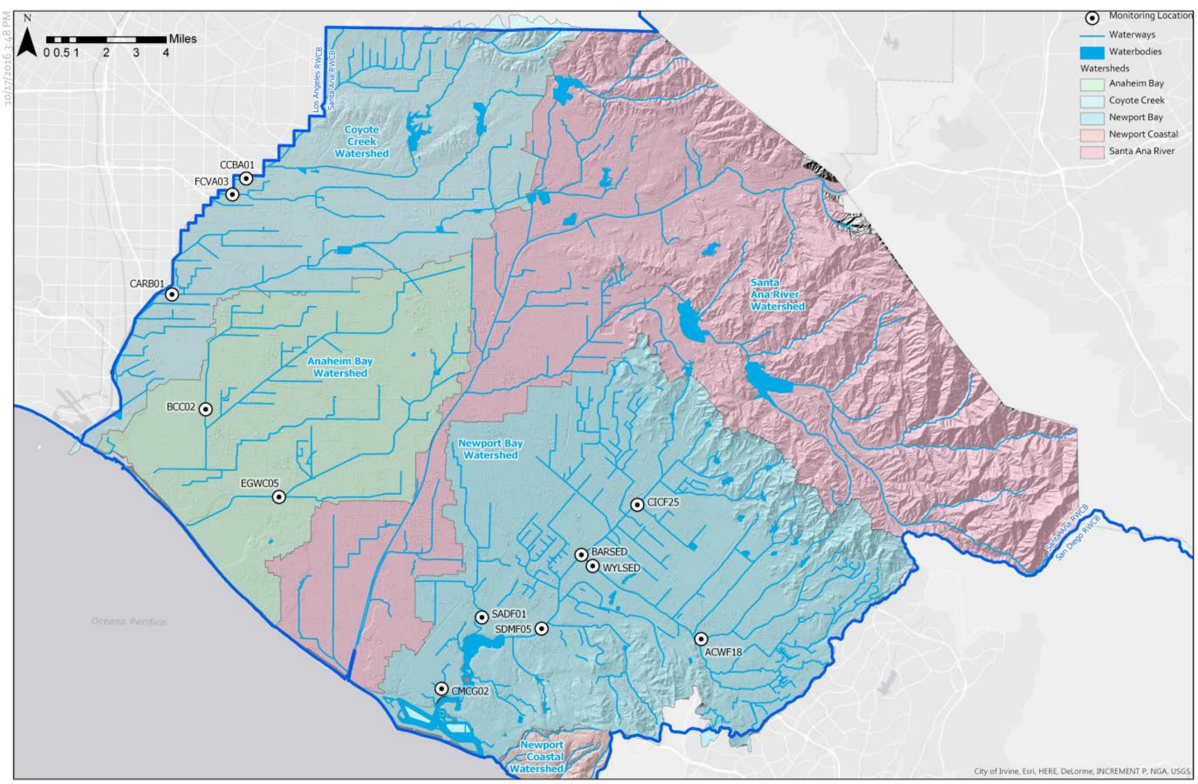
C-11-II.0 LONG TERM MASS EMISSIONS MONITORING

C-11-II.1 Core Monitoring Program

C-11-II.1.1 Overview

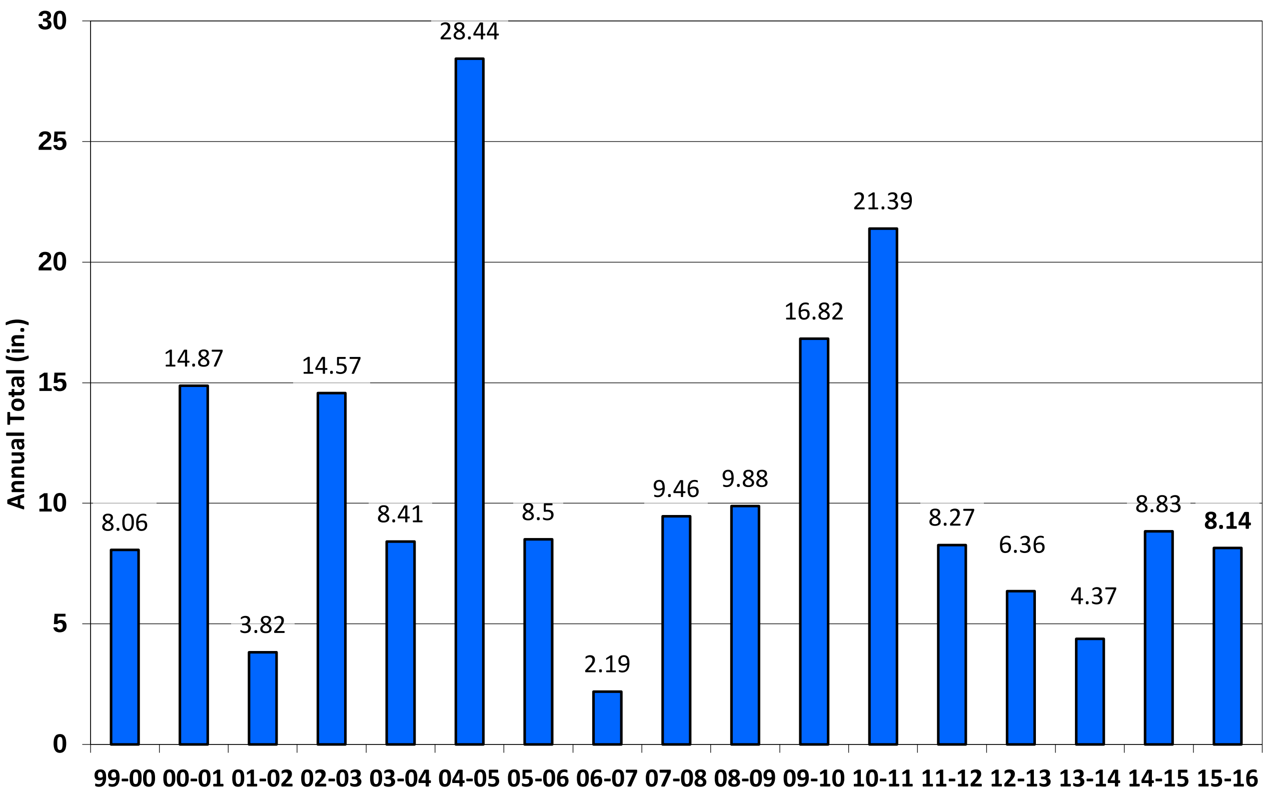
Long Term Mass Emissions (Mass Emissions) monitoring is conducted primarily to estimate the total annual load (or amount by weight) of a wide range of constituents which are transported by flood control drainage channels to receiving waters during both dry weather and stormwater runoff conditions. A secondary goal is to assess the relative toxicity of these samples, both by comparison to California Toxics Rule (CTR) criteria and from the results of aquatic toxicity tests. Water chemistry and channel discharge rates are measured to compute loads for specific dry weather and wet weather events each year. Ideally, the total annual load of a selected constituent from a channel would be determined from a continuous monitoring of the water chemistry and discharge rate throughout the year. However, the cost for analytical services and monitoring labor requirements make the continuous analysis of aquatic chemistry cost prohibitive. Consequently, monitoring of aquatic chemistry in runoff is conducted at representative times during dry weather and storm flow events and the information gathered is used to estimate the conditions throughout the year. The monitoring locations are shown in the figure below.

Figure C-11-II.1: Receiving Water Locations for Mass Emissions Monitoring Program.



The intent is to annually monitor each site during three periods influenced by stormwater runoff and a representative number of dry weather periods. The annual rainfall summary for Santa Ana, shown in the figure below, shows that this year's total of 8.14 inches was amongst the lower cumulative annual totals since 1997-98. Given the prolonged drought conditions, smaller sized storms, and low rainfall totals overall, dry or reduced flow conditions were observed in many of the regional channels, thereby making storm event monitoring a challenge during 2015-16. Storm monitoring activities at various monitoring stations were conducted for the first flush storm event (October, 2015) as well as the following other storm events: early January 2016 (Newport watersheds focus), late January/early February 2016 (North County watersheds focus), and March 2016 (Newport watersheds focus).

Figure C-11-II.2: Annual Rainfall at Station #121 in Santa Ana. The 2015-16 wet season annual rainfall total was below the historical average of 12.78 inches, and the sixth lowest cumulative total since a high of 30.59 inches in the 1997-98 season.



Water quality data from Mass Emissions stations were used to assess stormwater mass loads, toxicity effects associated with runoff, and compliance with respect to acute and chronic criteria from the CTR. Data sets below are presented in tables available at the following link: https://ocgov.box.com/v/2015-16-SAR-PEA-C11-Datasets

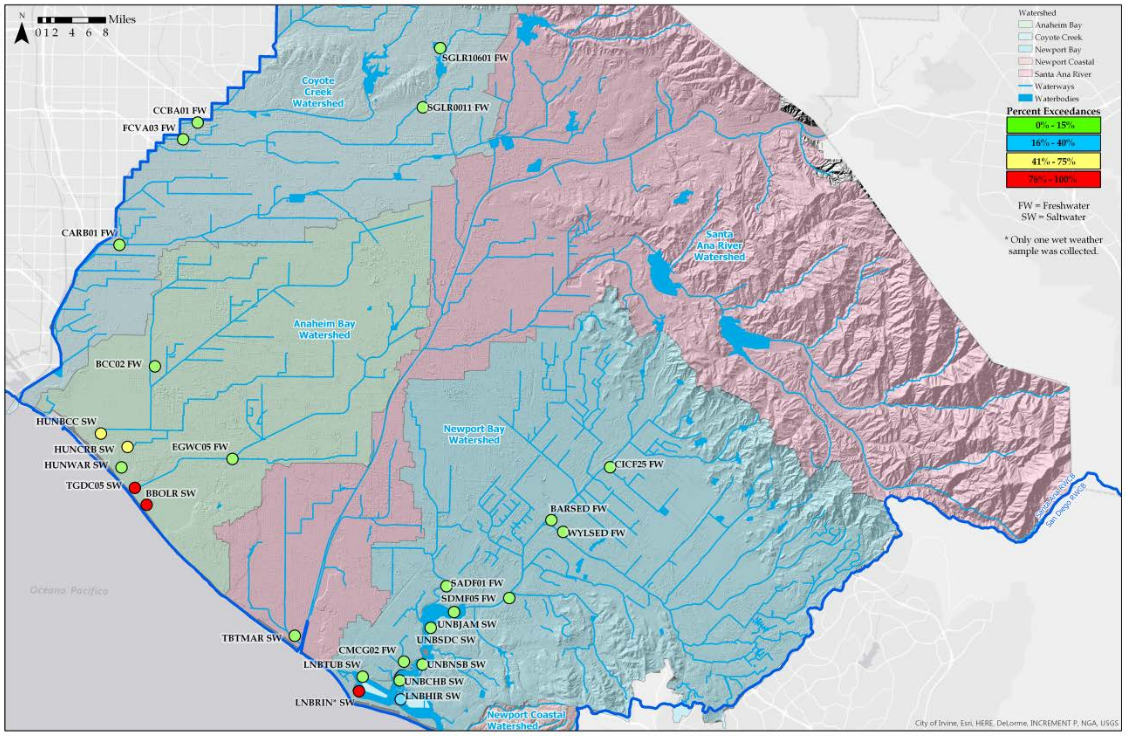
- **Table C-11-II.1** contains the stormwater mass loads of nutrients and trace elements.

- **Table C-11-II.2** contains the measured flow-weighted event mean concentrations (EMC) of these constituents.
- **Table C-11-II.3** presents the entire data set of aqueous chemistry and microbiology at Santa Ana Region mass loading sites.
- **Table C-11-II.4** summarizes the comparisons of metals samples results to the CTR criteria. The concentrations of dissolved metals and total recoverable selenium in each composite sample collected in the Mass Emissions program element are compared to the acute and chronic toxicity criteria from the CTR, where applicable. Freshwater criteria are used to evaluate channel discharges.
- **Table C-11-II.5** presents the entire set of toxicity data collected in 2015-16.

C-11-II.1.2 Metals and Selenium

Of the 120 composite samples collected during 2015-16 for the Mass Emissions program, exceedances of CTR criteria for dissolved metals were limited to cadmium, copper, and zinc, which are discussed in the following sections along with the trace element selenium. The complete summary of dissolved and total recoverable metals CTR exceedances are available in **Table C-11-II.4** for acute and chronic CTR criteria in both dry and wet weather. Additionally, **Figures C-11-II.3** and **C-11-II.4** display the data spatially for dissolved metals that had at least one exceedance, and are split into acute (upper figure) and chronic (lower figure) criteria. Both **Table C-11-II.4** and **Figures C-11-II.3** and **C-11-II.4** also include results from the Bioassessment and Estuary /Wetlands monitoring programs for regional comparison.

Figure C-11-II.3: Patterns of Dissolved Metals CTR Exceedances across the Region in Dry Weather, Acute (Upper Map) and Chronic (Lower Map) CTR Criteria. This figure includes the Mass Emissions monitoring stations as well as the Estuary/Wetlands and 2016 Bioassessment stations for comparison.



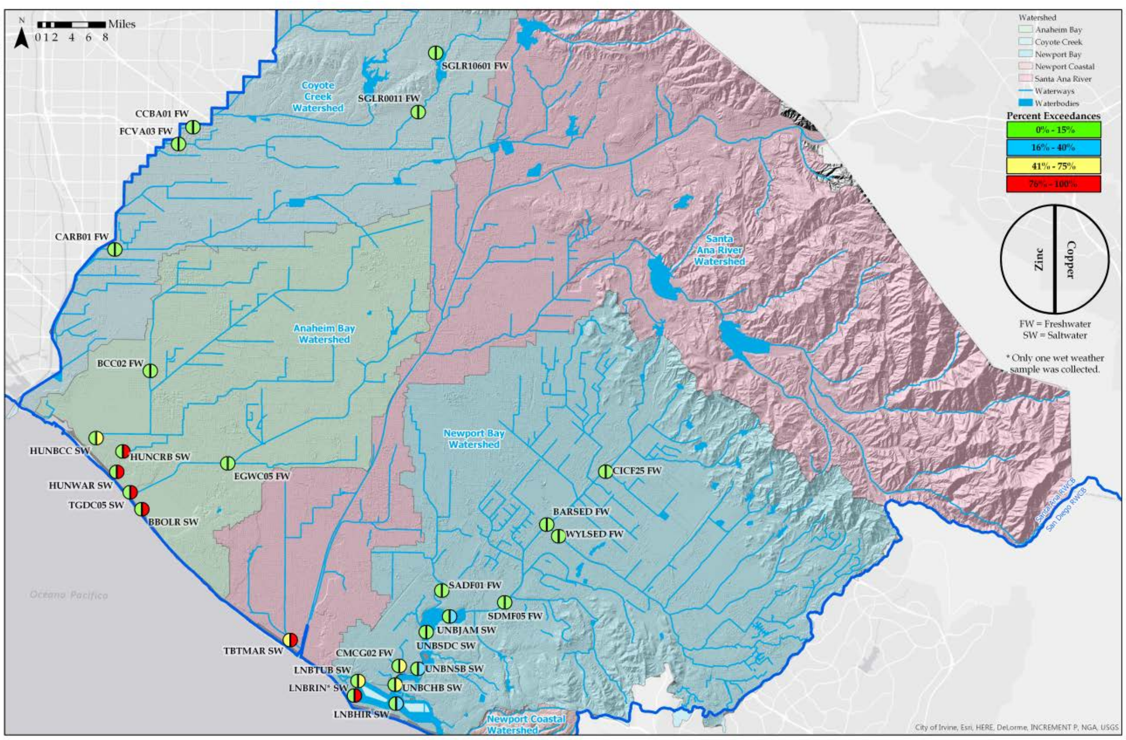
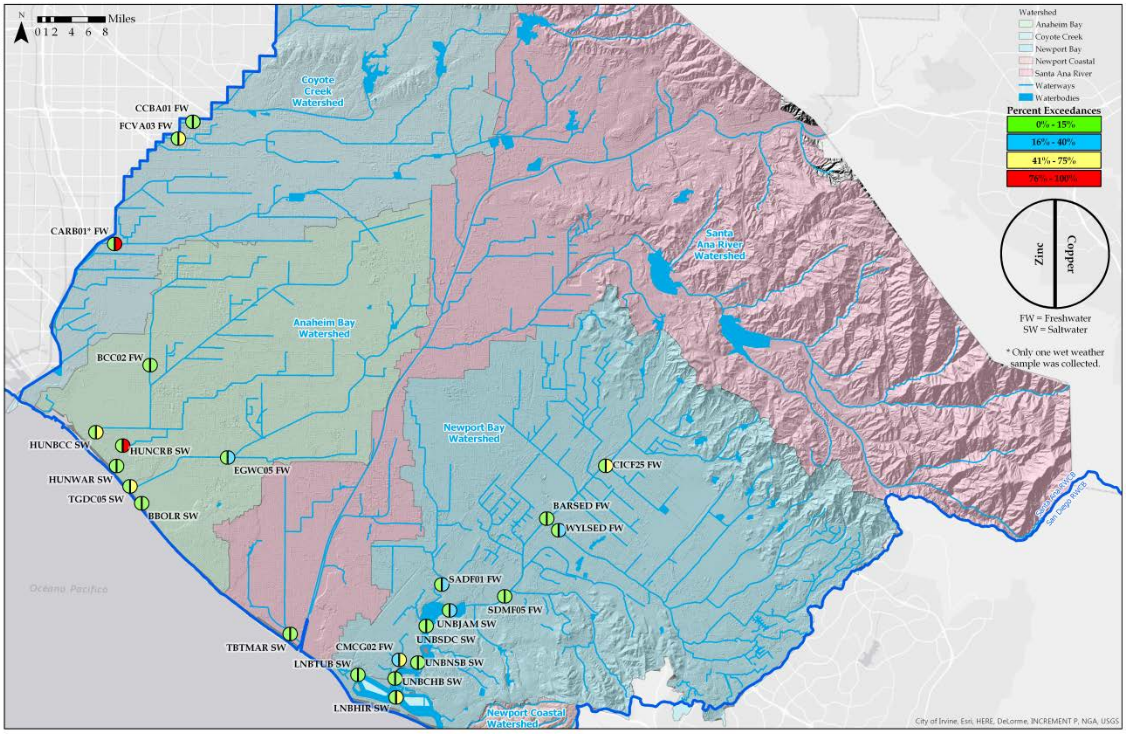
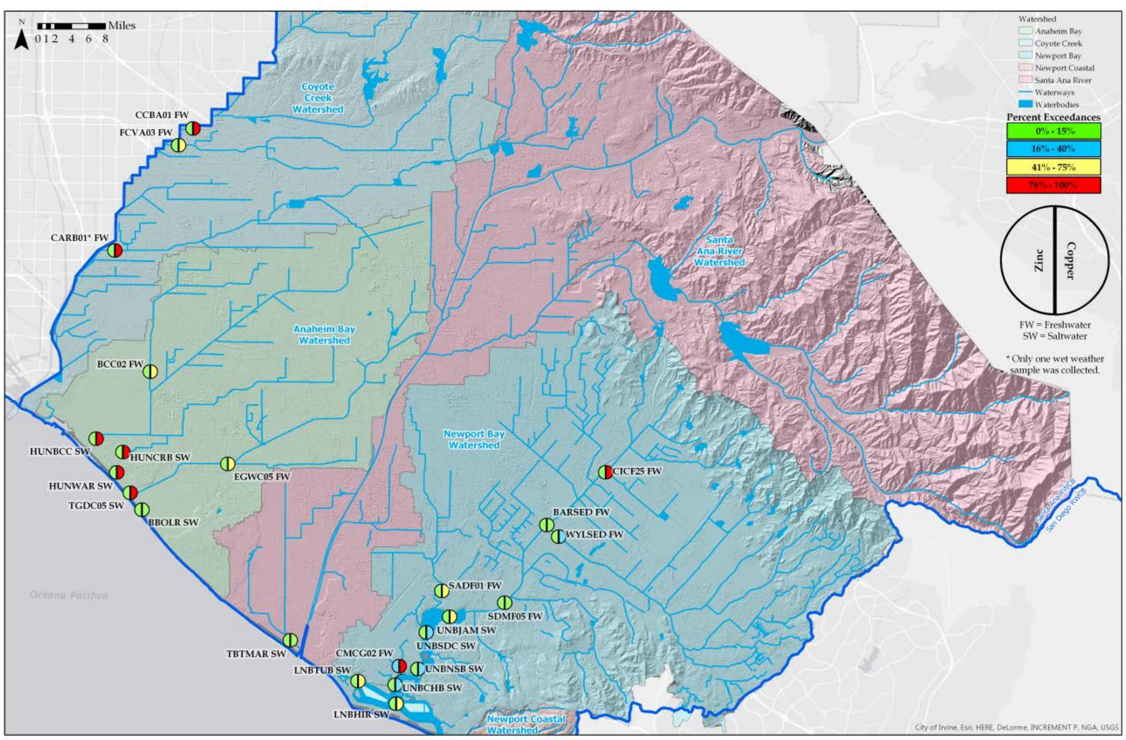


Figure C-11-II.4: Patterns of Dissolved Metals CTR Exceedances across the Region in Stormwater-Influenced Samples, Acute (Upper Map) and Chronic (Lower Map) CTR Criteria. This figure includes the Mass Emissions monitoring stations as well as the Estuary/Wetlands and 2016 Bioassessment stations for comparison.





Cadmium

A total of 1 of the 68 (<2%) dry weather samples collected for the Mass Emissions program showed an exceedance of the chronic CTR criterion for dissolved cadmium at Central Irvine Channel (CICF25). No exceedances of the acute CTR criterion were noted for dissolved cadmium in the 68 dry weather samples collected.

None of the 52 stormwater-influenced samples collected exceeded the acute and chronic CTR criteria for dissolved cadmium.

Copper

A total of 5 of the 68 (7%) dry weather samples collected for this program exceeded the chronic CTR criterion (adjusted for water hardness) for dissolved copper, four of which were at Costa Mesa Channel (CMCG02) and one was at Central Irvine Channel (CICF25). Of the four exceedances at CMCG02, one sample also exceeded the acute CTR criterion in addition to the chronic CTR criterion. The remaining exceedance was observed at Central Irvine Channel (CICF25), which had one sample that exceeded both the acute and chronic CTR criteria.

Of the 52 stormwater-influenced composite samples collected, 13 (25%) were in exceedance of the acute CTR criterion and 28 (54%) exceeded the chronic CTR criterion for dissolved copper. Exceedances of the chronic CTR criterion were noted at each of the Mass Emissions monitoring stations evaluated with the exception of San Diego Creek at Campus (SDMF05) and Peters Canyon Wash at Barranca Parkway (BARSED).

Zinc

No dissolved zinc exceedances were observed in the 78 dry weather composite samples collected for the entire program across all stations.

One of the 52 (2%) stormwater-influenced samples collected exceeded both the acute and chronic freshwater CTR criteria (adjusted for water hardness) for dissolved zinc. This sample was associated with CMCG02.

Selenium

Total selenium is evaluated instead of dissolved selenium, and total selenium only contains a chronic freshwater CTR criterion. A total of 68 selenium samples were collected during dry weather, 27 (40%) of which showed an exceedance of the chronic CTR criterion for total recoverable selenium. Exceedances of the selenium chronic CTR criterion were collected from the Newport Bay watershed at BARSED (10 of 10 samples), SDMF05 (8 of 11 samples), CICF25 (1 of 7 samples), San Diego Creek at Harvard Avenue (WYLSED – 10 of 10 samples), and SADF01 (11 of 11 samples). The chronic CTR criterion for total recoverable selenium was exceeded in 7 out of 52 stormwater-influenced samples. These samples were also all collected from the Upper Newport Bay watershed at SDMF05 (3 of 7 storm samples) and BARSED (4 of 6 storm samples).

C-11-II.1.3 Aquatic Toxicity

Aquatic toxicity testing is conducted on selected dry weather and stormwater-influenced runoff samples across the region for the Mass Emissions program. Toxicity testing provides a cumulative perspective of pollutant effects on receiving water aquatic species. One toxicity data set for Mass Emissions program was collected near the end of the 2015-16 reporting year and remains pending as of November 2016. The toxicity tests results for all available samples analyzed during 2015-16 are contained in **Table C-11-II.5**.

Samples were considered to be toxic if the organism response test results (i.e., survival, reproduction, or growth) were less than (<) 80% effect (e.g., less than 80% survival) compared to the control sample. Results indicate that toxicity effects in receiving waters across the region differed between dry weather and storm events as shown in **Figure C-11-II.5** and **Figure C-11-II.6** (see below), respectively. Toxicity occurred in 6 of 122 (4.9%) dry weather samples in comparison to 9 of 131 tests (6.9%) of stormwater-influenced samples collected from inland receiving waters.

As with **Figures C-11-II.3** and **C-11-II.4**, **Figures C-11-II.5** and **C-11-II.6** below also include data from Estuary/Wetlands and Bioassessment program data for regional comparisons. **Figure C-11-II.5** summarizes available dry weather 2015-16 toxicity data across the Santa Ana Region monitoring sites. Similarly, **Figure C-11-II.6** depicts stormwater-influenced toxicity results.

Figure C-11-II.5: Patterns of Toxicity across the Region in Dry Weather. The data provided includes Mass Emissions and Estuary/Wetlands stations for comparison.

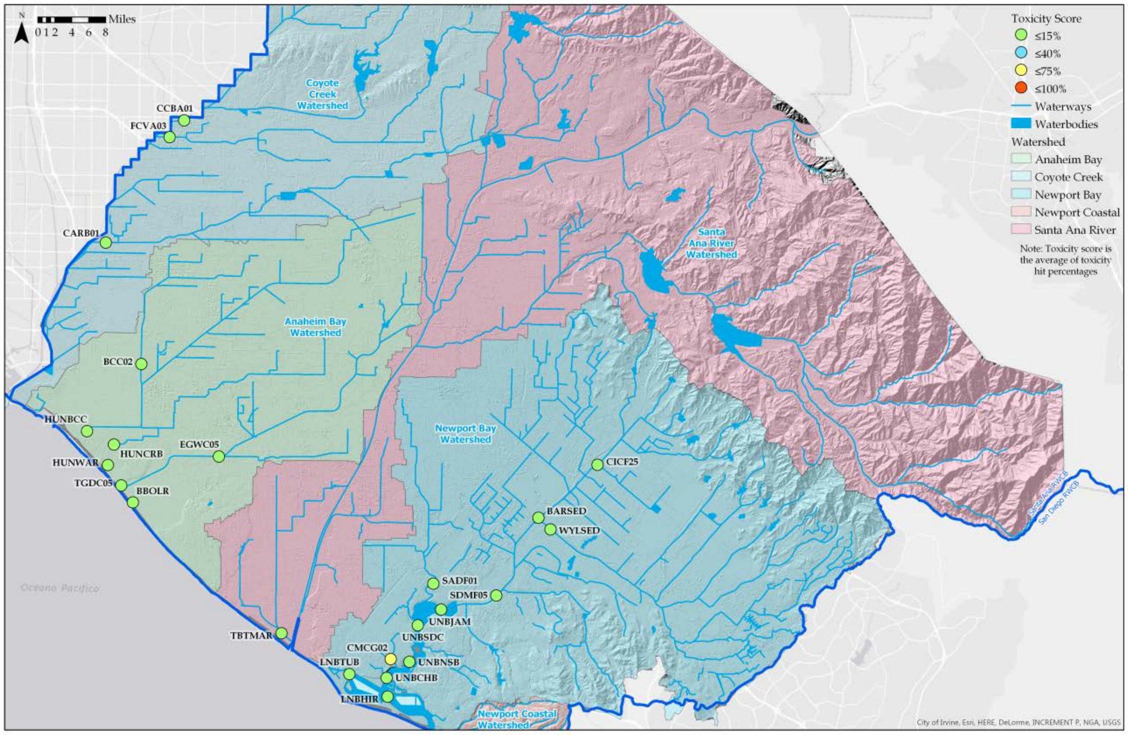
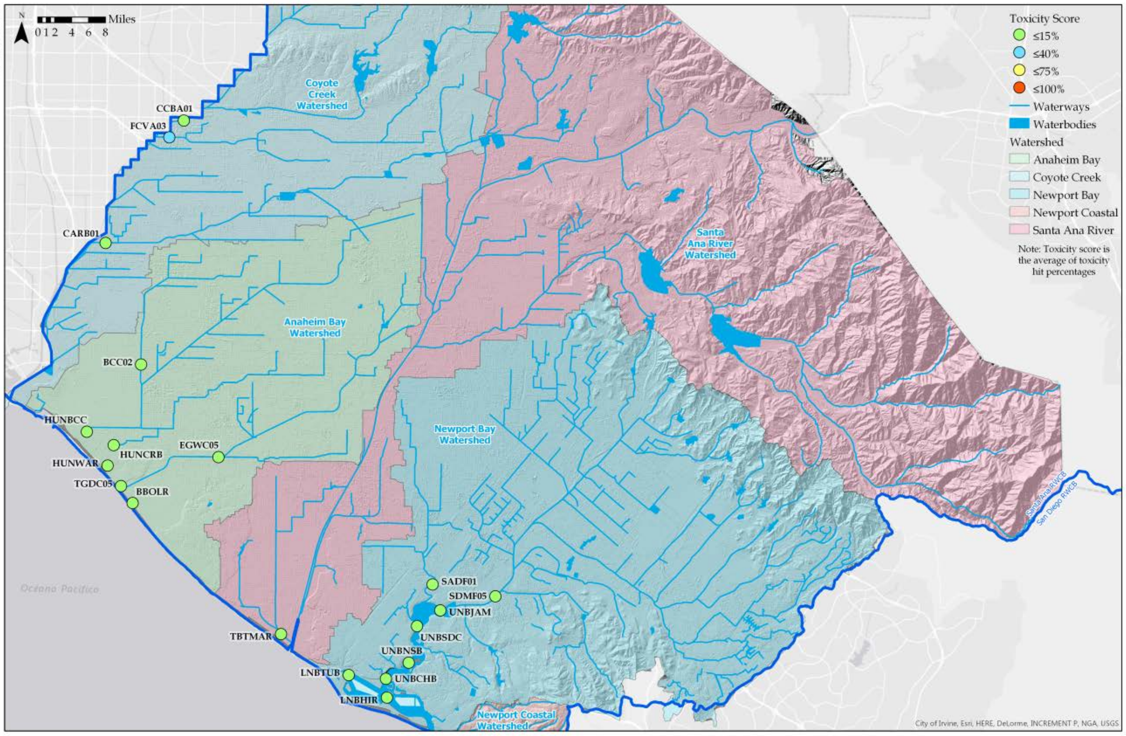


Figure C-11-II.6: Patterns of Toxicity across the Region in Wet Weather. The data provided includes Mass Emissions and Estuary/Wetlands stations for comparison.



The tests on the dry weather runoff samples are conducted with freshwater organisms, while the stormwater-influenced samples are evaluated with a combination of freshwater and marine organisms. The tests involve a statistical comparison of the mean organism responses (e.g., survival, growth, reproduction, or fertilization rates) in a series of sample dilutions to the mean value of responses in laboratory control samples.

A summary of toxicity test result statistics for samples collected during dry weather is provided in the table below, along with the individual organism used for each test.

Table C-11-II-6: Dry Weather Toxicity Testing Statistics. Testing results were considered to be toxic if the organism response results (i.e. survival, reproduction, or growth) were less than 80% effect. Mean and Min refer, respectively, to the mean of all test results and the minimum result in any single test. The Total column indicates the number of toxic sample results out of the total number of tests conducted.

Dry Weather Toxicity Test Statistics	Mean	Min	Total
Ceriodaphnia dubia Reproduction	115%	0%	3 of 23
Ceriodaphnia dubia 7 Day Survival	99%	30%	1 of 25
Ceriodaphnia dubia 48 Hour Survival	101%	100%	0 of 25
Hyalella azteca 96 Hour Survival	98%	78%	1 of 25
Selenastrum capricornutum Cell Density	116%	79%	1 of 24
*Hyalella azteca*10 Day Survival (Sediment)	98%	50%	1 of 16

As indicated above, toxicity occurred in 4.9% of dry weather sample tests conducted (6 out of 122 tests), suggesting that sites in the Santa Ana Region are predominantly above the water quality objectives for aquatic toxicity during dry weather. The following summarizes the three tests that showed toxicity:

- One of two samples collected at Central Irvine Channel (CICF25) exhibited *Selenastrum capricornutum* cell density toxicity. This was the only test that exhibited toxicity for this organism across all stations.

- The *Ceriodaphnia dubia* 7 day survival test and *Hyalella Azteca* 96 hour survival test both exhibited toxicity from the CMCG02 sampling event that occurred on August 25, 2015.

- Three dry weather samples were found to be toxic for the *Ceriodaphnia dubia* reproduction test. The toxic samples were found at SADF01 (75% response), WYLSED (79% response), and CMCG02 (0.5% response). The sample from CMCG02 was taken on August 25, 2015 and exhibited unusually high conductivity results (7,420 umhos/cm), which may have affected these results. Stations in the San Diego Region with similar high conductivities have also been known to display high toxicity to *Ceriodaphnia dubia.* At these stations, the testing organism was changed to a similar crustacean called *Daphnia magna,* an organism tolerant to brackish waters. When the testing organism was switched to *Daphnia magna*, the organism showed no toxic response, concluding that high conductivity was the driver for toxicity in the sample. Similarly the high conductivity most likely was the cause of toxicity in the CMCG02 sample as there were no elevated levels in any other constituent tested.

The toxicity test results for stormwater-influenced samples collected during 2015-16 were slightly different from the dry weather samples statistics and are summarized in the table below.

Table C-11-II-7: Wet Weather Toxicity Testing Statistics. Testing results were considered to be toxic if the organism response results (i.e. survival, reproduction, or growth) were less than 80% effect. Mean and Min refer, respectively, to the mean of all test results and the minimum result in any single test. The Total column indicates the number of toxic sample results out of the total number of tests conducted.

Wet Weather Toxicity Test Statistics	Mean	Min	Total
Americamysis bahia Growth	108%	61%	4 of 16
Americamysis bahia 7 Day Survival	99%	68%	1 of 17
Americamysis bahia 48 Hour Survival	98%	69%	1 of 17
Ceriodaphnia dubia Reproduction	129%	67%	3 of 20
*Ceriodaphnia dubia*7 Day Survival	98%	90%	0 of 20
Ceriodaphnia dubia 48 Hour Survival	99%	90%	0 of 20
Strongylocentrotus purpuratus Fertilization	100%	97%	0 of 21

As indicated above, toxicity occurred in approximately 6.9% of storm event sample tests (9 of 131 tests), across *Americamysis bahia* and *Ceriodaphnia dubia.* Additional data analysis is provided below:

- Consistent with data from prior reports, the results show that the most toxic responses in stormwater-influenced samples were seen in the *Americamysis bahia* tests. The most widespread *Americamysis bahia* toxicity was observed at FCVA03 on the February 2nd

2016 storm, with toxic effects for growth, and both chronic and acute survival. Growth toxicity effects were also found on this sampling event at BCC02 and CCBA01.

- Three stations saw toxicity for *Ceriodaphnia dubia* reproduction during the January 6th storm in 2016: CICF25, SDMF05, and BARSED. None of the stormwater-influenced samples analyzed for the *Ceriodaphnia dubia* survival tests were toxic.
- None of the stormwater-influenced samples analyzed for *Strongylocentrotus purpuratu*s were toxic.

On a regional basis, the 2015-16 monitoring results indicate that the Santa Ana Region portion of Orange County is above the target objectives for water quality toxicity in 238 out of 253 (94%) laboratory tests.

Sediment Toxicity

Sediment samples were collected quarterly during dry weather and tested using the 10 day *Hyallela azteca* survival test. Sediment toxicity samples ranged from 50% to 108% survival with a mean response of 98% survival compared to the control sample. Toxicity in the 10 day *Hyallela azteca* survival test occurred in 1 of 16 (6.25%) samples, with the toxic sample collected from BARSED. Other quarterly samples collected for these stations were above the 80% target effect.

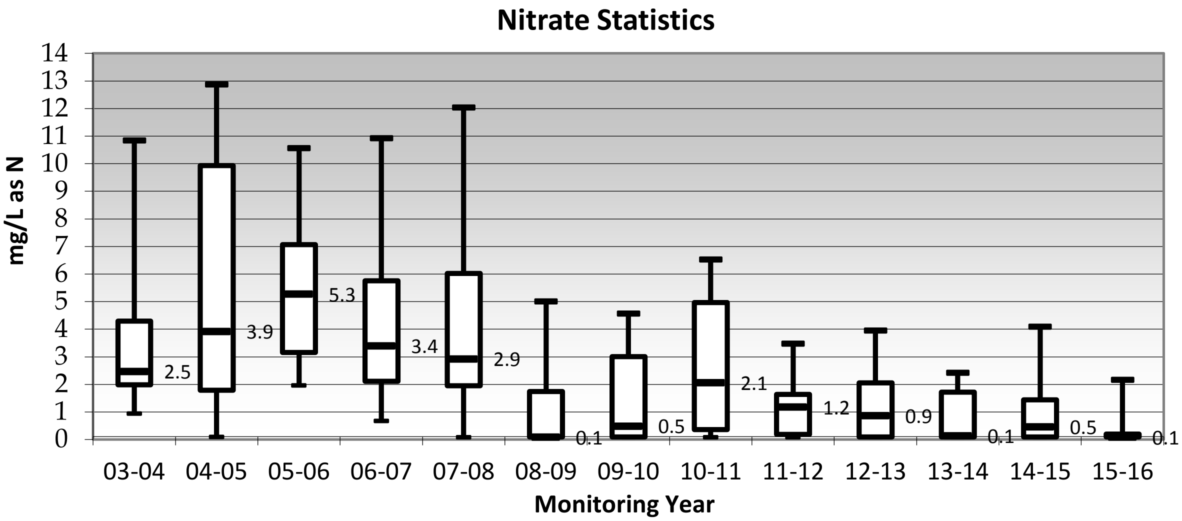
C-11-II.2 Regional Monitoring

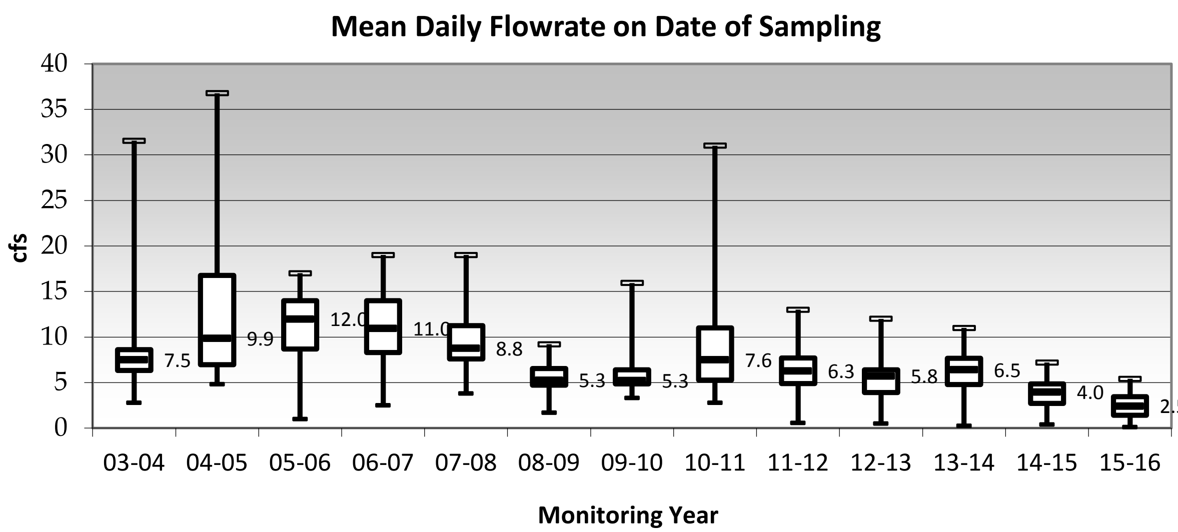
Dry weather monitoring for nutrients is conducted at the Mass Emissions sites and other stations in the Newport Bay watershed as part of the Nutrient TMDL program. Nutrient TMDL monitoring and reporting requirements were adjusted by the Regional Board on December 12, 2014, and implementation of the monitoring was changed. Monitoring changes included reduced sampling frequencies at existing monitoring locations, typically to either a monthly or quarterly frequency, as well as the removal of the Lane Channel monitoring station. Additionally, data reports are now prepared and submitted to the Regional Board on an annual basis (in lieu of quarterly). Electronic copies of the data reports have been submitted separately to the Santa Ana Regional Board and can be found on the www.ocwatersheds.com website in the OC Watersheds Document Library (http://prg.ocpublicworks.com/DocmgmtInternet/Search.aspx).

Natural Treatment System Wetlands off San Diego Creek

Since the late spring of 2008, samples collected from SDMF05 station have generally contained lower levels of nitrate during the periods when the Irvine Ranch Water District (IRWD) Natural Treatment System wetlands were operational. **Figure C-11-II.7** below shows the trends in dry-weather nitrate concentrations and mean daily flow rates at Campus Drive over the last 12 years. The nitrate statistics from 2015-16 are lower than the three prior monitoring years, and mean daily flow rate during sampling events is generally lower than recent monitoring years.

Figure C-11-II.7: Nitrate as N (mg/L) Statistics (Upper Chart) and Mean Daily Flow Rate on Date of Sampling (Lower Chart) at San Diego Creek at Campus, 2003-16. The nitrate concentrations and mean daily flow rates have decreased since the mid-2000s.





The decreased nitrate concentrations beginning in 2008-09 appear to be a function of diversion of flow to the IRWD Natural Treatment System wetlands. The maximum diversion rate of water from San Diego Creek to the IRWD Natural Treatment System wetlands is 2,600 gpm or 5.8 cfs. The median flow rate in San Diego Creek at Campus Drive during the 2015-16 reporting year was 2.5 cfs suggesting that a significant portion of the water in the creek entered the diversion system and was treated by the wetlands.

C-11-II.3 Special Studies on Pesticides

The standard suite of analyses was expanded to include additional organic compounds in selected dry weather and stormwater samples from the Mass Emissions sites. The analyses included organophosphate (dry weather and wet weather) and synthetic pyrethroid (wet weather) pesticides. A review of dry weather sampling results is incorporated into **Table C-11-II.8** below. In general, exceedances for organophoshate pesticides were infrequent overall, with chlorpyrifos, diazinon, dimethoate, and malathion detected in 0%, 2% (1 sample), 6% (3 samples), and 2% (1 sample) out of 46 total samples analyzed, respectively. Median values were at the detection limit for each compound.

Table C-11-II.8: Pesticides in Dry Weather (ng/L) at Mass Emissions Monitoring Sites, 2015-16. Table includes organophosphate pesticides.

Organophosphates	Samples	Detected	Min	Max	Median
Chlorpyrifos	46	0	<10	<10	<10
Diazinon	46	1	<10	76	<10
Dimethoate	46	3	<10	28	<10
Malathion	46	1	<10	98	<10

*Medians calculated using full detection limit values.

Samples were also collected and analyzed for pesticide constituents from the Mass Emissions stations during wet weather. **Table C-11-II.9** below summarizes the results of pesticide sampling during storm events completed during 2015-16, including both organophosphates and synthetic pyrethroids.

Table C-11-II.9: Pesticides in Stormwater (ng/L) at Mass Emissions Monitoring Sites, 2015-16. Table includes both organophosphate and synthetic pyrethroid pesticides.

Organophosphates	Samples	Detected	Min	Max	Median
Chlorpyrifos	49	0	<10	<10	<10
Diazinon	49	2	<10	17	<10
Dimethoate	49	3	<10	220	<10
Malathion	49	33	<10	520	18
Synthetic Pyrethroids	**Samples**	**Detected**	**Min**	**Max**	**Median**
Allethrin	49	0	<2	<2	<2
Bifenthrin	49	46	<10	200	22
Cyfluthrin	49	37	<2	190	11
Cypermethrin	49	20	<2	51	<2
Deltamethrin	49	8	<2	70	<2
Esfenvalerate	49	5	<2	11	<2
L-Cyhalothrin	49	17	<2	130	<2
Permethrin	49	41	<5	250	19
Prallethrin	49	0	<2	<2	<2

*Medians calculated using full detection limit values.

For 2015-16, chlorpyrifos, diazinon, and dimethoate were detected in 0%, 4% and 6% of stormwater-influenced samples collected for organophosphate pesticides, respectively. Malathion was detected in 67% of stormwater-influenced samples collected, which is the most frequent for this pesticide suite. Concentrations of Malathion ranged from non detect at <10 to 520 ng/L (parts per trillion).

Amongst the pyrethroid pesticides constituents monitored, bifenthrin was detected in 93% of samples, followed by Permethrin (84%), Cyfluthrin (76%), Cypermethrin (41%), and L-Cyhalothrin (35%). Deltamethrin and Esfenvalerate were detected at smaller frequencies, 8 (14%) and 5 (10%) of the 49 total samples analyzed per constituent, respectively.

Stormwater samples from the Mass Emissions sites from 2015-16 show that detection patterns continue to suggest a general shift towards the use of synthetic pyrethroid pesticides and away from organophosphate pesticides (with the exception of malathion) in urbanized areas.