

Monterey Bay National Marine Sanctuary Dry Run and First Flush Monitoring 2019



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Report Availability

Electronic copies of this report may be downloaded from the Office of National Marine Sanctuaries website at <https://MontereyBay.noaa.gov>.

Cover Photo: First Flush Sampling at 4th Avenue in Carmel. Photo A. Phillips.



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Introduction

In order to alleviate flooding of communities, roadways, or businesses during heavy rainstorms, storm water is directed to storm drain systems and outfalls which then direct storm flows to creeks, rivers and the ocean. Pollutants that accumulate on hard surfaces during months of dry weather are washed away by storm runoff, especially during the first major rainstorm of the winter season. This “first flush” will often have the highest concentration of pollutants washing into local waterways and can severely impact water quality. Pollutant sources can be brake dust from cars and trucks, emissions from cars, animal waste, detergents from restaurant kitchen mats or car washing, pesticides, fertilizers, as well as other chemicals commonly found in and around homes and businesses. Dry weather runoff flows are also an important component of water quality monitoring since contaminants can be less diluted and therefore more concentrated than those of wet weather flows. Runoff samples collected during dry weather prior to the first major rainstorm provide information about dry weather flows such as pollutant concentrations, amount of groundwater base flow, or contributions from urban sources such as car washing, pressure washing, irrigation or illicit discharges. Dry and wet weather storm drain outfall monitoring results provide resource managers with evidence of problem areas that may warrant further attention.

Sampling during wet weather can be challenging and require many participants in order to simultaneously capture storm drain flows at multiple locations during peak runoff when pollutant concentrations may be highest. To achieve this goal Monterey Bay National Marine Sanctuary (MBNMS) with the assistance of California Marine Sanctuary Foundation (CMSF), San Mateo Resource Conservation District (SMRCD) and Watsonville Wetlands Watch (WWW) teamed up with volunteers to monitor storm drain outfalls during dry weather, the Dry Run, and during the first major rain storm of the winter season, the First Flush.

The First Flush program has been coordinated by MBNMS and the California Marine Sanctuary Foundation (CMSF) since 2000 in partnership with the Coastal Watershed Council (CWC) until 2017. MBNMS coordinated the Dry Run and First Flush storm drain outfall monitoring in San Mateo (beginning in 2003) and Monterey counties while CWC coordinated Santa Cruz County. MBNMS/CMSF partnered with the Monterey Regional Storm Water Monitoring Program (MRSWMP) in 2007 and the program expanded. MRSWMP includes areas in Monterey County, Carmel Valley, and the Cities of Carmel-by-the-Sea, Monterey, Pacific Grove, Seaside and Sand City. Since 2003 staff and volunteers from SMRCD have conducted Dry Run and First Flush monitoring by sampling sites in the Cities of El Granada, Moss Beach, Montara, and Half Moon Bay. While not monitoring storm drain outfalls, WWW in Santa Cruz County has monitored Watsonville area slough and river sites during the Dry Run and First Flush since 2011 (not including 2014).

The geographic scope of this program extends from the City of Montara in San Mateo County in the north, through the City of Carmel in Monterey County in the south (Figure 1 and Table 1). A total of 41 sites were monitored in 2019. The graphs contain many more sites that were monitored historically.

First Flush Sites 2019

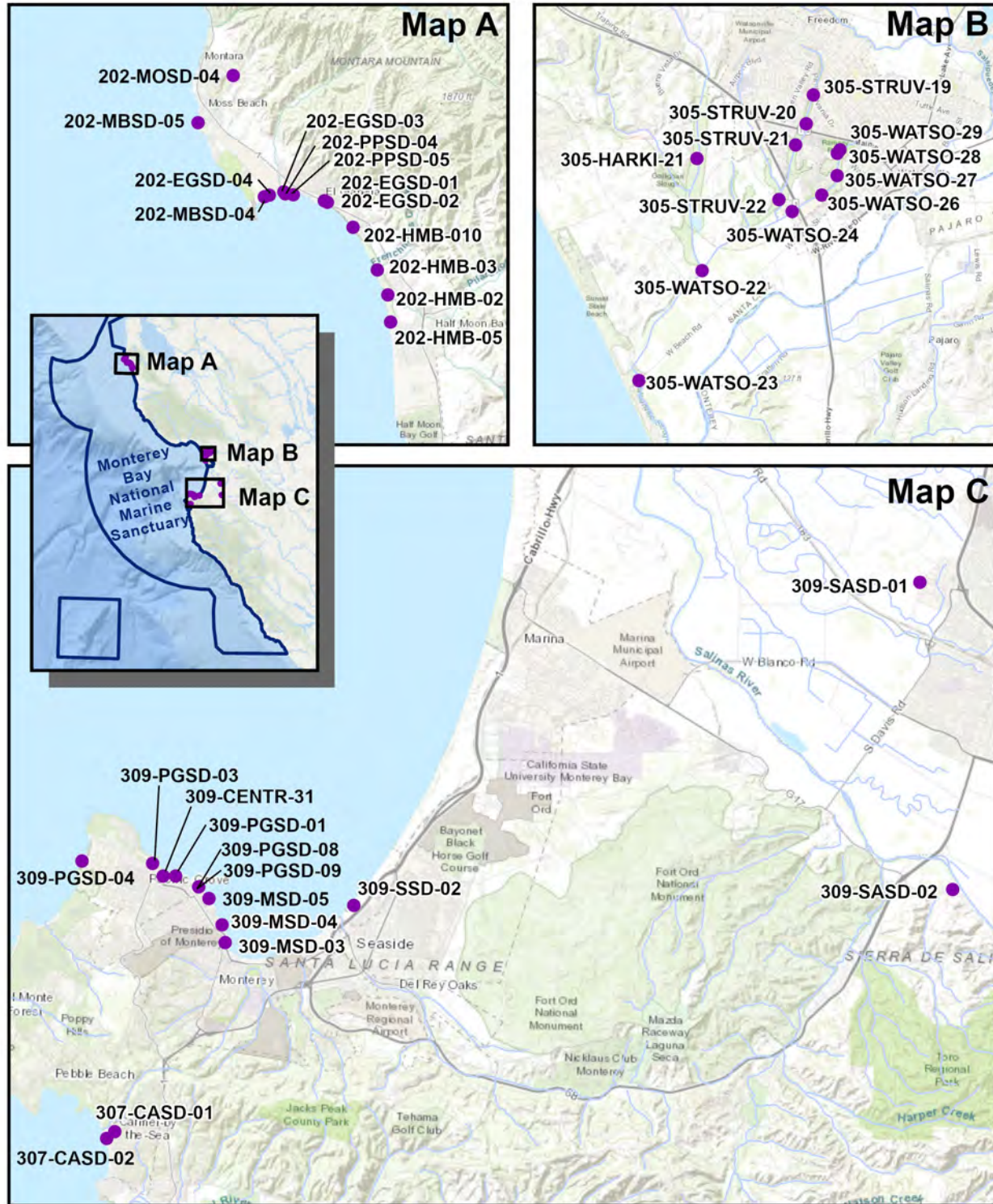


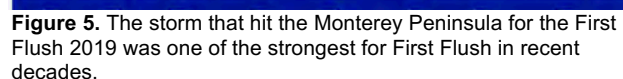
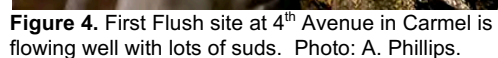
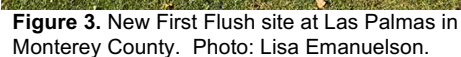
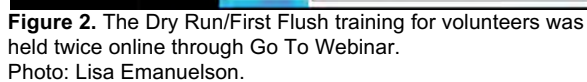
Figure 1. 2019 Dry Run and First Flush Sites

Table 1

2019 Dry Run and First Flush Sites in San Mateo, Santa Cruz, and Monterey Counties.

	Site ID	Site Description	Outfall (O) or Receiving Water (RW)	County
San Mateo County	202-MOSD-04	Montara Creek	RW	San Mateo
	202-MBSD-05	San Vicente Creek mouth	RW	San Mateo
	202-MBSD-04	Moss Beach Storm Drain at West Point	O	San Mateo
	202-EGSD-04	El Granada Storm Drain at Vassar Street	O	San Mateo
	202-EGSD-03	El Granada Storm Drain at Capistrano Street	O	San Mateo
	202-EGSD-01	El Granada Storm Drain at Surfers Beach North	O	San Mateo
	202-EGSD-02	El Granada Storm Drain at Surfer's Beach South	O	San Mateo
	202-PPSD-04	St. Augustine Storm Drain	O	San Mateo
	202-PPSD-05	Inner Harbor Parking Storm Drain	O	San Mateo
	202-HMB-02	Pilarcitos Creek mouth	RW	San Mateo
	202-HMB-03	Frenchman's Creek mouth	RW	San Mateo
	202-HMB-05	Half Moon Bay Storm Drain at Kelly Ave and Balboa	O	San Mateo
	202-HMB-10	Arroyo de En Medio Creek mouth	RW	San Mateo
Santa Cruz County	305-HARKI-21	Harkins Slough Middle at Harkins Slough Road	RW	Santa Cruz
	305-STRUUV-19	Struve Slough at Peninsula Drive	RW	Santa Cruz
	305-STRUUV-20	Struve Slough at Montebello Drive	RW	Santa Cruz
	305-STRUUV-21	Struve Slough Upper	RW	Santa Cruz
	305-STRUUV-22	Struve Slough Lower	RW	Santa Cruz
	305-WSTRU-22	West Struve Slough	RW	Santa Cruz
	305-WATSO-29	Watsonville Slough Upper	RW	Santa Cruz
	305-WATSO-28	Watsonville Slough at Ramsay Nature Center	RW	Santa Cruz
	305-WATSO-27	Watsonville Slough at Ford Street Walkway	RW	Santa Cruz
	305-WATSO-26	Watsonville Slough at Ohlone Parkway	RW	Santa Cruz
	305-WATSO-24	Watsonville Slough at Lee Road	RW	Santa Cruz
	305-WATSO-25	Watsonville Slough at RR tracks (Dry Run only)	RW	Santa Cruz
	305-WATSO-22	Watsonville Slough Lower	RW	Santa Cruz
	305-WATSO-23	Watsonville Slough at Beach Road	RW	Santa Cruz
	305-WATSO-20	Watsonville Slough at Pelican Point Drive	RW	Santa Cruz
Monterey County	309-SASD-01	Boronda Street Storm Drain	O	Monterey
	309-SASD-02	Riverbend Road and River Road Storm Drain at Las Palmas	O	Monterey
	309-SSD-02	Seaside Storm Drain at West Bay Street	O	Monterey
	309-MSD-03	Monterey Storm Drain Twin 51's	O	Monterey
	309-MSD-04	Monterey Storm Drain at San Carlos Beach	O	Monterey
	309-MSD-05	Monterey Storm Drain at Steinbeck Plaza	O	Monterey
	309-PGSD-09	Pacific Grove Storm Drain at HopkinsMon	O	Monterey
	309-PGSD-08	Pacific Grove Storm Drain at HopkinsPG	O	Monterey
	309-PGSD-01	Pacific Grove Storm Drain at 8th Street	O	Monterey
	309-CENTR-31	Pacific Grove Storm Drain in Greenwood Park at Central and 13th Streets	O	Monterey
	309-PGSD-03	Pacific Grove Storm Drain at Lovers Point Beach	O	Monterey
	309-PGSD-04	Pacific Grove Storm Drain between Pico and Arena Avenues	O	Monterey
	307-CASD-01	Carmel Storm Drain at 4th and San Antonio Avenues	O	Monterey
	307-CASD-02	Carmel Storm Drain at the end of Ocean Avenue	O	Monterey

Note: Sites are listed from north to south.



Methods

New and returning Dry Run and First Flush volunteers attend an online training and participate in face to face hands-on practice during the Dry Run: a half day event where volunteers demonstrate their skills, visit outfall sites and collect water samples if flowing water is found. Conducted well ahead of any predicted rain, Dry Run activities provide volunteers with a chance to test equipment at their specific sites as well as practice collecting water quality measurements and dry weather runoff samples. During the Dry Run and First Flush, field measurements (water temperature, pH, electrical conductivity and transparency) are taken, while water samples are also collected for lab analysis of nutrients (nitrate, orthophosphate and urea), bacteria (*Eschericia coli* (*E. coli*) and enterococcus), metals (total copper, total lead and total zinc), total suspended solids and turbidity. Each county analyzes samples for some or all of the above listed parameters.


Volunteers are mobilized for the First Flush when all or most mobilization criteria are met:

- A minimum of 0.10 inches of rain has fallen.
- Sheeting water on roadways.
- Conductivity at or below 1000 µS (Monterey County only).

Once sample collection is complete, samples and field equipment are delivered immediately to monitoring coordinators who deliver samples to labs.

Dry Run monitoring in all counties entails collecting a single grab sample from each site with flowing water. First Flush sampling in San Mateo and Santa Cruz Counties entails collecting a single grab sample at each sampling site, while in Monterey County, two sets of grab samples are collected 30 minutes apart for two time series samples. Results for sites where two grab samples are collected are reported as an average of the two results. Samples for urea are only collected in Monterey County and only during the first time series.

First Flush sampling includes a mix of storm drain outfall and receiving water sources. In San Mateo County five of the thirteen sites are receiving water; in Santa Cruz County all fifteen sites are receiving water; in Monterey County all fourteen sites are storm drain outfalls. For samples collected from outfalls, the results (field and lab) are compared to receiving water standards set for particular beneficial uses in a stream, lake or ocean—they are not meant for end-of-pipe discharges. However, lacking any other effluent standard, these standards provide some context for the results. Dilution and/or mixing is expected to occur in the receiving waters within a short distance of each outfall. Surface water results are comparable to receiving water Water Quality Objectives (WQO) and Action Levels (AL). Metal results are compared to the Regional Water Quality Control Board's Water Quality Control Plan for the Central Coast (Basin Plan)



WQOs for the protection of marine and aquatic life. Nitrate, orthophosphate, total suspended solids and turbidity results are compared with the Central Coast Ambient Monitoring Program's (CCAMP) ALs. Bacteria (*E. coli* and enterococcus) results are compared with the U.S. EPA's Ambient WQO (see Table 2).

Each analyte description includes a reporting of the Minimum Detection Limit (MDL), the smallest concentration that lab equipment can reliably detect for an analyte. MDL is a statistical analysis of the confidence of results. Results below the MDL are reported as “non-detect” since lab equipment cannot reliably determine where the results lay between zero and the MDL. For sites that have a non-detect listed, a marker is placed on the graph at half the MDL, however the value could be anywhere between zero and the MDL.

Table 2

Water Quality Objectives and Action Levels Used as a Comparison for Dry Run and First Flush Results

<u>Parameter (reporting units)</u>	<u>Water Quality Criterion</u>	<u>Source of criterion</u>
Copper (ppb)	Not to exceed 30 ¹	Water Quality Control Plan for the Central Coast- RWQCB
<i>E. coli</i> (MPN/100ml)	Not to exceed 235 ²	U.S. EPA Ambient Water Quality Criteria
Enterococcus (MPN/100ml)	Not to exceed 104	U.S. EPA Ambient Water Quality Criteria
Lead (ppb)	Not to exceed 30 ¹	Water Quality Control Plan for the Central Coast- RWQCB
Nitrate as N (ppm)	Not to exceed 2.25 ³	Central Coast Ambient Monitoring Program (CCAMP)
Orthophosphate as P (ppm)	Not to exceed 0.12 ⁴	Central Coast Ambient Monitoring Program (CCAMP)
pH (pH units)	Not lower than 6.5 or greater than 8.5	Water Quality Control Plan for the Central Coast- RWQCB
Total Suspended Solids (TSS) (ppm)	Not to exceed 500 ⁵	Central Coast Ambient Monitoring Program (CCAMP)
Transparency (cm)	Not less than 20 ⁶	Central Coast Ambient Monitoring Program (CCAMP)
Turbidity (NTU)	Not greater than 25	Central Coast Ambient Monitoring Program (CCAMP)
Water Temperature (°C)	Not more than 21 ⁷	Central Coast Ambient Monitoring Program (CCAMP)
Zinc (ppb)	Not to exceed 200 ¹	Water Quality Control Plan for the Central Coast- RWQCB

Note: Urea is not listed because it does not have a Water Quality Objective or Action Level.

¹ Water Quality Control Plan for Central Coast Cold Water objective for hard water

² Environmental Protection Agency, Updated WQO.

³ Central Coast Ambient Monitoring Program, Pajaro River Watershed Characterization Report 1998, rev 2003

⁴ Williamson, The Establishment of Nutrient Objectives, Sources, Impacts and Best Management Practices for the Pajaro River and Llagas Creek, 1994.

⁵ Central Coast Ambient Monitoring Program, Salinas River Watershed Characterization Report 1999, rev. 2000.

⁶ Based on equivalent turbidity guideline value used for 303(d) Listing Guideline Value (Sigler et al., 1985) (http://www.secchidipin.org/Transparency_Tube.htm)

⁷ 303(d) Listing guideline value, based on Moyle, P. 1976. Inland Fisheries of California. Univ. of California Press.

Results

The 2019 Dry Run-First Flush volunteer training was held online via GoToWebinar on the evening of Wednesday September 18, 2019 with a second, First Flush only online training session on Wednesday October 30, 2019. The Dry Run was conducted on four separate dates: September 3rd for San Mateo County sites, September 21st and 24th for Monterey County sites, and October 21st for Santa Cruz County sites. Dry Run sampling in San Mateo County entailed sampling at just one site: San Vicente Creek mouth (Moss Beach). In Santa Cruz County, due to funding constraints seven of the fifteen sites were sampled by WWW for the Dry Run on October 21st. They included Harkins Slough (Santa Cruz County), Watsonville Slough at Pelican Point (Santa Cruz County), Watsonville Slough at Ramsay Nature Center (Watsonville), Lower Watsonville Slough (Santa Cruz County), Watsonville Slough at Beach Road (Santa Cruz County), West Struve Slough at the WERC Center (Watsonville) and Watsonville Slough at RR tracks (Santa Cruz County). In Monterey County, thirty volunteers checked thirteen sites for the Dry Run on Saturday September 21st, 2019. Five sites had enough flow to be sampled: Twins (Monterey), Steinbeck (Monterey), Greenwood Park (Pacific Grove), Lovers (Pacific Grove) and Pico (Pacific Grove). Even though Lovers (Pacific Grove) was checked on Saturday September 21st, beach traffic made collecting a sample too difficult. The site was checked again on Tuesday September 24th when a sample was collected.

After the Dry Run and leading up to the First Flush event, monitoring coordinators from SMRCD, WWW and MBNMS closely watched the weather and notified volunteers of approaching storms. First Flush mobilization criteria were finally achieved for SMRCD staff and volunteers at 5:00 pm on Wednesday November 26th, 2019 when thirteen San Mateo County sites were monitored by twelve volunteers. Monterey County volunteers mobilized on November 26th, 2019 at 9:30 pm when a total of thirty-eight volunteers collected samples at thirteen outfall sites. One site, Boronda (Monterey County) was not sampled on the night of the First Flush due to an electrical transformer that exploded as the team was at the site. Team members left and data from Monterey County's sampling the day after the First Flush was used. Due to the Thanksgiving holiday, the fifteen Santa Cruz County WWW sites were not monitored during the First Flush but a number of days after on Monday December 2nd, 2019.

Dry Run and First Flush *field* measurements are not individually discussed but the range of results are presented along with the range of lab results in Table 3 to provide an understanding of environmental conditions during the two events. First Flush field measurements from San Mateo County sites include measurements for water temperature, conductivity, pH and transparency; pH and transparency measurements were not collected at every site. Santa Cruz County sites have field measurements for only seven of the fifteen sites and include water temperature, pH and conductivity. Monterey County sites only include field measurements for water temperature and conductivity but not pH or transparency for thirteen of the fourteen sites

because samples were collected at night.

All three counties conducted the same lab analysis for samples collected during the Dry Run and First Flush unless otherwise noted.

Table 3
Range of Field and Lab Results for Dry Run and First Flush 2019.

Parameter	Units	Dry Run	First Flush
Conductivity	µS	1067 - 2300	50 - >2000
Copper- total	µg/L	ND - 193	ND - 122
<i>Escherichia coli</i> (<i>E. coli</i>)	MPN/ 100 ml	ND – 17,407	109 - 59,850*
Enterococcus	MPN/ 100 ml	ND – 20,925	31 – 56,680*
Lead- total	µg/L	ND - 2	ND - 28
Nitrate as N	mg-N/L	ND – 6.4	0.10 – 22.97
Orthophosphate as P	mg-P/L	ND – 1.22	0.04 – 1.00
pH	pH units	4.5 – 7.5	5.7 – 8.11
Total Suspended Solids	mg/L	ND - 6	2 - 724
Transparency	cm	30.4 - >120	NC
Turbidity	NTU	0.7 – 71.9	6.7 – 900.0
Urea (Monterey County only)	µg/L	25- 197	144 - 481
Water temperature	°C	13.4 – 18.1	12.8 – 18.0
Zinc- total	µg/L	ND -119	ND - 286

NC= Not Conducted; ND=non-detect

Analyte descriptions are listed alphabetically and include box and whisker graphs showing the data divided into dry weather monitoring (DR) and wet weather monitoring (FF) by site. Box and whisker graphs show a distribution of the dataset in a convenient format for making comparisons between sites and the range of concentrations over the years. The box represents the range of 50% of the data with the median indicated. The lines above and below the boxes are upper and lower whiskers and represent the remaining upper and lower 25% of the data. The end point of each whisker represents the maximum and minimum result for that analyte at that location which provides an indication of the best- and worst-case results. Each graph includes an open circle for the most recent year's results for comparison to historical data. A few analytes have graphs that are split along the y-axis to display the entire dataset.

Copper

Storm water runoff in coastal urban areas is known to contain trace metals from sources such as automobile brake pads, tires and industrial waste. Very low concentrations of copper in the marine environment can cause reduced reproduction, developmental deformities and mortality. The Water Quality Control Plan for the Central Coast Water Quality Objective (WQO) established for total copper is 30 µg/L. Total copper was only measured in San Mateo and Monterey Counties. The Minimum Detection Limit (MDL) for total copper was 5 µg/L for the Dry Run and First Flush in San Mateo County, from 2 µg/L to 10 µg/L for the Dry Run in Monterey County, and 10 µg/L for the First Flush in Monterey County.

For the **Dry Run**, only one site of the six (17%) monitored for total copper exceeded the WQO for copper. The highest total copper result of 193 µg/L was from Steinbeck (Monterey). Two sites had non-detects: Frenchman's Creek Mouth (Half Moon Bay) and Lovers (Pacific Grove) (Figures 6 and 7).

During the **First Flush**, eight of the twenty-three sites (35%) where total copper was sampled exceeded the WQO. The highest concentration for copper was from Arroyo de En Medio (Half Moon Bay) with a result of 122 µg/L (Figures 6 and 7).

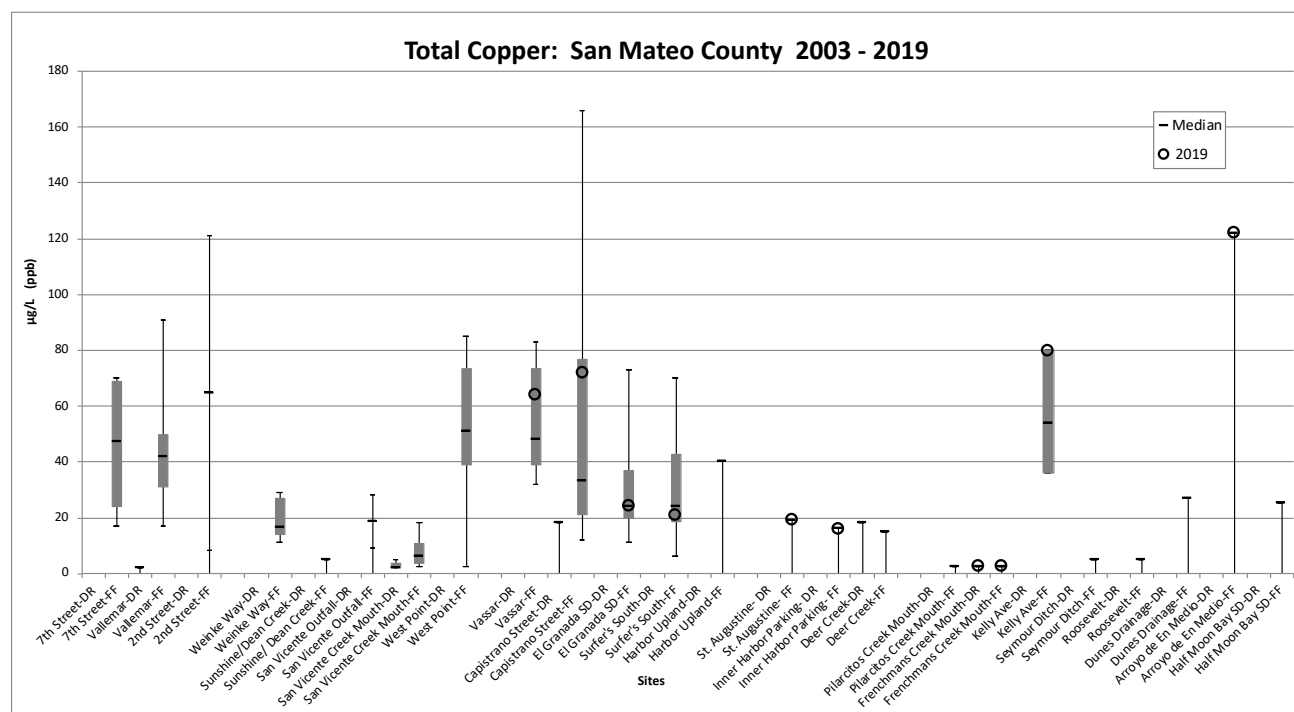


Figure 6. Single sample results for total copper for the Dry Run (DR) and First Flush (FF) in San Mateo County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

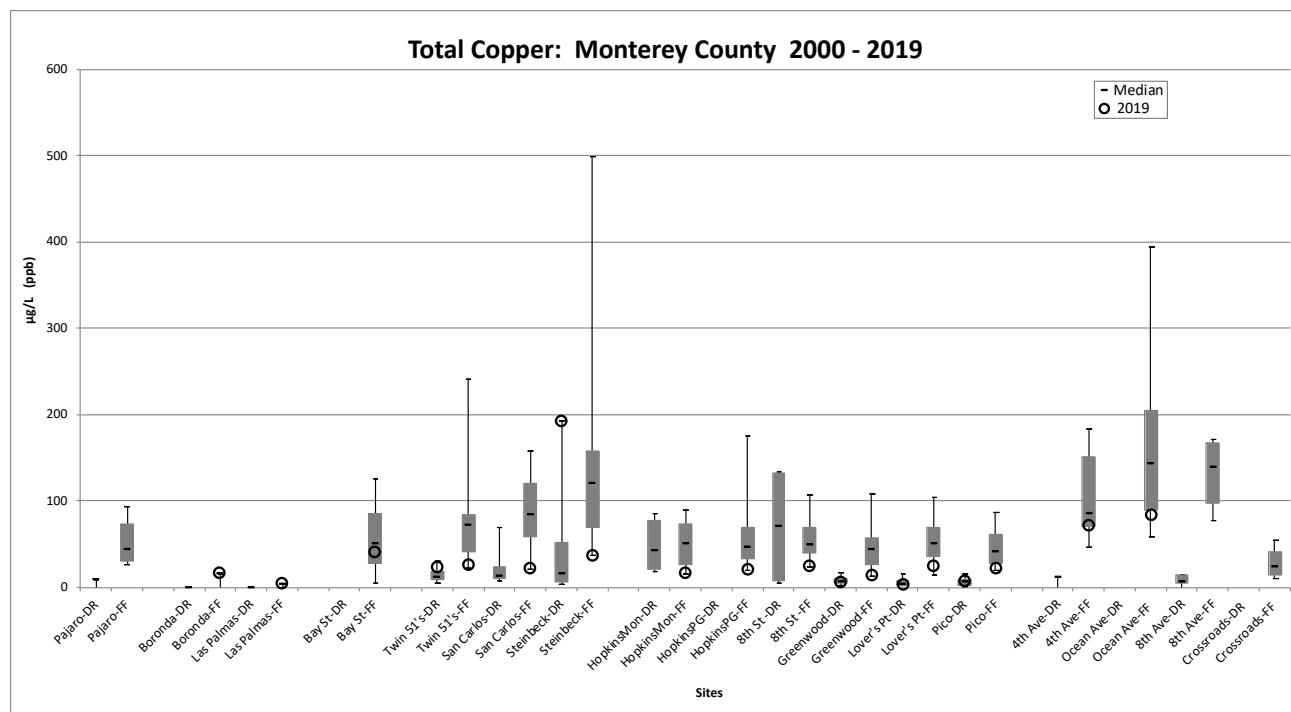


Figure 7. Single sample results for total copper for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.



E. coli

Escherichia coli (*E. coli*) is a type of fecal indicator bacteria. *E. coli*, found in the intestines of warm-blooded animals, makes its way from human and wildlife populations into waterways and the ocean, through improper domestic animal waste disposal, as well as failing sewer or septic systems. While these bacteria don't necessarily cause disease in humans, their presence indicates the potential for other human-specific pathogens to be present. The U.S. Environmental Protection Agency's water quality criterion for grab samples of *E. coli* is 235 MPN/100 ml. *E. coli* was measured in all three counties.

The Dry Run MDL for *E.coli* was 10 MPN/100ml in Santa Cruz County, not reported for San Mateo County, and from 2 MPN/100 ml to 20 MPN/100 ml for Monterey County. First Flush MDLs for *E. coli* in San Mateo and Santa Cruz Counties were unreported, and it was 100 MPN/100ml for Monterey County.

For the **Dry Run**, ten of the fourteen sites (71%) monitored for bacteria exceeded the WQO for *E. coli*. The highest concentration for *E. coli* was 17,407 MPN/100 ml from Lovers (Pacific Grove) (Figures 8, 9 and 10).

During the **First Flush**, forty of the forty-one sites (98%) monitored for *E. coli* exceeded the WQO. The highest average *E.coli* concentration of 59,850 MPN/100ml was found at Twins (Monterey). The one site that did not exceed the WQO for *E. coli* during the First Flush was Montara Creek (Montara) with a single sample result of 109 MPN/100ml (Figures 8, 9 and 10).

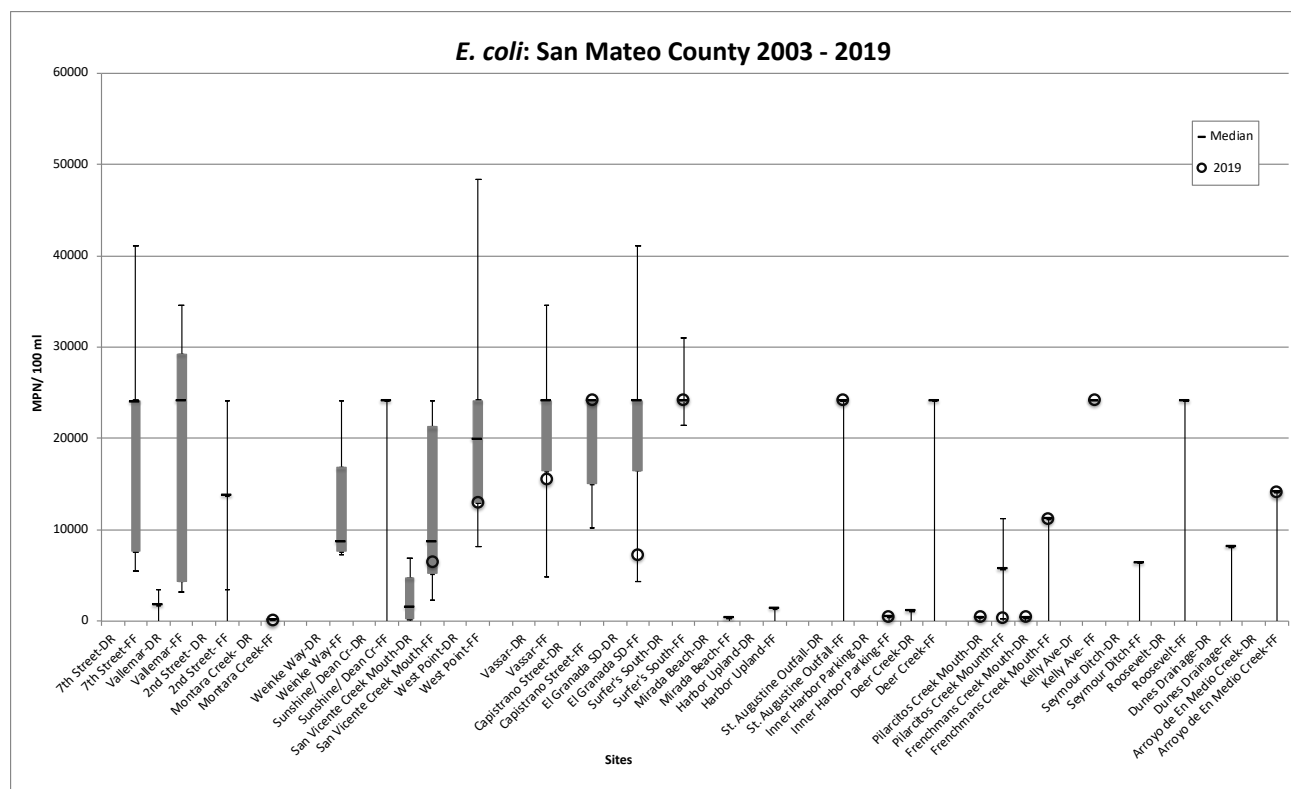


Figure 8. Single sample results for *E.coli* for the Dry Run (DR) and First Flush (FF) in San Mateo County. Sample results of >X are given that numerical value (X) despite a higher actual result. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

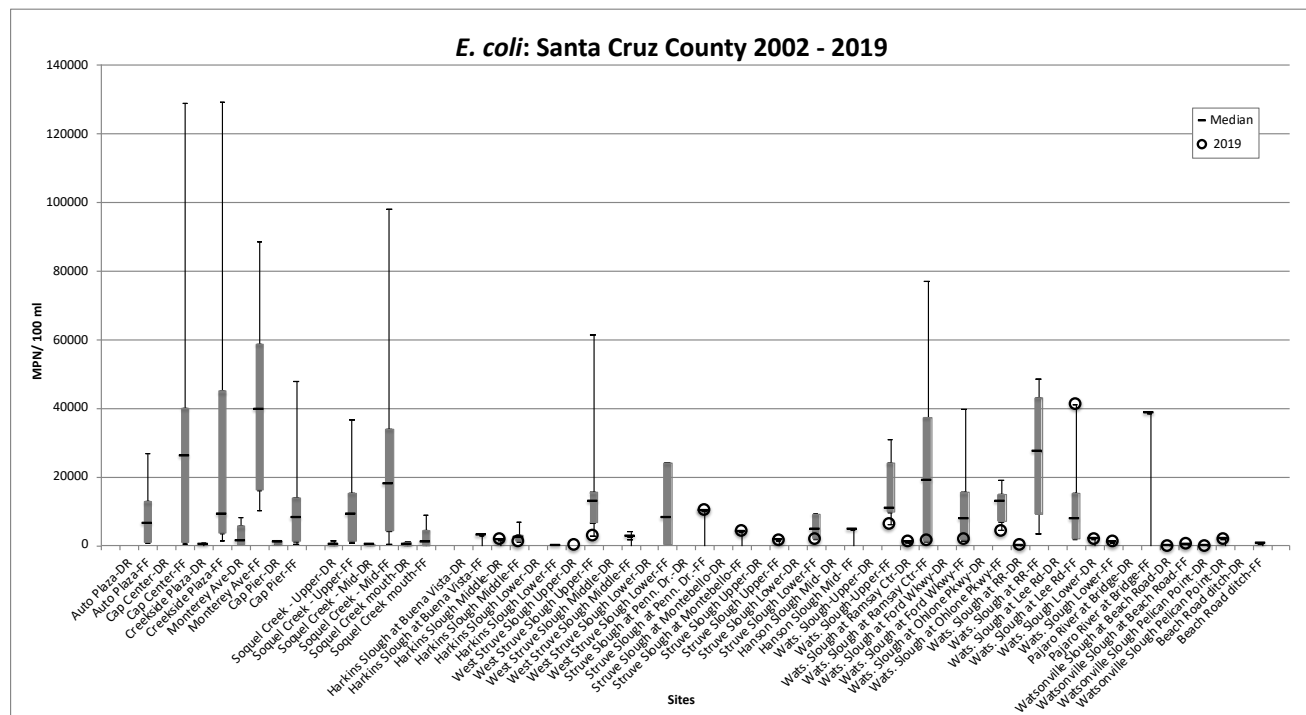


Figure 9. Single sample results for *E. coli* for the Dry Run (DR) and First Flush (FF) in Santa Cruz County. Three samples are not included in the graph to better illustrate more recent results: 241,959 MPN/100ml from Monterey Avenue (Capitola) for the 2007 First Flush; 242,000 MPN/100ml from Middle Hanson Slough (Santa Cruz County) for the 2017 First Flush; 155,000 MPN/100ml from Lower Harkins Slough (Santa Cruz County) for the 2018 First Flush. Sample results of >X are given that numerical value (X) despite a higher actual result. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south Santa Cruz, Live Oak, Capitola, Aptos and Watsonville.

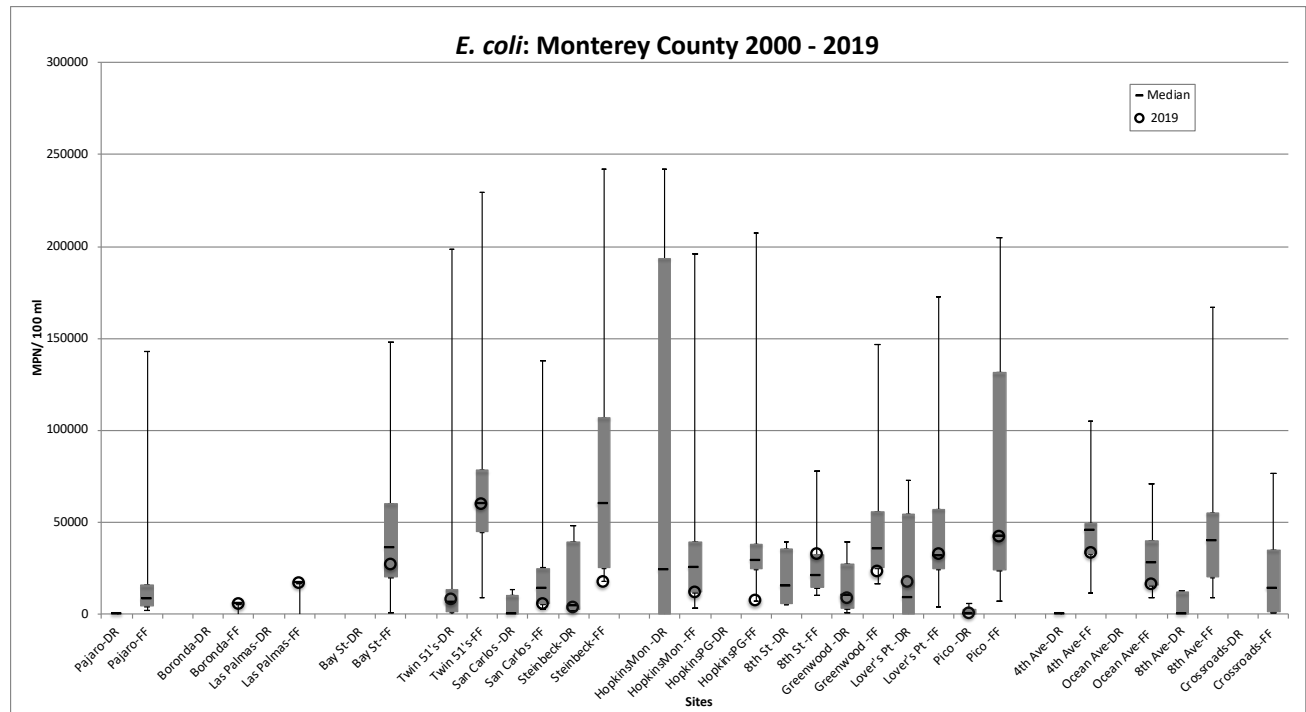


Figure 10. Single sample results for *E. coli* for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. Sample results of >X are given that numerical value (X) despite a higher actual result. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Enterococcus

Enterococcus is a type of fecal indicator bacteria found in the intestines of warm-blooded animals. Enterococcus makes its way into waterways and the ocean from human and wildlife populations, through improper domestic animal waste disposal, as well as failing sewer or septic systems. While these bacteria don't necessarily cause disease in humans, their presence indicates the potential for other human specific pathogens to be present. The U.S.

Environmental Protection Agency water quality criterion for grab samples of enterococcus is 104 MPN/100 ml. Enterococcus was measured in all three counties, but only at 8 sites in Santa Cruz County. The Dry Run MDL for enterococcus was not recorded for San Mateo County, was 10 MPN/100 ml in Santa Cruz County and from 2 MPN/100ml to 20 MPN/100ml in Monterey County. The First Flush MDL for enterococcus was not recorded in San Mateo or Santa Cruz Counties and was 100 MPN/ 100ml for Monterey County.

For the **Dry Run**, eight of the thirteen sites (62%) monitored for enterococcus exceeded the WQO. The highest enterococcus concentration of 20,925 MPN/100 ml was from Lovers (Pacific Grove) (Figures 11, 12 and 13).

During the **First Flush**, thirty of the thirty-two sites (94%) monitored for enterococcus exceeded the WQO. The highest average concentration of 56,680 MPN/100ml was from Twins (Monterey) (Figures 11, 12 and 13). Two sites did *not* exceed the WQO for enterococcus: Montara Creek (Montara) and Pilarcitos Creek Mouth (Half Moon Bay).

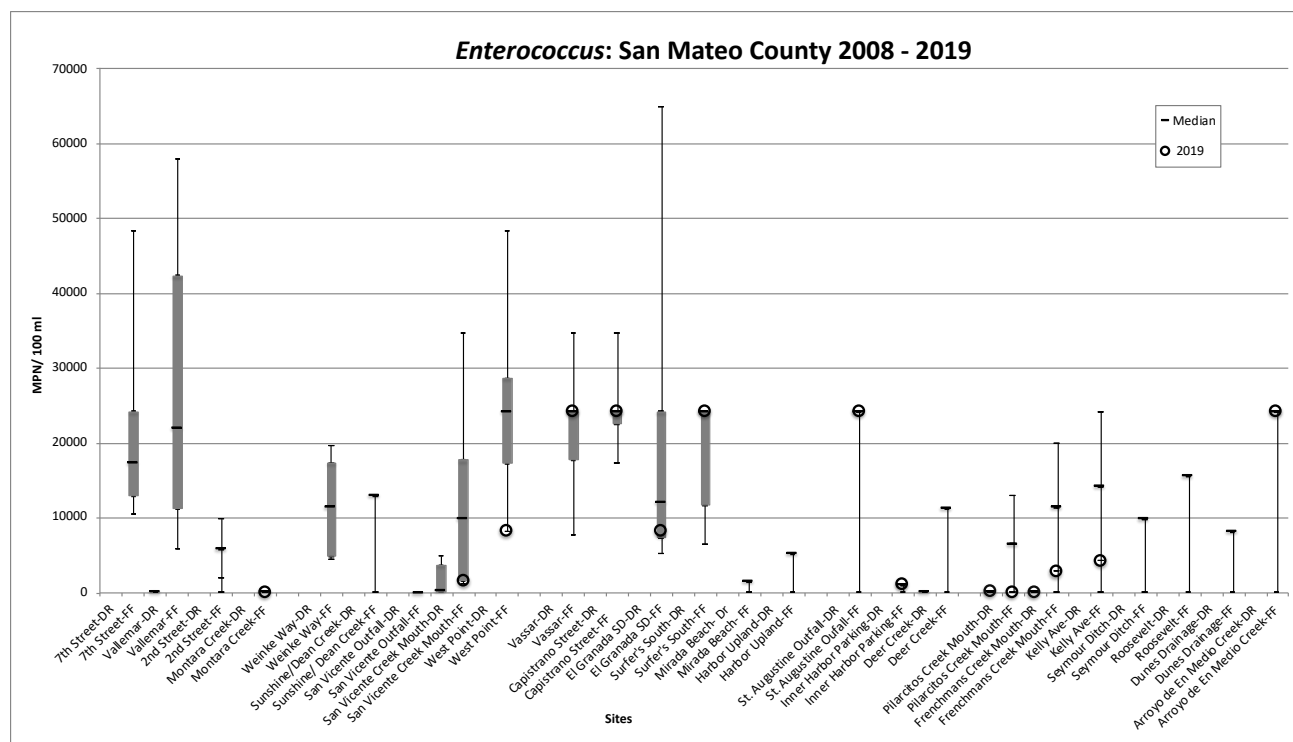


Figure 11. Single sample results for enterococcus for the Dry Run (DR) and First Flush (FF) in San Mateo County. Two samples are not included in the graph to better illustrate more recent results: 120,330 MPN/100ml from San Vicente Outfall (Moss Beach) for the 2009 First Flush; 92,084 MPN/100ml from Surfer's Beach South (El Granada) for the 2011 First Flush. Sample results of >X are given that numerical value (X) despite a higher actual result. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

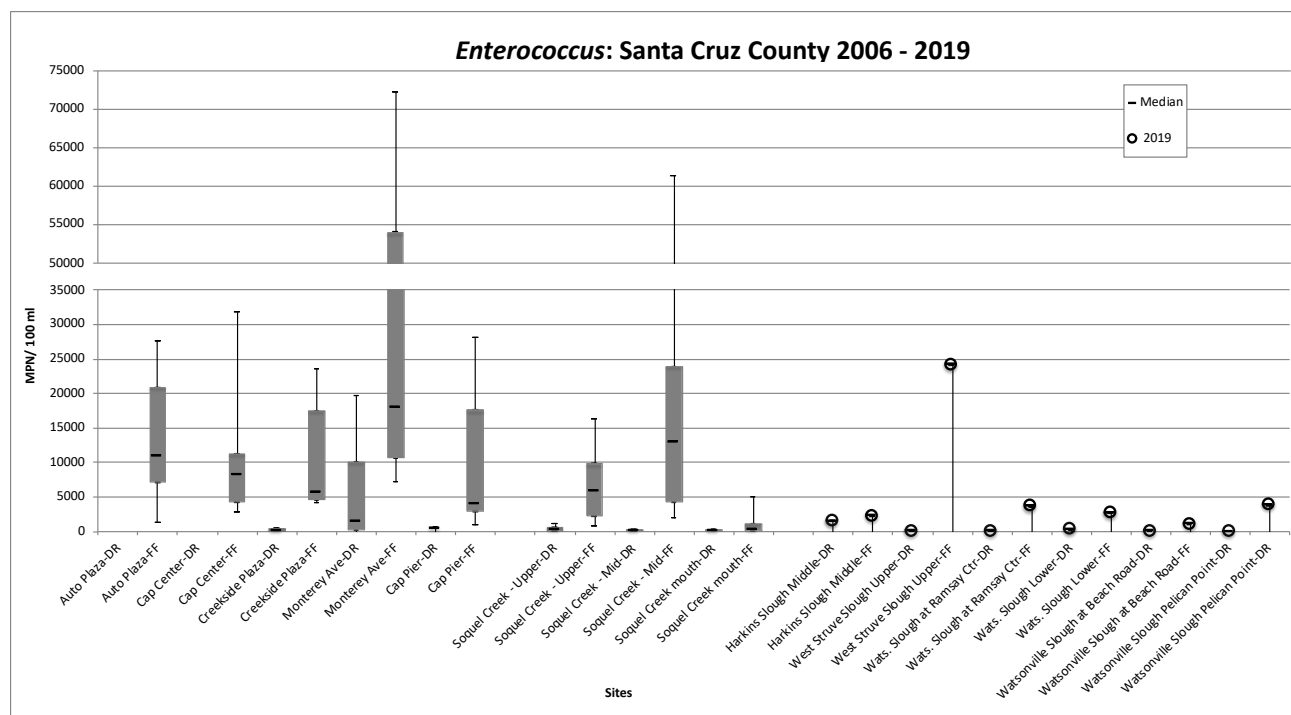


Figure 12. Single sample results for enterococcus for the Dry Run (DR) and First Flush (FF) in Santa Cruz County. Two samples are not included in the graph to better illustrate more recent results: 135,795 MPN/100ml from Capitola Center (Capitola) for the 2008 First Flush; 207,625 MPN/100ml from Monterey Avenue (Capitola) for the 2012 First Flush. To better illustrate remaining results, the scale on the graph is split between 35,000 and 50,000 MPA/100ml. Sample results of >X are given that numerical value (X) despite a higher actual result. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south Santa Cruz, Live Oak, Capitola, Aptos and Watsonville.

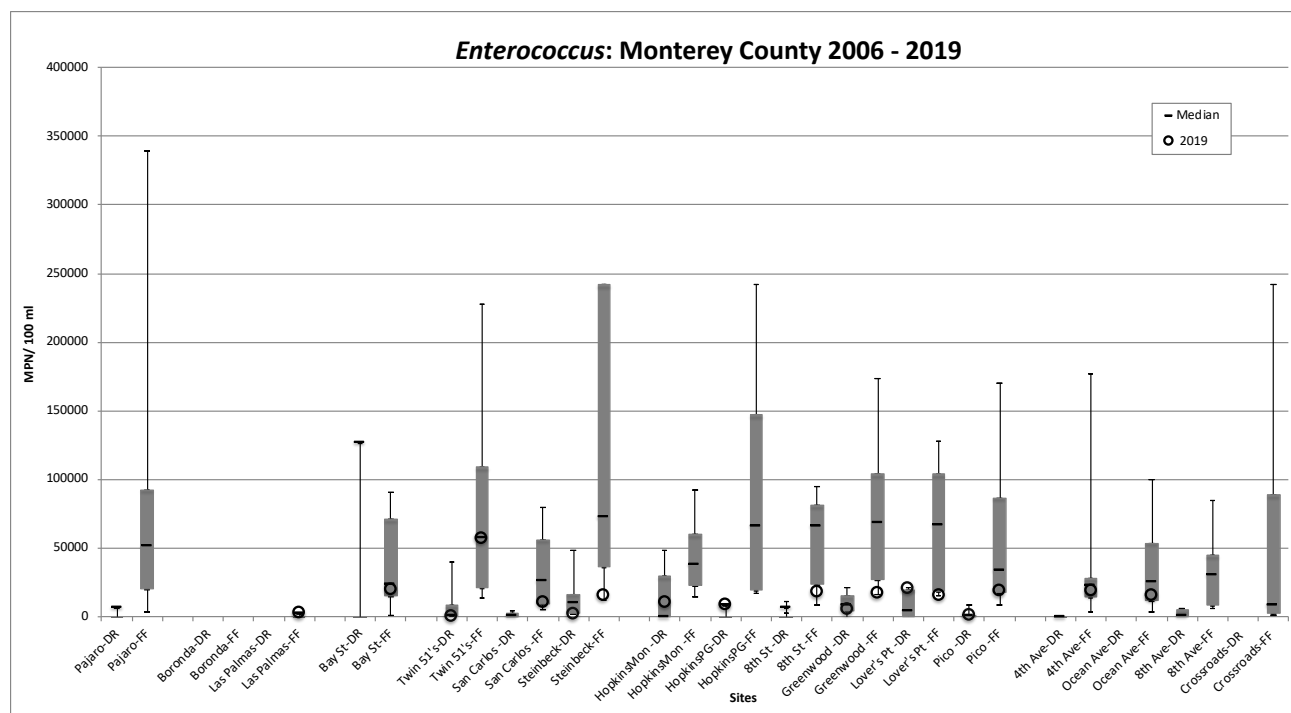


Figure 13. Single sample results for enterococcus for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. Sample results of >X are given that numerical value (X) despite a higher actual result. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Lead

Storm water runoff in coastal urban areas is known to contain trace metals from sources such as automobile brake pads, tires and industrial waste. Very low concentrations of lead in the marine environment can cause reduced reproduction, developmental deformities and mortality. The Water Quality Control Plan for the Central Coast WQO for total lead is 30 µg/L. Lead was only measured in San Mateo and Monterey Counties. The MDL for lead was 0.1 for the Dry Run and unreported for the First Flush in San Mateo County; 1 µg/L for the Dry Run and First Flush in Monterey County. Lead was not measured in Santa Cruz County.

For the **Dry Run** and **First Flush**, no sites exceeded the WQO for lead. (Figures 14 and 15).

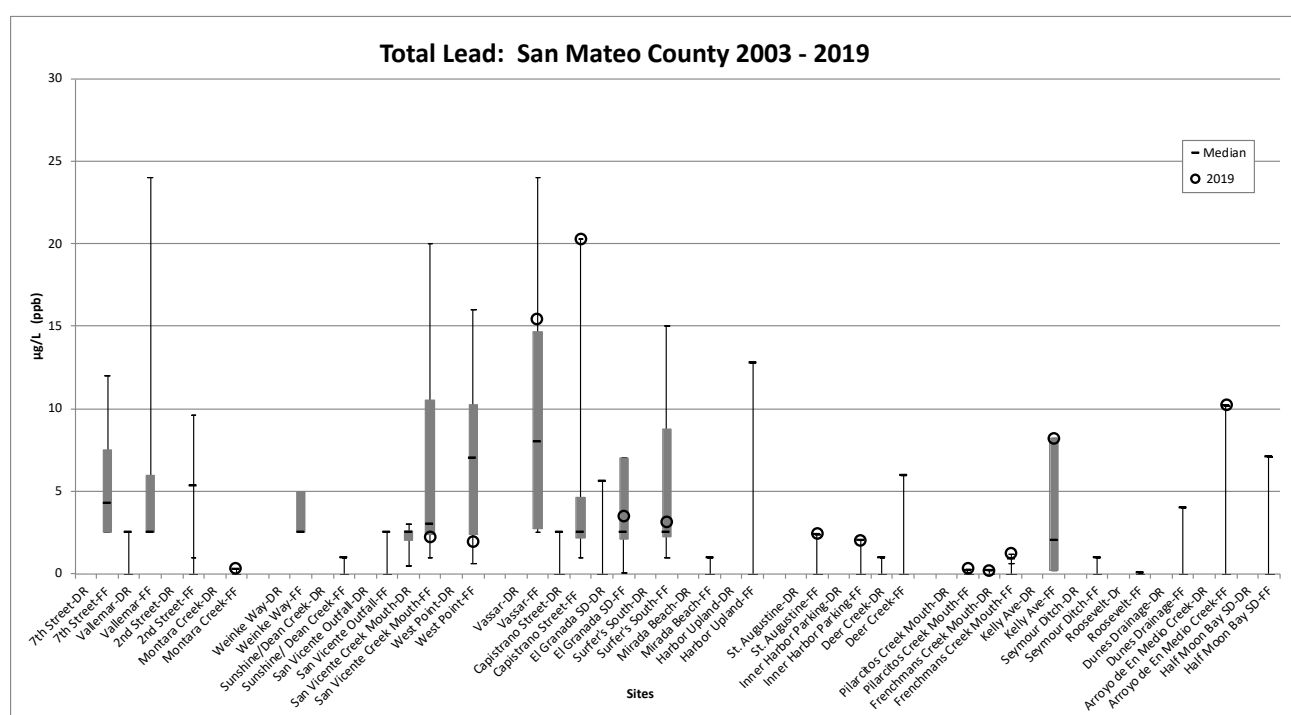


Figure 14. Single sample results for total lead for the Dry Run (DR) and First Flush (FF) in San Mateo County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

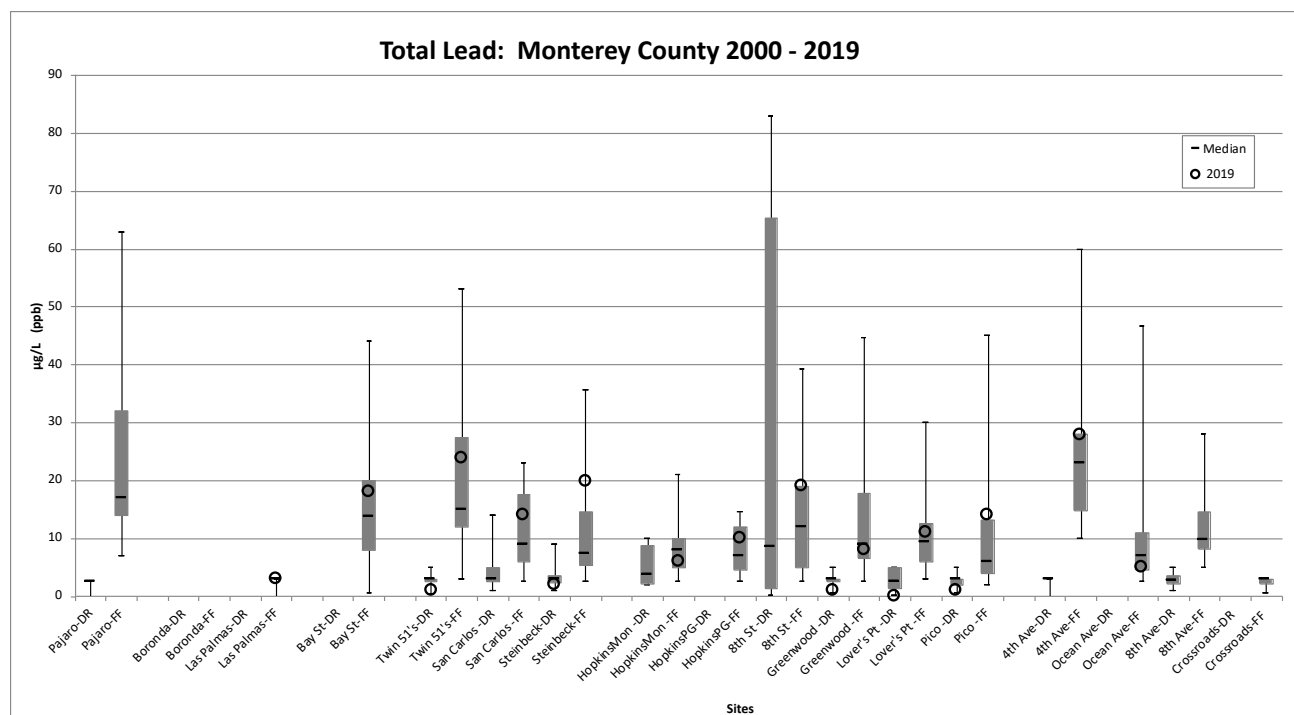


Figure 15. Single sample results for total lead for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Nitrate

Nitrate is needed for plant growth but is not naturally found in elevated concentrations in aquatic systems. Nitrate, as with other nutrients, can lead to algal blooms that degrade water quality as plants die off and consume oxygen in their decomposition. Nitrate sources include runoff from fertilized landscaping, agricultural and pasture lands, construction sites, as well as failing septic or sewer systems. The CCAMP Action Level for nitrate as N ($\text{NO}_3\text{-N}$) is 2.25 mg-N/L. Nitrate was measured in all three counties. The MDL was unreported for the Dry Run and First Flush in San Mateo County; 0.08 mg-N/L for Dry Run and unreported for the First Flush in Santa Cruz County; 0.1 mg-N/L for the Dry Run and 0.4 mg-N/L for the First Flush in Monterey County.

For the **Dry Run**, one of the thirteen sites (8%) sampled for nitrate as N exceeded the Action Level. The highest result of 6.4 mg-N/L was from Steinbeck (Monterey) (Figures 16, 17 and 18).

During the **First Flush**, five of the forty-one monitored sites (12%) had concentrations that exceeded the Action Level for nitrate as N. The highest result of 22.97 mg-N/L was from lower Watsonville Slough (Santa Cruz County) (Figures 16, 17 and 18).

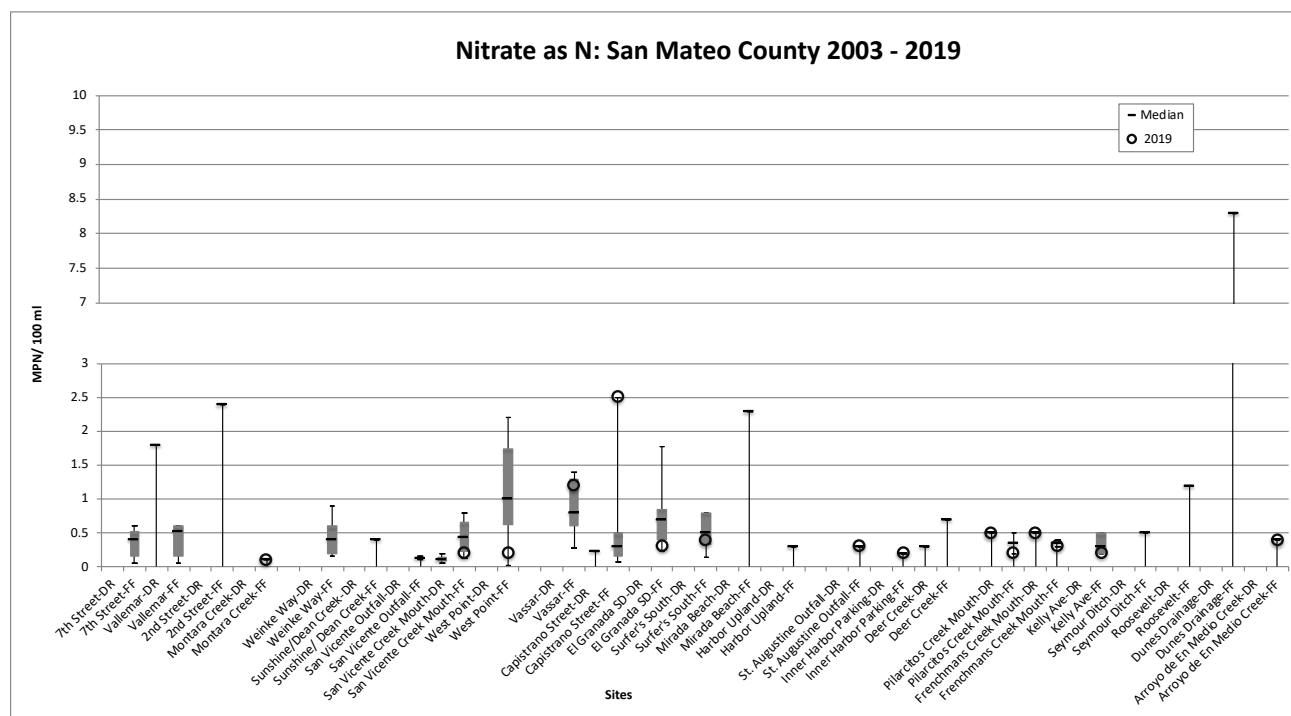


Figure 16. Single sample results for nitrate as N for the Dry Run (DR) and First Flush (FF) in San Mateo County. To better illustrate results, the scale on the graph is split between 3 and 7 mg-N/L. As a result, the First Flush 2018 result of 8.4 mg-N/L from Dunes Drainage (Half Moon Bay) is in the upper portion of the graph. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

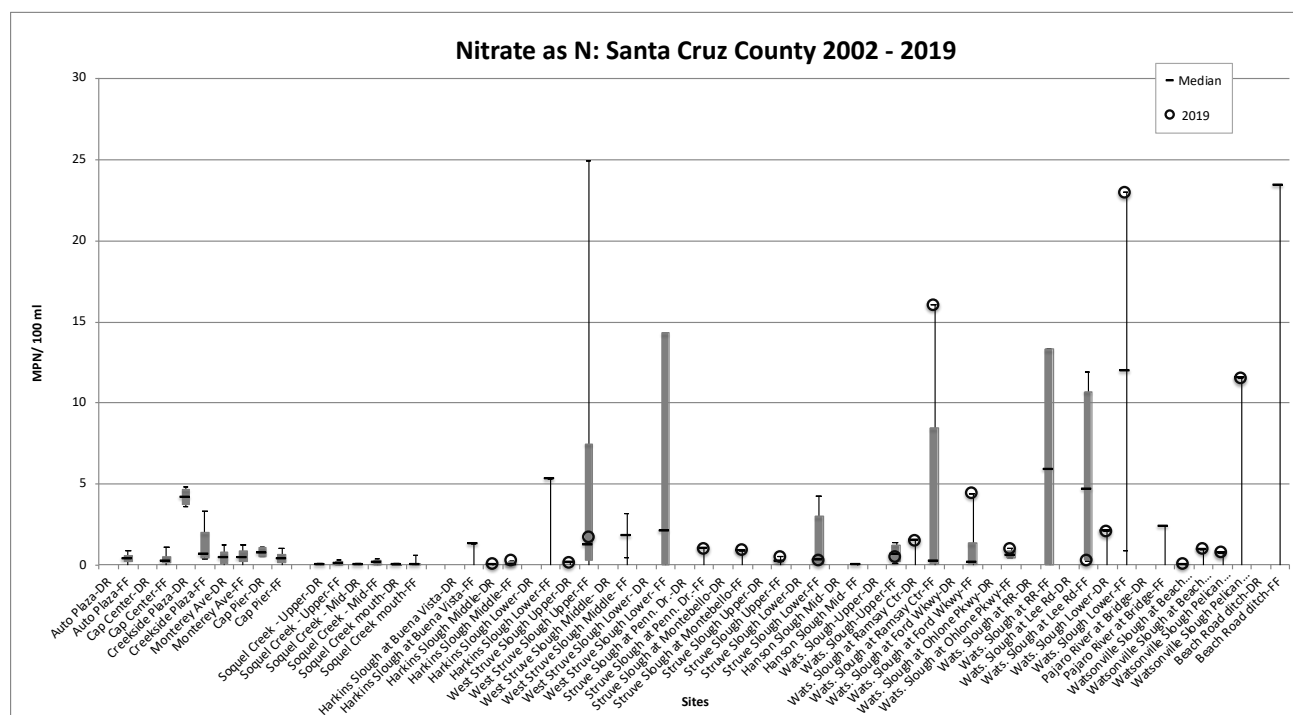


Figure 17. Single sample results for nitrate as N for the Dry Run (DR) and First Flush (FF) in Santa Cruz County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between zero and the MDL. All sites grouped by city from north to south Santa Cruz, Live Oak, Capitola, Aptos and Watsonville.

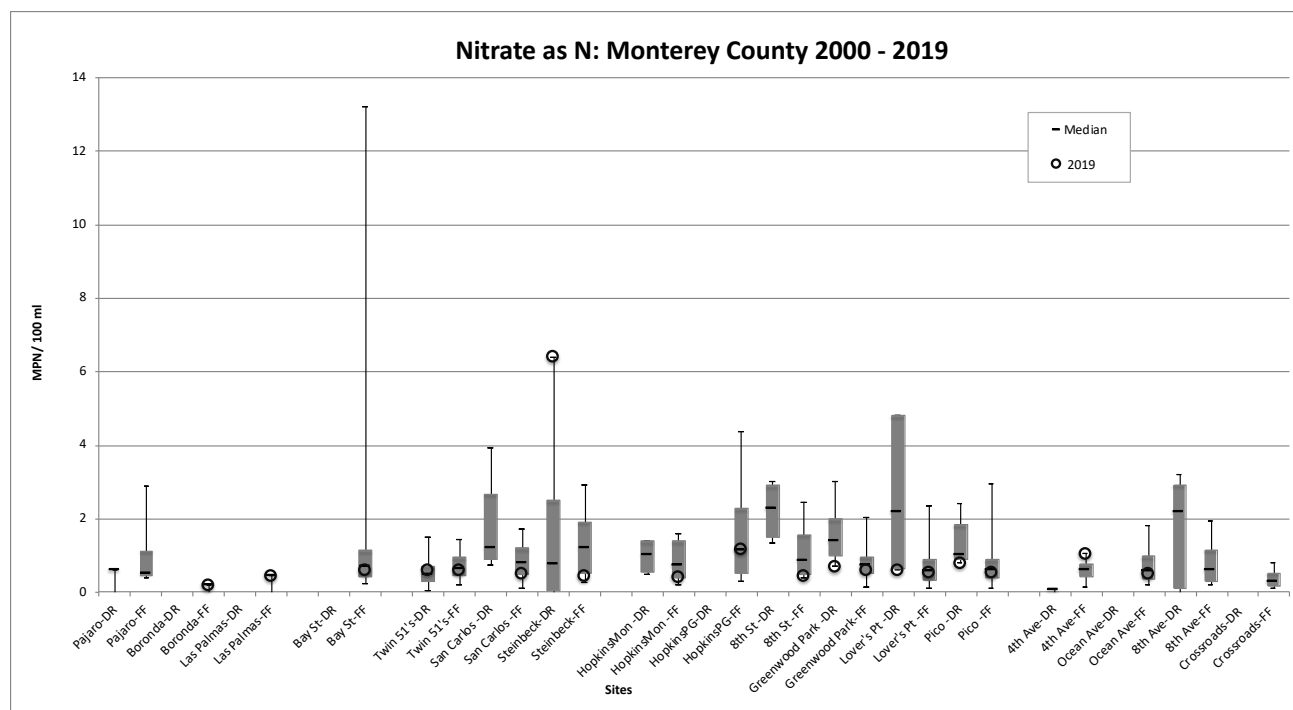


Figure 18. Single sample results for nitrate as N for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Orthophosphate

Orthophosphate, like nitrate, is necessary for plant growth and not commonly found in elevated levels in aquatic systems. As with nitrate, orthophosphate can lead to degradation of water as plants grow uncontrolled. Once plants complete their life cycle and decompose they consume oxygen from the surrounding water in the process. Sources of orthophosphate are similar to those for nitrate: leaks in sewer or septic systems, excess fertilizers from urban or agricultural areas and detergents. The CCAMP Action Level for orthophosphate ($\text{PO}_4\text{-P}$) is 0.12 mg-P/L. Orthophosphate was measured in all three counties. The MDL was not reported for San Mateo County; from 0.08 mg-P/L to 1.0 mg-P/L for the Dry Run and unreported for the First Flush in Santa Cruz County; 0.01 for the Dry Run and First Flush in Monterey County.

For the **Dry Run**, nine of the thirteen sites (69%) sampled for orthophosphate exceeded the Action Level. The highest result for orthophosphate of 1.22 mg-P/ L was from Watsonville Slough at Beach Road (Santa Cruz County). Three sites in Santa Cruz County had concentrations reported as below 1.0 or 0.8 mg-P/ L which would have been marked as non-detects if this level had not already been above the Action Level and instead these three sites were included in the number of exceedances (Figures 19, 20 and 21).

During the **First Flush**, thirty-seven of the forty-one sites (90%) monitored for orthophosphate exceeded the Action Level. The highest concentration of 1.0 mg-P/L was found at two sites: Watsonville Slough at Ramsay Nature Center (Watsonville) and 4th Avenue (Carmel). The 4th Avenue (Carmel) results are an average from the two time series samples (Figures 19, 20 and 21).

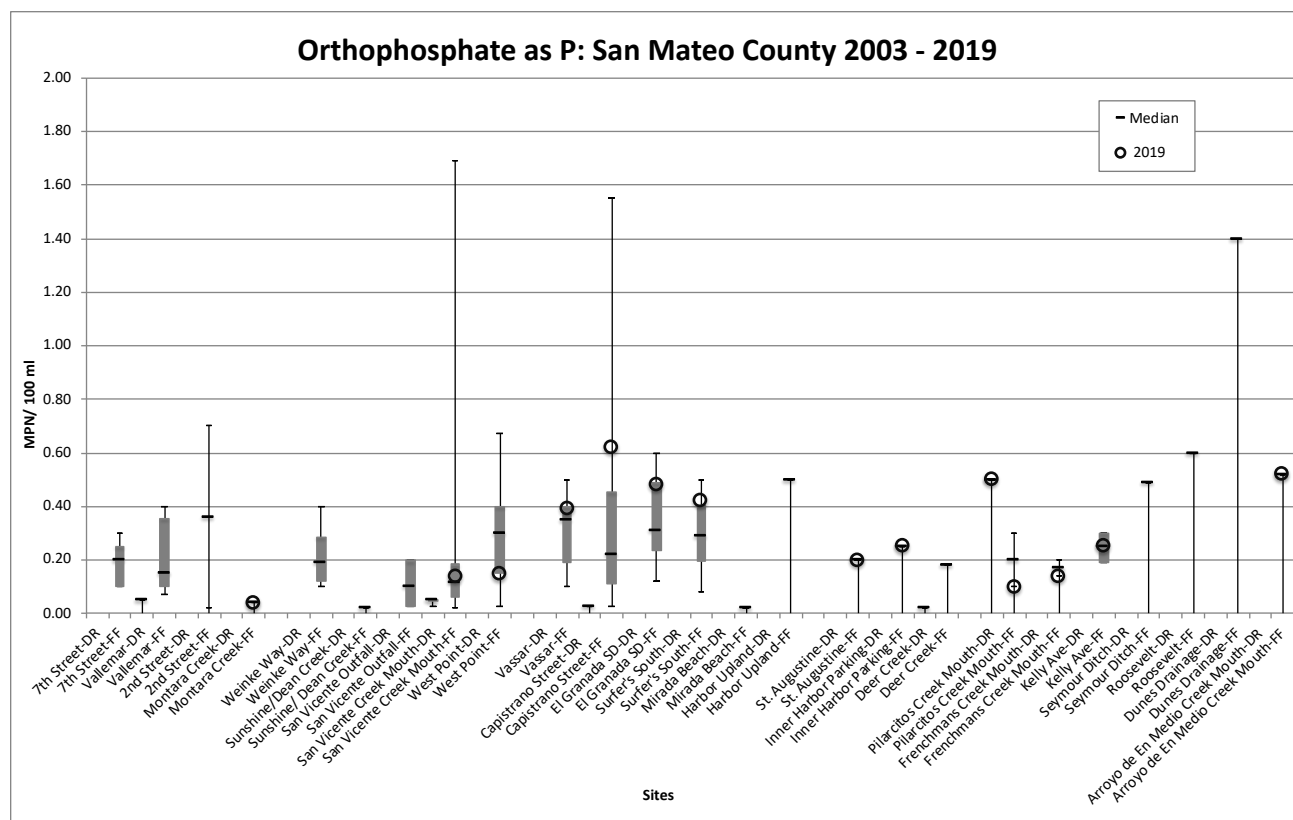


Figure 19. Single sample results for orthophosphate as P for the Dry Run (DR) and First Flush (FF) in San Mateo County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

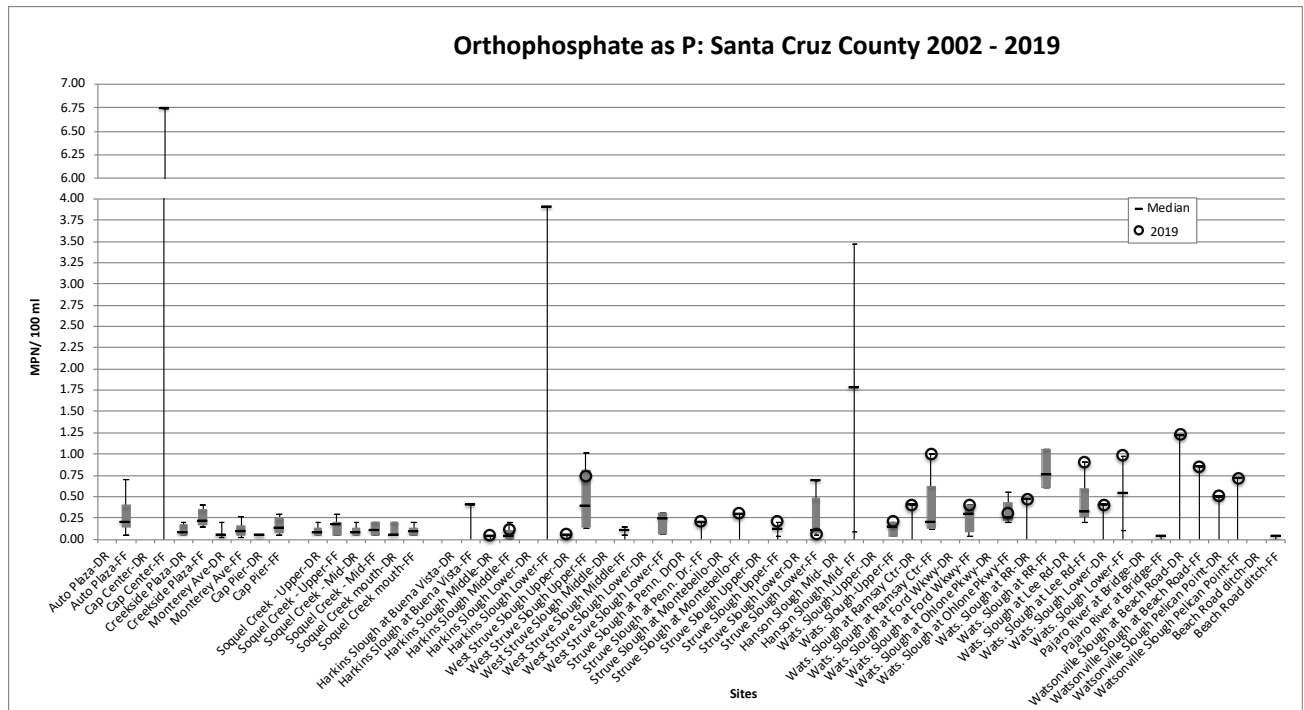


Figure 20. Single sample results for orthophosphate as P for the First Flush (FF) in Santa Cruz County. To better illustrate results, the scale on the graph is split between 4.00 and 6.00 mg-P/L. As a result, the First Flush 2006 result of 6.7 mg-P/L from Capitola Center (Capitola) is in the upper portion of the graph. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south Santa Cruz, Live Oak, Capitola, Aptos and Watsonville.

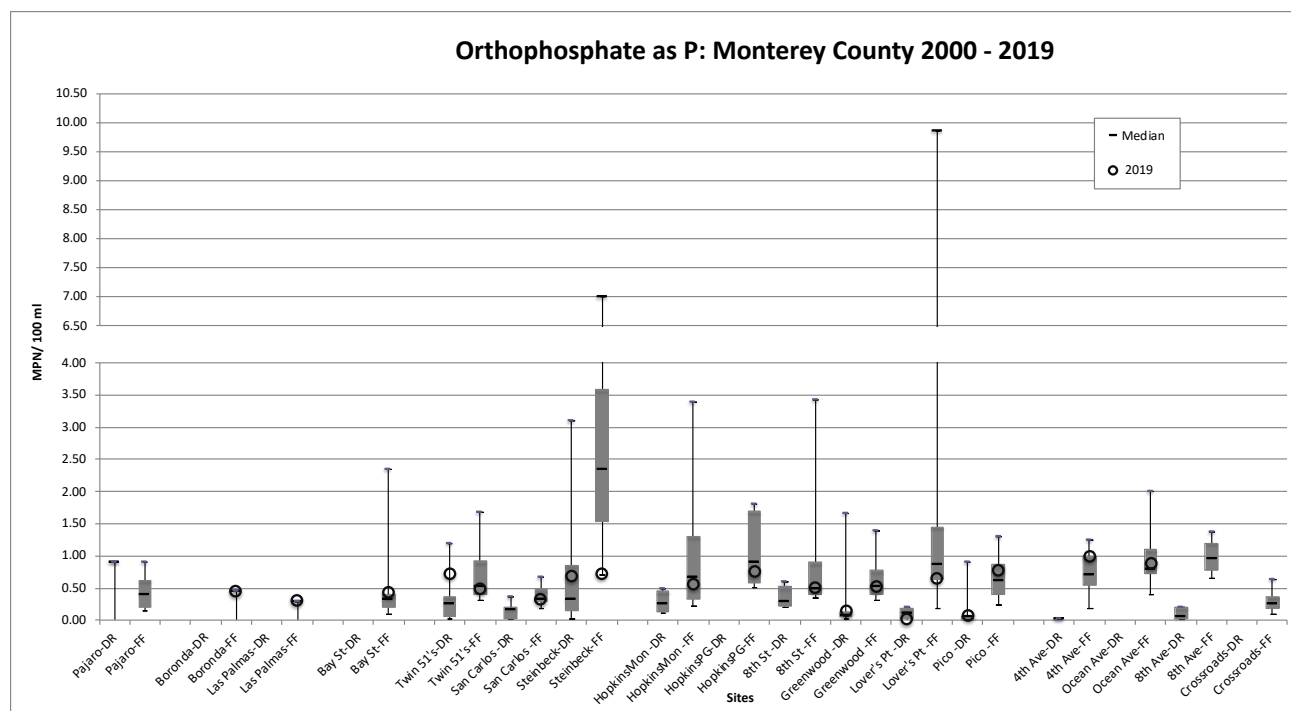


Figure 21. Single sample results for orthophosphate as P for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. To better illustrate results, the scale on the graph is split between 4.0 and 6.5 mg-P/L. As a result, the First Flush 2004 result of 9.85 mg-P/L from Lovers Pt (Pacific Grove) and the First Flush 2010 result of 7.01 mg-P/L from Steinbeck (Monterey) are in the upper portion of the graph. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Total Suspended Solids

Total suspended solids are particulate matter in water that attract charged particles such as pesticides and metals. Total suspended solids can additionally impact the environment through sedimentation which causes a reduction in the ability of aquatic and marine organisms to respire. Some sources of total suspended solids are construction sites with improper sediment control, bank erosion from rivers or streams, runoff from agricultural fields and over-irrigation. The CCAMP Action Level for total suspended solids is 500 mg/L. Total suspended solids were only measured in San Mateo and Monterey Counties. The MDL was unreported for San Mateo County, and 2 mg/L for both the Dry Run and First Flush in Monterey County.

For the **Dry Run**, none of the seven sites (0%) monitored for total suspended solids exceeded the Action Level (Figures 22 and 23).

For the **First Flush**, just one of the twenty-six sites (4%) monitored for total suspended solids exceeded the Action Level with a result of 724 mg/L from Boronda (Monterey County) and collected the day after the First Flush (Figures 22 and 23).

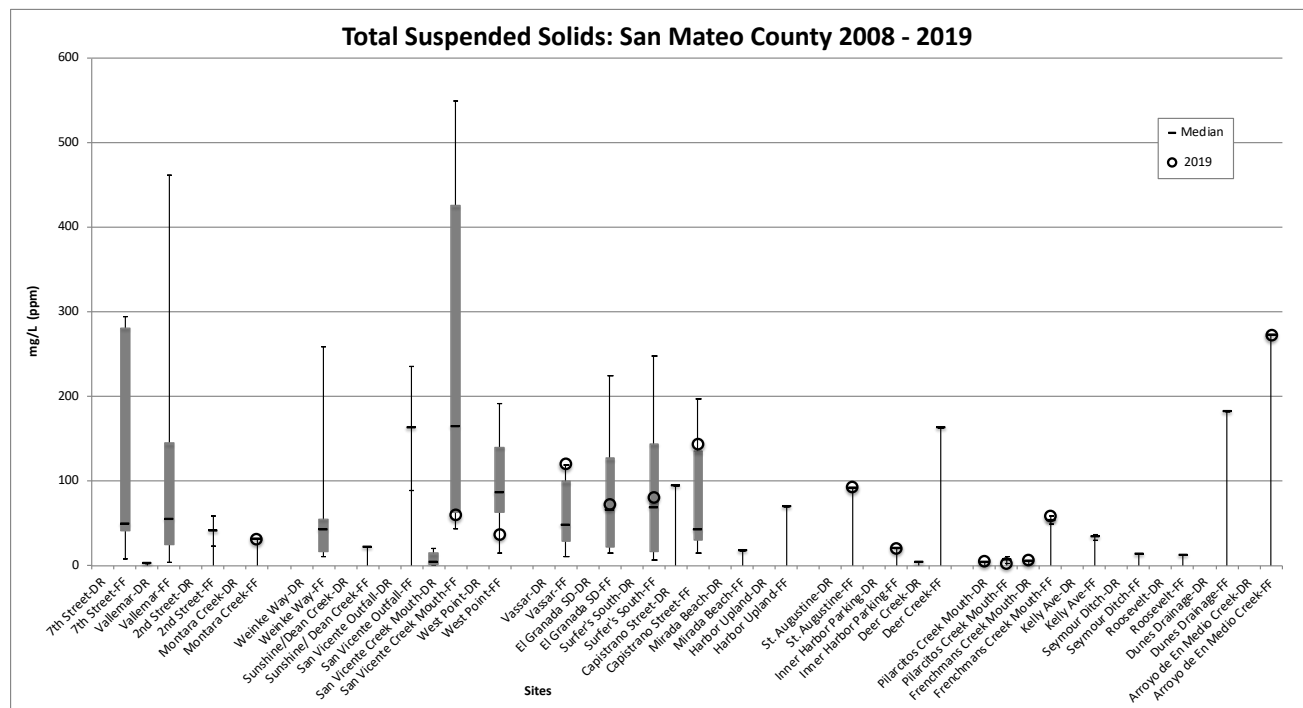


Figure 22. Single sample results for total suspended solids for the Dry Run (DR) and First Flush (FF) in San Mateo County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

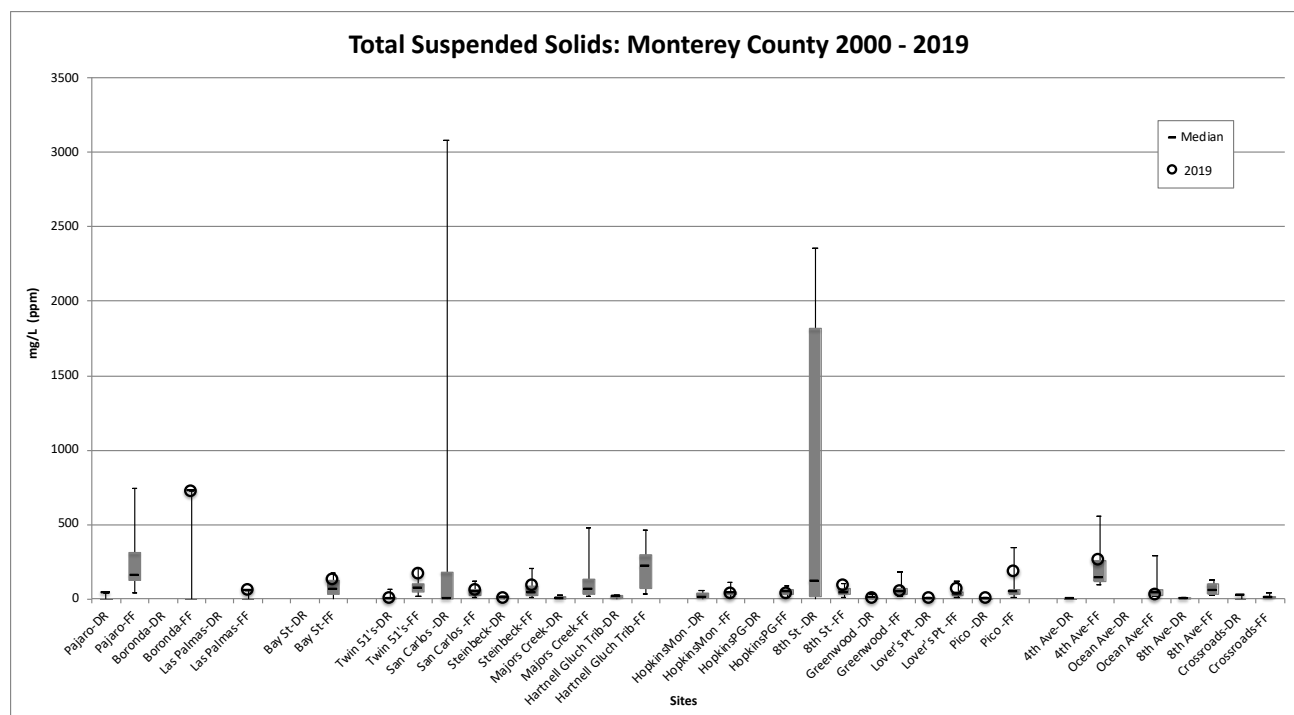


Figure 23. Single sample results for total suspended solids for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Turbidity

Turbidity is a measure of the clarity of a liquid. Normal turbidity measurements vary for different water bodies, but in general, high turbidity levels can indicate problems such as erosion, nutrient loading or extraordinary algae growth. CCAMP's Action Level for turbidity is not greater than 25 Nephelometric Turbidity Units (NTU's). Turbidity was only measured in Santa Cruz and Monterey Counties. The MDL for turbidity was not reported for Santa Cruz County, and was 0.05 NTU for the Dry Run and 0.5 NTU for the First Flush in Monterey County.

For the **Dry Run**, only one of the twelve sites (8%) monitored for turbidity exceeded the Action Level with a result of 71.9 NTU at middle Harkins Slough (Santa Cruz County) (Figure 24 and 25).

During the **First Flush**, seventeen of the twenty-eight sites (61%) monitored for turbidity exceeded the Action Level. The highest turbidity measurement of 900 NTU was from Boronda (Monterey County) and collected the day after the First Flush (Figure 24 and 25).

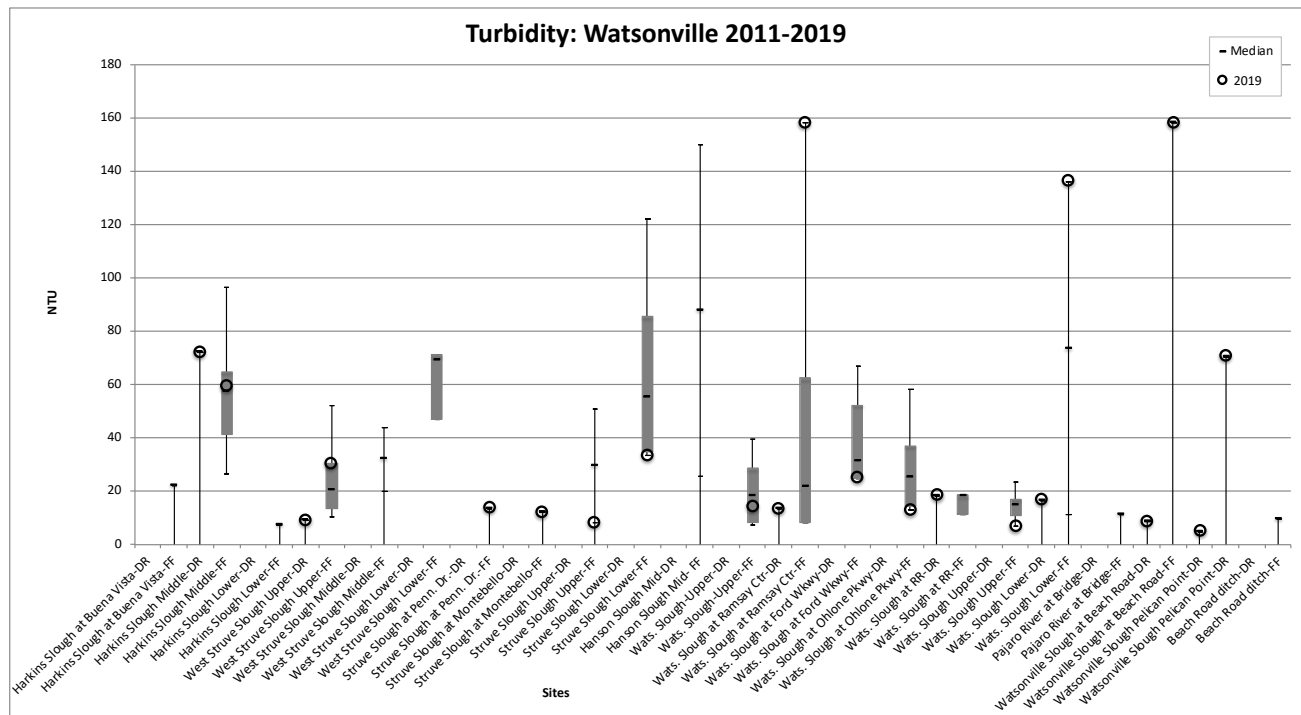


Figure 24. Single sample results for turbidity for the Dry Run (DR) and First Flush (FF) in Santa Cruz County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south in Watsonville.

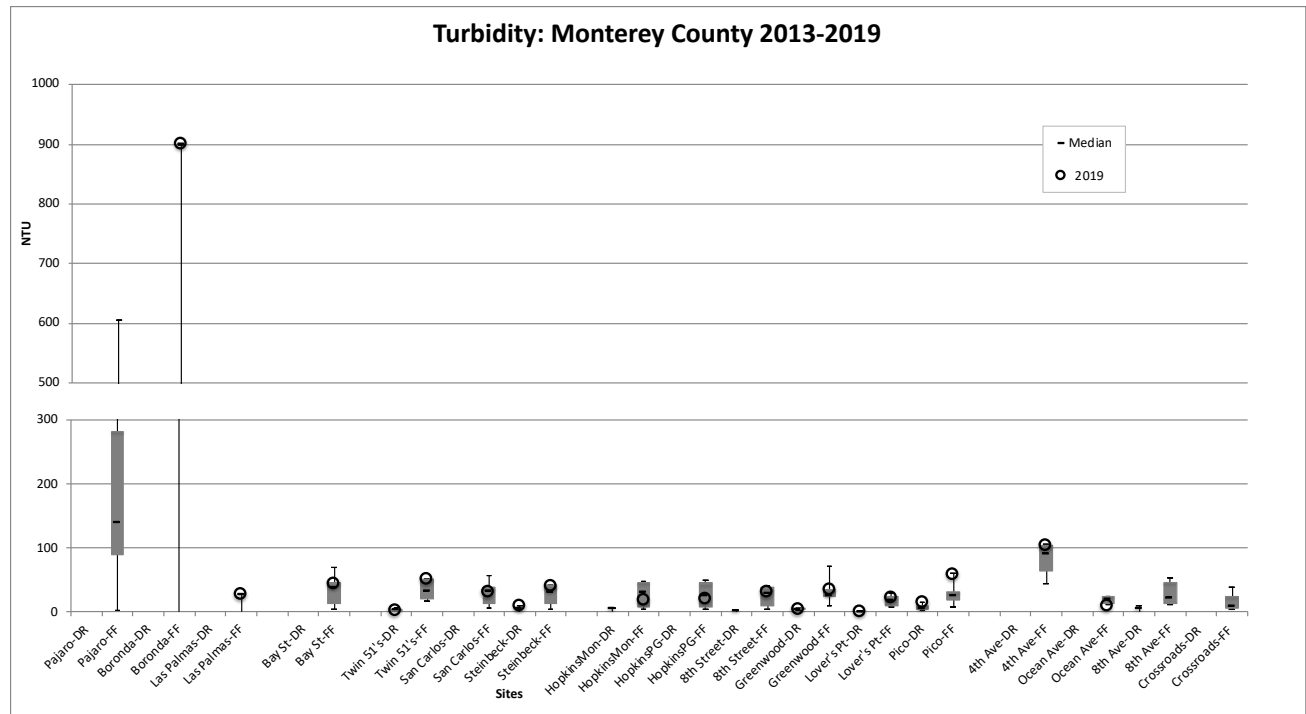


Figure 25. Single sample results for turbidity for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. To better illustrate results, the scale on the graph is split between 300 and 500 NTU. As a result, the First Flush 2017 result of 606 NTU from Pajaro (Monterey County) and the First Flush 2019 result of 900 NTU from Boronda (Monterey County) are in the upper portion of the graph. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Urea

Urea is an organic compound that is soluble in water; it is an excellent fertilizer and is often used for agricultural applications. There are many sources of urea including fire retardants, cigarettes, fertilizers, animal feeds, detergents and mammalian urine. While there is no water quality objective for urea, values are noted and compared to previous year's results in order to monitor trends. There is no Action Level or Water Quality Objective for urea. Urea was only measured in Monterey County. The MDL was 10 µg/L for the Dry Run and from 8 µg/L to 16 µg/L for the First Flush in Monterey County.

For the **Dry Run**, the highest result of 197 µg/L was from Twins (Monterey) (Figure 26).

During the **First Flush**, urea was only measured during the first time series at all Monterey County sites except Boronda (Monterey County). The highest average result of 481 µg/L was from Ocean Avenue (Carmel) (Figure 26).

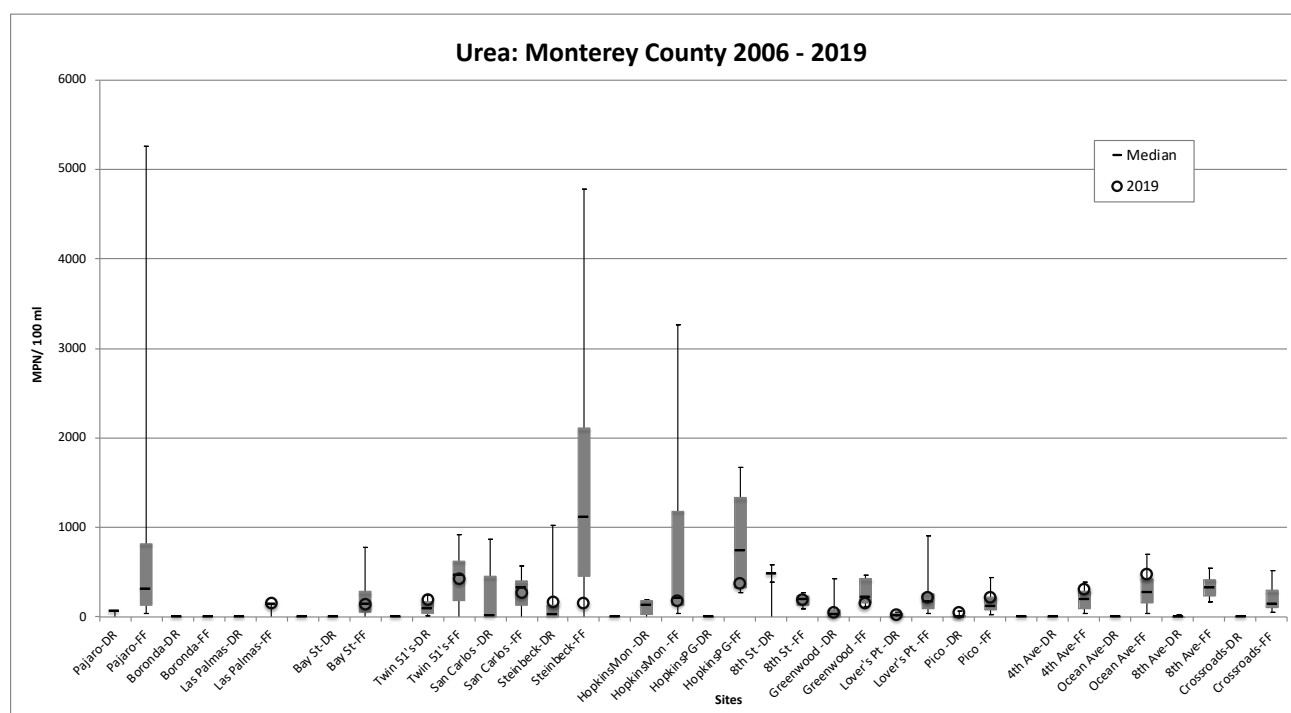


Figure 26. Single sample results for urea for the Dry Run (DR) and First Flush (FF) in Monterey County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Zinc

Storm water runoff in coastal urban areas is known to contain trace metals from sources such as automobile brake pads, tires and industrial waste. Very low concentrations of total zinc in the marine environment can cause reduced reproduction, developmental deformities and mortality. Total zinc was only measured in San Mateo and Monterey Counties. The Water Quality Control Plan for the Central Coast WQO for total zinc is <200 µg/L. The MDL for total zinc was unreported for the Dry Run and 10 µg/L for the First Flush in San Mateo County; from 5 µg/L to 10 µg/L for the Dry Run and 10 µg/L for the First Flush in Monterey County.

For the **Dry Run**, total zinc concentrations did not exceed the WQO at any of the sites where total zinc was monitored (Figures 27 and 28).

For the **First Flush**, five of the twenty-six sites (19%) monitored for total zinc exceeded the WQO. The highest average result of 286 µg/L was from HopkinsPG (Pacific Grove) (Figures 27 and 28).

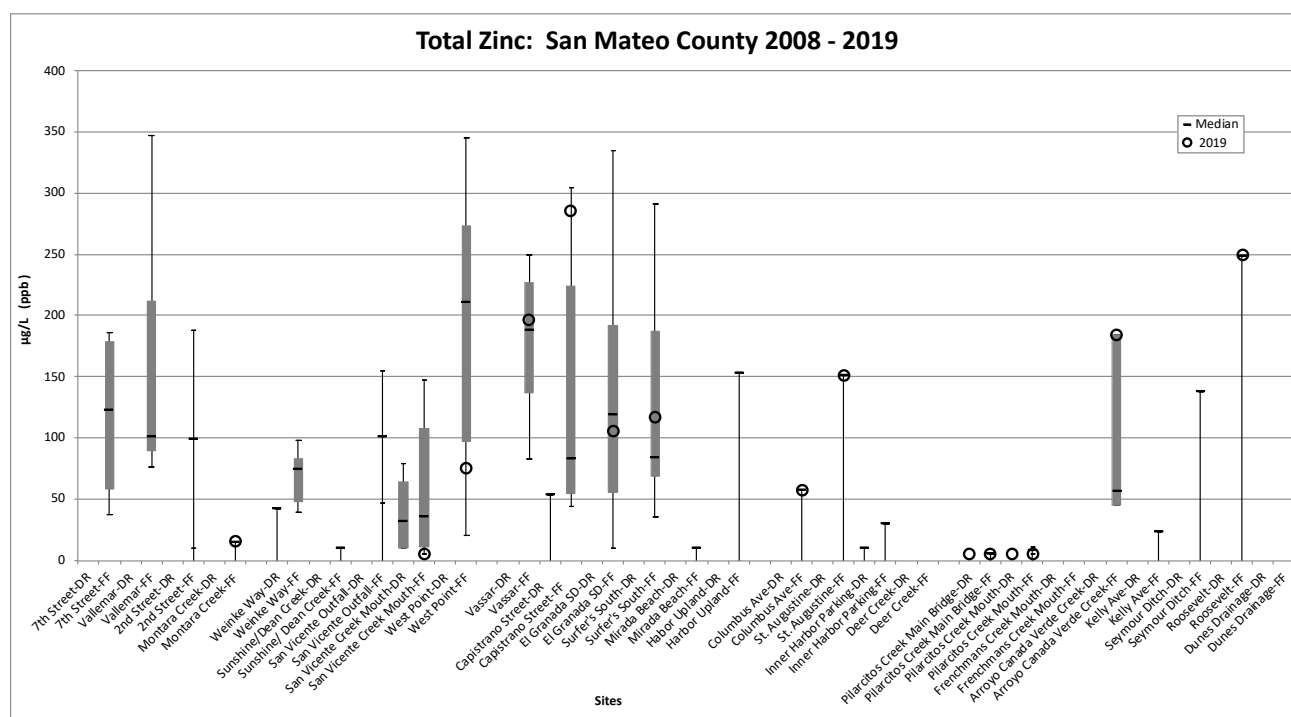


Figure 27. Single sample results for total zinc for the Dry Run (DR) and First Flush (FF) in San Mateo County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Montara, Moss Beach, El Granada and Half Moon Bay.

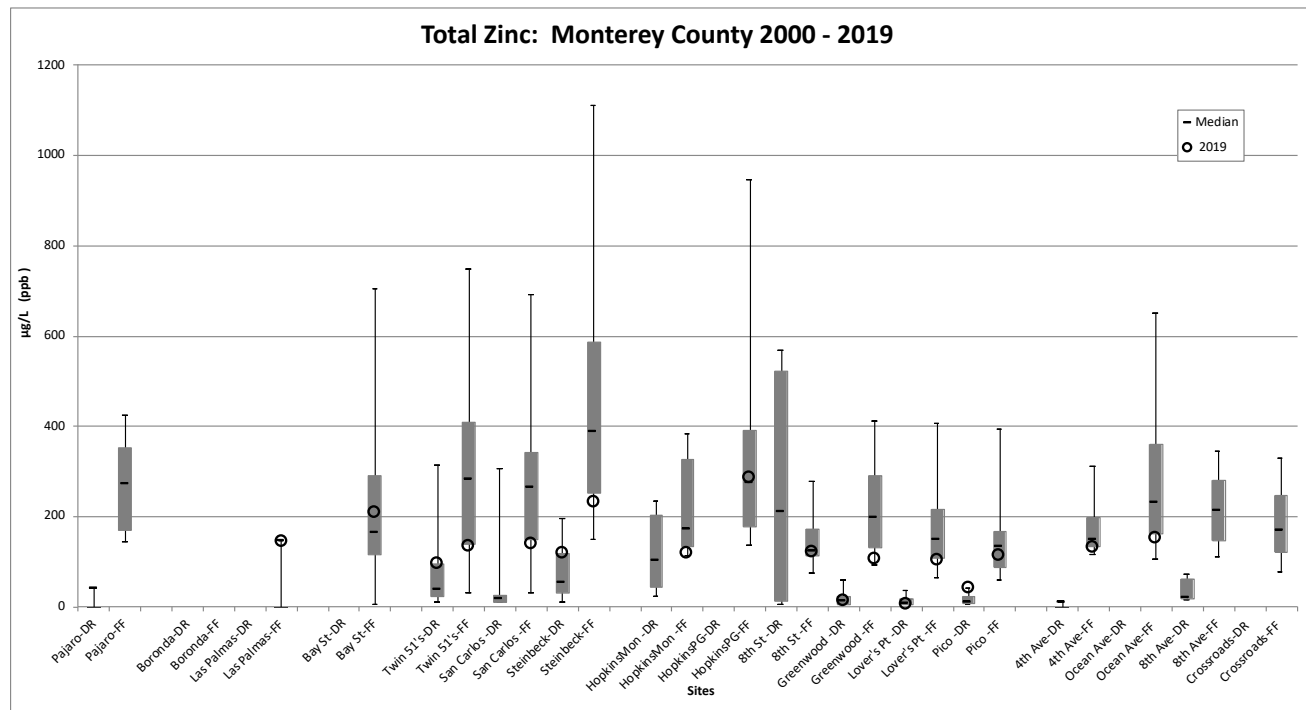


Figure 28. Single sample results for total zinc or the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County. Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL. All sites grouped by city from north to south- Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Conclusion


For the past twenty years, the Dry Run and First Flush have provided Central California coastal area residents and municipalities with valuable information about the quality of water running from storm drains into the ocean. Results from this and other Dry Run and First Flush events provide managers and researchers with information on pollutant concentrations during two critical times: late season dry weather and the initial flushing event when the most polluted water is expected to flow from the land into the ocean and Monterey Bay National Marine Sanctuary.

The 2019 Dry Run was conducted in all three counties: San Mateo, Santa Cruz and Monterey. Highlights from the 2019 Dry Run:

- Copper concentrations did not exceed the WQO in all San Mateo County sites but exceeded the WQO at just one Monterey County site: Steinbeck (Monterey). Copper was not measured in Santa Cruz County.
- *E. coli* results exceeded the WQO at 100% of Santa Mateo County sites, 43% of Santa Cruz County sites and 100% of Monterey County sites.
- Enterococcus results exceeded the WQO in 50% of San Mateo County sites, 33% of Santa Cruz County sites and 100% of Monterey Counties sites.
- Lead concentrations did not exceed the WQO at any San Mateo or Monterey County sites. Lead was not measured in Santa Cruz County.
- Nitrate concentrations did not exceed the Action Level in 100% of San Mateo and Santa Cruz County sites. Monterey County sites exceeded the Action Level in 20% of sites.
- Orthophosphate concentrations exceeded the Action Level in 100% of San Mateo County sites, in 83% of Santa Cruz County sites and 60% of Monterey County sites.
- Total suspended solids concentrations did not exceed the Action Level at any of the San Mateo and Monterey County sites. Total suspended solids were not measured in Santa Cruz County.
- Turbidity concentrations exceeded the Action Level in 14% of San Mateo County sites. Monterey County did not exceed the Action level for turbidity at any of sites. Turbidity was not measured in Santa Cruz County.
- Zinc concentrations did not exceed the WQO at any San Mateo or Monterey County sites. Zinc was not measured in Santa Cruz County.

The 2019 First Flush was conducted in all three counties: San Mateo, Santa Cruz and Monterey. Highlights from the 2019 First Flush:

- Copper concentrations exceeded the Action Level for 44% of San Mateo County sites, and 29% of Monterey County sites. Copper was not measured in Santa Cruz County.
- *E. coli* results exceeded the WQO in 100% of the sites in all three counties.

- 
- Enterococcus results exceeded the WQO for 85% of San Mateo County sites and 100% of Santa Cruz County and Monterey County sites.
 - Lead concentrations did not exceed the WQO at any San Mateo or Monterey County sites. Lead was not measured in Santa Cruz County.
 - Nitrate concentrations exceeded the Action Level in 8% of San Mateo County sites and 31% of Santa Cruz County sites. Monterey County sites did not exceed the Action Level at any of the sites.
 - Orthophosphate concentrations exceeded the Action Level in 85% of San Mateo County sites, 86% of Santa Cruz County sites and 100% of Monterey County sites.
 - Total suspended solids concentrations did not exceed the Action Level at any of the San Mateo County sites. Monterey County sites exceeded the Action Level in just 7% of sites. Total suspended solids were not measured in Santa Cruz County.
 - Turbidity concentrations exceeded the Action Level for 50% of San Mateo County sites and 71% of Monterey County sites. Turbidity was not measured in Santa Cruz County.
 - Zinc concentrations exceeded the WQO in 15% of San Mateo County sites and 23% of Monterey County sites. Zinc was not measured in Santa Cruz County.

First Flush data helps us to better understand *our* pollutants of concern over a very large area and helps to identify where concentrations are highest. This report can inform the placement of target projects and Best Management Practices (BMPs) that address specific contaminants. First Flush does not necessarily inform us as to whether our efforts are improving water quality—that requires a different monitoring design—but with the information provided by the First Flush event a prioritization of problem watersheds can be accomplished. Local cities have used First Flush information and addressed pollutant concentrations by cleaning out storm drains prior to the rains, installing dry weather diversions and litter-debris removal systems, as well as identifying opportunities to slow down runoff through vegetation and permeable surfaces. By addressing these issues on a watershed level more water quality improvements may be achieved.



AMERICA'S UNDERWATER TREASURES