Medea	North	Lower Medea Creek	No	34.115584	-118.755806	Same
LA_Bact	MCW_11	Medea	North	Lower Medea Creek	No	34.11535	-118.75565	Same
LVMWD	LibertyCanyonCrkatSewerXing	Liberty Canyon	North	Lower Las Virgenes Creek	No	34.110672	-118.716519	Different
HtB	30	Las Virgenes	North	Lower Las Virgenes Creek	No	34.109774	-118.713478	Same
LVMWD	LVCreek_WhiteOak_LV4	Las Virgenes	North	Lower Las Virgenes Creek	No	34.109769	-118.712528	Same
LVMWD	LV_belowLibertyCynCreek	Las Virgenes	North	Lower Las Virgenes Creek	No	34.105275	-118.712775	Same
NPS	R1_LIBCYN	Liberty Canyon	North	Lower Las Virgenes Creek	No	34.105202	-118.712675	Same
LVMWD	LV_atMulholland	Las Virgenes	North	Lower Las Virgenes Creek	No	34.103581	-118.713025	Same
HtB	5	Las Virgenes	North	Lower Las Virgenes Creek	No	34.097271	-118.720851	Different
LVMWD	RSW_MC003F	Las Virgenes	North	Lower Las Virgenes Creek	No	34.096422	-118.717819	Same
LA_Bact	MCW_7	Las Virgenes	North	Lower Las Virgenes Creek	No	34.09615	-118.717867	Same



Site redundancy analysis - Northern tributaries.

The locations of the sites highlighted in YELLOW differ from each other by less than 0.002 degrees latitude and longitude.

Six locations have been monitored by more than one agency by this criterion. However, three of the redundant sites are no longer monitored by the Malibu Creek Watershed Monitoring Project, yielding three sites currently monitored by one or more agencies in this region.

West

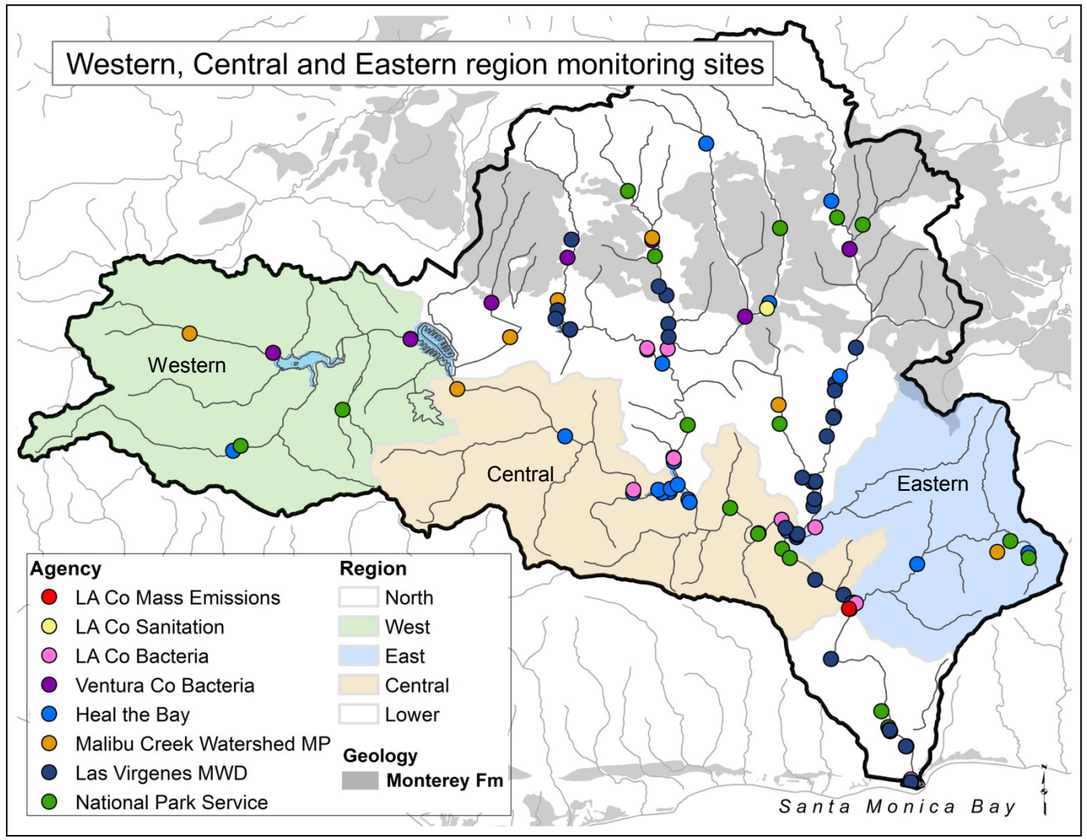
Agency	Agency's Site Name	Creek	Region	Subwatershed	Below Tapia WRF?	Latitude	Longitude	Site Overlap*
MCWMP	HV	Hidden Valley	West	Hidden Valley Creek	No	34.145944	-118.903372	same
MCWMP	POT	Potrero	West	Westlake	No	34.145074	-118.836112	same
Ventura	MCW_17	Potrero	West	Potrero Canyon Creek	No	34.144933	-118.836083	same
Ventura	MCW_18	Hidden Valley	West	Hidden Valley Creek	No	34.141233	-118.877883	different
NPS	R1_ELEANOR	Eleanor	West	Westlake	No	34.126989	-118.85661	different
NPS	S_CARLISLE	Carlisle	West	Hidden Valley Creek	No	34.117592	-118.887488	different
HtB	10	Carlisle	West	Hidden Valley Creek	No	34.116342	-118.889809	different
MCWMP	CC	Cold	West	Cold Creek	No	34.092222	-118.657016	different

Central

Agency	Agency's Site Name	Creek	Region	Subwatershed	Below Tapia WRF?	Latitude	Longitude	Site Overlap*
MCWMP	TRI	Triunfo	Central	Triunfo Creek	No	34.132444	-118.82175	Different
HtB	17	Triunfo	Central	Triunfo Creek	No	34.120689	-118.788785	Different
HtB	21	Medea	Central	Lower Medea Creek	No	34.114515	-118.755687	Different
HtB	28	Malibou Lake	Central	Triunfo Creek	No	34.10865	-118.754512	Different
HtB	27	Malibou Lake	Central	Triunfo Creek	No	34.107685	-118.75661	Different
HtB	26	Malibou Lake	Central	Triunfo Creek	No	34.107416	-118.760366	Different
LA_Bact	MCW_16	Triunfo	Central	Triunfo Creek	No	34.1073	-118.767883	Different
HtB	23	Malibou Lake	Central	Triunfo Creek	No	34.106695	-118.756909	Different
HtB	24	Malibou Lake	Central	Triunfo Creek	No	34.106526	-118.759126	Different
HtB	25	Triunfo	Central	Triunfo Creek	No	34.10647	-118.767986	Different
HtB	22	Malibou Lake	Central	Triunfo Creek	No	34.104943	-118.751166	Same
HtB	4	Malibu	Central	Upper Malibu Creek	No	34.104274	-118.750762	Same
NPS	R3_CRAGSRD	Malibu	Central	Upper Malibu Creek	No	34.102865	-118.738448	Different
LA_Bact	MCW_4	Malibu	Central	Upper Malibu Creek	No	34.10001667	-118.722733	Different
LVMWD	RSW_MC009U	Malibu	Central	Upper Malibu Creek	No	34.09795	-118.721572	Different
HtB	12	Malibu	Central	Upper Malibu Creek	No	34.096612	-118.729656	Same
NPS	J_MALICRKU	Malibu	Central	Upper Malibu Creek	No	34.096386	-118.729839	Same
NPS	R3_MALICRKSP	Malibu	Central	Middle Malibu Creek	No	34.092648	-118.722501	Different
NPS	R1_MALICRK	Malibu	Central	Middle Malibu Creek	No	34.090345	-118.720157	Different
LVMWD	RSW_MC001U	Malibu	Central	Middle Malibu Creek	No	34.084832	-118.712406	Different
LVMWD	RSW_MC002D	Malibu	Central	Middle Malibu Creek	Yes	34.081139	-118.703731	Different

East

Agency	Agency's Site Name	Creek	Region	Subwatershed	Below Tapia WRF?	Latitude	Longitude	Site Overlap*
LA_Bact	MCW_6	Stokes	East	Stokes Creek	No	34.09815	-118.712467	Different
HtB	16	Stokes	East	Stokes Creek	No	34.095692	-118.718155	Different
NPS	R3_COLDCRK	Cold	East	Cold Creek	No	34.095035	-118.653104	Different
HtB	3	Cold	East	Cold Creek	No	34.091997	-118.647616	Same
NPS	J_UCOLDCRK	Cold	East	Cold Creek	No	34.090792	-118.647407	Same
HtB	11	Cold	East	Cold Creek	No	34.088983	-118.68139	Different
NPS	J_LCOLDCRK	Cold	East	Cold Creek	No	34.079156	-118.700619	Same
HtB	2	Cold	East	Cold Creek	No	34.079154	-118.700634	Same
LVMWD	ColdCreekatMalibuCrkConfluence	Cold	East	Cold Creek	No	34.079119	-118.700931	Same
LA_Bact	MCW_5	Cold	East	Cold Creek	No	34.07898333	-118.699933	Same



Site redundancy analysis - West, Central & Eastern sub-Basins.

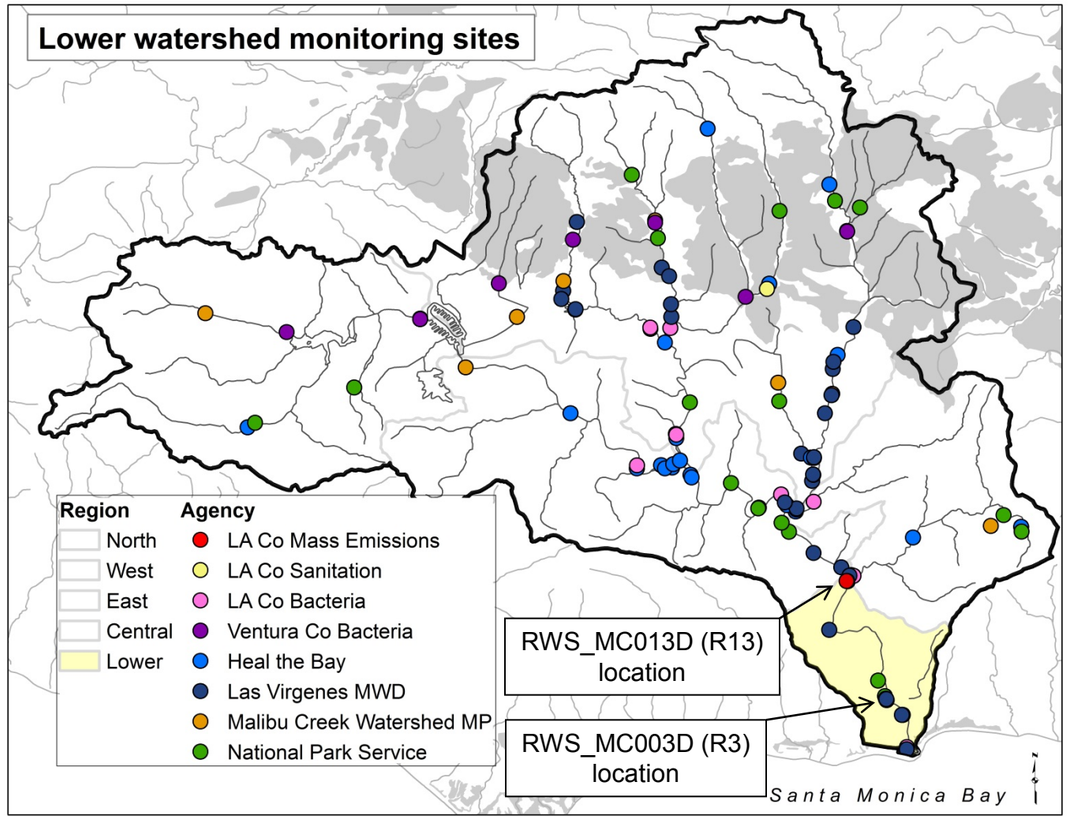
The locations of the sites highlighted in YELLOW differ from each other by less than 0.002 degrees latitude & longitude.

Redundant sites in the western subbasin are no longer monitored by multiple agencies. Apparent redundancy in the central subbasin in the vicinity of Malibou Lake is an artifact of the geographic separation criterion (<0.002 degrees); they actually measure different water bodies (Malibou Lake proper and immediately downstream of the lake outlet).

Redundant sites along Cold Creek (eastern subbasin) could probably be consolidated without significant loss in water quality information.

Lower

Agency	Agency's Site Name	Creek	Region	Subwatershed	Below Tapia WRF?	Latitude	Longitude	Site Overlap*
LVMWD	RSW_MC012D	Malibu	Lower	Middle Malibu Creek	Yes	34.079025	-118.701131	Same
NPS	MalibuCreekatGage	Malibu	Lower	Middle Malibu Creek	Yes	34.077624	-118.70184	Same
HtB	15	Malibu	Lower	Middle Malibu Creek	Yes	34.077624	-118.70184	Same
LVMWD	RSW_MC013D	Malibu	Lower	Lower Malibu Creek	Yes	34.077569	-118.701859	Same
LA_Bact	MCW_3	Malibu	Lower	Middle Malibu Creek	Yes	34.07756667	-118.70175	Same
LACoME	S02	Malibu	Lower	Lower Malibu Creek	Yes	34.07611	-118.702206	Same
LVMWD	RSW_MC010D	Malibu	Lower	Lower Malibu Creek	Yes	34.064883	-118.707397	Different
NPS	R3_CROSSCRK	Malibu	Lower	Lower Malibu Creek	Yes	34.051745	-118.691979	Different
NPS	J_MALICRKL	Malibu	Lower	Lower Malibu Creek	Yes	34.047717	-118.689797	Same
LA_Bact	MCW_2	Malibu	Lower	Lower Malibu Creek	Yes	34.04708333	-118.689517	Same
LVMWD	RSW_MC003D	Malibu	Lower	Lower Malibu Creek	Yes	34.046974	-118.689381	Same
MCWMP	MAL	Malibu	Lower	Lower Malibu Creek	Yes	34.046713	-118.689262	Same
LVMWD	RSW_MC004D	Malibu	Lower	Lower Malibu Creek	Yes	34.042888	-118.684444	Same
HtB	1	Malibu	Lower	Lower Malibu Creek	Yes	34.042882	-118.684228	Same
LA_Bact	MCW_1	Malibu	Lower	Malibu Lagoon	Yes	34.03448333	-118.682817	Same
LVMWD	RSW_MC011D	Malibu	Lower	Malibu Lagoon	Yes	34.033896	-118.682837	Same



Site redundancy analysis - Lower watershed

Locations of the sites highlighted in YELLOW differ from each other by less than 0.002 degrees latitude & longitude.

Four locations are monitored by multiple agencies: in the vicinity of the Tapia WRF, at the Los Angeles County stream gauge site, at the Cross Creek road bridge and at Malibu Lagoon.