

Monterey Bay National Marine Sanctuary Dry Run and First Flush Monitoring Report 2020



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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 site Greenwood Park in Pacific Grove, CA.
Photo by K. Terry.



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Executive Summary

Monitoring stormwater flows through urban storm drains provides information on non-point source pollution flowing into streams, lakes, and the ocean. In coastal central California the Monterey Bay National Marine Sanctuary covers nearly 300 miles of coastline with stormwater inputs from local cities and agricultural areas. Pollutants that accumulate on hard surfaces in urban areas 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 which can severely impact water quality. Pollutant sources can be brake dust and emissions from cars and trucks, animal waste, detergents from restaurant kitchen mat washing, in-street car washing, pesticides, fertilizers, as well as other chemicals commonly found in and around homes and businesses. Water quality monitoring of dry and wet weather storm drain flows provides critical information about types and concentrations of pollutants.

Urban water quality monitoring for the 2020 winter season started with the Dry Run conducted across three counties: September 3rd in San Mateo County, October 20th in Santa Cruz County, September 17th and October 5th in Monterey County. Sixteen samples were collected for the Dry Run across all three counties. The First Flush was conducted on Tuesday November 17th starting at 1:00 pm in coastal San Mateo County, on Wednesday November 18th starting at 2:00 pm in Santa Cruz County and on two dates, December 13th starting at 9:45 am and December 17th at 3:45 am in Monterey County. Thirty-six sites were monitored for First Flush. Sixty-five volunteers assisted with Dry Run and First Flush monitoring in the three counties.

Range of Field and Lab Results for Dry Run and First Flush 2020.


Parameter	Units	Dry Run	First Flush
Conductivity*	µS	880 - 3500	80 - 1516
Copper- total*	µg/L	ND - 58	ND - 106
<i>Escherichia coli</i> (<i>E. coli</i>)	MPN/ 100 ml	ND – >24,196	200 – 242,000
Enterococcus*	MPN/ 100 ml	ND – 17,329	200 – 242,000
Lead- total*	µg/L	ND – 0.90	ND – 33.1
Nitrate as N*	mg-N/L	0.5 – 8.6	ND – 3.1
Orthophosphate as P*	mg-P/L	ND – 0.70	ND – 1.32
pH*	pH units	7.0 – 8.0	5.65 – 8.02
Total Suspended Solids*	mg/L	ND - 44	ND - 847
Transparency***	cm	7.0 - >120	5.1 – 24.0
Turbidity**	NTU	0.4 – 21.0	22.0 – 325.0
Urea***	µg/L	16- 234	85 - 745
Water temperature*	°C	12.8 – 14.6	11.5 – 16.2
Zinc- total*	µg/L	ND - 39	ND - 202

Introduction

Underground, a network of pipes link storm drains and city streets to rivers, streams and the ocean. In order to alleviate flooding of communities, roadways, or businesses during heavy rainstorms, storm water is directed to storm drain systems and eventually 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 which can severely impact water quality. Pollutant sources can be brake dust and emissions from cars and trucks, animal waste, detergents from restaurant kitchen mat washing, in-street car washing, pesticides, fertilizers, as well as other chemicals commonly found in and around homes and businesses. Dry weather runoff flows are an important component of water quality monitoring since contaminants can be less diluted and therefore more concentrated than those of wet weather flows. 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, sidewalk and building 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 early fall 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 in San Mateo County by the SMRCD, in Santa Cruz County by WWW, and in Monterey County by CMSF and MBNMS with funding from the Monterey Stormwater Education Alliance (SEA). SMRCD has conducted Dry Run and First Flush monitoring since 2003 by sampling sites in the Cities of El Granada, Moss Beach, Montara, and Half Moon Bay. WWW in Santa Cruz County has monitored Watsonville area slough and river sites (not storm drain outfalls) during the Dry Run and First Flush since 2011 (not including 2014). Monterey SEA is a consortium of local Monterey Peninsula cities and Monterey County under one National Pollution Discharge and Elimination System (NPDES) permit and includes areas in Monterey County, Carmel Valley, and the Cities of Carmel-by-the-Sea, Monterey, Pacific Grove, Seaside and Sand City. Monitoring for Monterey SEA has been conducted since 2007.



The geographic scope of First Flush monitoring extends from the City of Montara in San Mateo County in the north, through the City of Carmel in Monterey County in the south. First Flush sampling includes a mix of storm drain outfall and receiving water sources (Figure 1 and Table 1).

First Flush Sites 2020

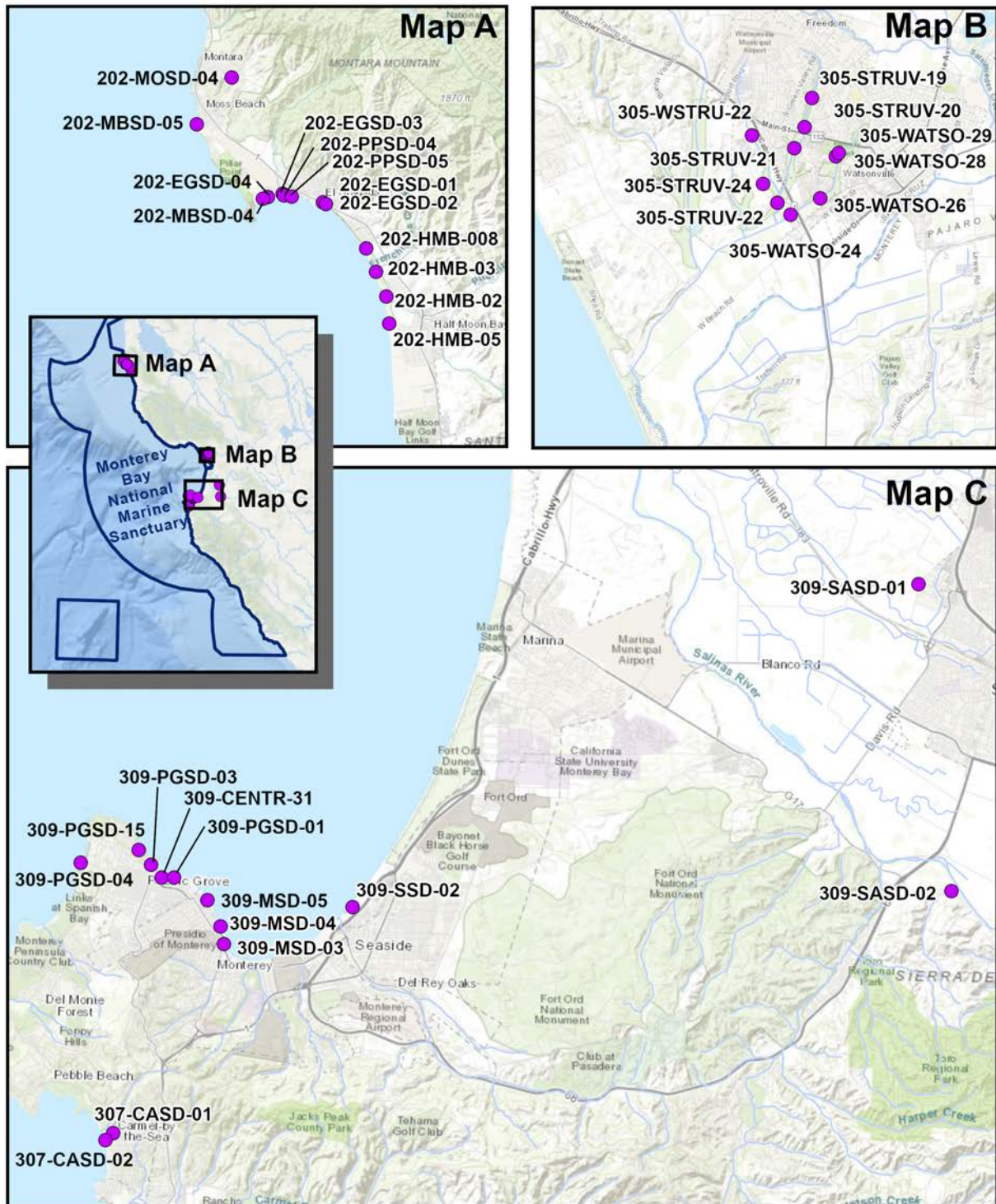


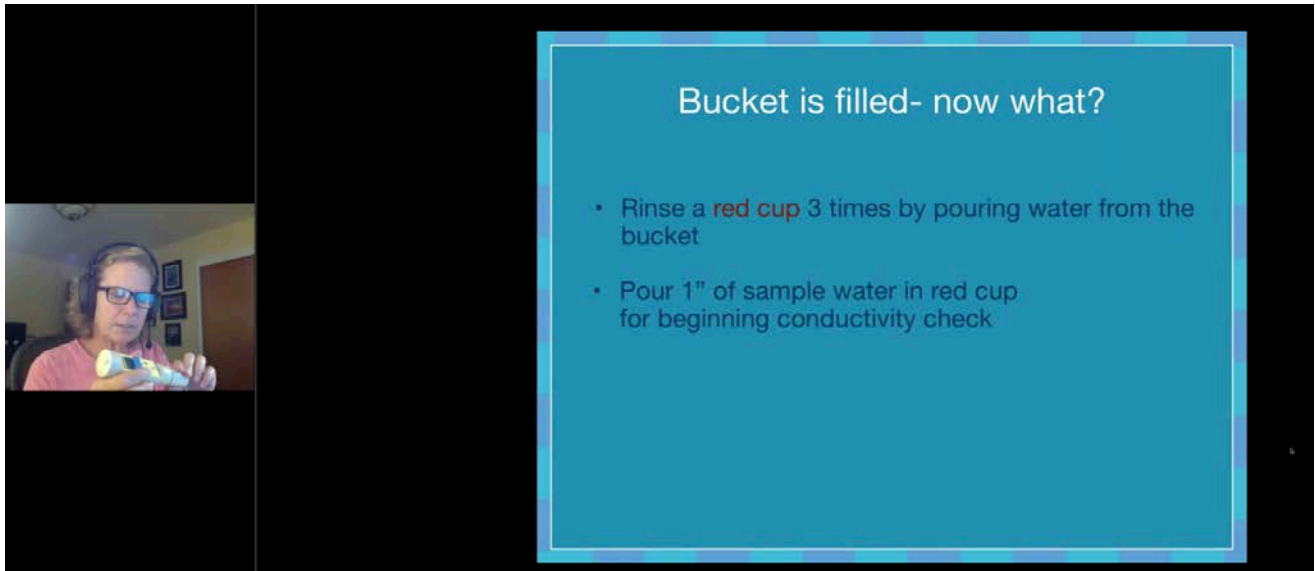
Figure 1. 2020 Dry Run and First Flush Sites

Table 1

2020 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 (Dry Run only)	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-08	Dunes drainage at HMB State Beach	RW	San Mateo
Santa Cruz County	305-WSTRU-22	West Struve Slough- upper	RW	
	305-WSTRU-24	West Struve Slough- lower	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-WATSO-29	Watsonville Slough Upper	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
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-01	Pacific Grove Storm Drain at 8 th 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-15	Pacific Grove Storm Drain at Sea Palm	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.



Bucket is filled- now what?

- Rinse a **red cup** 3 times by pouring water from the bucket
- Pour 1" of sample water in red cup for beginning conductivity check

Figure 2. The Dry Run/First Flush training for volunteers was held twice online through Go To Webinar. Photo: Lisa Emanuelson.



Figure 3. The First Flush site at Sea Palm in Pacific Grove has also been monitored for Urban Watch (image from 2019). Photo: Lisa Emanuelson.



Figure 4. First Flush site at 4th Avenue in Carmel is flowing well with lots of suds. Photo: Lisa Emanuelson.

Methods

In years prior to 2020, new and returning Dry Run and First Flush volunteers attend an online training and participate in face to face hands-on training and 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. However due to the COVID pandemic, First Flush volunteer training was conducted online and Dry Run samples were collected without the assistance of volunteers.

During the Dry Run and First Flush, field measurements for water temperature, pH, electrical conductivity and transparency are gathered, and water samples are collected for lab analysis of nutrients (nitrate, orthophosphate and urea), bacteria (*Escherichia coli* (*E. coli*) and enterococcus), metals (total copper, total lead and total zinc), total suspended solids and turbidity. Samples from each county are analyzed 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 μ S (Monterey County only).

Dry Run monitoring in all counties that conduct it 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. Once sample collection is complete, samples and field equipment are delivered immediately to monitoring coordinators who deliver samples to labs.

In Monterey County the Cities of Carmel and Pacific Grove operate dry weather storm drain diversions for dry and some wet weather flows in the storm drain system. Two sites in Carmel, 4th Avenue and Ocean Avenue, are within the city's diversion system boundaries, where dry weather storm drain flows are retained and diverted into infiltration trenches. The City of Carmel's diversion is never on during the First Flush. The Carmel 4th Avenue site is monitored above the connection point with the diversion system for the Dry Run and First Flush due to access issues at the outfall. Ocean Avenue is sampled at the outfall for both the Dry Run and First Flush events as outfall access is available year-round.

The City of Pacific Grove's diversion collects dry and wet weather storm drain flows and pumps them into the sanitary sewer. Sites monitored in 2020 within the City of Pacific Grove's



diversion system boundaries are: 8th Street, Greenwood Park and Lovers. During dry weather, 8th Street and Lovers are sampled at the outfall, which may or may not have flow as any flow is diverted unless the system is blocked by debris and some water is allowed to bypass the diversion. Greenwood Park is always monitored above the diversion system in both dry and wet weather due to safety and access issues at the outfall. If the City of Pacific Grove's diversion remains on during the First Flush, as it was this year, sites are still monitored as follows: Greenwood Park and Lovers are monitored above the diversion system; 8th Street is monitored at the outfall if flow is present, as it was this year. Water quality data from sites monitored above any dry or wet weather diversions are still valuable as contaminants identified in the runoff may not flow to the ocean.

Dry Run and First Flush results (field and lab) are compared to receiving water standards set for particular beneficial uses, such as a stream, lake or ocean. These standards are not meant for end-of-pipe discharges such as those collected at many Dry Run and First Flush sites. However, lacking any other effluent standard, these receiving water 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. Sampling results are comparable to Water Quality Objectives (WQO) and Action Levels (AL) for receiving water. 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).

The description of each analyte includes the Minimum Detection Limit (MDL), the lowest 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

Due to the COVID pandemic, only already trained First Flush, Snapshot Day or Urban Watch volunteers were recruited to participate in First Flush in 2020. The 2020 Monterey County Dry Run-First Flush volunteer training was held online via GoToWebinar on the evening of Tuesday September 22nd, 2020 with a second, online training session on Wednesday October 7th, 2020. Twenty-four people attended the September training date and another 24 for the October training date. No training dates were reported for San Mateo County or Santa Cruz County events.

In 2020, the Dry Run was conducted on four separate dates in San Mateo, Santa Cruz and Monterey Counties without the help of volunteers: September 3rd for San Mateo County sites, October 20th in Santa Cruz County, September 17th and October 5th for Monterey County sites. Dry Run sampling in San Mateo County was conducted at just one site (Saint Augustine). No other sites were checked due to budgetary constraints. In Santa Cruz County seven sites were sampled: upper Struve Slough, lower Struve Slough, upper Watsonville Slough (2 sites), Watsonville Slough at Ohlone Parkway, Watsonville Slough at Ford Walkway, and lower West Struve Slough. In Monterey County, all thirteen sites were visited, only eight sites had enough flow to be sampled: Twins, San Carlos, Steinbeck, 8th Street, Greenwood Park, Lovers, Sea Palm, and Pico.

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 1:00 pm on Tuesday November 17th, 2020 when twelve San Mateo County sites were monitored by twenty volunteers. The ten Santa Cruz County WWW sites were not monitored on November 17th during the rainstorm because WWW monitors slough sites which take time for urban runoff to reach. WWW sampled the following day on the afternoon of Wednesday November 18th, 2020. Monterey County volunteers mobilized on December 13th, 2020 at 9:45 am when a total of twenty-eight volunteers collected samples at ten outfall sites that had enough flow to meet the mobilization criteria. The remaining three Monterey County sites were later sampled on December 17th at 3:45 am with the help of eight volunteers after enough rain had fallen to sample these remaining sites.

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 (not averages) in Table 3 to provide an understanding of environmental conditions during the two events. First Flush field measurements from San Mateo County data includes measurements for water temperature, conductivity, and pH however, pH was not collected at every site. Santa Cruz County data did not include field measurements. Monterey County data includes field measurements for water


temperature, conductivity, pH and transparency for ten of the thirteen sites, and only water temperature and conductivity for three of the ten sites because samples were collected at night.

Table 3
Range of Field and Lab Results for Dry Run and First Flush 2020.

Parameter	Units	Dry Run	First Flush
Ammonia-N ^{a b}	mg/L	ND – 0.21	0.22 – 1.82
Chloride ^a	mg/L	40 - 78	22 - 368
Color ^b	Color Units	ND - 84	20 - 224
Conductivity ^c	µS	880 - 3500	80 - 1516
Copper- total*	µg/L	ND - 58	ND - 106
<i>Escherichia coli</i> (<i>E. coli</i>)	MPN/ 100 ml	ND – >24,196	200 – 242,000
Enterococcus*	MPN/ 100 ml	ND – 17,329	200 – 242,000
Fluoride ^a	mg/L	0.19 – 0.76	0.058 – 0.43
Hardness ^b	mg/L	227 - 639	ND - 118
Lead- total*	µg/L	ND – 0.90	ND – 33.1
MBAS ^b	mg/L	0.07 – 0.20	0.04 – 1.02
Nitrate as N*	mg-N/L	0.5 – 8.6	ND – 3.1
Nitrite as N ^a	mg/L	<0.2 - <0.4	<0.02 – 0.14
Orthophosphate as P*	mg-P/L	ND – 0.70	ND – 1.32
pH ^c	pH units	7.0 – 8.0	5.65 – 8.02
Phosphorous ^a	mg/L	Not sampled	0.32 – 1.17
Potassium ^b	ag/L	4.4 – 10.8	1.8 – 10.5
Sulfate ^a	mg/L	7.5 – 130.0	<0.2 - 110
Total Kjeldahl Nitrogen ^a	mg/L	0.6 – 10.2	0.6 - 9.8
Total Suspended Solids*	mg/L	ND - 44	ND - 847
Transparency ^b	cm	7.0 - >120	5.1 – 24.0
Turbidity**	NTU	0.4 – 21.0	22.0 – 325.0
Urea***	µg/L	16- 234	85 - 745
Water temperature ^c	°C	12.8 – 14.6	11.5 – 16.2
Zinc- total*	µg/L	ND - 39	ND - 202

ND=non-detect; * reported for San Mateo and Monterey Counties only; ** reported for Santa Cruz and Monterey Counties only; ***reported for Monterey County only. ^a documented for Santa Cruz County only, but not reported below, ^b documented for Monterey County only but not reported below. ^c documented for San Mateo and Monterey Counties only but not reported below.

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. Total copper was only measured in San Mateo and Monterey Counties in 2020. The Water Quality Control Plan for the Central Coast Water Quality Objective (WQO) established for total copper is 30 µg/L. The Dry Run and First Flush total copper Minimum Detection Limit (MDL) was 5 µg/L for San Mateo County samples, unreported for Santa Cruz County samples, and 5 µg/L for the Dry Run and 10 µg/L for the First Flush for Monterey County samples.

For the **Dry Run**, only one site of the nine (11%) monitored for total copper exceeded the WQO for copper. The highest total copper result of 58 µg/L was from Steinbeck (Monterey County) (Figures 6a and b).

During the **First Flush**, eleven of the twenty-five sites (44%) where total copper was sampled exceeded the WQO. The highest average concentration for copper was from 4th Avenue (Monterey County) with a result of 96 µg/L (Figures 6a and b).

Figures 6 a and b display total copper data for San Mateo and Monterey County sites. All sites are listed north to south (right to left). In each 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.

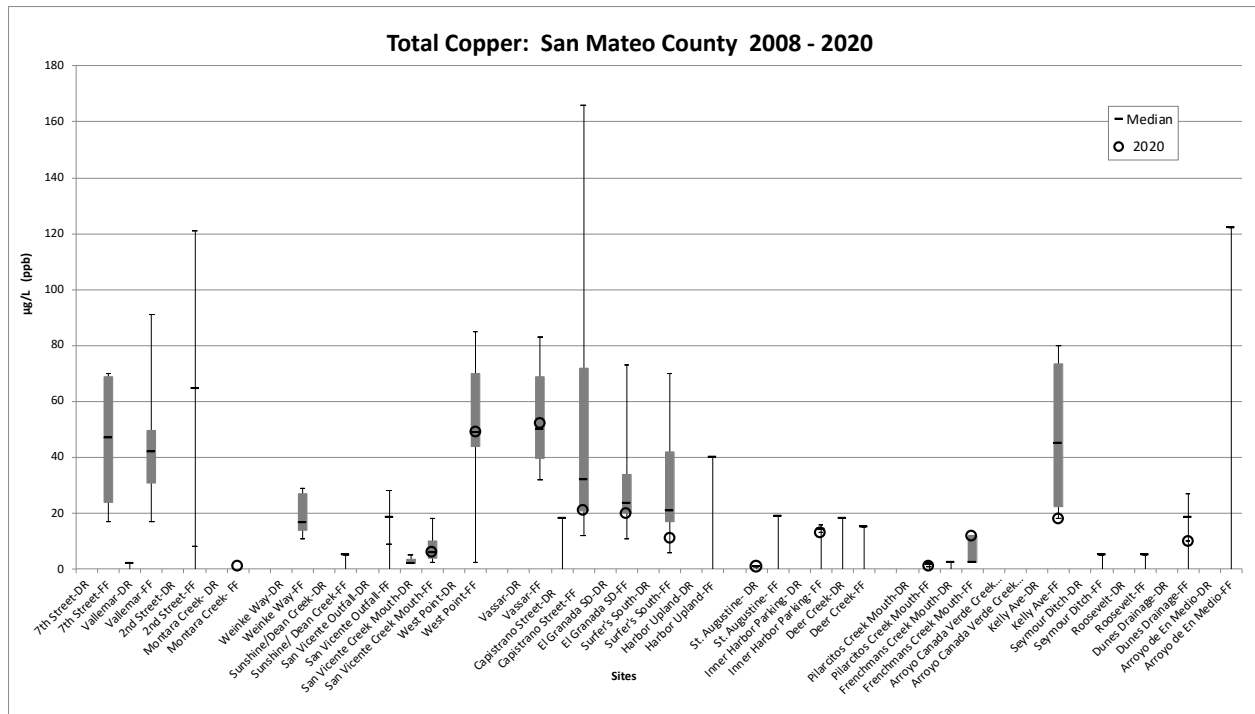


Figure 6a. Single sample results for total copper for the Dry Run (DR) and First Flush (FF) in San Mateo County.

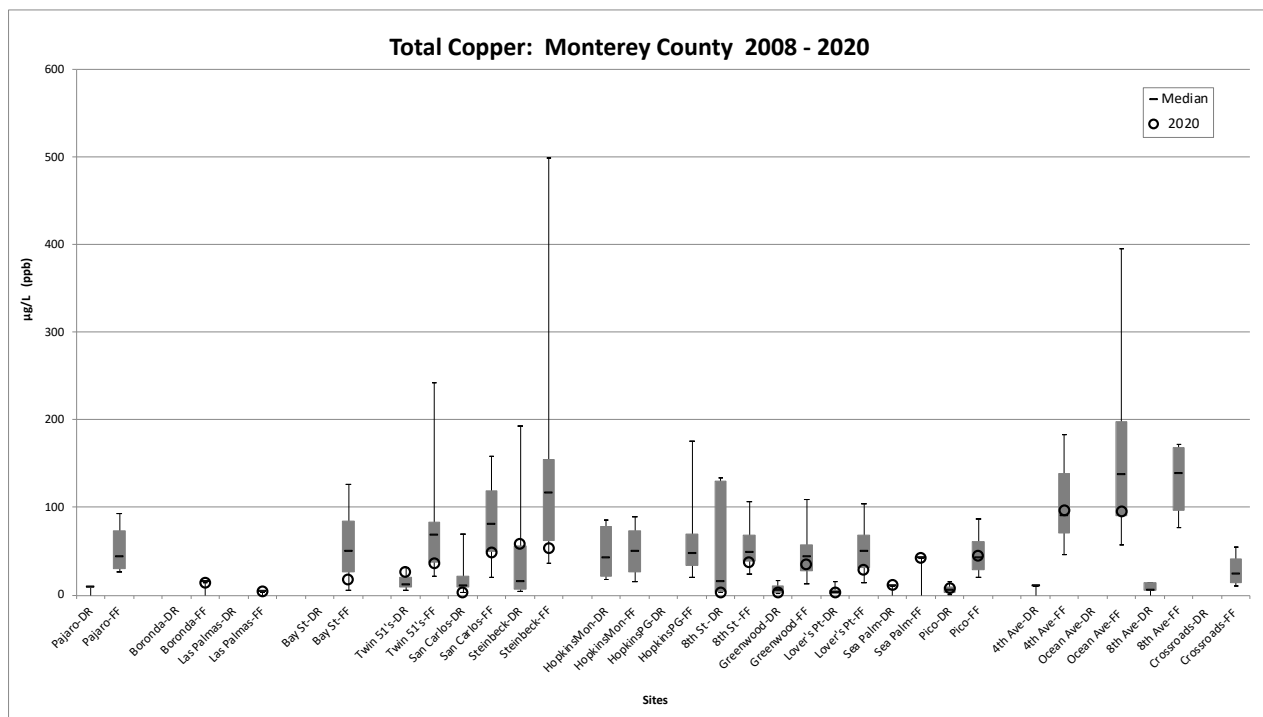


Figure 6b. Single sample results for total copper for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County.

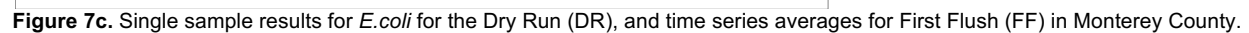
E. coli

Escherichia coli (*E. coli*) is a type of fecal indicator bacteria found in the intestines of warm-blooded animals. *E. coli* 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. *E. coli* was measured in all three counties in 2020. The U.S. Environmental Protection Agency's water quality criterion for grab samples of *E. coli* is 235 MPN/100 ml. The Dry Run and First Flush *E. coli* MDL was 10 MPN/100 ml or 100 MPN/100 ml (depending upon dilution) for San Mateo County samples, 1 MPN/100 ml for Santa Cruz County samples, and 1 MPN/100 ml or 100 MPN/100 ml (depending upon dilution) for Monterey County samples.

For the **Dry Run**, ten of the sixteen sites (63%) monitored for *E. coli* exceeded the WQO. The highest *E. coli* concentration of >24,196 MPN/100 ml was from Greenwood Park (Monterey County) (Figures 7 a, b and c).

During the **First Flush**, thirty-four of the thirty-five sites (97%) monitored for *E. coli* exceeded the WQO. The highest average *E. coli* concentration of 242,000 MPN/100ml was from 8th Street (Monterey County) (Figures 7 a, b and c). 8th Street (Monterey County) is within Pacific Grove's diversion system boundary. Wet weather flow from this outfall indicates that either the flow capacity exceeded the diversion system, or debris blocked the diversion conveyance system allowing water to bypass the diversion.

Figures 7 a, b and c display *E. coli* data for San Mateo, Santa Cruz and Monterey County sites. All sites are listed north to south (right to left). Sample results of >X are given that numerical value (X) despite a higher actual result. In each 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.



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. As with *E. coli*, enterococci don't necessarily cause disease in humans, but their presence indicates the potential for other human specific pathogens to be present. Enterococcus was measured in San Mateo and Monterey Counties in 2020. The U.S. Environmental Protection Agency water quality criterion for grab samples of enterococcus is 104 MPN/100 ml. The Dry Run and First Flush enterococcus MDL was 10 MPN/ 100 ml or 100 MPN/ 100 ml (depending upon dilution) for San Mateo County samples, and 1 MPN/100ml or 100 MPN/100ml (depending upon dilution) for Monterey County samples.

For the **Dry Run**, seven of the nine sites (78%) monitored for enterococcus exceeded the WQO. The highest enterococcus concentration of 17,329 MPN/100 ml was from Greenwood (Monterey County) (Figures 8a and 8b), this site is diverted to the sanitary sewer downstream of the collection site.

During the **First Flush**, all of the twenty-five sites (100%) monitored for enterococcus exceeded the WQO. The highest average concentration of 185,959 MPN/100ml was from Pico (Monterey County) (Figures 8a and 8b).

Figures 8a and 8b display enterococcus data for San Mateo and Monterey County sites. All sites are listed north to south (right to left). Sample results of >X are given that numerical value (X) despite a higher actual result. In each 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.

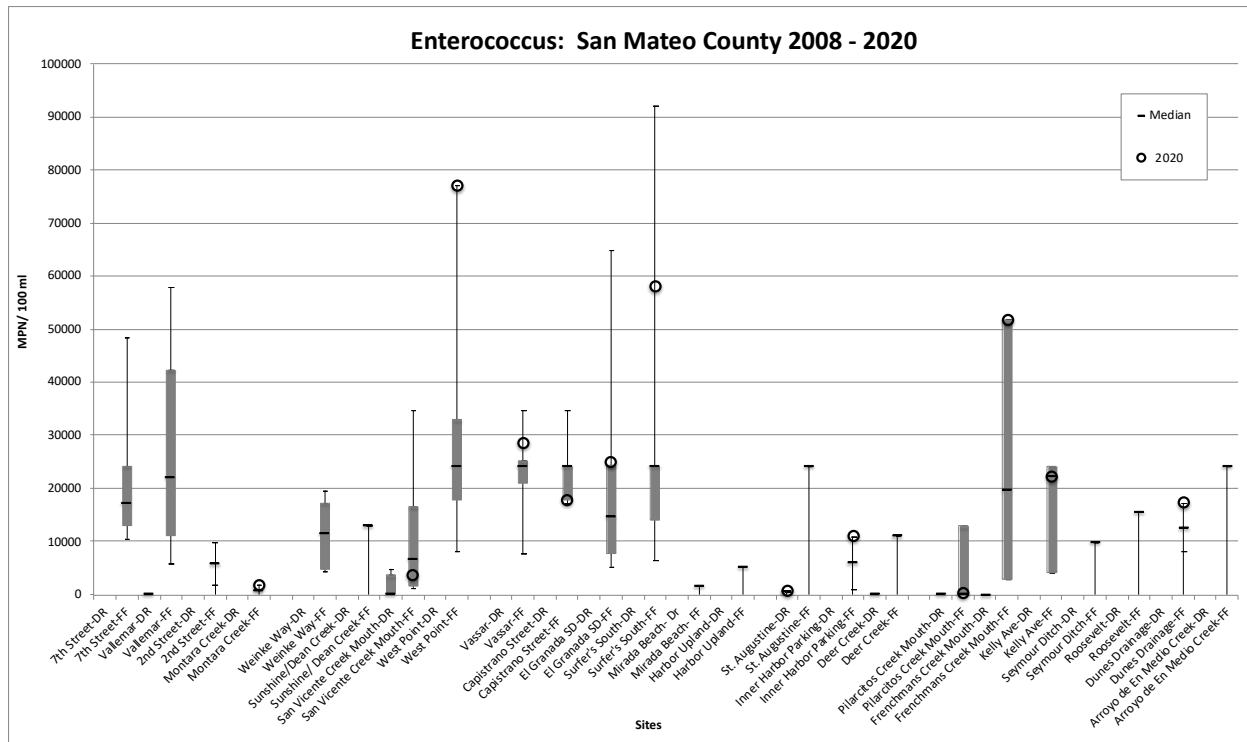


Figure 8a. Single sample results for enterococcus for the Dry Run (DR) and First Flush (FF) in San Mateo County.

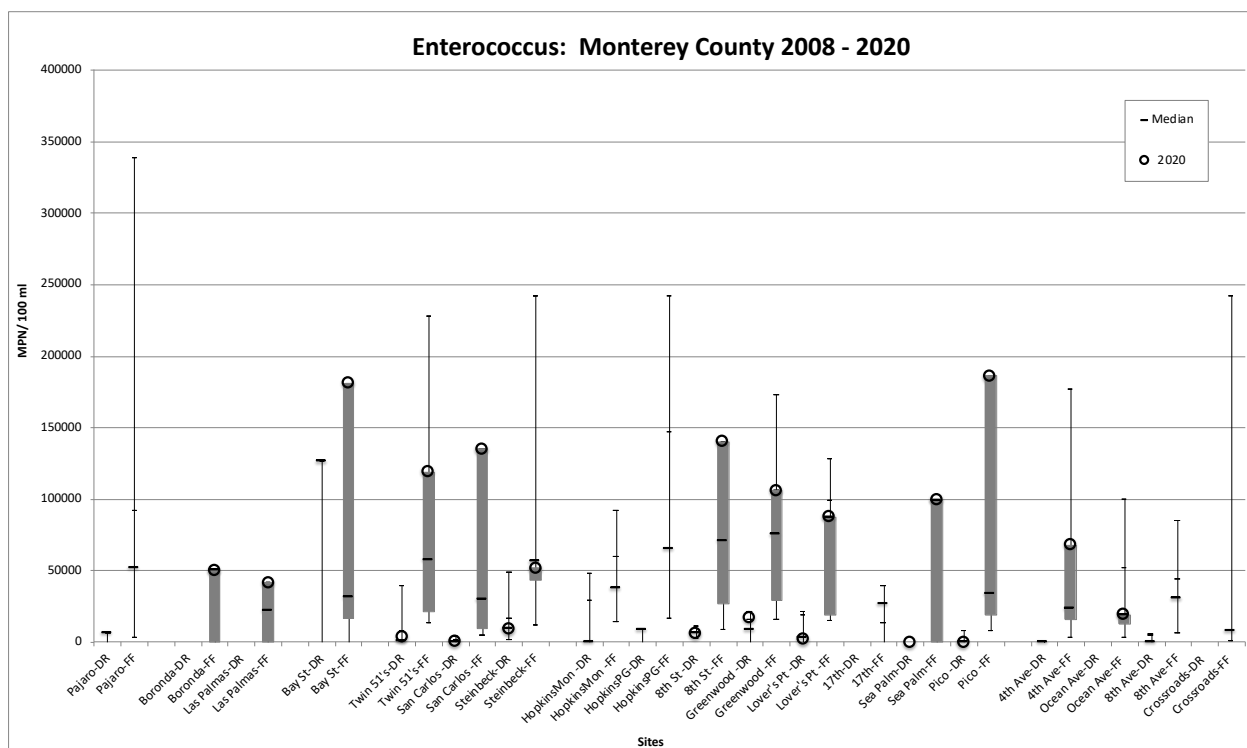


Figure 8b. Single sample results for enterococcus for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County.



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. Lead was only measured in San Mateo and Monterey Counties in 2020. The Water Quality Control Plan for the Central Coast WQO for total lead is 30 µg/L. The Dry Run and First Flush total lead MDL was 0.1 µg/L for both San Mateo County and Monterey County samples.

For the **Dry Run**, no sites exceeded the WQO for total lead (Figures 9a and 9b).

For the **First Flush**, just one site out of twenty-five sites (4%) monitored for total lead exceeded the WQO. The highest result for total lead of 33.1 µg/L was from Vassar Avenue (San Mateo County) (Figures 9a and 9b).

Figures 9a and 9b display lead data for San Mateo and Monterey County sites. All sites are listed north to south (right to left). For each 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.

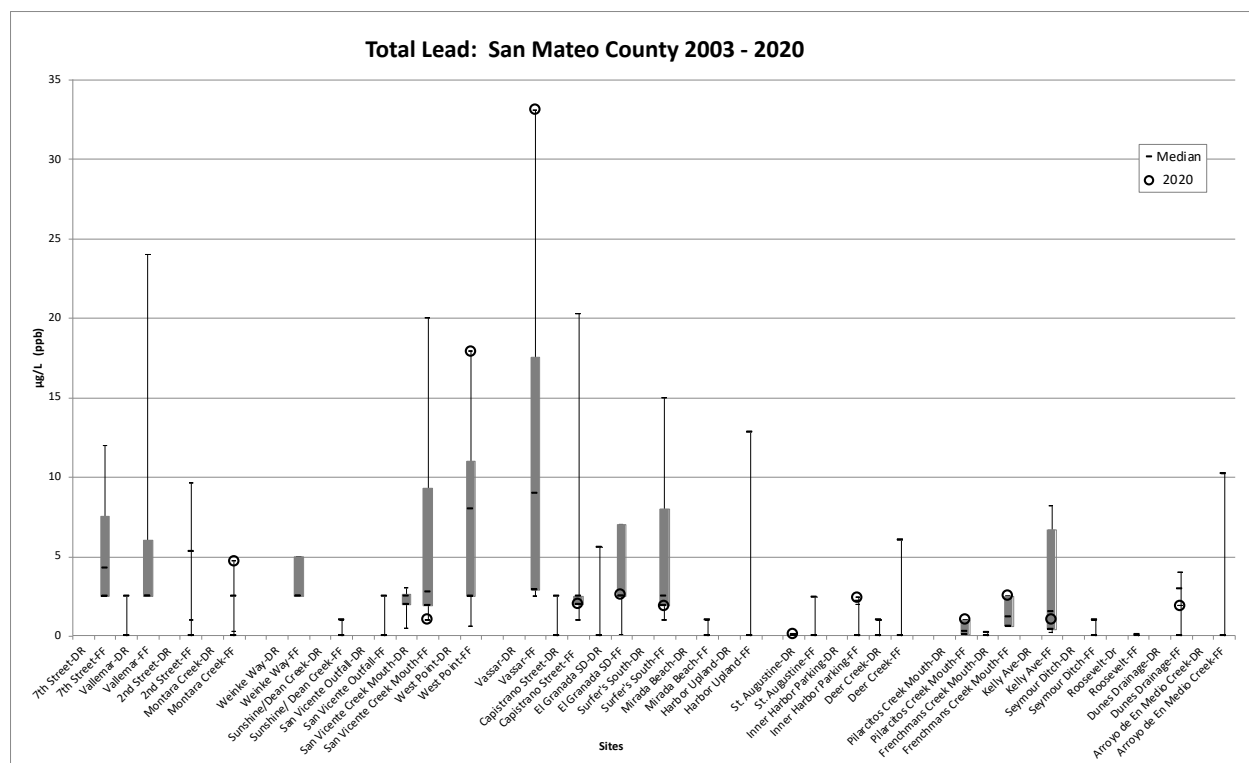


Figure 9a. Single sample results for total lead for the Dry Run (DR) and First Flush (FF) in San Mateo County.

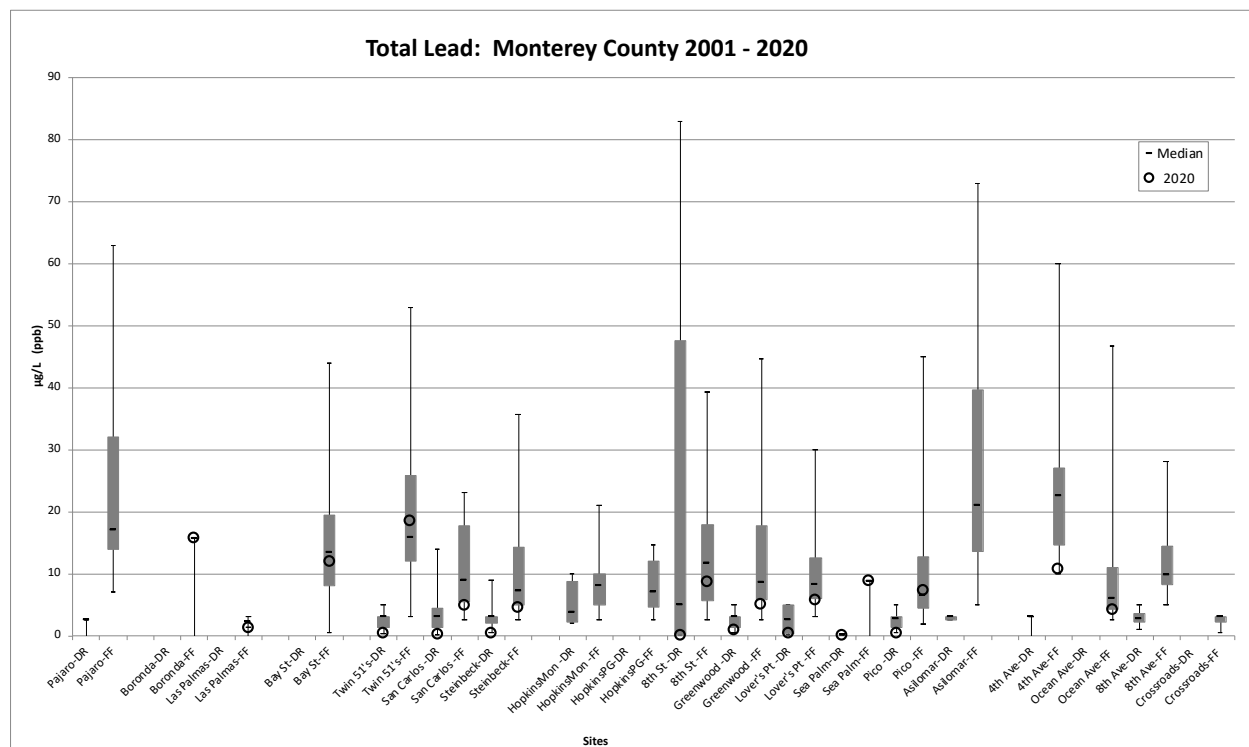


Figure 9b. Single sample results for total lead for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County.

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, bacteria consume oxygen in the decomposition or decay process. Nitrate sources include runoff from fertilized landscaping, agricultural and pasture lands, construction sites, as well as failing septic or sewer systems. Nitrate was measured in all three counties in 2020. The CCAMP Action Level for nitrate as N ($\text{NO}_3\text{-N}$) is 2.25 mg-N/L. The Dry Run and First Flush nitrate as N MDL was 0.04 mg-N/L for San Mateo County samples, 0.02 mg-N/L for Santa Cruz County samples, and 0.01 mg-N/L for in Monterey County samples.

For the **Dry Run**, two of the sixteen sites (13%) monitored for nitrate as N exceeded the Action Level. The highest result of 8.6 mg-N/L was from Lovers (Monterey County) (Figures 10a, b and c). Dry weather flows from Lovers (Monterey County) were de minimus due to active flow diversion.

During the **First Flush**, just one of the thirty-five sites (3%) monitored for nitrate as N had concentrations that exceeded the Action Level. The highest result of 3.1 mg-N/L was from Montara Creek (San Mateo County) (Figures 10a, b and c).

Figures 10a, b and c display nitrate as N data for San Mateo, Santa Cruz and Monterey County sites. All sites are listed north to south (right to left). For each 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.

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 begin to decompose, bacteria 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. Orthophosphate was measured in all three counties in 2020. The CCAMP Action Level for orthophosphate as P ($\text{PO}_4\text{-P}$) is 0.12 mg-P/L. The Dry Run and First Flush orthophosphate as P MDL was 0.08 mg-P/L for San Mateo County samples, 0.02 mg-P/L for Santa Cruz County samples, and 0.02 mg-P/L for Monterey County samples.

For the **Dry Run**, seven of the sixteen sites (44%) monitored for orthophosphate as P exceeded the Action Level. The highest result for orthophosphate as P of 0.70 mg-P/L was from Steinbeck (Monterey County) (Figures 11a, b and c).

During the **First Flush**, twenty-nine of the thirty-five sites (83%) monitored for orthophosphate as P exceeded the Action Level. The highest concentration of 1.32 mg-P/L was from Montara Creek (San Mateo County) (Figures 11a, b and c).

Figures 11a, b and c display orthophosphate as P data for San Mateo, Santa Cruz and Monterey County sites. All sites are listed north to south (right to left). For each 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.

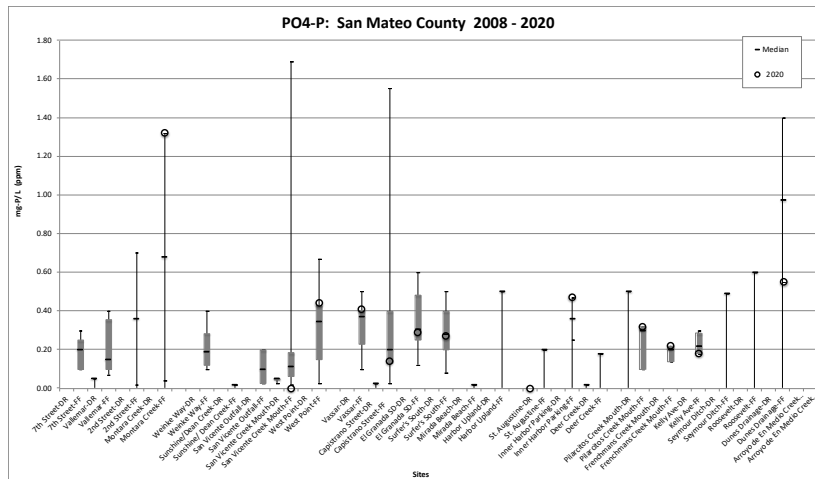


Figure 11a. Single sample results for orthophosphate as P for the Dry Run (DR) and First Flush (FF) in San Mateo County.

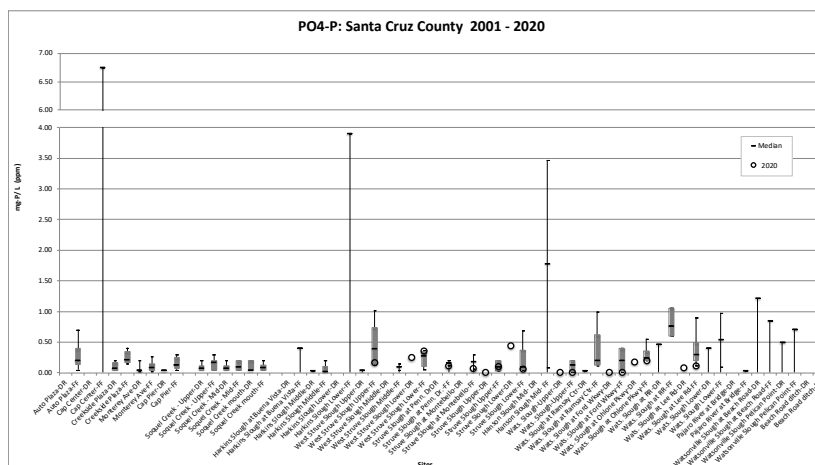


Figure 11b. Single sample results for orthophosphate as P for the First Flush (FF) in Santa Cruz County.

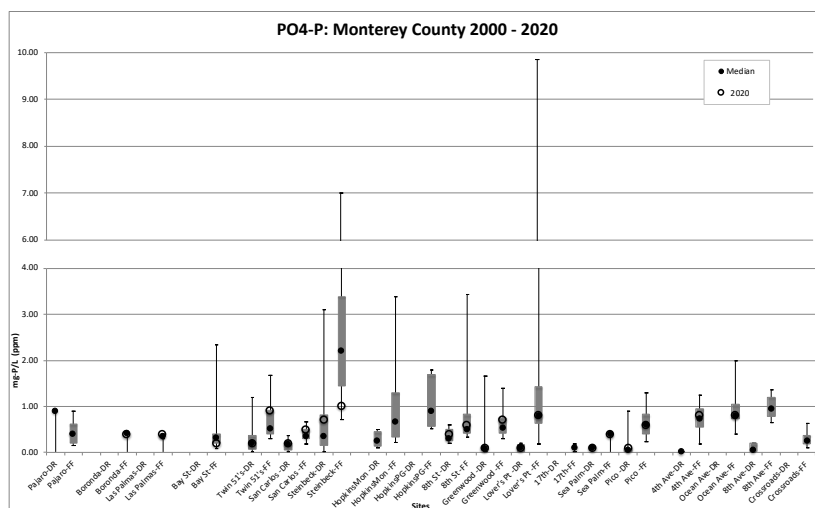


Figure 11c. Single sample results for orthophosphate as P for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County.



Total Suspended Solids

Total suspended solids (TSS) 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 may smother fish eggs and benthic organisms or when suspended 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. Total suspended solids was only measured in San Mateo and Monterey Counties in 2020. The CCAMP Action Level for total suspended solids is 500 mg/L. The Dry Run and First Flush total suspended solids MDL was 2 mg/L for both San Mateo County and Monterey County samples.

For the **Dry Run**, none of the nine sites (0%) monitored for total suspended solids exceeded the Action Level (Figures 12a and 12b).

For the **First Flush**, just two of the twenty-five sites (8%) monitored for total suspended solids exceeded the Action Level. The highest result was from Dunes Drainage (San Mateo County) with a result of 847 mg/L (Figures 12a and 12b).

Figures 12a and 12b display total suspended solids data for San Mateo and Monterey County sites. All sites are listed north to south (right to left). For each 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.

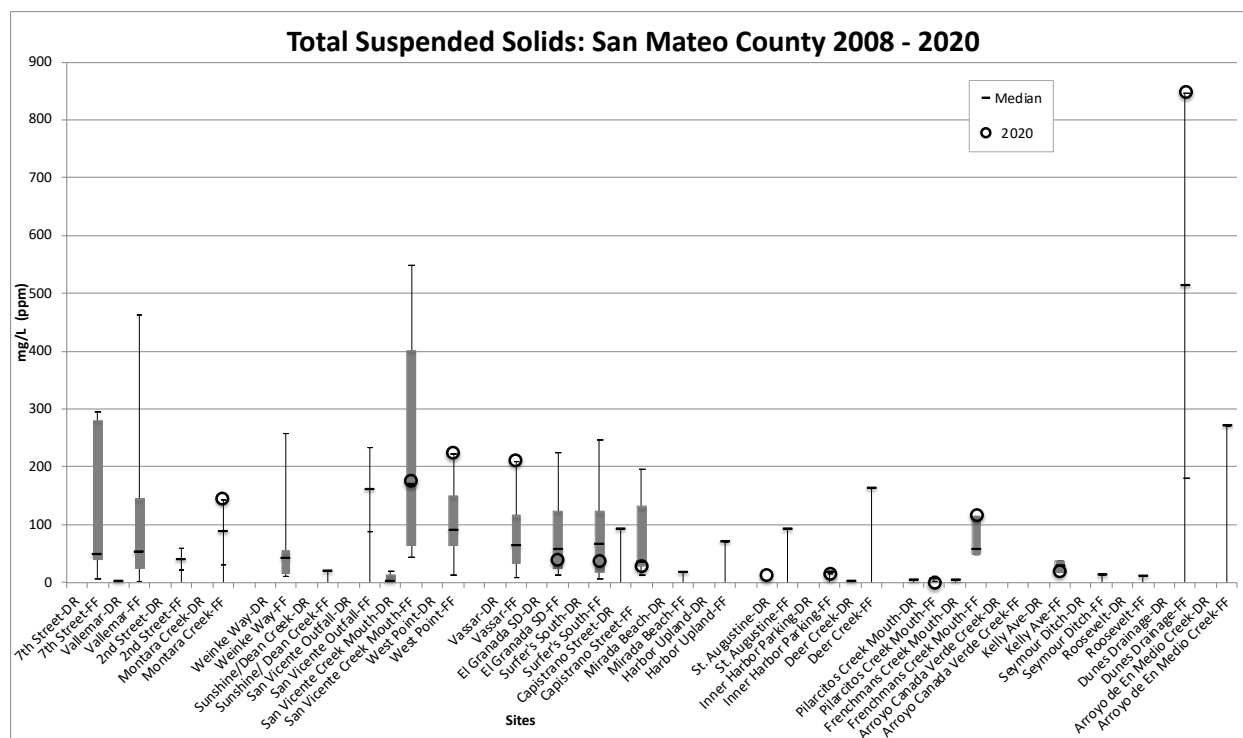


Figure 12a. Single sample results for total suspended solids for the Dry Run (DR) and First Flush (FF) in San Mateo County.

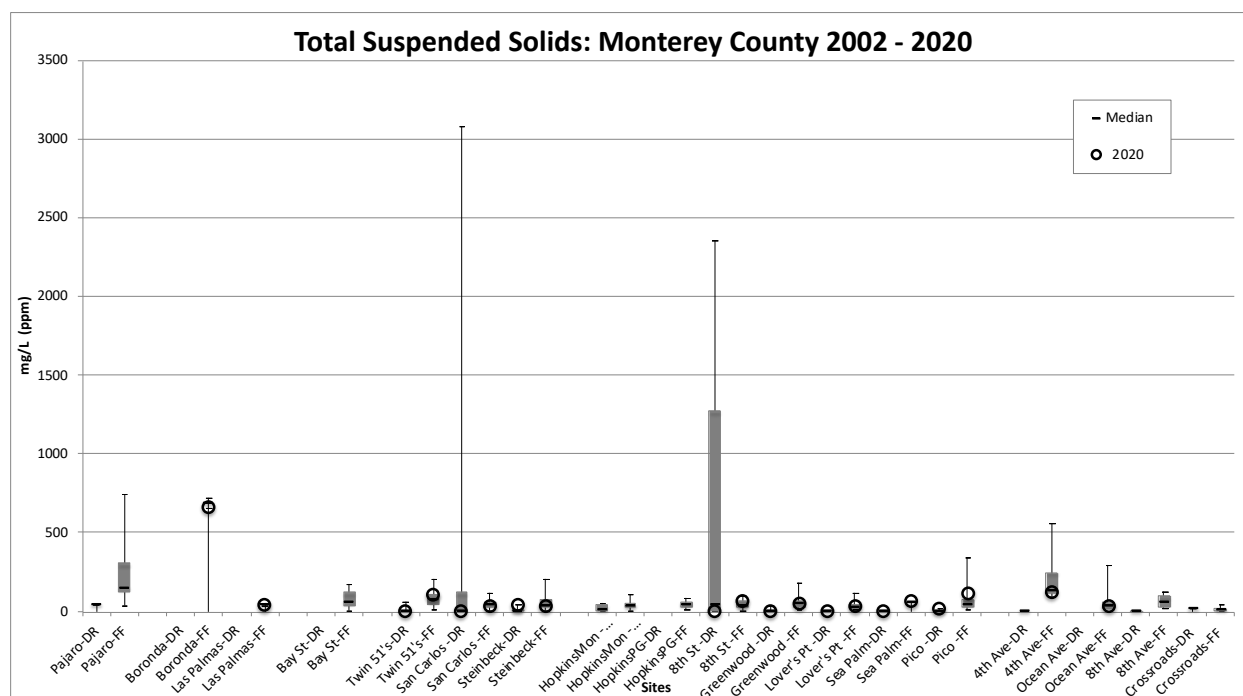


Figure 12b. Single sample results for total suspended solids for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County.



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. Turbidity was only measured in Santa Cruz and Monterey Counties in 2020. CCAMP's Action Level for turbidity is not greater than 25 Nephelometric Turbidity Units (NTU's). The Dry Run and First Flush turbidity MDL was 0.05 NTU for Monterey and Santa Cruz County samples.

For the **Dry Run**, only five of the fifteen sites (30%) monitored for turbidity exceeded the Action. The highest result of 120.0 NTU was from lower West Struve Slough (Santa Cruz County) (Figure 13a and 13b).

During the **First Flush**, seventeen of the twenty-three sites (74%) monitored for turbidity exceeded the Action Level. The highest turbidity measurement of 325 NTU was from Boronda (Monterey County) (Figure 13a and 13b).

Figures 13a and 13b display turbidity data for Santa Cruz and Monterey County sites. All sites are listed north to south (right to left). For each 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.

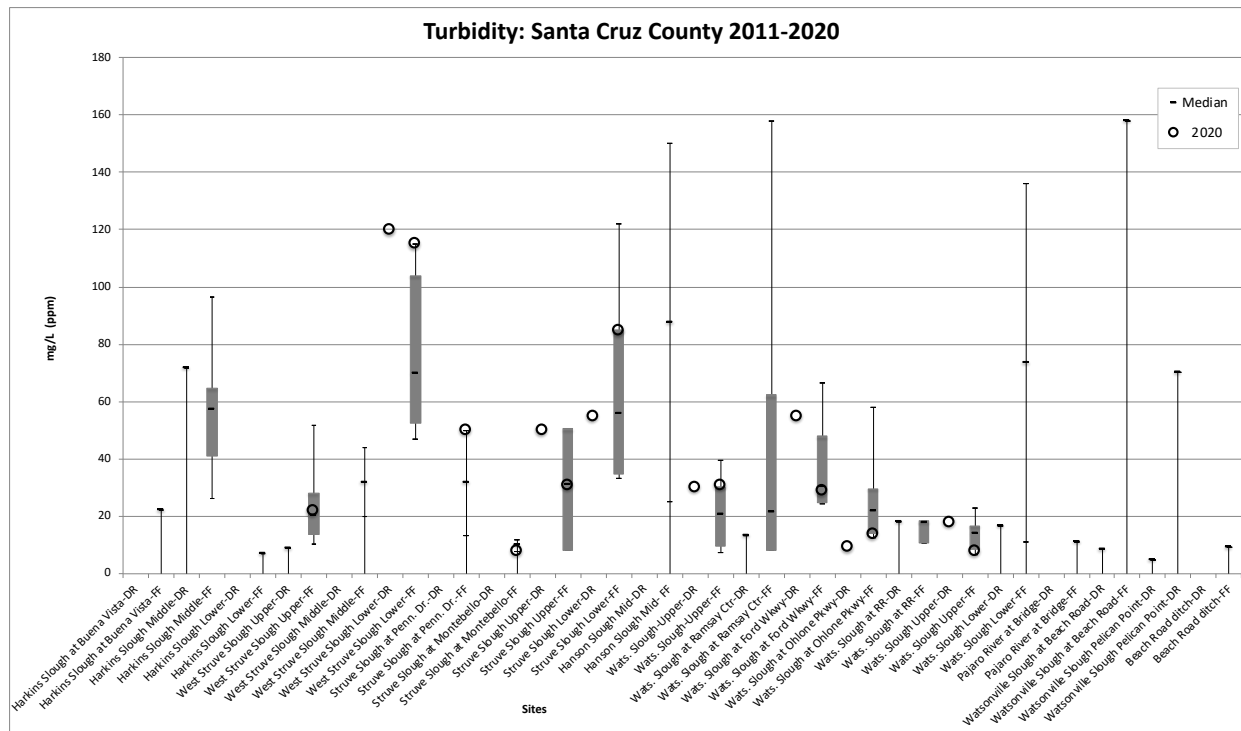


Figure 13a. Single sample results for turbidity for the Dry Run (DR) and First Flush (FF) in Santa Cruz County.

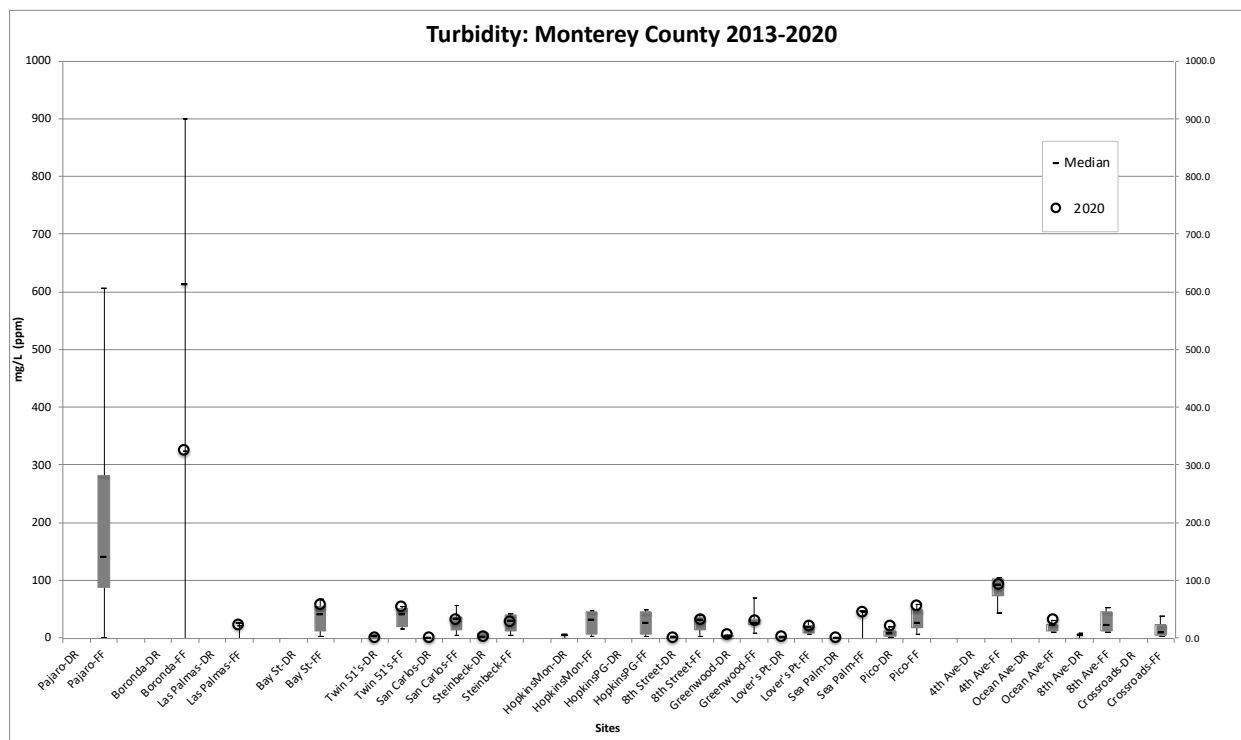


Figure 13b. Single sample results for turbidity for the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County.



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. Urea was only measured in Monterey County in 2020. There is no Action Level or Water Quality Objective for urea. The Dry Run and First Flush urea MDL was 8 µg/L.

For the **Dry Run**, the highest result of 234 µg/L was from 8th Street (Monterey County) (Figure 14a). 8th Street (Monterey County) is within Pacific Grove's diversion system boundary. Dry weather flows from this outfall indicate that debris blocked the diversion conveyance system and allowed some water to bypass the diversion.

During the **First Flush**, urea was only measured during the first time series at all Monterey County sites. The highest result of 745 µg/L was from Steinbeck (Monterey County) (Figure 14a).

Figure 14a displays urea data for Monterey County sites. All sites are listed north to south (right to left). Non-detects were given the value of half the Minimum Detection Limit (MDL) but their true value lies between the zero and the MDL.

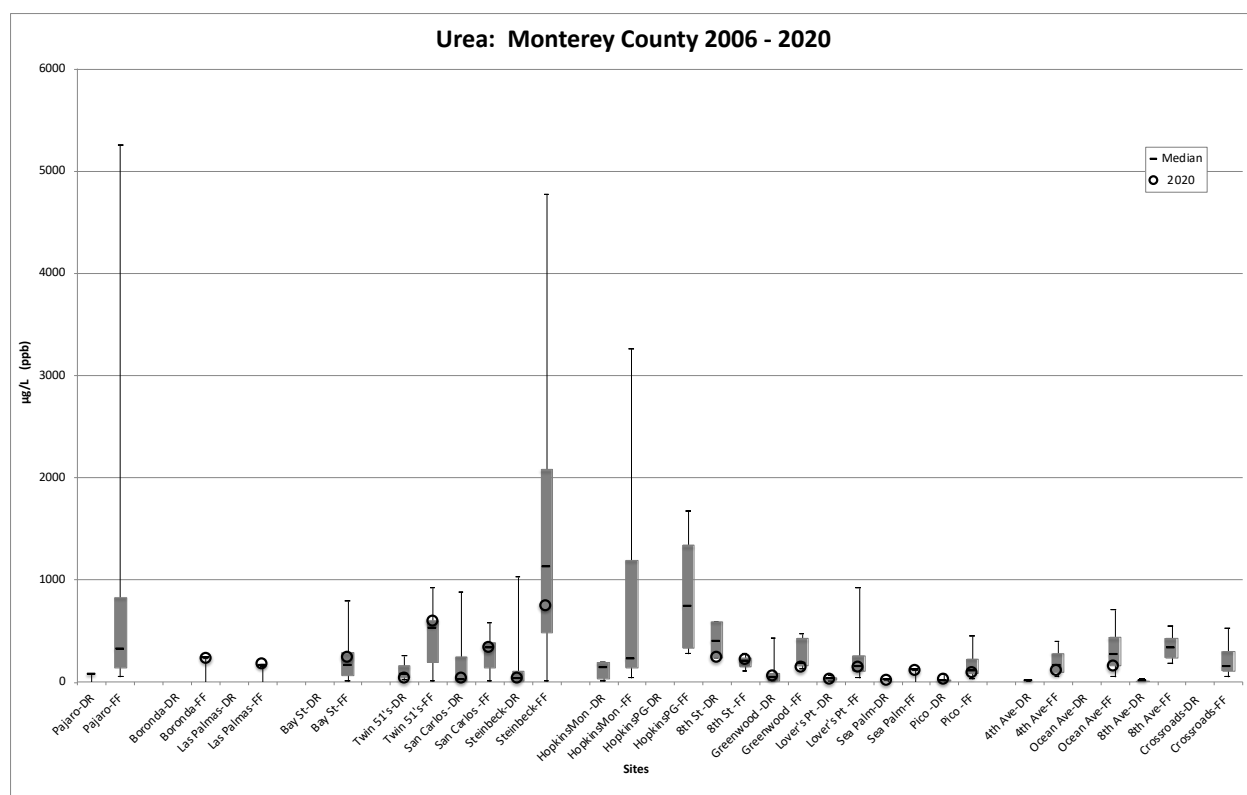


Figure 14a. Single sample results for urea for the Dry Run (DR) and First Flush (FF) in Monterey County.

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 $<200 \mu\text{g/L}$. The Dry Run and the First Flush total zinc MDL was $10 \mu\text{g/L}$ for San Mateo and Monterey County samples.

For the **Dry Run**, total zinc concentrations did not exceed the WQO at any of the sites where total zinc was monitored (Figures 15a and 15b).

For the **First Flush**, just one of the twenty-five sites (4%) monitored for total zinc exceeded the WQO. The highest result of $202 \mu\text{g/L}$ was from Vassar (San Mateo County) (Figures 15a and 15b).

Figures 15a and 15b display total zinc data for San Mateo and Monterey County sites. All sites are listed north to south (right to left). For each 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.

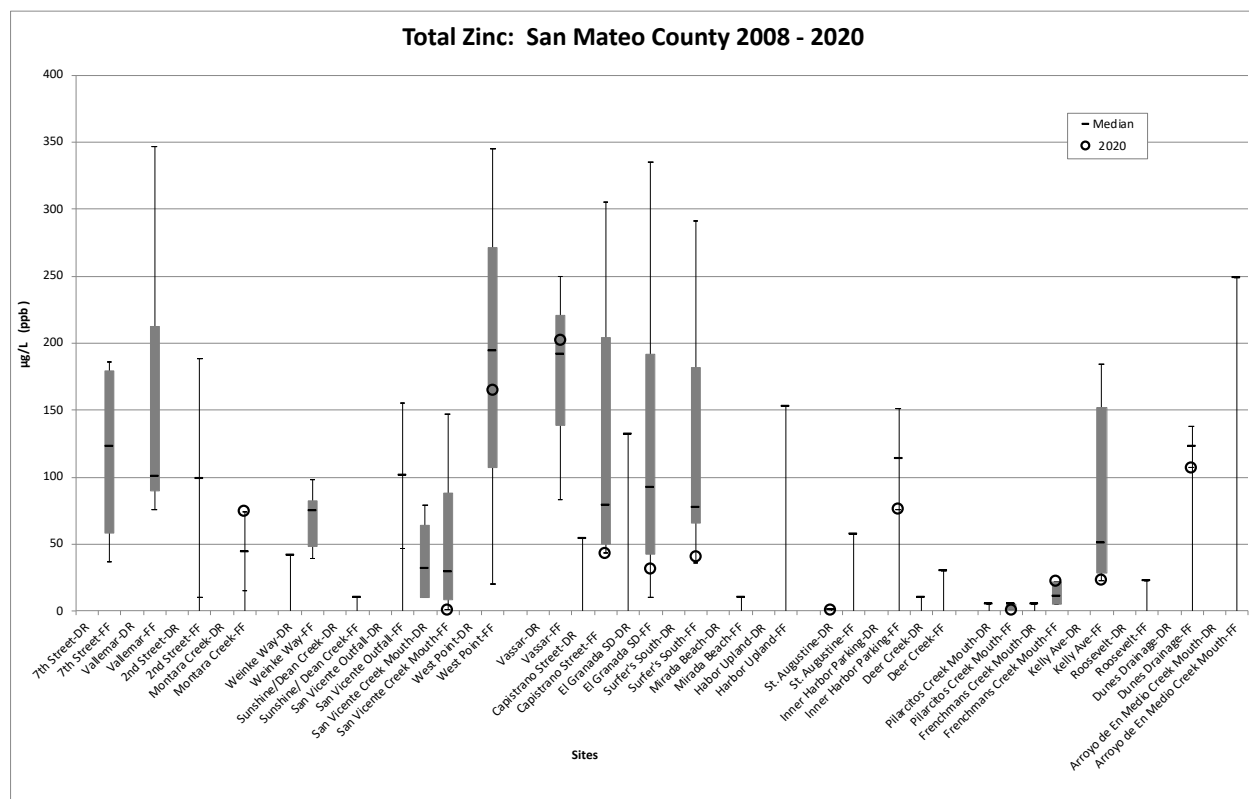


Figure 15a. Single sample results for total zinc for the Dry Run (DR) and First Flush (FF) in San Mateo County.

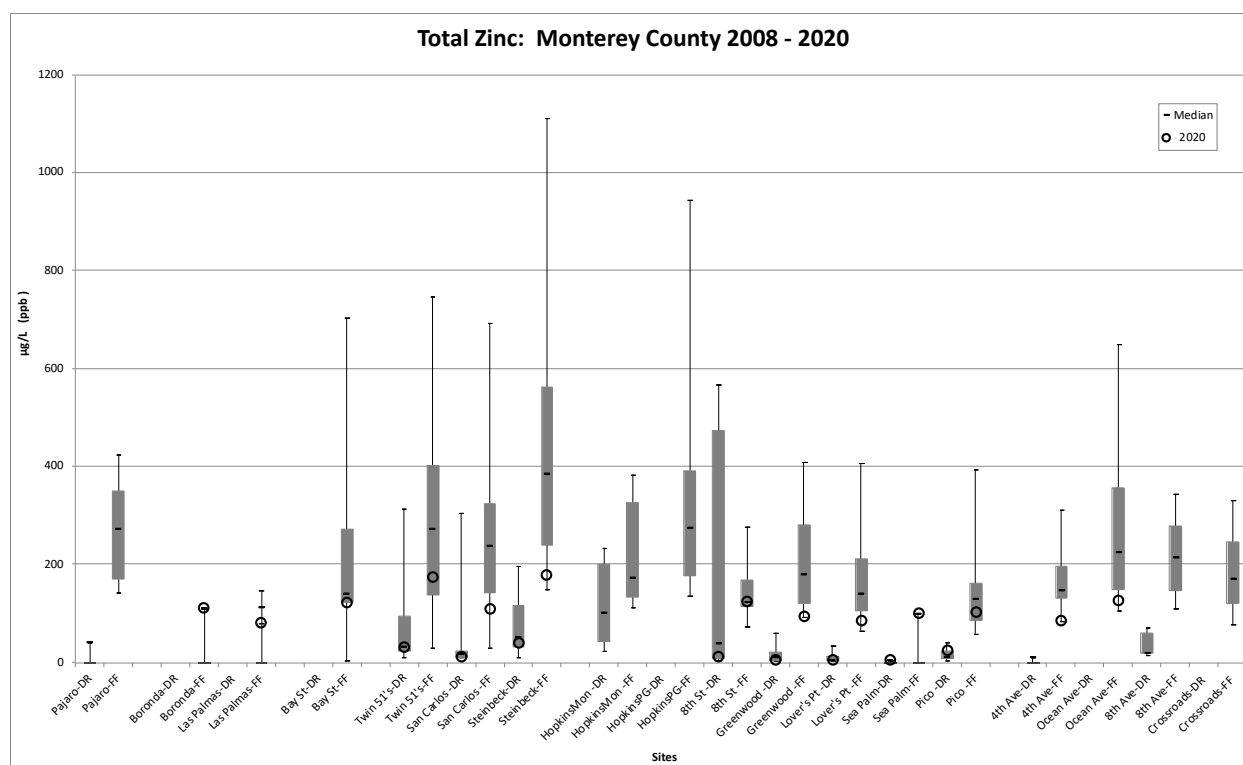


Figure 15b. Single sample results for total zinc or the Dry Run (DR), and time series averages for First Flush (FF) in Monterey County.

Conclusion

For the past twenty-one years, the Dry Run and First Flush have provided central California coastal area residents, municipal staff, and resource managers with valuable information about the quality of water flowing 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 wet weather flushing event when the most polluted water is expected to flow from the land into the ocean and Monterey Bay National Marine Sanctuary.


The 2020 **Dry Run** was conducted in three coastal central California counties: San Mateo, Santa Cruz and Monterey. Highlights from the 2020 Dry Run:

- Copper concentrations exceeded the WQO in one sample from a Monterey County site (Steinbeck). Copper concentrations did not exceed the WQO in the sample from the single San Mateo County site. Copper was not measured in Santa Cruz County.
- *E. coli* results exceeded the WQO in 75% of samples from Monterey County sites and 57% of samples from Santa Cruz County sites, but did not exceed the WQO in the sample from the single Santa Mateo County site.
- Enterococcus results exceeded the WQO in 75% of samples from Monterey Counties sites and at the single San Mateo County site. Enterococcus was not measured in Santa Cruz County.

- Lead concentrations did not exceed the WQO in any samples from San Mateo or Monterey County sites. Lead was not measured in Santa Cruz County.
- Nitrate as N concentrations exceeded the WQO in 25% of samples from Monterey County sites, but did not exceed the Action Level in any sample from San Mateo or Santa Cruz County sites.
- Orthophosphate as P concentrations exceeded the Action Level in 47% of samples from Santa Cruz County sites and 50% of samples from Monterey County sites, but did not exceed the Action Level in the sample from the San Mateo County site.
- Total suspended solids concentrations did not exceed the Action Level in any samples from San Mateo or Monterey County sites. Total suspended solids was not measured in Santa Cruz County.
- Turbidity concentrations exceeded the Action Level in 86% of samples from Santa Cruz County sites, but did not exceed the Action Level in any sample from any site in Monterey County. Turbidity was not measured in San Mateo County.
- Zinc concentrations exceeded the WQO in one sample from a Monterey County site (Steinbeck), but did not exceed the WQO in the single sample from the San Mateo County site.

The 2020 **First Flush** was conducted in three coastal central California counties: San Mateo, Santa Cruz and Monterey. Highlights from the 2020 First Flush:

- Copper concentrations exceeded the Action Level in 17% of samples from San Mateo County sites, and in 69% of sample averages for Monterey County sites. Copper was not measured in Santa Cruz County.
- *E. coli* results exceeded the WQO in 92% of samples from San Mateo County sites. Santa Cruz County sites exceeded the WQO in 100% of samples and Monterey County sites exceeded the WQO in 100% of sample averages.
- Enterococcus results exceeded the WQO in 100% of San Mateo County samples and 100% of sample averages for Monterey County sites. Enterococcus was not measured in Santa Cruz County.
- Lead concentrations exceeded the WQO at one San Mateo County site (Vassar Avenue.) None of the sample averages from Monterey County sites exceeded the WQO. Lead was not measured in Santa Cruz County.
- Nitrate as N concentrations exceeded the Action Level in the sample from just one site in San Mateo County (Montara Creek). None of the samples from Santa Cruz County sites or sample averages from Monterey County sites exceeded the Action Level.
- Orthophosphate as P concentrations exceeded the Action Level in 92% of samples from San Mateo County sites, 20% of samples from Santa Cruz County sites, and 100% of sample averages from Monterey County sites.

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- Total suspended solids concentrations exceeded the Action Level in a sample at one site in San Mateo County (Dunes Drainage), and in the sample average for one site in Monterey County (Boronda). Total suspended solids were not measured in Santa Cruz County.
 - Turbidity concentrations exceeded the Action Level for 60% of samples from Santa Cruz County sites and 85% of sample averages from Monterey County sites. Turbidity was not measured in San Mateo County.
 - Zinc concentrations exceeded the WQO in a sample from one site in San Mateo County (Vassar Avenue). None of the sample averages for any site in Monterey County exceeded the WQO. Zinc was not measured in Santa Cruz County.

Data from First Flush aids in our understanding of *our* pollutants of concern over a very large area while identifying where concentrations are highest. This report can inform the placement of 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 a prioritization of problem watersheds can be accomplished. Local cities have used First Flush information and addressed high 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 scale more water quality improvements may be achieved.









