



**Monterey Bay Sanctuary Citizen Watershed Monitoring Network**  
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# First Flush

## 2008 Monitoring Report

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## **Introduction**

Pollutants are common in the environment due to our everyday activities, be it driving to work, gardening, walking the dog or making improvements to the exterior of our houses. During the dry weather months in the Monterey Bay area pollutants collect on our roadways, sidewalks, in our yards, parks and beaches. Once the winter rain begins to fall these pollutants are swept along with rain water into nearby creeks, storm drains and eventually into the ocean. The first rain storms pick up a whole summer's worth of pollutants that if measured can give an indication of pollution sources and pollution loads going into the ocean. The Monterey Bay National Marine Sanctuary (MBNMS), the Coastal Watershed Council (CWC) and the San Mateo Resource Conservation District (SMRCD) teamed up with volunteers to monitor dry weather flows and the water flowing into the ocean from the first major rain storm in two events called the Dry Run and First Flush.

Volunteer programs monitoring water quality have become a useful tool for local jurisdictions to meet their Environmental Protection Agency (EPA) National Pollution Discharge and Elimination System (NPDES) permit requirements. Volunteers assist municipalities thereby increasing manpower and monitoring abilities especially during discrete and time sensitive events such as the first rains of a winter storm season. Since 2000 the First Flush program has utilized volunteers from San Mateo, Santa Cruz and Monterey Counties to collect water samples and conduct water quality assessments during the first significant rain event of the season. Volunteers are trained to perform basic field water quality sampling tests: water temperature, pH, electrical conductivity, and transparency measurements; as well as how to collect water samples for lab analysis of nutrients (nitrate, orthophosphate, urea), bacteria (*Escherichia coli* and enterococcus), metals (copper, lead and zinc), hardness, and total suspended solids.

Programs such as the Dry Run and First Flush are important for their monitoring data, but also educate, inspire and create environmental stewards. Without volunteers these programs would not happen to the extent that they do or with the impact that they have.

## **Methods**

Prior to the First Flush, volunteers are trained in monitoring techniques including how to use a conductivity meter, pH strips, transparency tube, thermometers and how to collect water samples for lab analysis. During this training volunteers go out and perform field tests and collect water samples at the same sites used for First Flush, this is the Dry Run. The Dry Run is intended to be a comparison between the dry weather flows and the flows from the first major rainstorm of the season. For many sites Dry Run results can be much higher than those for First Flush since pollutants can become extremely concentrated during dry weather months. Volunteers in San Mateo County received training and collected Dry Run samples on September 13<sup>th</sup>, volunteers in Santa Cruz County and Monterey County received training and collected Dry Run samples on September 20<sup>th</sup>, 2008. The same equipment and protocols are used for both the Dry Run and First Flush however, during the Dry Run only one sample is collected as compared to three time series samples for First Flush. All Dry Run results (and San Mateo First Flush samples) are from a single sample while all First Flush results are three time series samples averaged together.

Seven new sites were added to the Dry Run and First Flush in 2008. In Monterey County, north of Half Moon Bay, new sites for 2008 were: Wienke Way, San Vicente Creek, San Vicente Outfall, West Point, 7<sup>th</sup> Street, and Vallemar. In Monterey County one new site was added at an outfall discharging into the Pajaro River (see Figure 1).

# First Flush Sites 2008

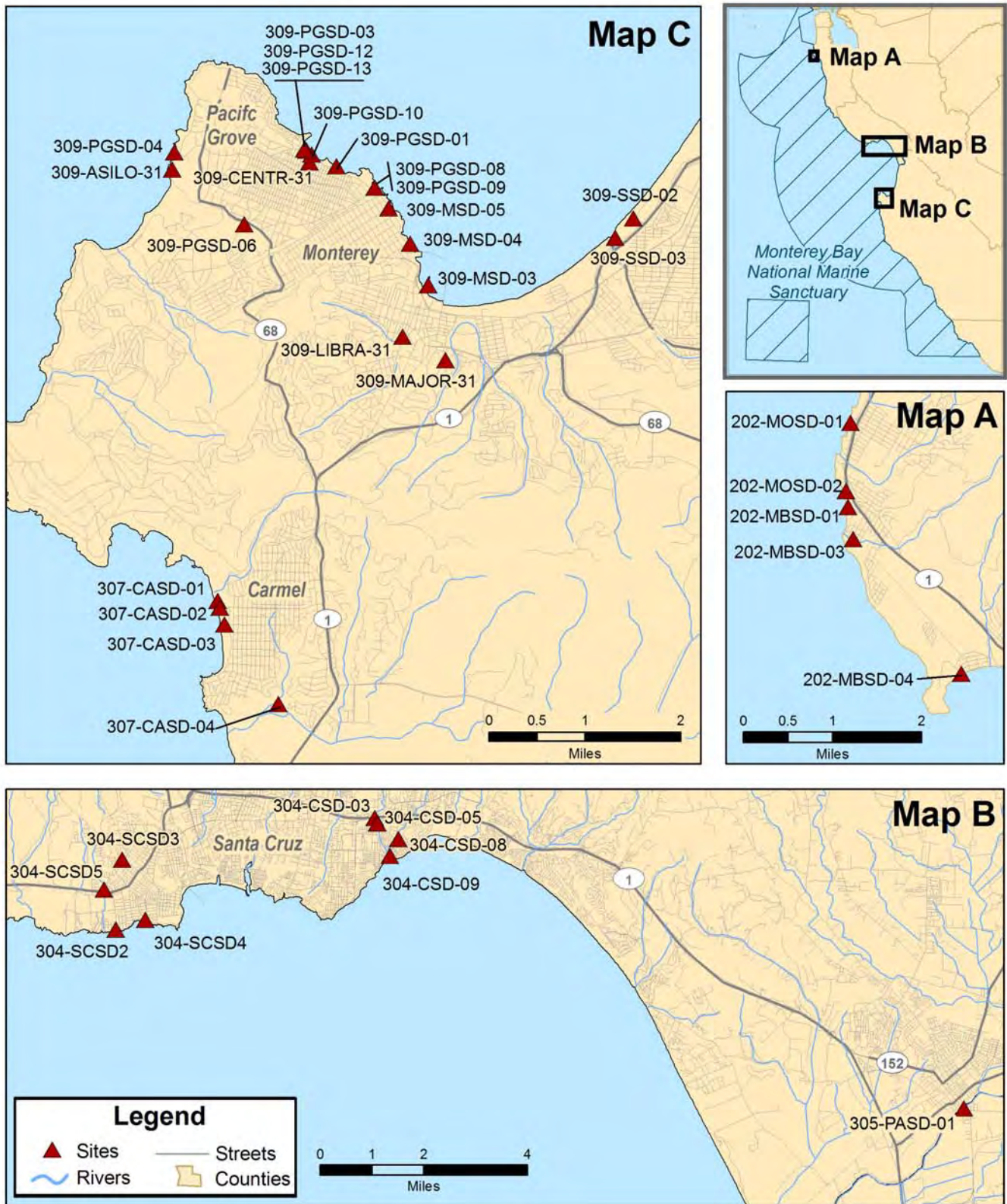


Figure 1. 2008 Dry Run and First Flush sites

Leading up to the First Flush event, the coordinators from the SMRCD, CWC and MBNMS closely monitored the weather, notifying volunteers of approaching storms. When a storm had the potential to generate enough rainfall for First Flush mobilization, the coordinators placed the volunteers on standby until particular criteria were met. Mobilization criteria includes sheeting water on roadways, heavy flow through the storm drain system and conductivity levels less than 1000 micro Siemens ( $\mu\text{S}$ ) and declining. Since conductivity measures the amount of salts in the water, low conductivity measurements indicate rainfall runoff as opposed to typical dry weather runoff. The First Flush event includes a time series collection of water and field measurements conducted at 30-minute intervals for a total of three sets of data and water samples, usually during the rising limb of the rainfall hydrograph in order to capture the heaviest pollution load and highest concentrations.

Conductivity was measured using either an Oakton EC Tester 3 or 4; water temperature was measured using a spirit bulb or digital thermometer; pH was measured using Macherey-Nagel non-bleeding pH strips. Physical observations such as trash, odor, bubbles, scum, and oil sheen were also recorded on the data sheet. Bottles were filled with sample water for lab analysis for nitrate as nitrogen, orthophosphate as phosphorus, *E. coli*, enterococcus, total coliform, total zinc, total copper, total lead, hardness and total suspended solids (TSS). Additionally, the first time series sample was analyzed for urea at each site.

Lab results are compared to receiving water standards. These standards target ambient concentrations for a stream, lake, or ocean—they are not meant for end-of-pipe applications like this, but lacking any other standard, they provide some means of comparison for the results. Metal results were compared to the Central Coast Basin Plan Water Quality Objectives (WQO) for the protection of marine aquatic life. Nitrate, orthophosphate, and total suspended solids (TSS) results were compared with the Central Coast Ambient Monitoring Program's (CCAMP) attention levels (see Table 1). These attention levels are set for receiving water concentrations at which pollutants may impact cold-water fish or human health. Both the Basin Plan water quality objectives and CCAMP attention levels are established for receiving waters and NOT for end of pipe discharges. Dilution and/or mixing usually occur in the receiving waters within a short distance of each outfall. For all analytes Minimum Detection Limits (MDL) are noted. The MDL is the minimum concentration that a lab instrument can detect for a given analyte. For sites that have a non-detect listed, it is placed on the graph at zero, however the value is not zero but instead somewhere between zero and the MDL.

## **Results/Discussion**

**Dry Run** samples were collected in San Mateo on September 13<sup>th</sup>, and all other sites on September 20<sup>th</sup>. All sites were visited for the Dry Run but only 18 of the 36 sites had enough water flow to be sampled. They include:

Montara - Vallemar St.

Santa Cruz - Bay Street, Arroyo Seco, Merced and Woodrow

Capitola - Monterey Avenue

Seaside - Hotel

Monterey - Library, Twins, San Carlos Beach, Steinbeck and HopkinsMon\*

Pacific Grove – HopkinsMon\*, Greenwood Park, Lover's Point, Pico, Asilomar and Congress

Carmel - 8<sup>th</sup> Avenue

\* HopkinsMon is listed for both Monterey and Pacific Grove as the drainages originate in both cities.

The **First Flush** occurred on October 3<sup>rd</sup>, 2008 in San Mateo and Santa Cruz counties. However rainfall amounts in Monterey County were not sufficient to mobilize. Another storm system moved through on November 1<sup>st</sup>, 2008, when Monterey county teams mobilized and were able to conduct the First Flush monitoring. Because of some safety and logistical complications three sites were not monitored that night. They included Bay Street in Seaside, 15<sup>th</sup> Street in Pacific Grove and 4<sup>th</sup> Avenue in Carmel. The Bay Street and 4<sup>th</sup> Avenue sites were monitored during the next rain event on November 26<sup>th</sup> however the Pacific Grove site (15<sup>th</sup> Street) was still not accessible due to construction activities and so was not monitored at all.

**Table 1: Water Quality Objectives (not listed is Urea)**

<u>Parameter</u> (reporting units)	<u>Water Quality Objectives</u>	<u>Source of Objective</u>
pH	Not lower than 6.5 or greater than 8.5	General Basin Plan Objective
Water Temperature (°C)	Not more than 22	Basin Plan Objective for Cold Water Fish
Transparency (cm)	Not less than 25	Central Coast Ambient Monitoring Program (CCAMP)
Nitrate as N (ppm)	Not to exceed 2.25	Central Coast Ambient Monitoring Program (CCAMP)
Orthophosphate as P (ppm)	Not to exceed 0.12	Central Coast Ambient Monitoring Program (CCAMP)
<i>E. coli</i> (MPN/100ml)	Not to exceed 400	EPA Ambient Water Quality Criteria
Enterococcus (MPN/100ml)	Not to exceed 104	EPA Ambient Water Quality Criteria
Zinc (ppb)	Not to exceed 200	Basin Plan Objective
Copper (ppb)	Not to exceed 30	Basin Plan Objective
Lead (ppb)	Not to exceed 30	Basin Plan Objective
Total Suspended Solids (TSS) (ppm)	Not to exceed 500	Basin Plan Objective

**Table 2: Range of results for Dry Run and First Flush 2008:**

Parameter	Dry Run 2008	First Flush 2008
Conductivity	140- 1790 µS	300- 1790 µS
Transparency	15.8-125 cm	2-24 cm *
Water temperature	15-20 °C	14-20 °C
pH	6.5- 7.5	6.0 – 7.5
Urea	10-173 µg/L	10-1015 µg/L
Nitrate as N	0.10-4.90 mg-N/L	0.05 – 3.4 mg-N/L
Orthophosphate as P	0.20- 3.1 mg-P/L	0.20 –4.8 mg-P/L
Total Copper	2-189 µg/L	10-440 µg/L
Total Zinc	10- 110 µg/L	10-463 µg/L
Total Lead	5- 6 µg/L	5-63 µg/L
Total Suspended Solids (TSS)	1.9- 54 mg/L	7.8–726 mg/L
<i>Escherichia coli</i> ( <i>E. coli</i> )	<20- >/=48,400 MPN/100ml	10->/= 241,960 MPN/100ml
Enterococcus	<20- >48,400 MPN/100ml	10- >/= 241,960 MPN/ 100ml

\* Bay Street (Seaside), 4<sup>th</sup> Street (Carmel) and Pajaro (Monterey County) were monitored during daylight hours enabling transparency to be measured.

## Nutrients

Although nitrate and phosphate are needed for plant growth, they are not normally found in elevated concentrations in aquatic systems. Nitrate as with other nutrients can lead to algal blooms that consequently degrade water quality as those plants die off and consume oxygen in their decomposition. Nitrate sources include runoff from fertilized lawns, agricultural and pasture lands, construction sites and septic/sewer system leachate. The CCAMP attention level for nitrate as N (NO<sub>3</sub>-N) is 2.25 mg-N/L. The minimum detection limit (MDL) is 0.1 mg-N/L.

For the **Dry Run**, four (23%) of the eighteen sites monitored were above the attention level for nitrate. The highest result was in Pacific Grove (Lover's Pt) with a value of 4.9 mg-N/L (Fig. 2). Three sites in Santa Cruz (Merced, Bay and Woodrow) and one in Montara (Vallemar) had uncharacteristically high concentrations for the Dry Run. Two sites had non-detects, one in Santa Cruz (Arroyo Seco) and one in Carmel by the Sea (8<sup>th</sup> Avenue).

During **First Flush**, two (6%) of the thirty-six monitored sites were above the attention level for nitrate. The highest concentrations were in Monterey County (Pajaro) with a time series average of 2.90 mg-N/L and in Pacific Grove (Forest) with a time series average of 2.5 mg-N/L (Fig. 2). Sites with non-detects were spread across the region from Montara (7<sup>th</sup> Street, Vallemar, Wienke Way, San Vicente Outfall and West Pointe), Capitola (Capitola Pier, Auto Plaza, Capitola Center, Monterey Avenue), to Seaside (Hotel). As in previous First Flush events, nitrate concentrations were typically below the attention level.

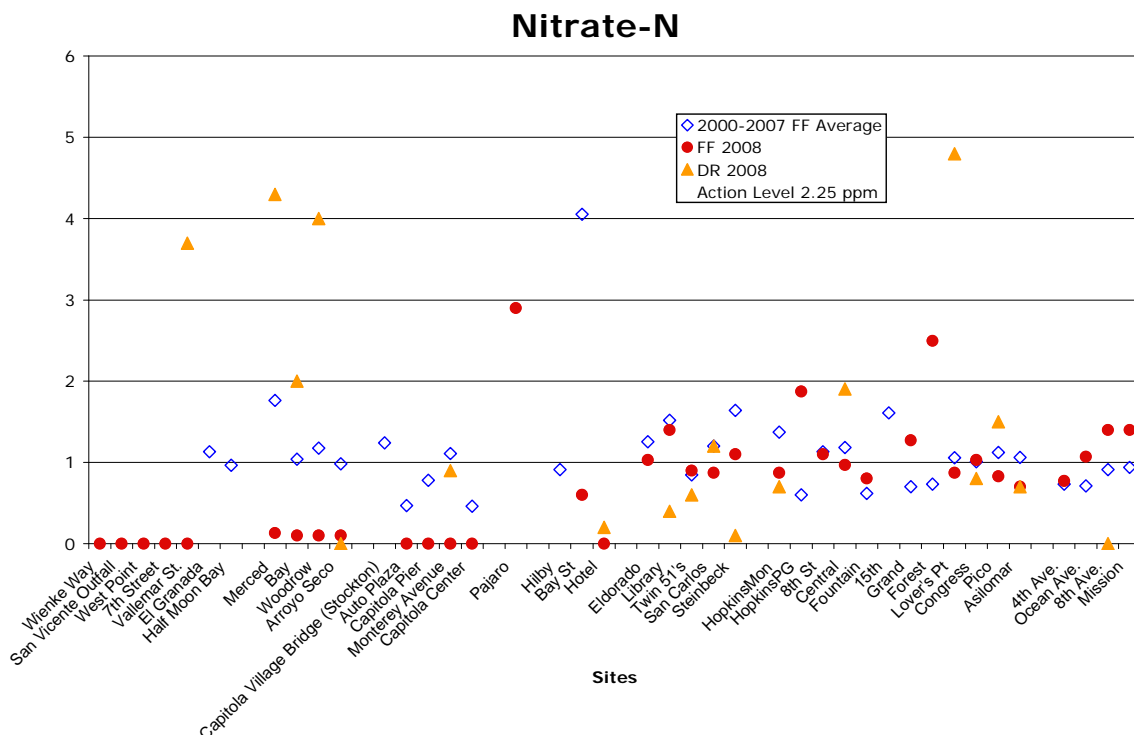


Figure 2. Results for Nitrate-N for the 2008 Dry Run and time series averages for First Flush. Sites grouped by city from north to south- Montara, Santa Cruz, Capitola, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

Phosphate, like nitrate, is also necessary for plant growth. As with nitrate, phosphate can lead to degradation of water as plants grow uncontrolled, complete their life cycle, and decompose, taking up oxygen in the process. Sources of phosphate are similar to those for nitrate: leaks in sewer or septic systems, excess fertilizers from urban or agricultural areas, and detergents. The CCAMP attention level for orthophosphate (PO<sub>4</sub>-P) is 0.12 mg-P/L. Unfortunately for the Dry Run and First Flush 2008, the MDL for orthophosphate was mistakenly increased by the lab to 0.2 mg-P/L, which is above the attention level. This discrepancy has been corrected for future events however for 2008 when assessing the results of this event this discrepancy must be considered.

For the **Dry Run**, six (33%) of the eighteen sites monitored were at or above the MDL of 0.2 mg-P/L. The two highest values were Hotel (Seaside) with a concentration of 0.6 mg-P/L and Steinbeck Plaza (Monterey) with a result of 3.1 mg-P/L (Fig. 3). Non-detects were reported for twelve (66%) sites: Santa Cruz (Merced, Bay, Woodrow, Arroyo Seco), Capitola (Monterey), Monterey (Library, San Carlos Beach), Pacific Grove (Lover’s Point, Pico, Congress, and HopkinsPG) and Carmel (8<sup>th</sup> Avenue).

During **First Flush**, twenty-three (64%) sites monitored were at or above the MDL for orthophosphate. Steinbeck (Monterey) had the highest average time series concentration for orthophosphate (3.77 mg-P/L) (Fig. 3). The Forest Avenue site (Pacific Grove) was next with an average time series concentration of 2.57 mg-P/L. All of the northern sites reported non-detects during the First Flush. As in previous years, all of the Monterey County sites exceeded the MDL and therefore the attention level.

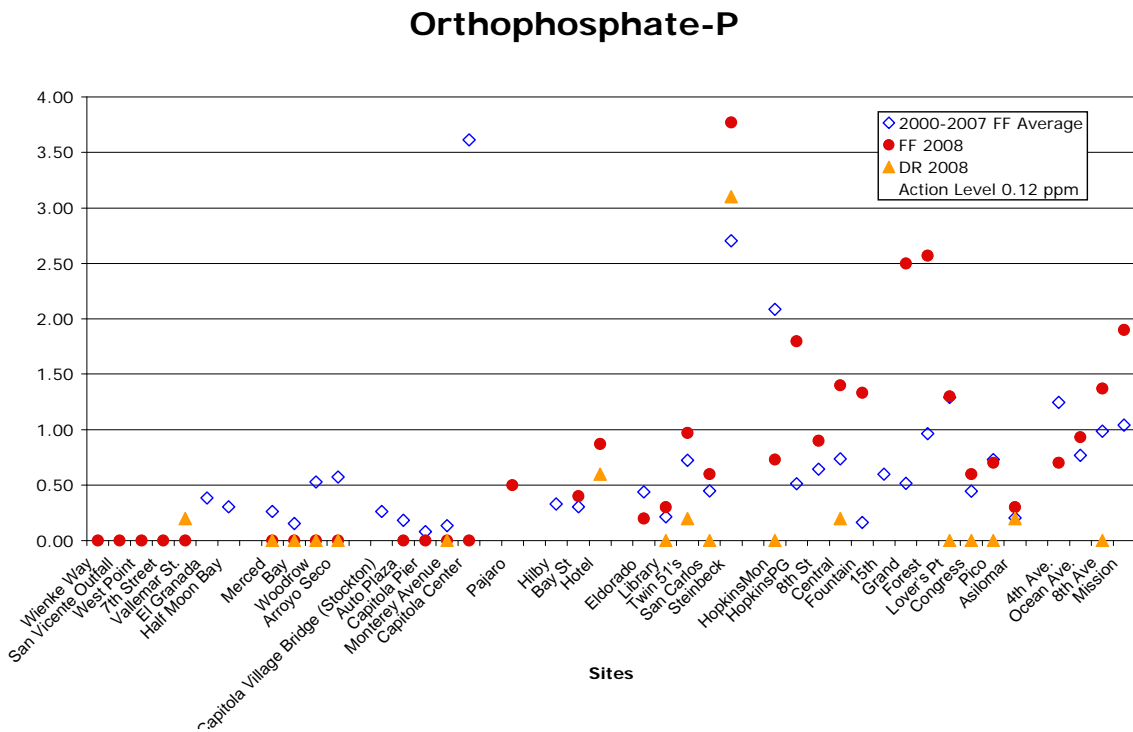


Figure 3. Results for Orthophosphate-P for the 2008 Dry Run and time series averages for First Flush. Sites group by city from north to south- Montara, Santa Cruz, Capitola, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.



## Urea

Urea is an organic compound that is soluble in water; therefore it is an excellent fertilizer and is often used for agricultural applications. Some research shows that excess urea can cause toxic algal blooms in the ocean. There are many sources of urea including fire retardants, cigarettes, fertilizers, animal feeds, detergents, and mammalian urine. This was the third year that urea was analyzed for this program. While there is no water quality objective for urea, values are noted and compared to previous year's results in order to monitor trends.

For the **Dry Run**, the highest urea result was in Monterey (Hopkins) with a concentration of 173 µg/L and in Pacific Grove (Greenwood Park) with a concentration of 84 µg/L (Fig. 4). Non-detects were noted for one site in Montara (Vallemar), three sites in Santa Cruz (Merced, Bay St. and Woodrow) and one site in Carmel by the Sea (8<sup>th</sup> Avenue).

During **First Flush**, urea was only measured during the first time series. Pacific Grove (Forest Avenue) had the highest result of 1015 µg/L. The Hotel site in Seaside was the only outfall to report a non-detect (Fig. 4).

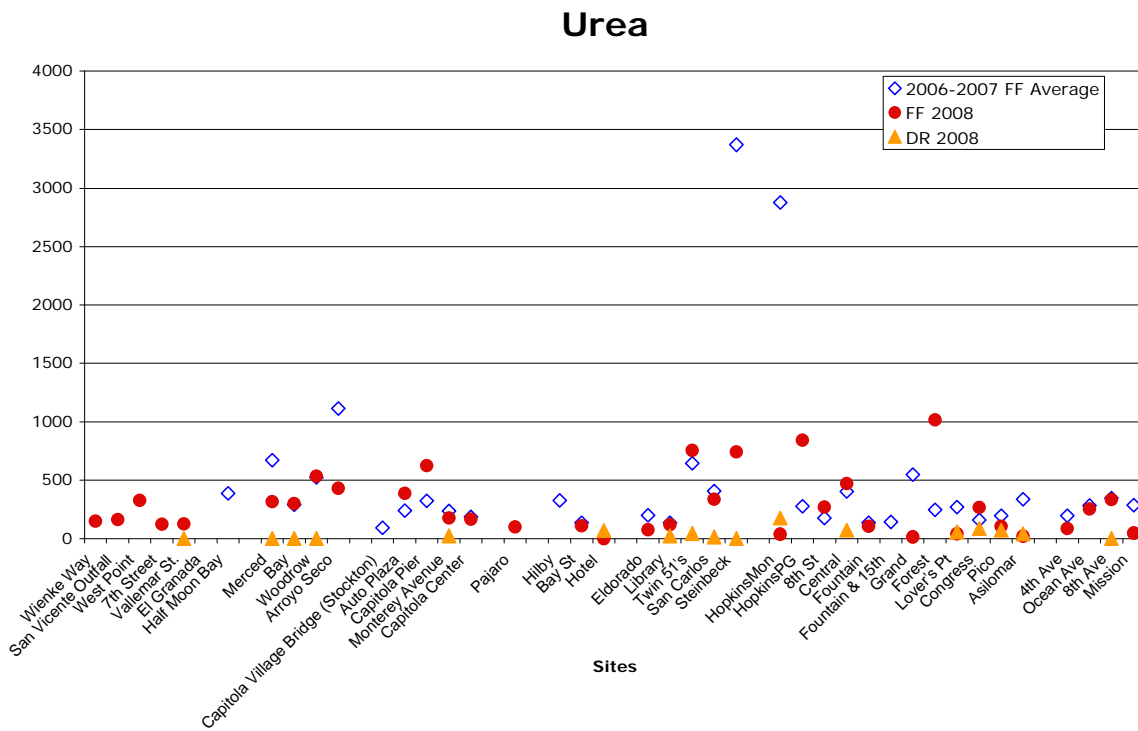


Figure 4. Urea results for the 2008 Dry Run and time series averages for First Flush. All sites grouped by city from north to south- Montara, Santa Cruz, Capitola, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

## **Bacteria**

*Escherichia coli* (*E. coli*) and enterococcus are two forms of indicator bacteria. *E. coli* and enterococcus are found in the intestines of warm blooded animals and can make their way into waterways and the ocean from wildlife populations, through improper domestic animal waste disposal, as well as sewer or septic system leakages. While these bacteria don't necessarily cause disease in humans, their presence does indicate the potential for other human specific pathogens to be present. The U.S. Environmental Protection Agency water quality criterion for grab samples for *E. coli* is 400 MPN/100 ml and for enterococcus, 104 MPN/100 ml. The PQL for both *E.coli* and enterococcus is 20 MPN/100ml.

For the **Dry Run** thirteen (72%) of the eighteen sites monitored were above the WQO for *E. coli* of 400 MPN/100 ml. The highest average *E. coli* result was 48,400 MPN/100 ml both in Santa Cruz (Arroyo Seco) and in Monterey (Steinbeck Plaza) (Fig. 5). For enterococcus, seventeen (94%) of the eighteen sites were above the WQO of 104 MPN/100 ml. The highest average enterococcus result was 48,400 MPN/ 100 ml in Monterey (Steinbeck Plaza) (Fig. 6).

During the **First Flush** both types of bacteria were high in all cities and at most sites; thirty-four (94%) of the thirty six sites monitored were above the WQO for *E.coli* and thirty five (97%) of the thirty six sites were above the attention level for enterococcus. The highest average results for *E.coli* were 204,626 MPN/100 ml in Pacific Grove (Pico) and 168,490 MPN/100 ml in Santa Cruz (Woodrow). The highest average results for enterococcus were 193,983 MPN/100 ml in Monterey (Steinbeck) and 190,186 MPN/ 100 ml in Pacific Grove (Grand). Lowest *E.coli* and enterococcus results for the First Flush were in Montara (San Vicente Outfall) with results (10 MPN/ 100 ml) well below the WQO (Fig. 5 and 6).

## E. coli

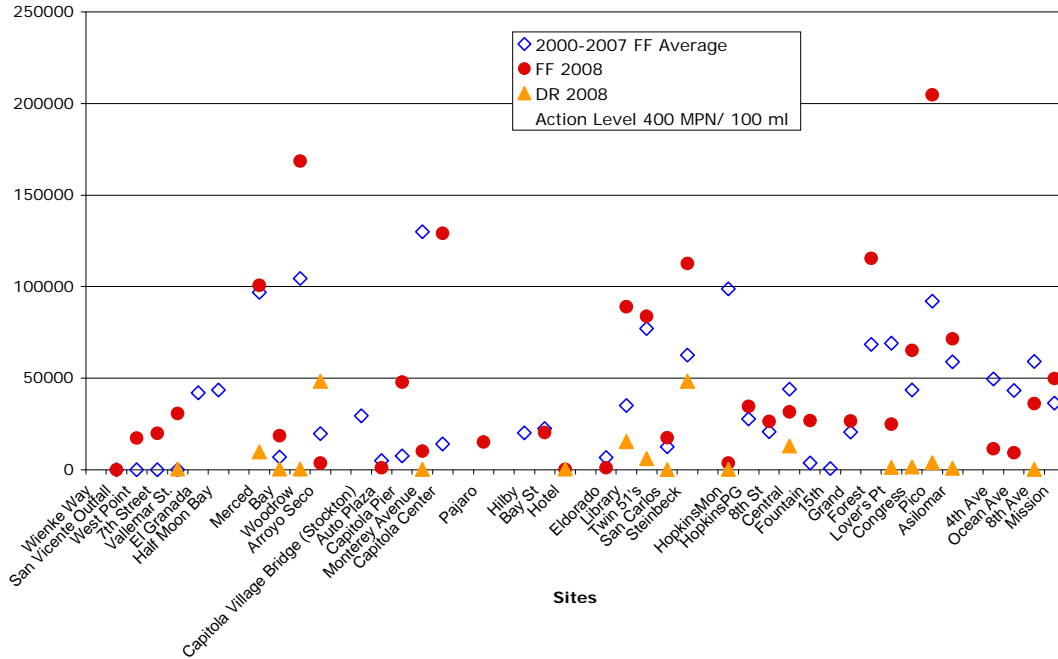


Figure 5. *E. coli* results for the 2008 Dry Run and time series averages for First Flush. All sites grouped by city from north to south- Montara, Santa Cruz, Capitola, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

## Enterococcus

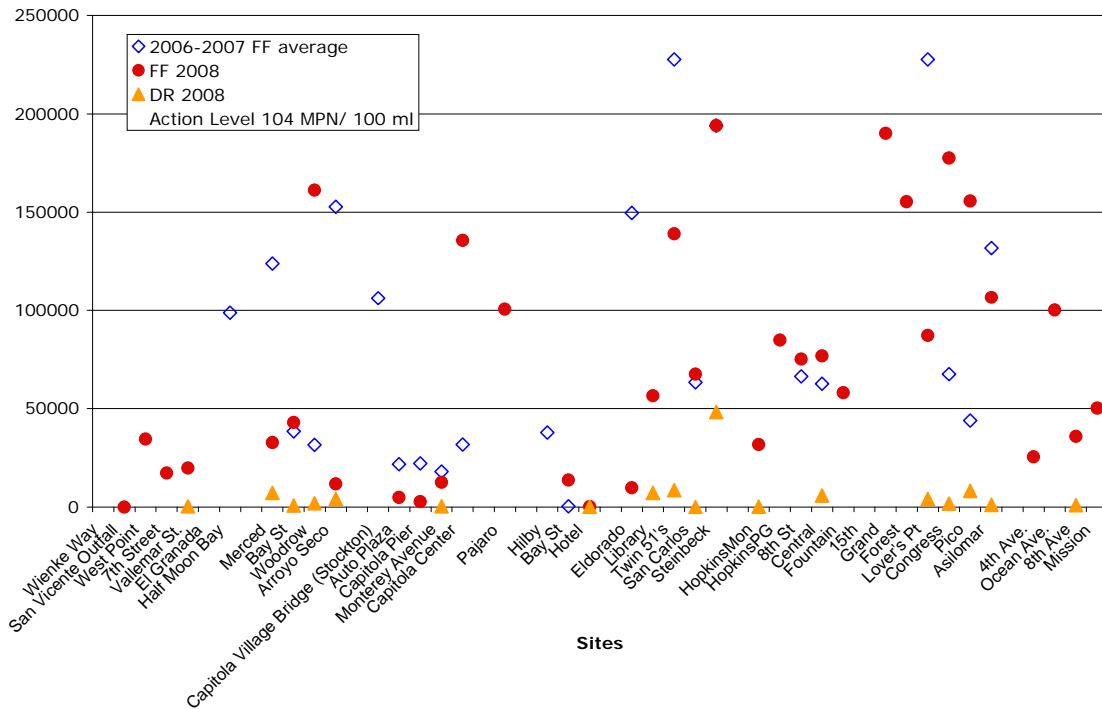


Figure 6. Results for enterococcus for the 2008 Dry Run and time series averages for First Flush. All sites grouped by city from north to south- Montara, Santa Cruz, Capitola, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

## Metals

Storm water runoff in coastal urban areas is known to contain trace metals from common sources such as automobile brake pads, industrial waste, and metal roofs or downspouts. The effect of these metals in very low concentrations in the marine environment includes reduced reproduction, developmental deformities, and mortality. For the Dry Run and First Flush, samples were analyzed for total zinc (Zn), total copper (Cu), and total lead (Pb).

### Zinc

The background concentration for zinc (Zn) in seawater on the Central Coast is 8.0 micrograms per liter ( $\mu\text{g/L}$ ); the Basin Plan WQO for Zn is  $<200 \mu\text{g/L}$ ; and the MDL for zinc is 10  $\text{mg/L}$ .

For the **Dry Run**, zinc concentrations were below the WQO of  $200 \mu\text{g/L}$  for all sites (Fig. 7). The highest concentrations were found at Steinbeck Plaza and HopkinsMon both in Monterey.

For **First Flush**, fourteen (39%) of the thirty-six sites exceeded the WQO for zinc. The highest average zinc concentration was  $400 \mu\text{g/L}$  in Santa Cruz (Merced), and a close second was  $396 \mu\text{g/L}$  in Capitola (Capitola Center). Seaside (Hotel) had the lowest average concentration and neither Seaside site exceeded the WQO for zinc (Fig. 7).

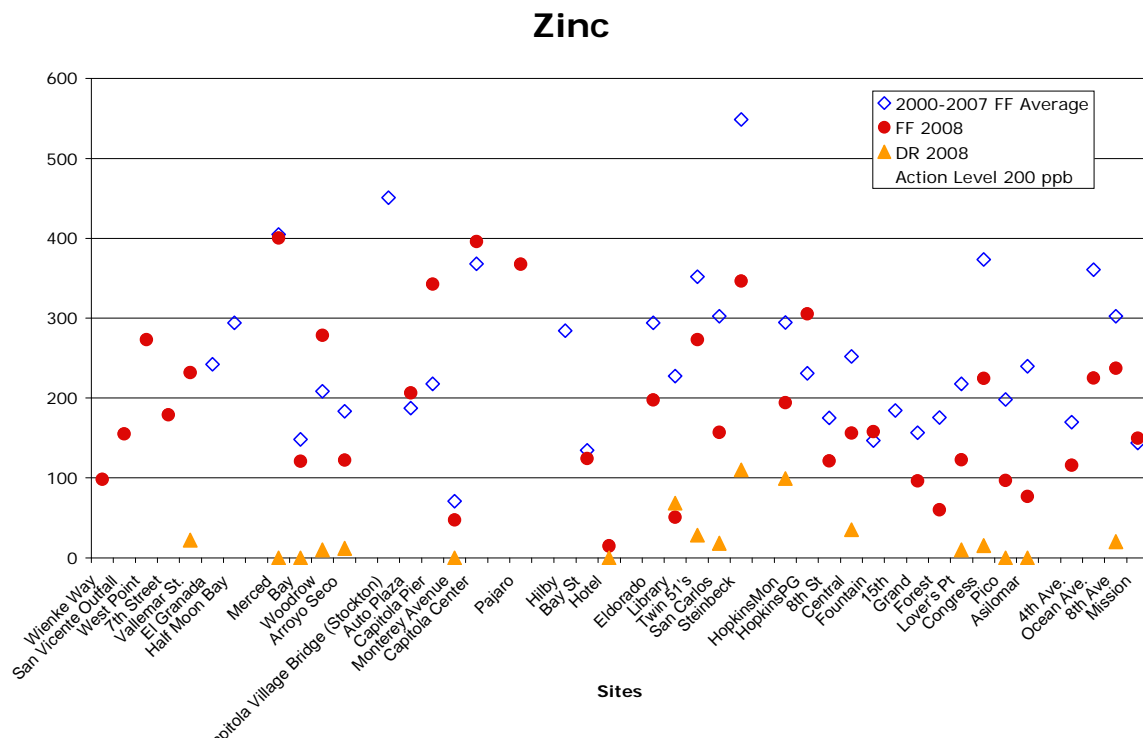


Figure 7. Time series averages for all sites for total zinc. All sites grouped by city from north to south- Montara, Santa Cruz, Capitola, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

## Copper

The background concentration for copper (Cu) in seawater is 2.0 µg/L; the Basin Plan WQO established for total Cu is 30 µg/L; the MDL for copper is 2.0 µg/L.

For the **Dry Run**, copper concentrations were all low with only two (11%) of the eighteen sites monitored above the WQO. The highest copper result was 185 µg/L in Monterey (Steinbeck Plaza). Another Monterey site (HopkinsMon) had a concentration of 54 µg/L (Fig. 8).

During **First Flush**, thirty-one (86%) of the thirty-six monitored sites exceeded the WQO. The highest copper concentration was in Pacific Grove (Forest) with an average of 408 µg/L. Seaside (Hotel) had the only non-detect. Carmel by the Sea (8<sup>th</sup> Avenue) had the second highest average copper concentrations with a result of 170 µg/L (Fig. 8).

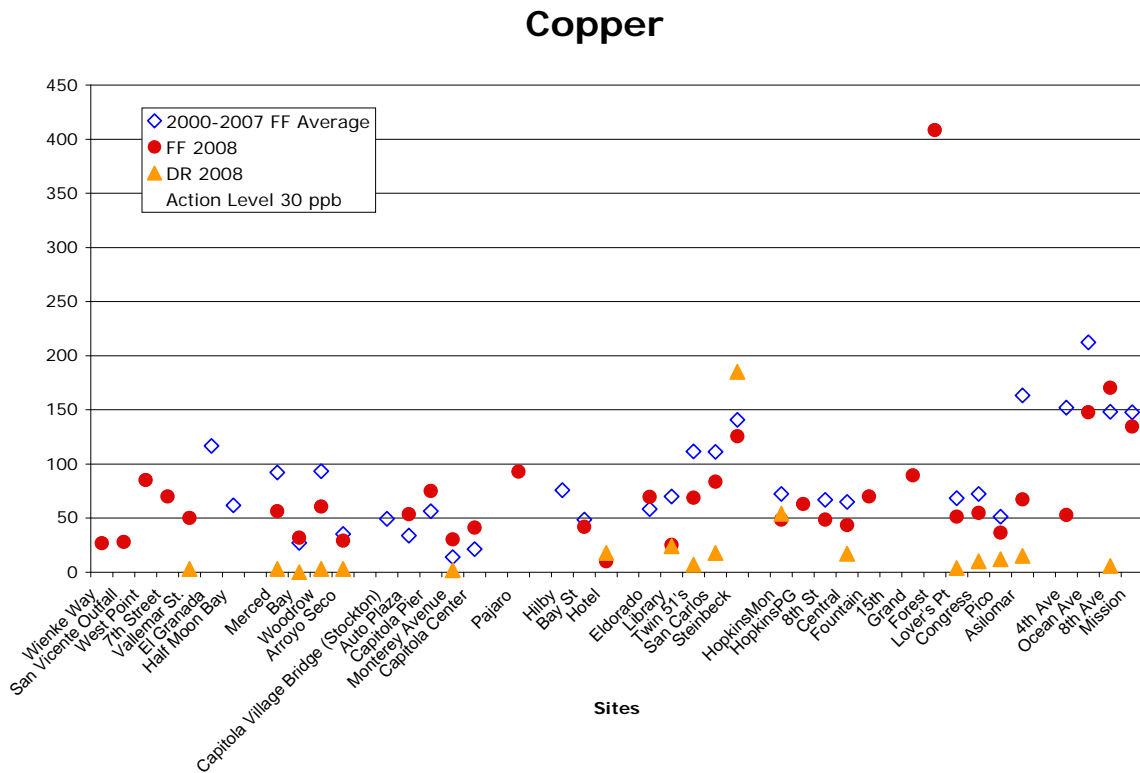


Figure 8. Total copper results for the 2008 Dry Run and time series averages for First Flush. All sites grouped by city from north to south- Montara, Santa Cruz, Capitola, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

**Lead**

The Basin Plan WQO for total lead (Pb) is 30 µg/L. The MDL for lead is 5 µg/L.

For the **Dry Run**, lead concentrations for all sites were below the WQO. Only one site, Monterey (Twins) had any detectable amount of lead (5.0 µg/L) (Fig. 9).

For **First Flush**, only one site (3%) from the thirty-six monitored exceeded the WQO: Pajaro (Monterey County) with the highest average of any monitored site at 63µg/L. Non-detects were noted in Santa Cruz (Merced, Arroyo Seco), Capitola (Auto Plaza, Capitola Center), Pacific Grove (8th St., Congress, and Hopkins (Pacific Grove)) and Seaside (Hotel) (Fig. 9).

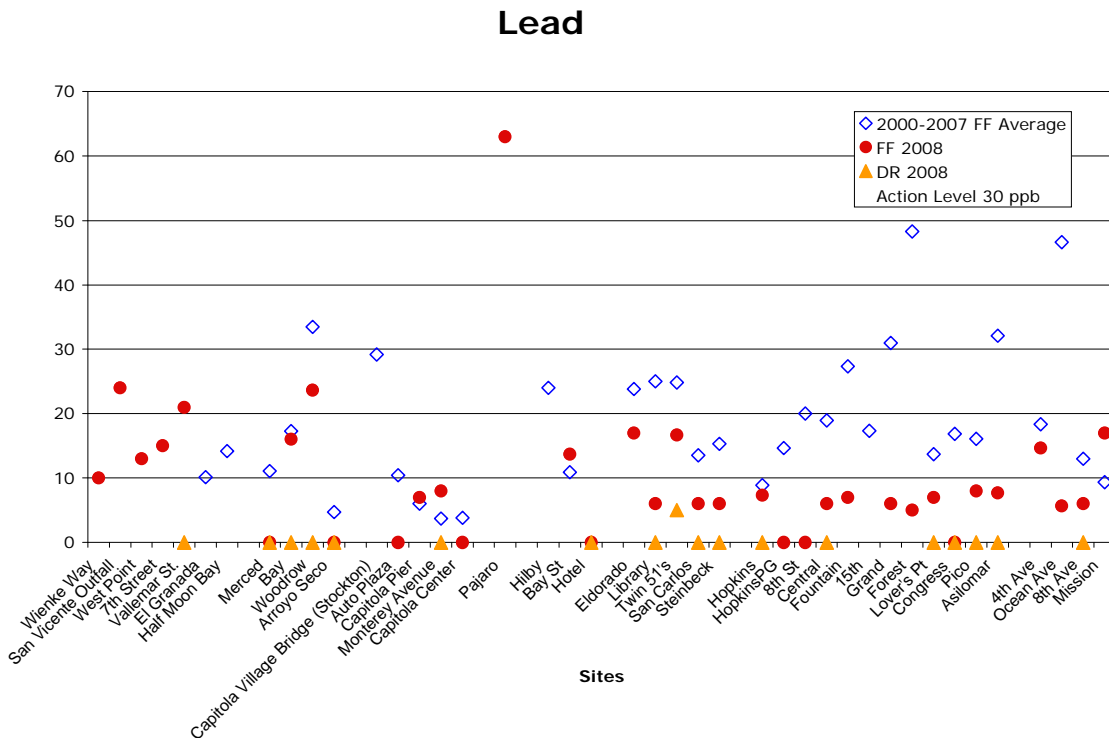


Figure 9. Total lead results for all sites for 2008 Dry Run and time series averages for First Flush. All sites grouped by city from north to south- Montara, Santa Cruz, Capitola, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

## Total Suspended Solids (TSS)

TSS are particulate matter in water that attract charged particles which can often be pesticides and metals. TSS can additionally impact the environment through sedimentation and reduction in the ability of marine organisms to respire. Sources of TSS are construction sites with improper sediment control, bank erosion from rivers or streams, runoff from agricultural fields, and over irrigation in urban areas. The attention level for TSS is 500 mg/L, with an MDL of 5 mg/L.

For the **Dry Run**, all sites were below the WQO (Fig. 10). Sites that had non-detects for TSS were in Santa Cruz (Merced and Bay St.), Monterey (Twins and San Carlos Beach), and Carmel by the Sea (8<sup>th</sup> Ave.).

For the **First Flush**, the only site to exceed the attention level of the thirty-six monitored was Pajaro (Monterey County) with an average of 743 mg/L. There were no non-detects (Fig. 10).

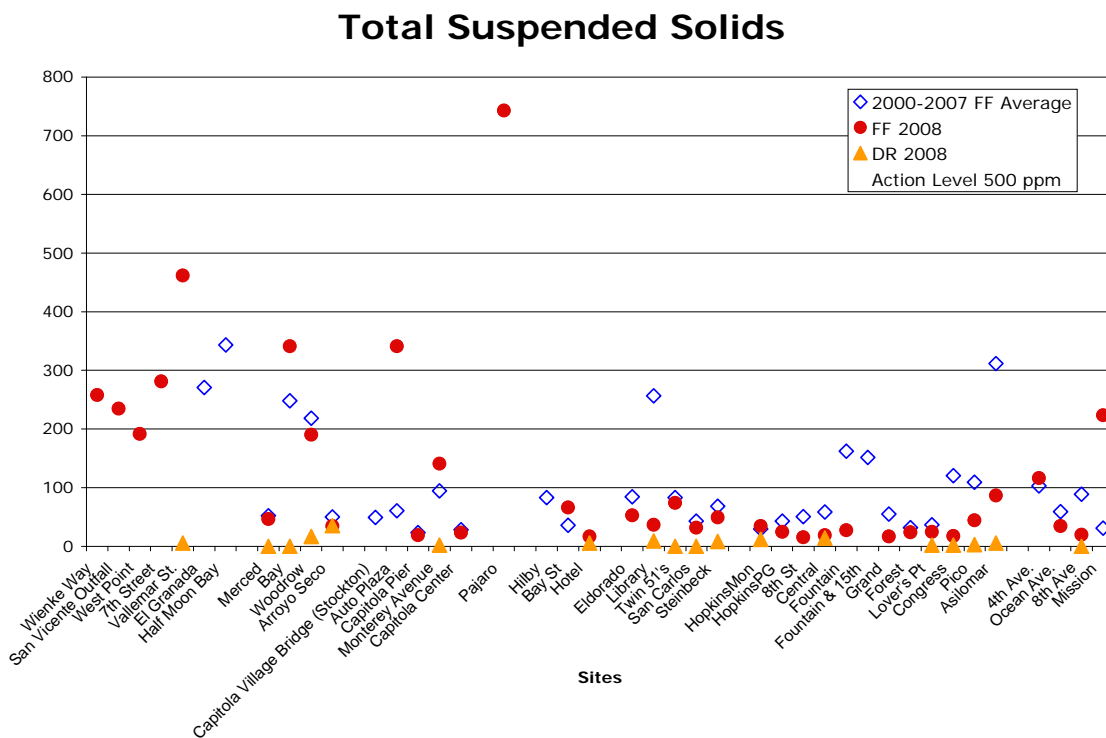


Figure 10. TSS results for all sites for 2008 Dry Run and time series averages for First Flush. All sites grouped by city from north to south- Montara, Santa Cruz, Capitola, Pajaro (Monterey County), Seaside, Monterey, Pacific Grove and Carmel.

## Visual Observations

At each site during the First Flush 2008, volunteers recorded the presence of trash, sewage (sited or smelled), oil sheen, and scum. Trash was noted at only two sites (6%)- Auto Plaza (Capitola) and Pajaro (Monterey County). Observations of bubbles were noted at 9 sites (26%)- Wienke Way (Montara), Merced (Santa Cruz), Woodrow (Santa Cruz), Auto Plaza (Capitola), Eldorado (Monterey), San Carlos (Monterey), Library (Monterey), Congress (Pacific Grove), and 8<sup>th</sup> Avenue (Carmel). Smell was noted for two sites (6%) - Capitola Center (Capitola) and Pajaro (Monterey County).

## Conclusion

For the past nine years, the Dry Run and First Flush has provided central California coastal area residents and municipalities with valuable information about the quality of water running from the storm drains to the ocean. Results from the 2008 events show that:

- Nitrate concentrations were higher during the Dry Run in Santa Cruz County and lower during the First Flush compared to cities in Monterey County. The two highest sites for nitrate during the First Flush were Pajaro (Monterey County) and Forest (Pacific Grove). This was the first year the Pajaro site was monitored for First Flush and may warrant further upstream source tracking during wet weather events.
- Steinbeck Plaza orthophosphate results were the same in the dry weather as during the FF with concentrations thirty times higher than the CCAMP attention level. Capitola Center went from a historical average orthophosphate concentration of greater than 3.5 mg-P/L to non-detect this year.
- Forest Avenue in Pacific Grove had the highest urea level of all the sites. The First Flush result was 1015 µg/L. Hopkins Monterey and Steinbeck Plaza urea concentrations dropped significantly from historical First Flush averages.
- During the Dry Run; zinc and copper concentrations were the highest of all sites at Steinbeck Plaza and Hopkins which are located less than a mile from each other along Cannery Row in Monterey. Source tracking is underway. During the First Flush, copper concentrations were similar to previous years, with one exception at Forest (Pacific Grove) which had copper concentrations well above any other site and over 13 times higher than the WQO. Carmel by the Sea had the highest average copper concentrations of any city.
- Lead concentrations were particularly low and did not exceed the WQO at any site monitored except Pajaro (Monterey County).
- During First Flush, *E. coli* and enterococcus were high everywhere as in previous years. Ninety-four percent of the sites exceeded the enterococcus WQO during the Dry Run. Steinbeck Plaza's *E. coli* and enterococcus levels were over 120 times the WQO during the Dry Run. A thorough upstream source tracking of bacteria is currently under way to locate sources in this urban drainage.

Eight new sites were added to the Dry Run and First Flush in San Mateo and Monterey counties. The San Mateo sites drain small residential communities and the results reflect low concentrations of pollutants. Nitrate was detected during the Dry Run at the one site flowing. Metals and *E. coli* were detected during the First Flush, some exceeding the WQOs. The other new site was in Pajaro, which exceeded all of the WQO for all of the analytes during the First Flush. This site warrants further investigation during wet weather. It has been dry every time it was visited in the dry season (3 times).

The addition of new sites is valuable for broadening the baseline of Dry Run and First Flush data. While First Flush data is by design, limited in scope, the information obtained can point out problem sites and watersheds needing more attention to address water quality problems. A watershed-based focus may be the best method for determining pollution sources and reducing impacts to the local environment and the Monterey Bay National Marine Sanctuary. Further study is warranted to determine the impact of pollutants on organisms inhabiting the intertidal, where many of these pollutants end up.



**Appendix I. Results by City from North to South**

## Montara

The Dry Run in Montara was conducted on September 13<sup>th</sup>, 2008. Only one site (Vallelmar Street) had flow and was sampled.

Dry Run results from the lab analysis showed:

- Exceedance of nitrate WQO (3.7 mg-N/L) (Fig. 11).
- Exceedance of orthophosphate WQO (0.2 mg-P/L) (Fig. 11).
- Total suspended solids were below the attention level (Fig. 12).
- Urea was not detected (Fig. 13).
- All results for total copper, total lead, and total zinc, were below the WQO (Fig. 14).
- *E. coli* concentration (346 MPN/ 100 ml) was below the WQO and enterococcus (484 MPN/100mL) was above (Fig. 15).

For First Flush 2008, the Montara team mobilized at approximately 11:00 p.m. on Friday evening October 3rd and began sampling at 11:18 p.m. ending with the last sample collected at 11:50 p.m. Due to limited funding only one sample was collected at each of the five sites as opposed to a time series done at all other First Flush sites.

First flush results from the lab analysis showed:

- Nitrate was not detected at any site (Fig. 11).
- Orthophosphate was not detected at any site (Fig. 11).
- Total suspended solids were all below the attention level (Fig. 12).
- Urea had a range of 121 -310  $\mu\text{g/L}$  (Fig. 13).
- Copper exceeded the WQO for three (60%) of the five sites, with maximum concentration of 85  $\mu\text{g/L}$  at West Point (Fig. 14).
- Zinc exceeded the WQO in two (40%) of the five sites with a high of 273  $\mu\text{g/L}$  at West Point (Fig. 14).
- Lead results did not exceed the WQO at any site (Fig. 14).
- *E. coli* and enterococcus were measured at four out of the five sites and were above the WQO for three (75%) of those sites monitored. Only Wienke Way was not monitored for bacteria due to a mishap with the sample. The high for *E. coli* was 30,760 MPN/100 ml at Vallelmar St., and 34,480 MPN/100 ml for enterococcus at West Point (Fig. 15).

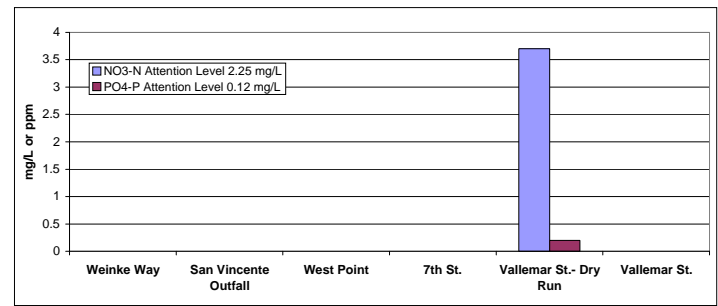


Figure 11. Nutrient concentrations for the Dry Run and First Flush 2008 in Montara, CA

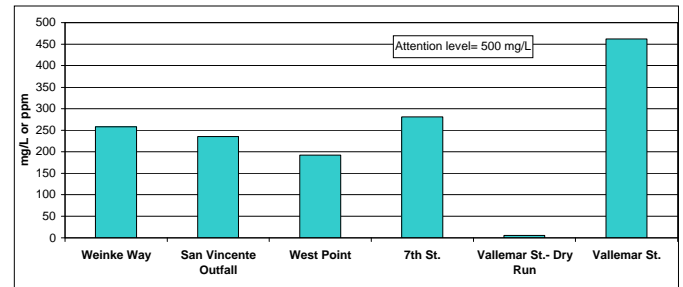


Figure 12. Total suspended solids (TSS) concentrations for the Dry Run and First Flush 2008 in Montara, CA

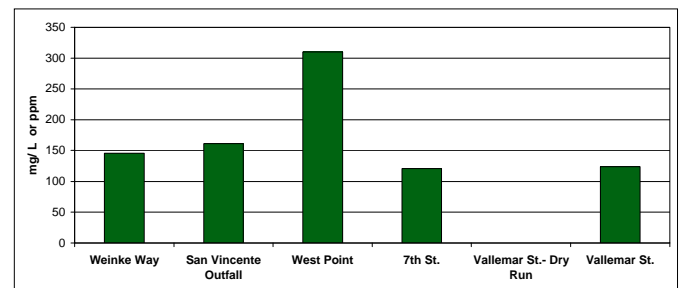


Figure 13. Urea concentrations for the Dry Run and First Flush 2008 in Montara, CA.

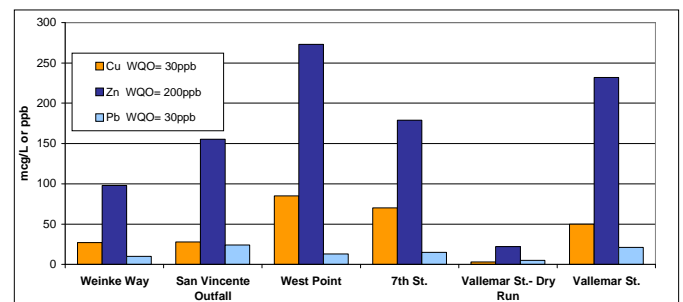


Figure 14. Total metal concentrations of copper, lead and zinc for the Dry Run and First Flush 2008 in Montara, CA.

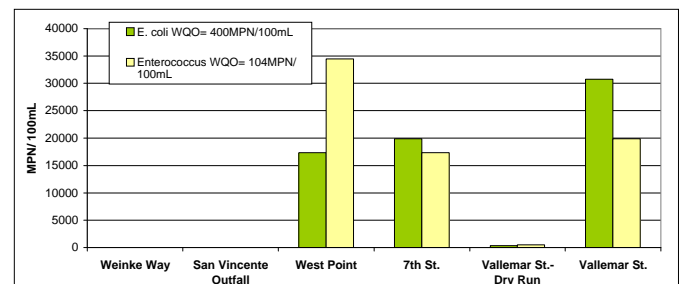


Figure 15. *E. coli* and enterococcus concentrations for the Dry Run and FF.

## Santa Cruz

The Dry Run was performed on Saturday, September 20<sup>th</sup> 2008 in Santa Cruz at all four of the same sites as for First Flush.

### Dry Run results:

- Nitrate exceeded the attention level in two (50%) of the four sites monitored with a high at Merced (4.3 mg-N/L) and Woodrow (4.0 mg-N/L). Arroyo Seco was the only site with a non-detect (Fig. 16).
- Orthophosphate was not detected in any site (Fig. 16).
- Total suspended solids were below the attention level at all sites (Fig. 17).
- Urea was not monitored at Arroyo Seco and was not detected at any other site (Fig. 18).
- Metals were not above the WQO at any site (Fig. 19).
- *E.coli* was detected at all sampled sites with a high of over 48,400 MPN/100 ml at Arroyo Seco and a low below the WQO at 338 MPN/100 ml at Bay St. Enterococcus was detected at all sampled sites with a high of 7,310 MPN/100 ml at Merced (Fig. 20).

For First Flush 2008 Santa Cruz teams mobilized on October 4<sup>th</sup> at about 12:45 a.m. and began monitoring at 1:19 a.m. The last sample was collected at 2:50 a.m. Time series results are displayed in the graphs.

### Results for the First Flush were:

- Nitrate and orthophosphate concentrations did not exceed attention levels in any time series sample (Fig. 16).
- Total suspended solids exceeded the attention level in one (8%) of the twelve time series samples (Fig. 17).
- Urea results ranged from 238- 532 µg/L with the highest result at Woodrow (Fig.18).
- Woodrow was the only site to exceed all WQOs for metals in the first time series (Fig. 19).
- Each site exceeded the WQO for *E. coli* and enterococcus with Woodrow consistently having the highest results (Fig. 20).

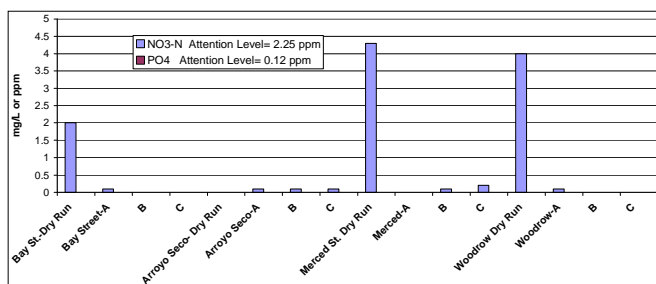


Figure 16. Nitrate and orthophosphate concentrations for the Dry Run and First Flush 2008 in Santa Cruz, CA

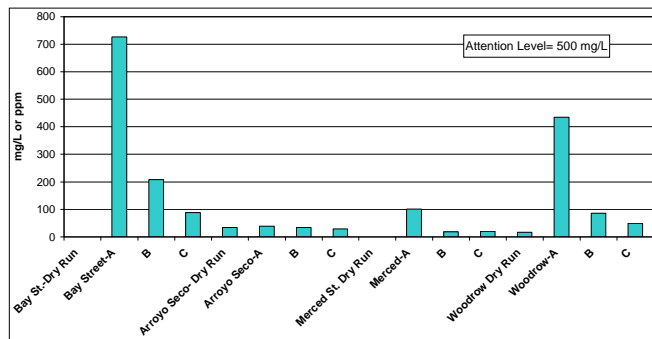


Fig. 17. Total suspended solids (TSS) concentrations for the Dry Run and First Flush 2008 in Santa Cruz, CA

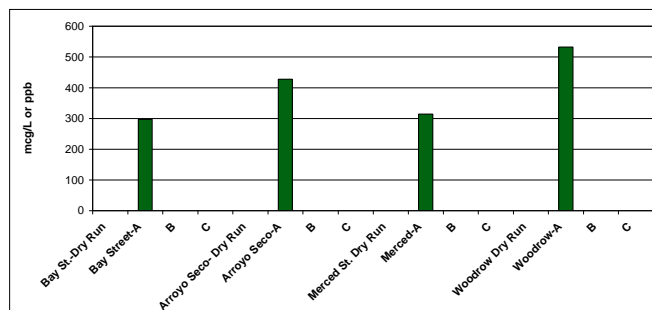


Figure 18. Urea concentrations for the Dry Run and First Flush 2008 in Santa Cruz, CA.

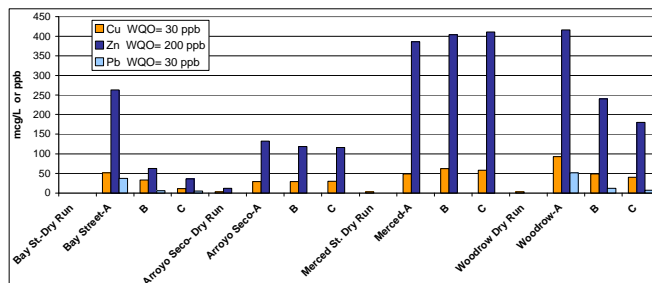


Figure 19. Total metal concentrations for copper, lead and zinc for the Dry Run and First Flush 2008 in Santa Cruz, CA

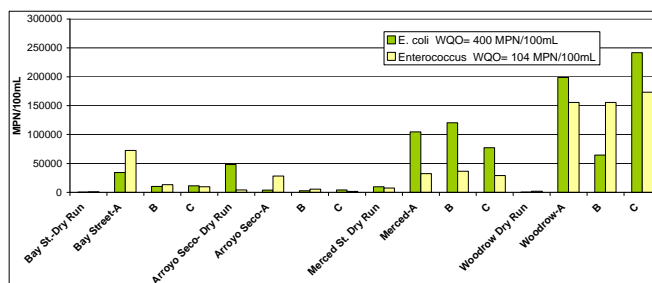


Figure 20. *E. coli* and enterococcus concentrations for the Dry Run and First Flush 2008, Santa Cruz, CA

## Capitola

The Dry Run was conducted in Capitola on Saturday, September 20<sup>th</sup>, 2008. All sites were visited but only the Monterey Avenue site had flowing water and was monitored.

### Dry Run results:

- Neither nitrate nor orthophosphate exceeded the attention level.
- Urea was 25 µg/L (Fig. 22).
- Total copper, zinc and lead did not exceed any WQO's (Fig. 23).
- *E. coli* was below the WQO with a result of 312 MPN/100 ml and enterococcus exceeded the WQO with a result of 318 MPN/100 ml (Fig. 24).

For First Flush 2008, Capitola teams mobilized at about 12:45 a.m. on October 4<sup>th</sup>, 2008. The earliest samples were taken at 1:24 a.m. sampling was finished by 2:50 a.m.

### Results for **First Flush** were:

- Nitrate and orthophosphate was not detected in any time series.
- The highest concentration of TSS was 359 mg/L during the first time series sample at Monterey Avenue (Fig. 21).
- Urea results ranged from 165 to 622 µg/L, the highest concentration was at the Capitola Pier (Fig. 22).
- Total copper concentrations exceeded the WQO in ten (83%) of the twelve time series samples. The highest copper result was 79 µg/L for the Capitola Pier's second time series sample (Fig. 23).
- Total zinc exceeded the WQO in eight (67%) of the twelve time series samples. Monterey Avenue was the only site not to exceed the zinc WQO with non-detects for the second and third time series samples. The highest zinc result was 463 µg/L in the Capitola Center's last time series sample (Fig. 23).
- *E. coli* and enterococcus concentrations were over the WQO at all sites in all time series. The highest concentration for both *E. coli* and enterococcus was 241,957 MPN/100 ml at Capitola Center during the third time series (Fig. 24).

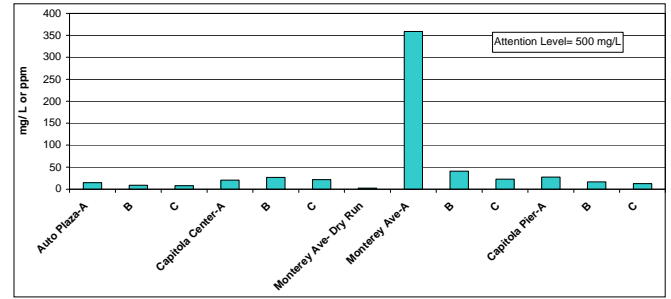


Figure 21. Total suspended solids (TSS) concentrations for the Dry Run and First Flush 2008 in Capitola, CA

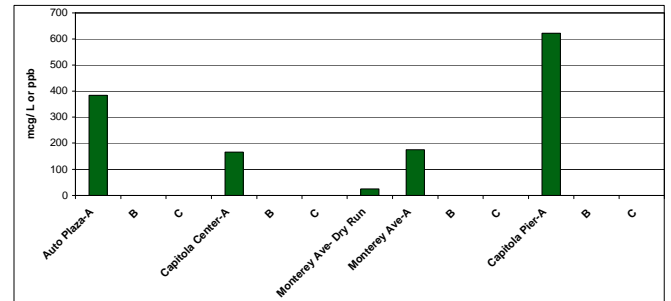


Figure 22. Urea concentrations for the Dry Run and First Flush 2008 in Capitola, CA.

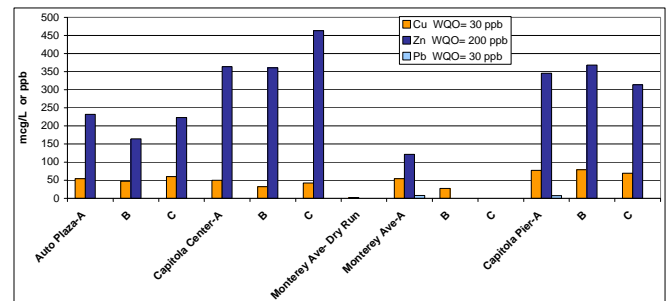


Figure 23. Total metal concentrations for copper, lead and zinc for the Dry Run and First Flush 2008 in Capitola, CA.

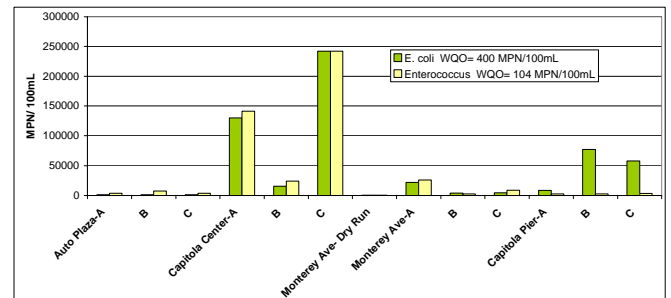


Figure 24. *E. coli* and enterococcus concentrations for the Dry Run and First Flush 2008, Capitola, CA

## Pajaro (Monterey County)

No field testing or sample collection was conducted at the Pajaro site for the Dry Run in September.

This is the first year the Pajaro site was monitored for First Flush. Volunteers mobilized on November 1<sup>st</sup> at approximately 3:00 p.m. The first sample was collected at 3:40 p.m. and the last at 4:40 p.m.

The results of **First Flush** were:

- Nitrate exceeded the attention level in all time series samples. The highest concentration was 3.6 mg-N/L during the first times series (Fig. 25).
- Orthophosphates exceeded the attention level for all time series samples. The highest concentration was 0.6 mg-P/L during the last time series (Fig 25).
- Total suspended solids exceeded the attention level in 100% of the time series samples, the highest concentration was 1120 mg/L (Fig. 26).
- Urea was 98 µg/L.
- Total copper exceeded the WQO in all time series samples. The highest concentration was 139 µg/L during the first time series sample (Fig. 27).
- Total zinc exceeded the WQO in all time series samples. The highest concentration was 552 µg/L in the first time series sample (Fig. 27).
- Total lead exceeded the WQO in all time series samples. The highest concentration of 88 µg/L was found in the first time series sample (Fig. 27).
- *E. coli* and enterococcus exceeded the WQO in all time series samples. *E. coli* had a high of 19,179 MPN/100 ml in the second time series sample. The highest concentration for enterococcus was 155,312 MPN/100 ml during the third time series (Fig. 28).

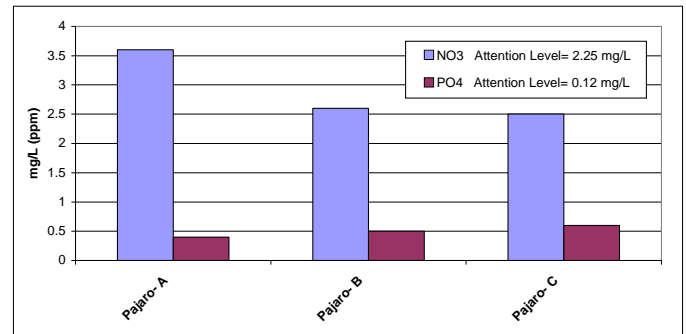


Figure 25. Nitrate and Orthophosphate concentrations for the First Flush at the Pajaro site in Monterey County, CA

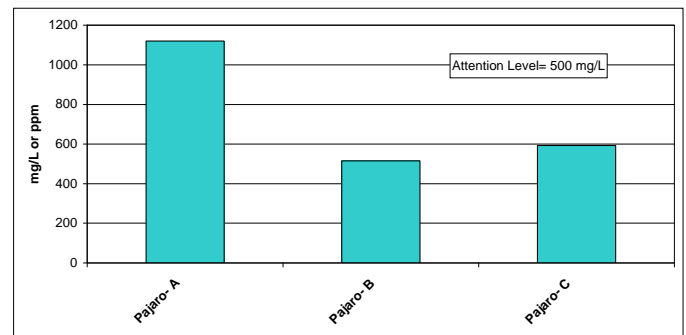


Figure 26. Total suspended solids (TSS) concentrations for the First Flush at the Pajaro site in Monterey County, CA

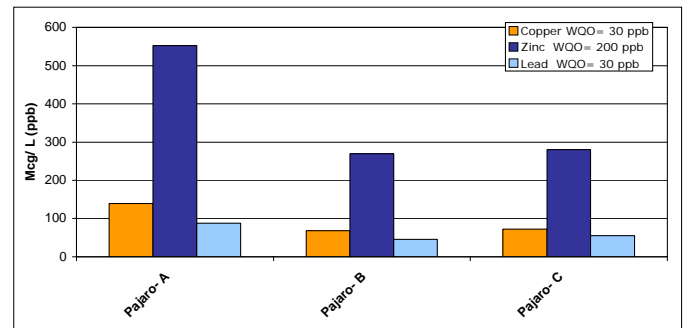


Figure 27. Total metal concentrations for copper, lead & zinc for the First Flush at the Pajaro site in Monterey County, CA.

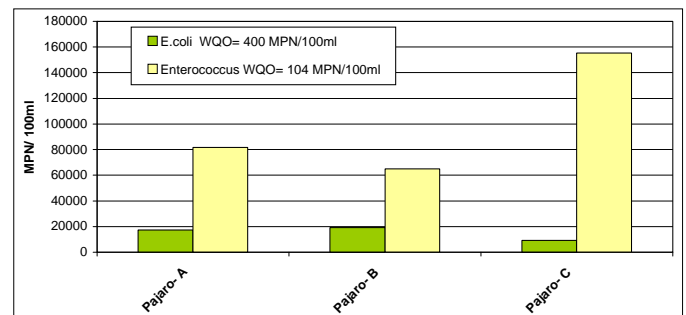


Figure 28. *E. coli* and enterococcus concentrations for the First Flush 2008 at the Pajaro site in Monterey County, CA

## Seaside

The Dry Run in Seaside was conducted on Saturday, September 20<sup>th</sup> for the Hotel site only. The Bay Street site was checked but only stagnant water was in the culvert.

### Dry Run results:

- The nitrate concentration was very low at 0.2 mg-N/L and orthophosphate was above the attention level at 0.6 mg-P/L (Fig. 29).
- Total suspended solids were well below the attention level at 5.9 mg/L (Fig. 30).
- Urea was 66 µg/L (Fig. 31).
- Total copper, zinc and lead were all below the WQO (Fig. 32).
- *E.coli* and enterococcus were both slightly above the WQO at 480 MPN/100 ml and 196 MPN/100 ml respectively (Fig. 33).

For First Flush 2008 Seaside teams mobilized at approximately 8:00 p.m. on November 1<sup>st</sup>. The first measurements were taken at 8:47 p.m. and the last samples collected at 9:48 p.m. It was determined that the Bay Street site was not safe to sample at the end of pipe due to the rising tide. It was sampled during the next rain event on November 26<sup>th</sup> with an ISCO sampler.

### Results for First Flush were:

- Nitrate concentrations were below the attention levels for each time series samples at both sites (Fig. 29).
- Orthophosphate concentrations were above the attention level at both sites for all time series samples. The highest concentration was 0.9 mg-P/L for both the second and the third time series samples at the Hotel site (Fig. 29).
- Total suspended solids were below the attention levels for all samples (Fig. 30).
- Urea was 108 µg/L at Bay Street and not detected at Hotel (Fig. 31).
- Total copper exceeded the WQO in all of the Bay Street samples but was non-detect at Hotel. Total zinc and lead was below the WQO at both sites for all time series samples (Fig. 32).
- *E.coli* and enterococcus exceeded their WQO in all of the Bay Street time series samples and none of the Hotel site samples. *E. coli* had a high concentration of 26,100 MPN/ 100 ml in the second time series sample and enterococcus had a high concentration of 17,890 MPN/ 100 ml in the first time series sample (Fig. 33).

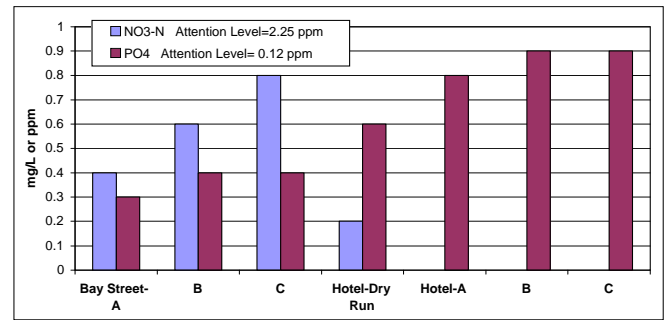


Figure 29. Nitrate and Orthophosphate concentrations for Dry Run and First Flush 2008 in Seaside, CA.

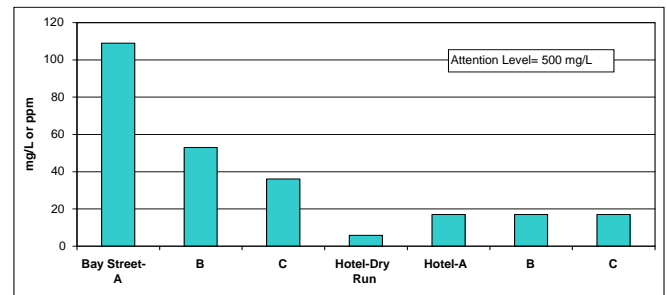


Figure 30. Total suspended solids (TSS) concentrations for the Dry Run and First Flush 2008 in Seaside, CA.

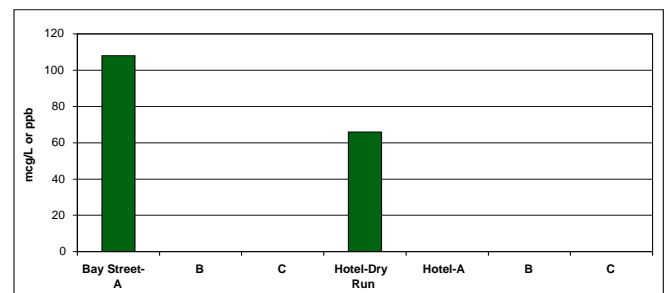


Figure 31. Urea concentrations for the Dry Run and First Flush 2008 in Seaside, CA.

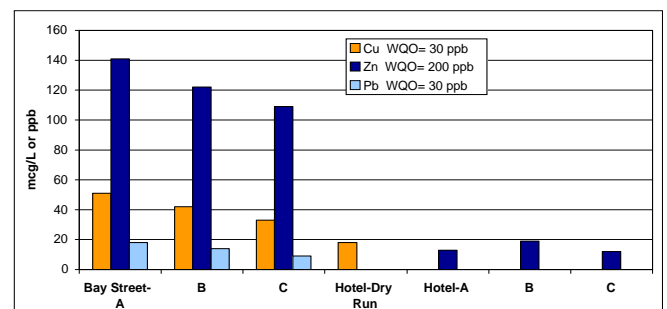


Figure 32. Total metal concentrations for copper, lead and zinc for the Dry Run and First Flush 2008 in Seaside, CA.

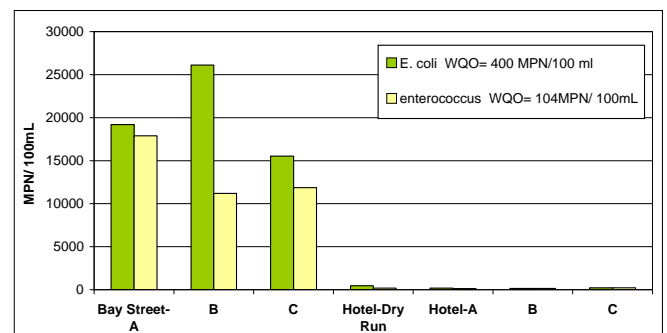


Figure 33. *E.coli* and enterococcus concentrations for the Dry Run and First Flush 2008 in Seaside, CA

## Monterey

The Dry Run was conducted on Saturday, September 20<sup>th</sup>, 2008. All sites were monitored except for Eldorado which did not have flowing water. Hopkins (Monterey) is included in both the Monterey and Pacific Grove results as this site's runoff originates in both cities.

**Dry Run** results from the lab analysis showed:

- Nitrates did not exceed the attention level for any site or sample. The highest concentration was 1.2 mg-N/L at San Carlos Beach (Fig. 34).
- Orthophosphate concentrations exceeded the attention level at two (40%) of the five sites, with the highest concentration of 3.1 mg-P/L at Steinbeck (Fig. 34).
- Total suspended solids were below the attention level for all sites. The highest concentration was at HopkinsMon with a concentration of 12 µg/L (Fig. 35).
- Urea results ranged from 15 to 144 µg/L with the highest result from HopkinsMon (Fig. 36).
- Total copper exceeded the WQO in only one (20%) of the five samples collected. The highest concentration was 183 µg/L at Steinbeck (Fig. 38).
- Total zinc did not exceed the WQO at any site; the highest concentration was 110 µg/L at Steinbeck (Fig. 37).
- Total lead did not exceed the WQO at any site. All sites were non-detect except at the Library, which had a concentration of 5µg/L (Fig. 37).
- *E.coli* and enterococcus WQOs were exceeded at three (60%) of the five sites. The highest results were at Steinbeck (48,400 MPN/100 ml for both *E.coli* and enterococcus) (Fig. 38).

For First Flush 2008, Monterey teams mobilized at approximately 8:00 p.m. on the 1<sup>st</sup> of November. The first measurements were taken at 8:19 p.m. and the last sample was collected at 9:52 p.m.

**First Flush** lab analysis results showed:

- No sites exceeded the attention level for nitrate. The highest measurement for nitrate was at Steinbeck (1.7 mg-N/L) during the second time series (Fig. 34).
- The orthophosphate attention level was exceeded in 100% of the time series samples with the highest concentration at Steinbeck (4.8 mg-P/L) in the last time series sample (Fig. 34).
- Total suspended solids were well below the attention level for all time series samples, the highest result was 89 mg/L for the third time series sample at Twins (Fig. 35).
- Urea ranged from 73 to 753 µg/L. The highest concentrations were at Twins and Steinbeck (Fig. 36).
- Total copper exceeded the WQO in fifteen (83%) of the eighteen samples with the highest concentration at Steinbeck (143 µg/L) during the last time series sample (Fig. 37).
- Total zinc exceeded the WQO in eight (44%) of the eighteen time series samples with the highest result from Steinbeck (360 µg/L) during the last time series (Fig. 37).
- Total lead did not exceed the WQO for any time series samples at any site (Fig. 37).
- *E. coli* and enterococcus WQO's were exceeded for all time series samples with the highest results at Steinbeck (*E.coli* was 198,629 MPN/100 ml & enterococcus >241,960 MPN/100 ml) (Fig. 38).

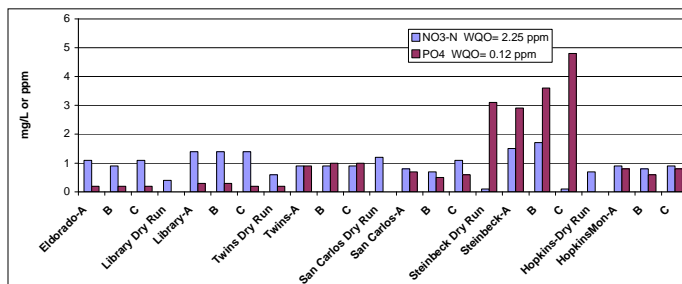


Figure 34. Nitrate and Orthophosphate concentrations for Dry Run and First Flush 2008 in Monterey, CA.

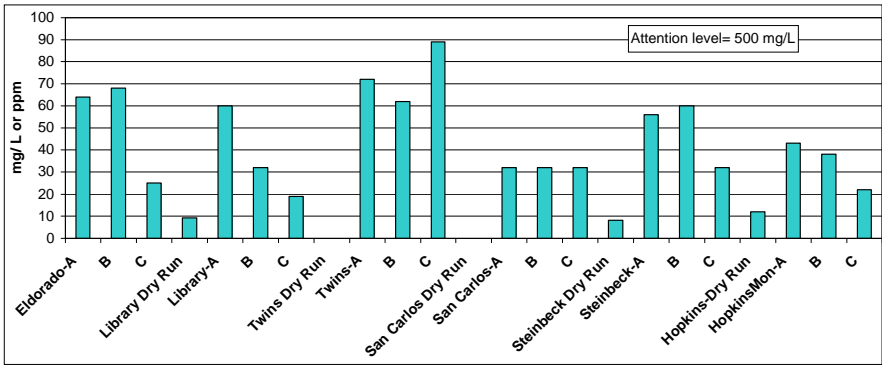


Figure 35. Total suspended solids (TSS) concentrations for the Dry Run and First Flush 2008 in Monterey, CA.

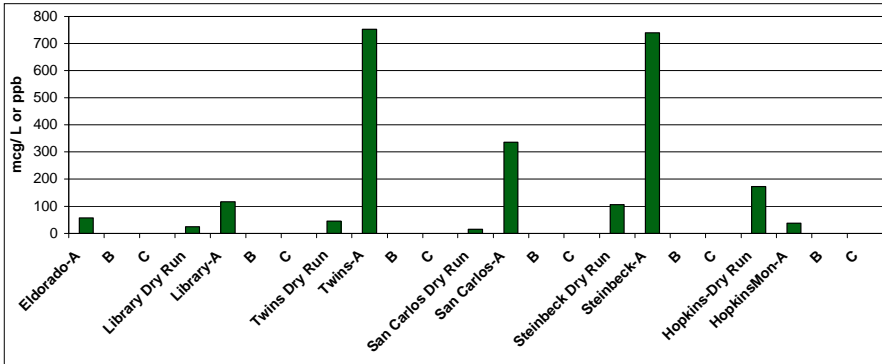


Figure 36. Urea concentrations for the Dry Run and First Flush 2008 in Monterey, CA.

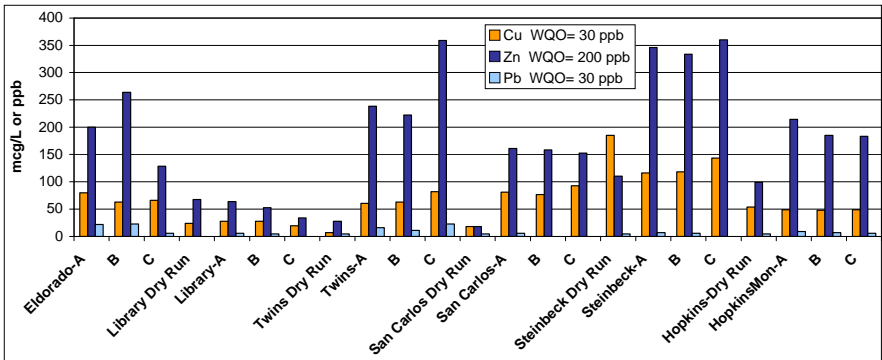


Figure 37. Total metal concentrations for copper, lead and zinc for the Dry Run and First Flush 2008 in Monterey, CA.

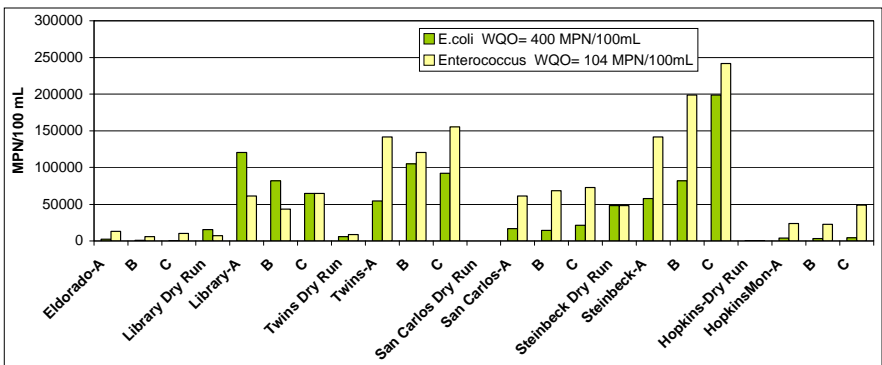


Figure 38. E. coli and enterococcus concentrations for the Dry Run and First Flush 2008 in Monterey, CA.



## Pacific Grove

The Dry Run was conducted on September 20<sup>th</sup>, 2008. All eleven sites were checked but only six (Hopkins (Monterey), Greenwood, Lover's Point, Pico, Asilomar, and Congress) had flowing water and were monitored. The City of Pacific Grove diverts their dry weather flows from Lover's Point, Fountain, Grand, Forest, Greenwood Park, and 8<sup>th</sup> Street outfalls to the Monterey Regional Water Pollution Control Agency. This diversion starts on April 1<sup>st</sup> and continues until the end of October or longer depending upon weather conditions.

Hopkins (Monterey) is included in both the Monterey and Pacific Grove results as this site's runoff originates in both cities.

### Dry Run results:

- The nitrate attention level was only exceeded at Lover's Point with a concentration of 4.8 mg-N/L (Fig. 39).
- Orthophosphate was not detected in four of the six sites. Two sites (Greenwood and Asilomar) had concentrations of 0.2 mg-P/L, while four sites (Hopkins (Monterey), Lover's, Pico, Congress) had non-detects (Fig.39).
- Total suspended solids were below the attention level for all sites (Fig. 40).
- Urea ranged from 39 to 173 µg/L, with the highest concentration at Hopkins (Monterey) (Fig. 41).
- The copper WQO was exceeded in only one (17%) of the six sites monitored, with a high of 54 µg/L at Hopkins (Monterey) (Fig. 42).
- The zinc and lead WQO's were not exceeded at any site. Two sites (Pico, Asilomar) had non-detects (Fig. 42).
- The *E.coli* WQO was exceeded in five (83%) of the six sites with the highest concentration at Greenwood Park (13,000 MPN/100 ml). The enterococcus WQO was exceeded at all sites with the highest concentration at Pico (8,201 MPN/100 ml) (Fig. 43).

First Flush 2008 teams mobilized in Pacific Grove on November 1<sup>st</sup> at 8:00 p.m. and began monitoring by 8:20 p.m. For the First Flush event, the dry weather diversion was still operating but volunteers were able to collect samples from the overflow that did eventually flow into the MBNMS. Because of the diversion, the majority of storm water runoff went to

the wastewater treatment plant. Three time series samples were collected at eleven sites and measured for each analyte: nitrate, orthophosphate, urea, copper, zinc, lead, hardness, total suspended solids, *E.coli* and enterococcus. Urea was monitored only once, during the first time series. One site, 15<sup>th</sup> Street, was not monitored for First Flush due to low flow on November 1<sup>st</sup>. Another attempt to monitor was made on November 26<sup>th</sup> but due to construction activity in the area access to the outfall was not possible. Hopkins (Monterey) is included in both the Monterey and Pacific Grove results as this site's runoff originates in both cities.

### First Flush lab analysis results showed:

- The nitrate attention level was exceeded in three (9%) of the thirty-three time series samples with the highest concentration in the last time series sample from Hopkins (Pacific Grove) (3.4 mg-N/L) (Fig. 39).
- The orthophosphate attention level was exceeded in thirty-two (97%) of the thirty three samples, with the highest concentration in the last time series sample at Hopkins (Pacific Grove) (3.2 mg-P/L). The only site to have a non-detect was Asilomar, during the first time series sample (Fig. 39).
- Total suspended solids were below the attention level for all samples (Fig. 40).
- Urea ranged from 38 to 1015 µg/L. The highest concentration was at Forest (Fig. 41).
- The total copper WQO was exceeded in 100% of the time series samples, with the highest concentration in the first time series sample at Forest (440 µg/L)(Fig. 42).
- Total zinc exceeded the WQO in seven (21%) of the thirty-three time series samples. The highest result (417 µg/L) was in the third time series sample from Hopkins (Pacific Grove) (Fig. 42).
- Total lead did not exceed the WQO in any sample from any site. Many sites had non-detects throughout the sampling (Fig. 42).
- The *E.coli* WQO was exceeded in 100% of the time series samples, with the highest concentration in the first time series sample at Pico (>241,960 MPN/100 ml). The enterococcus WQO was exceeded in 100% of the time series samples, with the highest concentration in the third time series sample from Congress (>241,960 MPN/100 ml) (Fig 43).

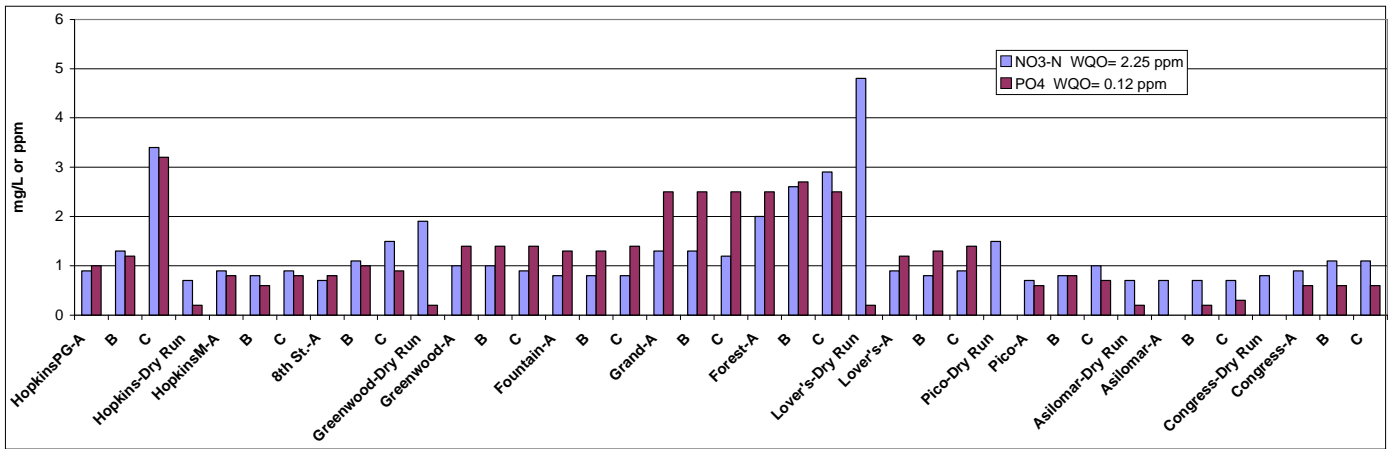


Figure 39. Nitrate and Orthophosphate concentrations for Dry Run and First Flush 2008 in Pacific Grove, CA.

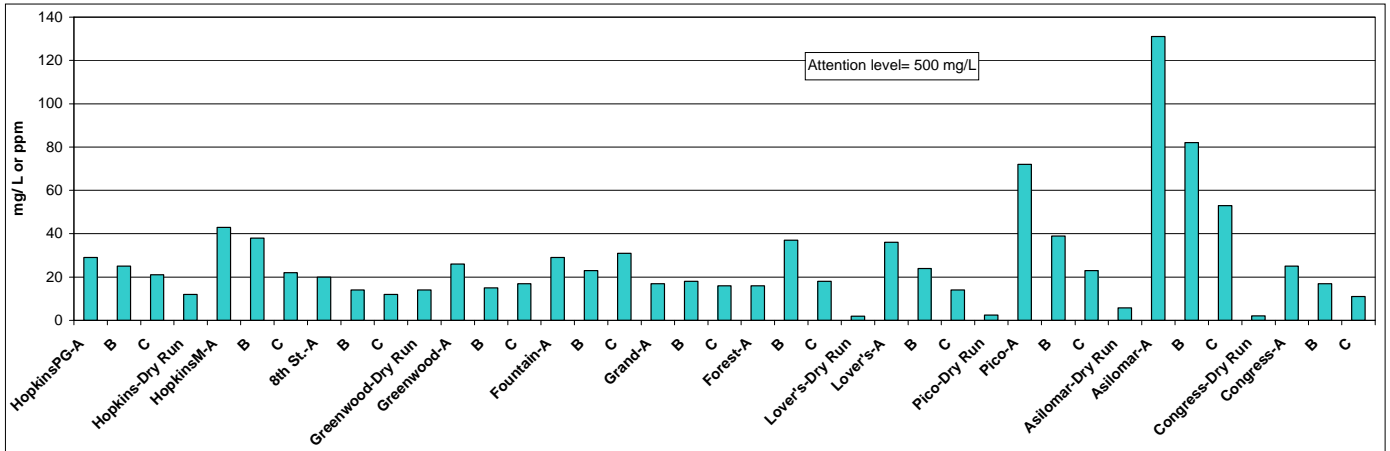


Figure 40. Total suspended solids (TSS) concentrations for the Dry Run and First Flush 2008 in Pacific Grove, CA.

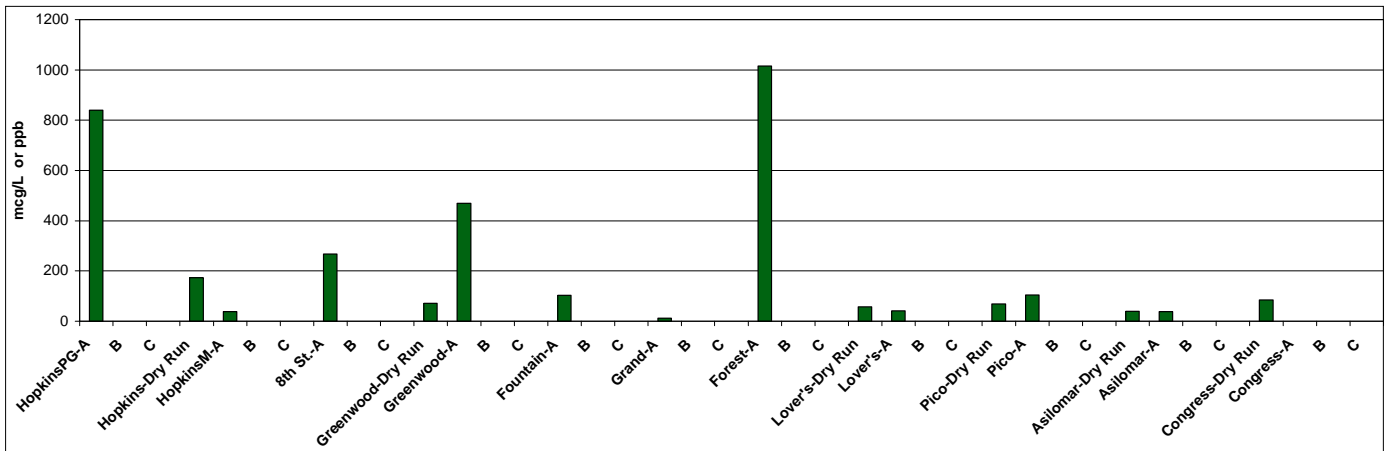


Figure 41. Urea concentrations for the Dry Run and First Flush 2008 in Pacific Grove, CA. Urea was only measured during the first time series of the First Flush event.

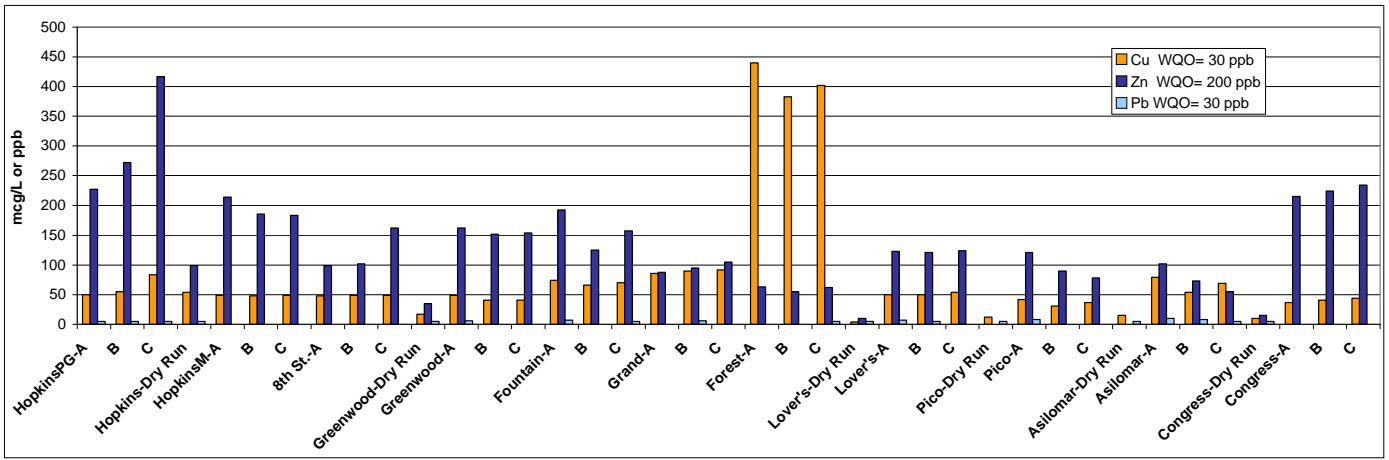


Figure 42. Total metal concentrations for copper, lead & zinc for the Dry Run and First Flush 2008 in Pacific Grove, CA.

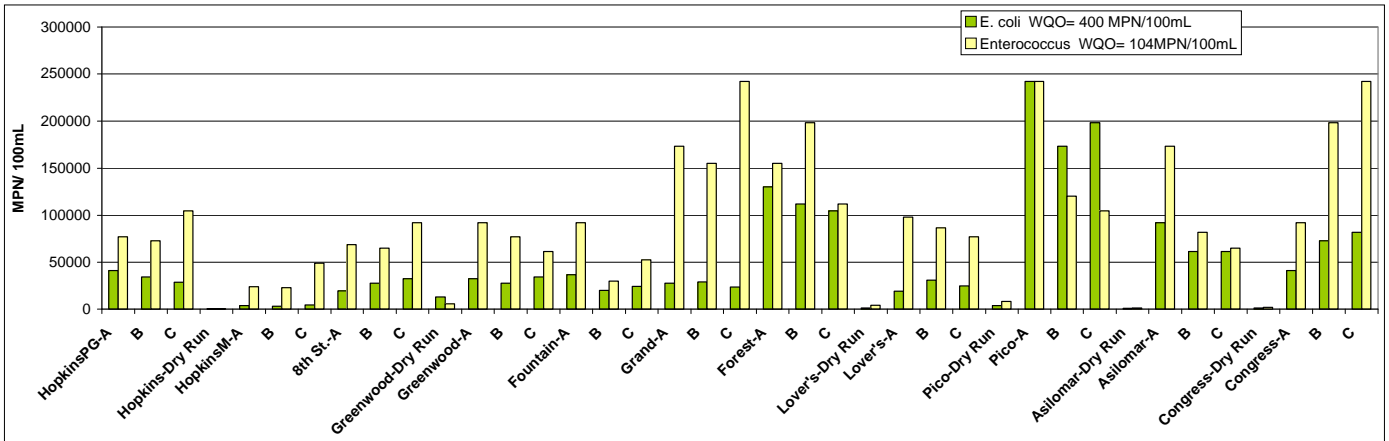


Figure 43. E.coli and enterococcus concentrations for the Dry Run and First Flush 2008 in Pacific Grove, CA.

## Carmel

The Dry Run (DR) for Carmel was conducted on September 20<sup>th</sup>, 2008. All sites were checked but only 8<sup>th</sup> Avenue had flowing water and was monitored. The only parameter that exceeded a WQO was enterococcus (942 MPN/100 ml).

First Flush 2008 team members mobilized at approximately 8:00 p.m. on November 1<sup>st</sup>, the first measurements were taken at 8:30 p.m. Three time series samples were collected at three sites and measured for each analyte: nitrate, urea, orthophosphate, copper, zinc, lead, hardness, total suspended solids, *E.coli* and enterococcus. Urea was monitored only once, during the first time series. A fourth site, 4<sup>th</sup> Avenue, was not monitored on November 1<sup>st</sup> due to construction activity at the site. Instead 4<sup>th</sup> Avenue was monitored during a later storm on November 26<sup>th</sup> lab results are included below with the November 1<sup>st</sup> storm event lab results.

First Flush lab analysis showed:

- No sites exceeded the attention level for nitrate (Fig. 44).
- Orthophosphate exceeded the attention level in 100% of the time series samples. The highest concentration was at Mission Street (1.9 mg-P/L) (Fig. 44).
- Total suspended solids were below the attention level for all time series samples except for the first time series sample at Mission Street (509 mg/L) (Fig. 45).
- Urea ranged from 46 to 331 µg/L with the highest concentration at 8<sup>th</sup> Avenue (Fig.46).
- Total copper exceeded the WQO in 100% of the time series samples, with the highest concentration in the first time series sample at Mission Street (188 µg/L) (Fig. 47).
- Total zinc exceeded the WQO in seven (58%) of the twelve time series samples. The highest concentration was from the first time series sample at Mission Street and in the second time

series sample from 8<sup>th</sup> Street both with a value of 238 µg/L (Fig. 47).

- Total lead exceeded the WQO for one (8%) of the twelve time series samples. The high value was from Mission Street (36 µg/L) during the first time series sample (Fig 47).
- *E. coli* and enterococcus levels were both above WQO's for 100% of the time series samples at all sites. The highest *E. coli* measurements were at Mission Street in the first and third time series samples, with a high of 51,721 MPN/ 100 ml. The highest enterococcus concentration was > 241,960 MPN/100 ml in Ocean Avenue's second time series sample (Fig. 48).

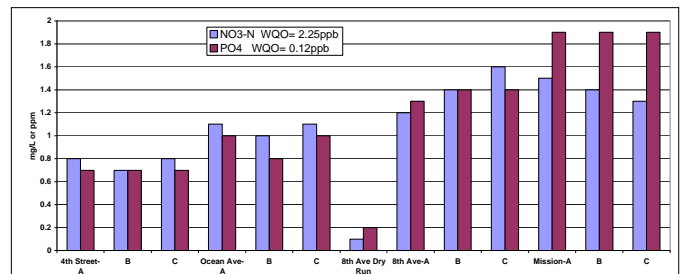


Figure 44. Nitrate and Orthophosphate concentrations for the Dry Run and First Flush 2008 for Carmel by the Sea, CA

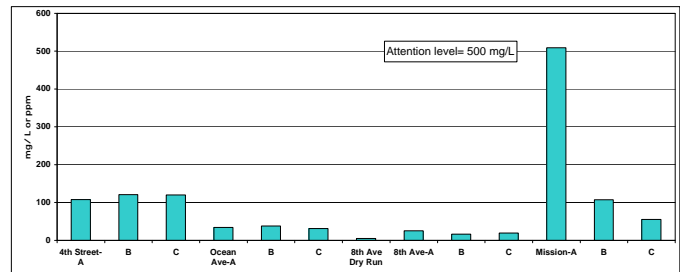


Figure 45. Total suspended solids (TSS) concentrations for the Dry Run and First Flush 2008 for Carmel by the Sea, CA

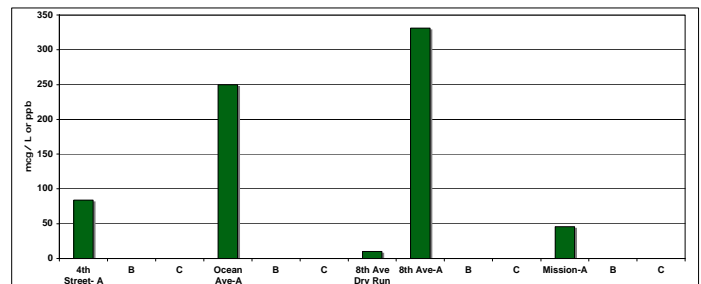


Figure 46. Urea concentrations for the Dry Run and First Flush 2008 for Carmel by the Sea, CA.

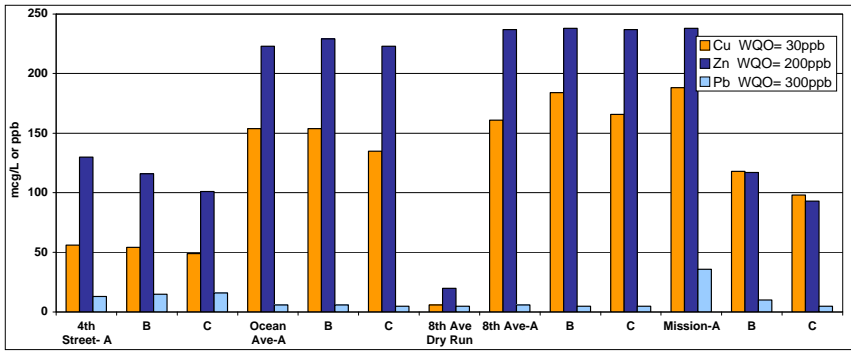


Figure 47. Total metal concentrations for copper, lead and zinc for the Dry Run and First Flush 2008 for Carmel by the Sea, CA.

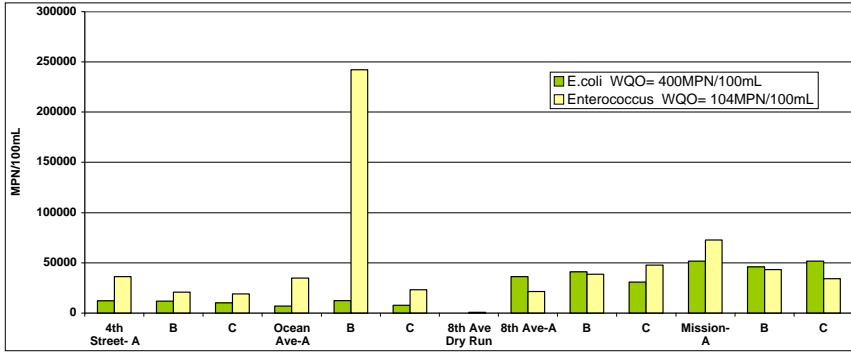


Figure 48. E.coli and enterococcus concentrations for the Dry Run and First Flush 2008, Carmel by the Sea, CA.

**Attachment 2: Site name and location**

