

2010 First Flush Program Final Report

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Prepared for:

**City of Santa Cruz
Department of Public Works**



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Introduction

As part of a regional effort throughout the Monterey Bay, the Coastal Watershed Council (CWC) conducted the 2010 First Flush Program in Santa Cruz County in the fall of 2010. As CWC's program partner, the Monterey Bay National Marine Sanctuary conducted similar activities in Monterey and San Mateo Counties. CWC's work was partially funded by contracts with the City of Capitola, County of Santa Cruz and City of Santa Cruz (City). This report covers First Flush monitoring in the City of Santa Cruz, including:

- Classroom training of volunteers
- Follow-up training through the Dry Run event for volunteer teams to visit sites and conduct dry weather water quality monitoring
- First Flush water quality monitoring during the first significant rainfall of the 2010-11 wet season

Three storm drain outfall sites were monitored for the City of Santa Cruz and are referred to as: (1) Bay Avenue; (2) Woodrow; and (3) Arroyo Seco. Other storm drain sites outside of the City limits were monitored for other funding partners in Santa Cruz County.

Rationale for Program: Pollutants have become abundant within the environment, often due to human activities. This includes everyday activities such as performing lawn care, washing clothes with detergents, and driving motor vehicles. Pollutants collect on local street surfaces, sidewalks, driveways, rooftops and other impermeable surfaces, as well as in yards, parks and beaches throughout the year. During the lengthy dry season common for our regional climate, there are no storms to “rinse away” these contaminants. The result of these several months of dry weather is a significant build-up of pollutants, which are then “flushed” into storm drains, creeks, rivers and the Monterey Bay during the first heavy rains of the wet season. The First Flush Program aims to gather data about the amount of pollution entering local waters during this onset of the rainy season.

Results are communicated to the general public and to local leaders through a variety of means, including this report. It is hoped that this program will foster more informed efforts to prevent pollution and protect the natural resources this region relies on for tourism, jobs, overall economy, and quality of life for residents. The First Flush Program also represents an efficient way for local jurisdictions to meet a portion of their USEPA National Pollution Discharge Elimination System (NPDES) and MS4 General Permit requirements. Public education and outreach is an integral part of the First Flush Program. Volunteers such as those trained by CWC engage in citizen science and help spread the news about stormwater runoff throughout their communities. While citizen science efforts such as the First Flush Program are important for generating valuable water quality data, they also represent an opportunity to educate and inspire the public to

become more environmentally aware and to act as responsible stewards of our unique natural resources.

Since 2000, the First Flush Program has trained citizen 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 tests including measurements of pH, electrical conductivity, transparency and water temperature. They also receive training in collecting water samples for delivery to laboratories for analysis of nutrients (nitrate and orthophosphate), bacteria (*Escherichia coli*, total coliform and enterococcus), metals (copper, lead and zinc), total suspended solids and hardness. All CWC trainings for water quality monitoring focus on imparting to volunteer teams the knowledge and skill required to follow quality assurance protocols consistent with USEPA and State Water Resources Control Board procedures. All training stresses the importance of volunteer safety above all other considerations.

The involvement of trained citizen volunteers provides benefits to the funding agencies in terms of human resource cost savings and skilled monitoring personnel. This is especially valuable during events such as First Flush that are time sensitive, as the water quality monitoring must be done immediately upon the onset of the first winter storm, regardless of what time of day or night that occurs.

Methods

Training

Prior to First Flush, volunteers were trained in the classroom on field monitoring techniques, including how to use a conductivity meter, pH strips, transparency tube, and thermometer, and how to properly collect and preserve water samples for laboratory analysis using appropriate containers, and while wearing nitrile gloves. During a follow-up training, volunteers went out to their sites and performed field tests and collected water samples. Known as the First Flush Dry Run, this second training served several purposes. One was to familiarize volunteers with their team members so they form a unified team, and more importantly to give them the opportunity to visit their monitoring site in daylight and during good weather. This is an important safety measure as the First Flush storm often comes during the night, and the familiarity volunteer teams gain during the Dry Run prepares them to visit their site when conditions are wet and possibly dark. In addition, as the Dry Run generates valid data, the results offer a comparison between pollutant concentrations in the dry weather flows and the flows during the First Flush storm.

Volunteers in Santa Cruz County received the classroom training on September 7, 2010, and Dry Run training on September 11, 2010. A separate training was held on September 10, 2010, for twenty-five Cabrillo College students. Monterey County volunteers received their trainings on September 16 and 18, 2010. For the three City sites, CWC had eighteen trained volunteers prepared; for the event, nine volunteers participated in the

actual event. The same equipment and protocols were used for both the Dry Run and First Flush events.

Monitoring

Having completed classroom and Dry Run training, volunteer teams were prepared for the arrival of the First Flush storm. CWC staff monitored the offshore storms through the U.S. Naval Research Laboratory in Monterey to anticipate when the first significant rainfall would occur in the Santa Cruz region. Using a phone tree, CWC staff then mobilized team leaders who activated all volunteers to meet on-site. Upon seeing that the rain was sheeting off of the street at their site, volunteer teams began monitoring activities.

When budgets allow for ideal sampling design, the First Flush event includes a time series collection of water and field measurements conducted at intervals for up to three sets of data and water sample collection. This is intended to cover multiple points along the rising limb of the rainfall hydrograph, to capture the heaviest pollution load and highest concentrations of measured constituents. For City sites, a one time series water sample was collected for storm drain sites. While the budget allowed for only one sample collected for lab analysis, field measurements and visual observations were conducted during all three time series at City storm drain sites. The Arroyo Seco team, trained to collect samples at zero minutes along with a duplicate sample set at the same time (for Quality Assurance purposes), instead collected a second sample set at 30 minutes.

Conductivity was measured using an Oakton EC Testr; water temperature was measured using a spirit bulb or digital thermometer; pH was measured using Macherey-Nagel non-bleeding pH strips; and transparency was measured using 120 cm transparency tubes. Physical observations such as trash, odor, bubbles, scum, and oil sheen were also recorded on the field data sheet. Sample containers were filled with storm drain discharges for laboratory analysis of nitrate, orthophosphate, *E. coli*, enterococcus, total coliform, copper, lead, zinc, hardness, and total suspended solids (TSS). All collected water samples were analyzed as a grab sample rather than a composite of samples.

Data Analysis

Lab results were compared to ambient water quality standards to provide an indication of relative pollutant levels. These standards apply only to ambient concentrations within “receiving waters”, i.e., a stream, lake, or ocean—they do not apply directly to end-of-pipe applications such as storm drain discharges. Nonetheless, absent any other standard, they provide some means of comparison for the results. Metals results were compared to the Central Coast Basin Plan Water Quality Objectives (WQOs) for the protection of aquatic life. Nitrate, orthophosphate, and total suspended solids (TSS) results were compared with the Central Coast Ambient Monitoring Program’s (CCAMPs) attention levels. These attention levels indicate receiving water concentrations at which pollutants may impact cold-water fish or human health. Again, both the Basin Plan water quality objectives and CCAMP attention levels are established for receiving waters and *not* for end of pipe discharges. Dilution via mixing with ambient water usually occurs in the receiving waters within a short distance of each storm drain outfall.

Water Quality Objectives (WQOs) and Minimum Detection Limits (MDLs) are noted in Table 1 for each constituent. The MDL is the minimum concentration that a laboratory’s analytical procedure can detect for a given analyte. For “non-detect” results, the data point is placed on the graph at zero, although the actual value is in fact nominally at some level between zero and the MDL.

Table 1: Water Quality Objectives (WQO) & Minimum Detection Limits (MDL)

<u>Parameter</u>	<u>Water Quality Objectives</u>	<u>Minimum Detection Limits</u>	<u>Source of Objective</u>
Nitrate as N	not to exceed 2.25 mg/L	0.1 mg/L	CCAMP Attention Level
Orthophosphate as P	not exceed 0.12 mg/L	0.05 mg/L	CCAMP Attention Level
<i>E.coli</i>	not to exceed 235 MPN/100 mL	1 MPN/100mL	CCRWQCB Basin Plan
Enterococcus	not to exceed 104 MPN/100 mL	1 MPN/100mL	CCRWQCB Basin Plan
Copper	<30 µg/L	4 µg/L	CCRWQCB Basin Plan
Lead	<30 µg/L	5 µg/L	CCRWQCB Basin Plan
Zinc	<200 µg/L	10 µg/L	CCRWQCB Basin Plan
Total suspended solids (TSS)	<500 mg/L	5 mg/L	CCAMP Attention Level
Water temperature	no more than 22°C	N/A	Basic Plan Objective for Cold Water Fish
pH	no lower than 6.5 and no greater than 8.5	N/A	CCRWQCB Basin Plan

Results/Discussion

The 2010 First Flush event in the City of Santa Cruz occurred on October 17, 2010, during a slow-moving storm of cold, unstable air that approached from the North. First Flush teams were able to monitor a total of fifteen sites across Santa Cruz County, starting at approximately 12:30 PM, including three storm drain sites within the City.

The range of results obtained for each monitoring constituent is shown in Table 2. Table 3 then shows the specific results for each constituent at each site for the First Flush event.

Table 2: Range of Results for 2010 Monitoring Events

<u>Parameter</u>	<u>Dry Run 2010</u>	<u>First Flush 2010</u>
Orthophosphate as P	ND to 0.11 mg/L	0.66 to 0.84 mg/L
Nitrate as N	0.85 to 1.84 mg/L	ND to 1.77 mg/L
Urea	NA	128 to 384 µg/L
<i>E.coli</i>	40 to 284 MPN/100mL	304 to 112,000 MPN/100mL
Enterococcus	126 to 476 MPN/100mL	19,900 to 242,000 MPN/100mL
Total suspended solids (TSS)	Non Detect (ND)	33 to 250 mg/L
Water temperature	16.0 to 17.5 °C	15.0 to 16.0 °C
pH	6.5	6.0 to 6.5
Conductivity	90 to 500 µS	140 to 500 µS
Calcium	54 to 89 mg/L	15 to 52 mg/L
Magnesium	8 to 11 µg/L	3 to 8 µg/L
Hardness as CaCO₃	180 to 255 µg/L	50 to 159 µg/L
Copper	ND to 5 µg/L	28 to 97 µg/L
Lead	Non Detect (ND)	ND to 54 µg/L
Zinc	ND to 15 µg/L	173 to 444 µg/L

Table 3: City of Santa Cruz First Flush 2010 - Summary of Results

			SCSD-03	SCSD-03	SCSD-03	SCSD-04	SCSD-04	SCSD-04	SCSD-05	SCSD-05	SCSD-05
			Bay	Bay	Bay	Woodrow	Woodrow	Woodrow	Arroyo Seco	Arroyo Seco	Arroyo Seco
			Time Series 1	Time Series 2	Time Series 3	Time Series 1	Time Series 2	Time Series 3	Time Series 1	Time Series 2	Time Series 3
Parameter	Units	WQO/Attn Level:									
Flow	H/M/L	N/A	M	N/A	N/A	M	M	M	L	L	No water
Trash	Y/N	N/A	Y	N/A	N/A	Y	Y	Y	N	N	N
Sewage	Y/N	N/A	N	N	N	N	Y	N	N	N	N
Oil Sheen	Y/N	N/A	N	N	N	Y	N	N	N	N	N
Scum	U	N/A	N	N	N	Y	Y	Y	N	N	N
Water Temperature	°C	<22°	15.5	16.0	15.0	16.0	15.0	16.0	15.5	15.5	15.7
Electrical Conductivity	uS	<2000	500	300	300	400	400	300	140	220	290
pH	units	7.0-8.5	6.5	6.5	6.5	6.5	6.5	6	6.5	6.5	6.5
Calcium	mg/L	N/A	52	N/A	N/A	28	N/A	N/A	21	15	N/A
<i>E. coli</i>	#/100ml	<235	98,000	N/A	N/A	112,000	N/A	N/A	304	738	N/A
Total Coliform	#/100ml	<10,000	>242,000	N/A	N/A	>242,000	N/A	N/A	242,000	242,000	N/A
Enterococci	MPN/100mL	<104	32,600	N/A	N/A	242,000	N/A	N/A	19,900	29,100	N/A
Hardness (as CaCO3)	mg/L	N/A	159	N/A	N/A	103	N/A	N/A	69	50	N/A
Magnesium (Mg)	mg/L	N/A	7	N/A	N/A	8	N/A	N/A	4	3	N/A
Nitrate-N (NO3-N)	mg/L	<2.25	ND	N/A	N/A	1.42	N/A	N/A	1.77	1.28	N/A
Orthophosphate-P (OP-P)	mg/L	<0.12	ND	N/A	N/A	0.77	N/A	N/A	0.84	0.66	N/A
Total Suspended Solids (TSS)	mg/L	<500	151	N/A	N/A	250	N/A	N/A	44	33	N/A
Urea-N	ug/L	N/A	128	N/A	N/A	384	N/A	N/A	199	N/A	N/A
Lead (Pb)	ug/L	<30	14	N/A	N/A	54	N/A	N/A	6	ND	N/A
Copper (Cu)	ug/L	<30 ug/L or <10 ug/L*	38	N/A	N/A	97	N/A	N/A	37	28	N/A
Zinc (Zn)	ug/L	<200	173	N/A	N/A	444	N/A	N/A	282	214	N/A
Transparency	cm	N/A	5.9	6.8	36.2	N/A	N/A	N/A	18	18	21

Shaded values = Exceedence of WQO or Attention Level
 * Copper WQO is Hardness dependent

For each parameter monitored, this section also includes a brief narrative summary and a plot showing the results for that parameter. All plots chart the results of the three storm drain sites in the City of Santa Cruz, as well as a line indicating the water quality objective or attention level, for easy comparison of results to these useful values. The data labeled as “Time Series 1” are results from the samples collected upon arrival at the site. “Time Series 2” and Time Series 3” results are field measurements and visual observations, taken 30 and 60 minutes later, respectively. The Arroyo Seco team, trained to collect water samples at zero minutes (“Time Series 1”) along with a set of duplicate samples at the same time (for Quality Assurance purposes), instead collected a second sample set at 30 minutes. These results are presented in the table and graphs as “Time Series 2”. Note: no Dry Run samples were collected at the Arroyo Seco site due to volunteer scheduling conflicts.

Nutrients

Nitrate is a vital nutrient for plant growth. Normally nitrate is not found in elevated concentrations within aquatic environments unless there is an anthropogenic source. Elevated nitrate levels can cause algal blooms which in turn impact water quality, most notably via decreased dissolved oxygen levels as the algae decay. Sources of nitrate may include runoff from fertilized lawns, farms, and construction sites, as well as leakage from septic systems and sanitary sewers. The CCAMP attention level for nitrate (NO₃-N) is 2.25 mg-N/L. The minimum detection limit (MDL) is 0.1 mg-N/L.

During First Flush none of the City sites monitored were over the attention level for nitrate. The highest concentration detected was 1.77 mg-N/L at the Arroyo Seco site.

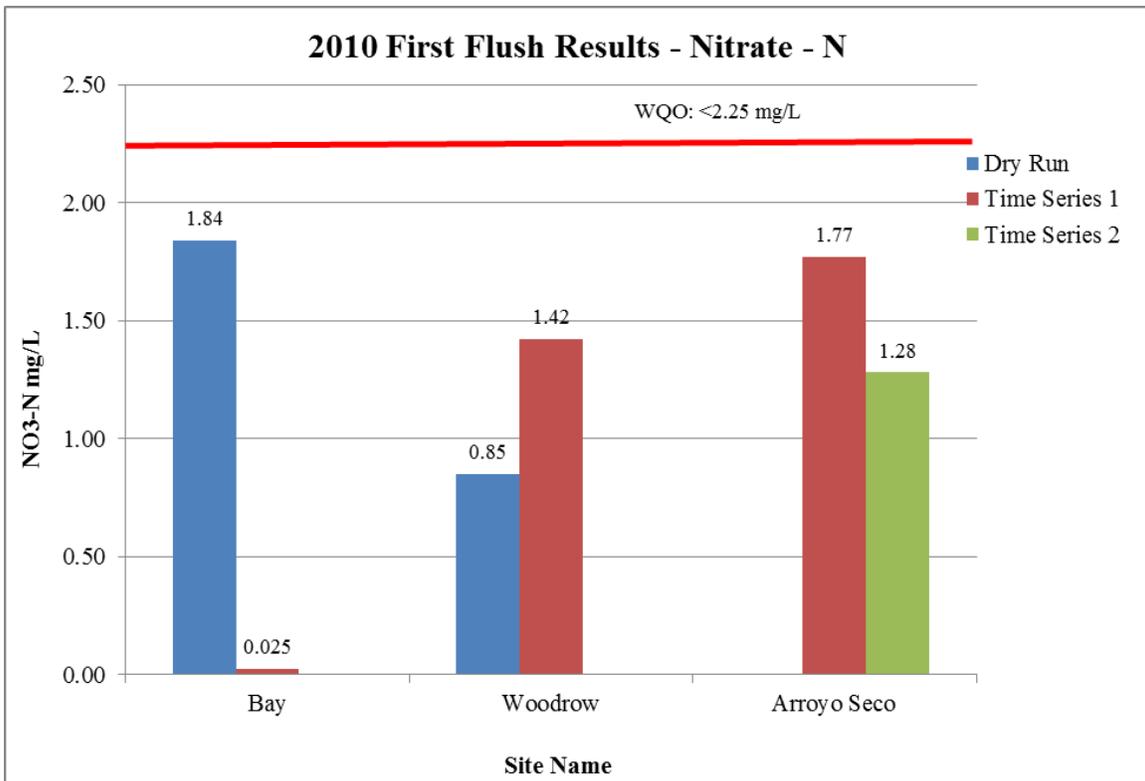


Figure 1: City of Santa Cruz Dry Run and First Flush Results: Nitrate as Nitrogen at Bay, Woodrow & Arroyo Seco storm drain sites.

Similar to nitrate, phosphate is also a necessary nutrient for plant growth, and is rarely found in elevated levels in the environment unless there is an anthropogenic source. The CCAMP attention level for orthophosphate (PO₄-P) is 0.12 mg-P/L. The MDL is 0.05mg-P/L. Samples taken at the Woodrow and Arroyo Seco sites exceeded the CCAMP attention level, as shown in Figure 2.

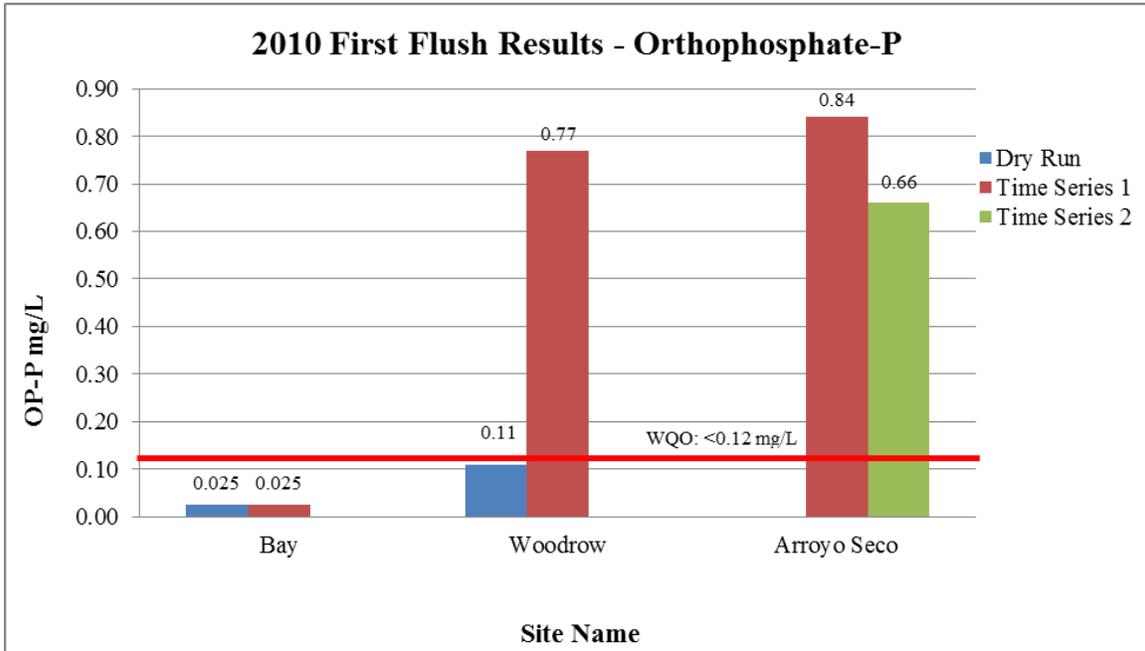


Figure 2: City of Santa Cruz Dry Run and First Flush Results: Orthophosphate as Phosphate at Bay, Woodrow & Arroyo Seco storm drain sites.

Urea is an organic compound containing nitrogen. It is one of the compounds found in nature as part of the nitrogen cycle. Mammals metabolize nitrogen into urea and excrete it in urine. The toxicity of urea and ammonia in aquatic systems depends on the pH, temperature and salinity, which control its form and availability. There are no CCAMP attention levels specifically for urea or ammonia. Urea, not ammonia, was measured during First Flush, with a MDL of 0.05 µg-N/L. Figure 3 shows the urea results for First Flush.

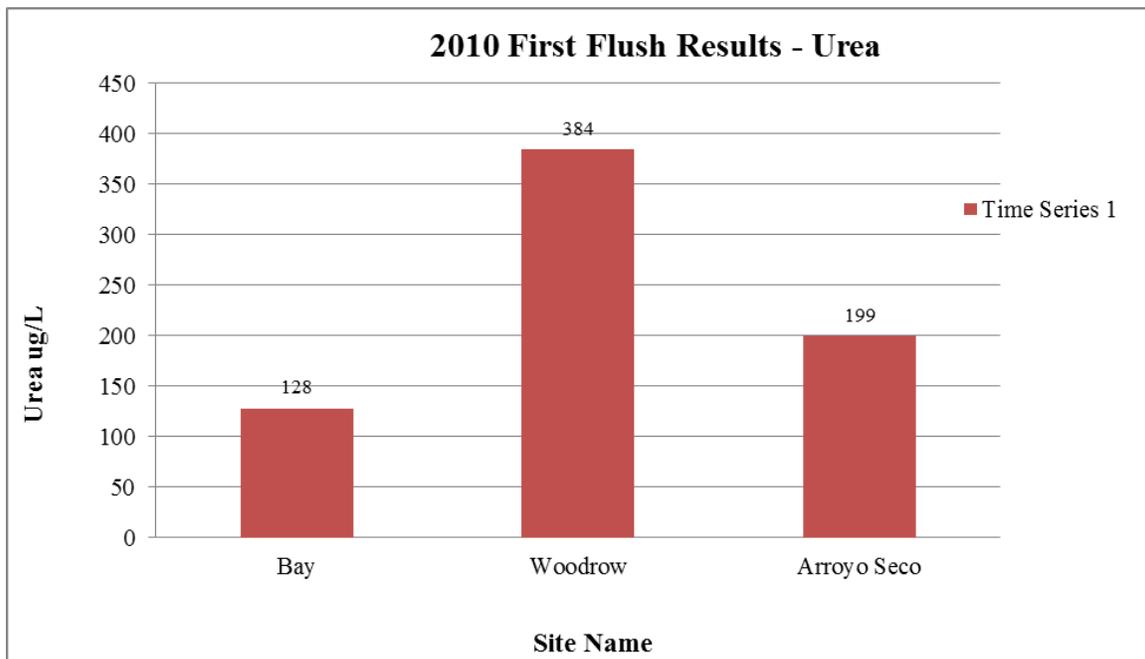


Figure 3: City of Santa Cruz Dry Run and First Flush Results: Urea as Nitrogen at Bay, Woodrow & Arroyo Seco storm drain sites. There is no established WQO for urea.

Bacteria

Bacteria are microscopic, single-celled organisms that have essential functions within watersheds, including functioning as decomposers by breaking down plant and animal remains. While many bacteria perform beneficial functions in healthy natural systems, some forms of bacteria cause disease in humans and other organisms. *E.coli* and enterococcus are each common types of bacteria whose presence suggests the presence of disease-causing bacteria. As such, stormwater professionals and public health officials focus on these “indicator” bacteria, and measure them during events such as First Flush.

The Basin Plan Water Quality Objective for *E.coli* is 235 MPN/100mL and the MDL is 1 MPN/100mL. For enterococcus, the WQO is 104 MPN/100mL and the MDL is 1 MPN/100mL.

Results for *E. coli* (Figure 4) show that samples at Woodrow exceeded the WQO during the Dry Run and all sites exceeded the WQO during the First Flush. Enterococcus results (Figure 5) show that samples at all sites exceeded the WQO during both the Dry Run and First Flush. These elevated levels indicate possible contributions to stormwater from sources such as leaky sewage pipes or septic systems, fecal waste from pets, feces from birds and other wild animals, and/or runoff from livestock areas.

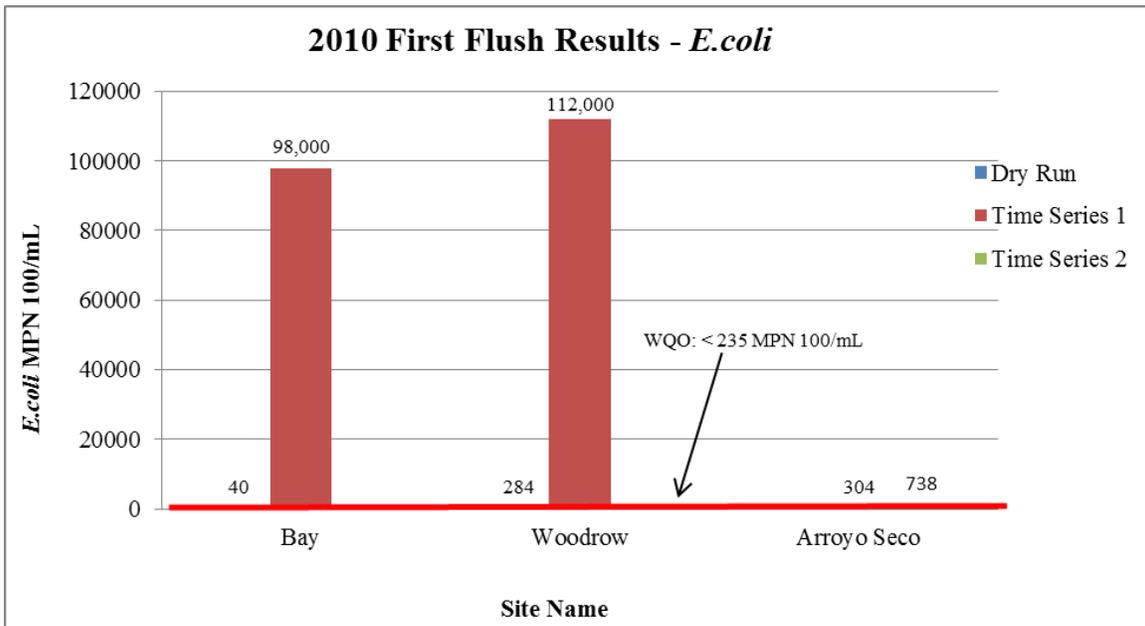


Figure 4: City of Santa Cruz Dry Run and First Flush Results: *E. coli* levels at Bay, Woodrow & Arroyo Seco storm drain sites.

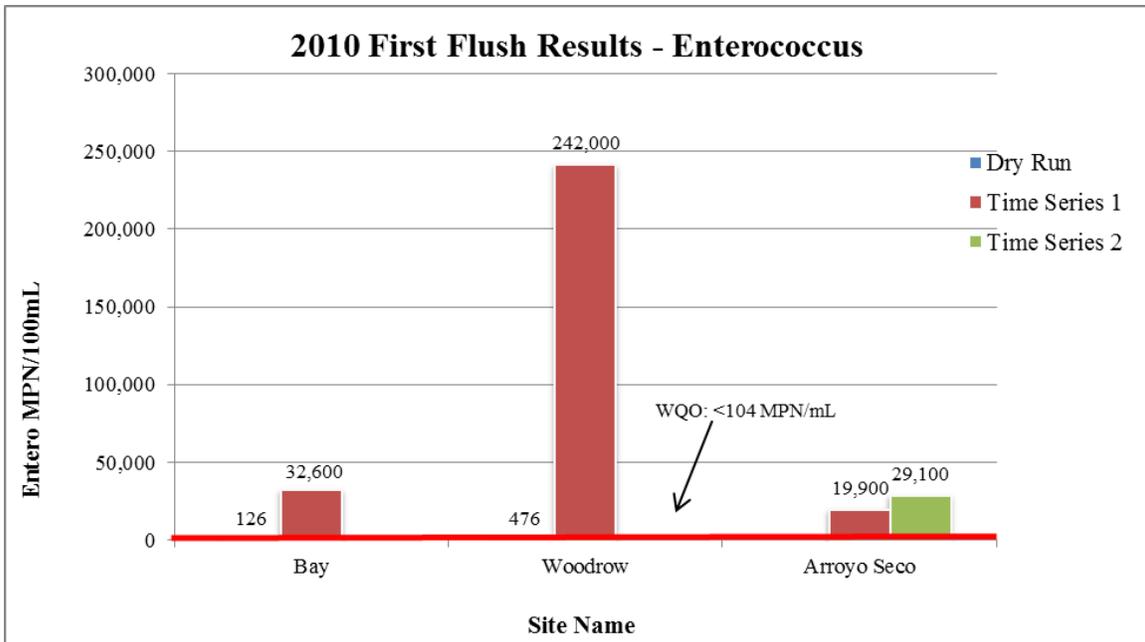


Figure 5: City of Santa Cruz Dry Run and First Flush Results: Enterococcus levels at Bay, Woodrow & Arroyo Seco storm drain sites.

Metals:

Copper is a naturally-occurring mineral element; however it is also used in many industrial applications, and is a common urban runoff pollutant, with a wide range of sources in urban environments. Lead is a metal found in natural deposits and zinc is found naturally in water. Surface runoff and stormwater flows pick up copper and zinc from sources such as brake pad and tire wear, vehicle wash-water, and building materials. For the Dry Run and First Flush, samples were analyzed for total copper (Cu), total lead (Pb) and total zinc (Zn).

Copper

The Basin Plan Water Quality Objective for copper is <30 µg/L. The minimum detection limit (MDL) is 4 µg/L. Figure 6 shows the copper results for the First Flush.

The copper WQO is dependent on hardness levels (hardness results shown in Figure 10). When the hardness level is >100 µg/L then the WQO is < 30 µg/L; when hardness levels are <100 µg/L then the WQO is <10 µg/L.

During the First Flush samples taken at all sites exceeded the Basin Plan WQO.

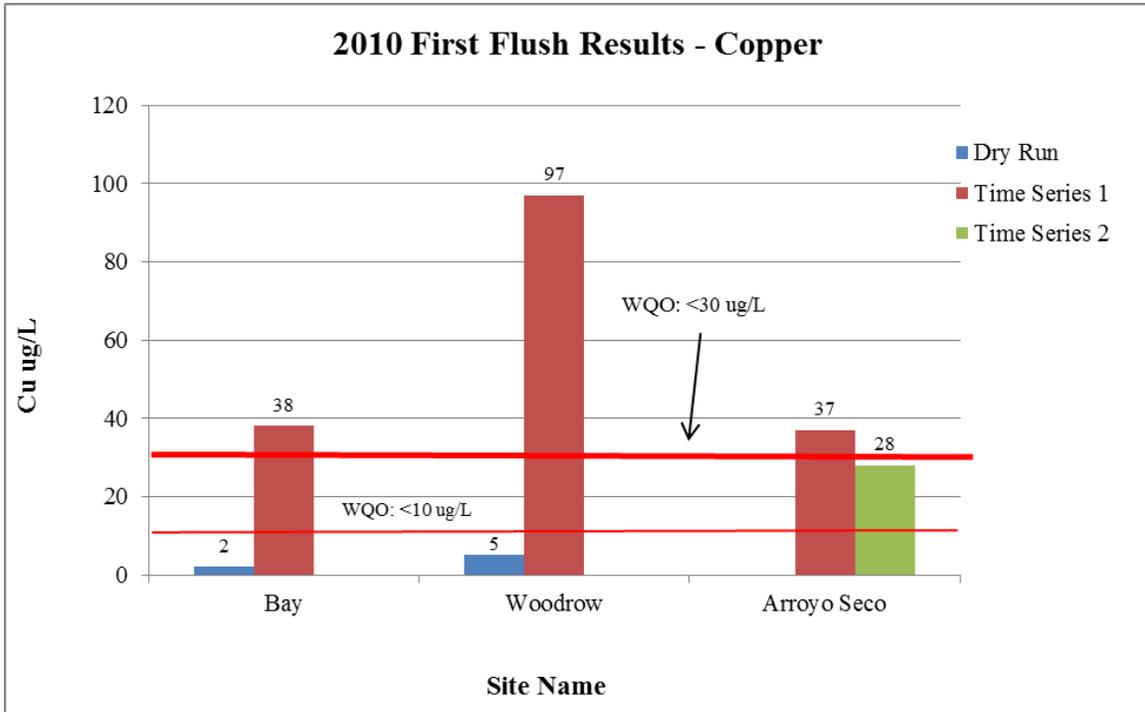


Figure 6: City of Santa Cruz Dry Run and First Flush Results: Copper levels at Bay, Woodrow & Arroyo Seco storm drain sites.

Lead

The Basin Plan Water Quality Objective for lead is <30 µg/L. The minimum detection limit (MDL) is 5 µg/L. Figure 7 shows the lead results for the First Flush.

During the First Flush samples taken at the Woodrow site exceeded Basin Plan WQO.

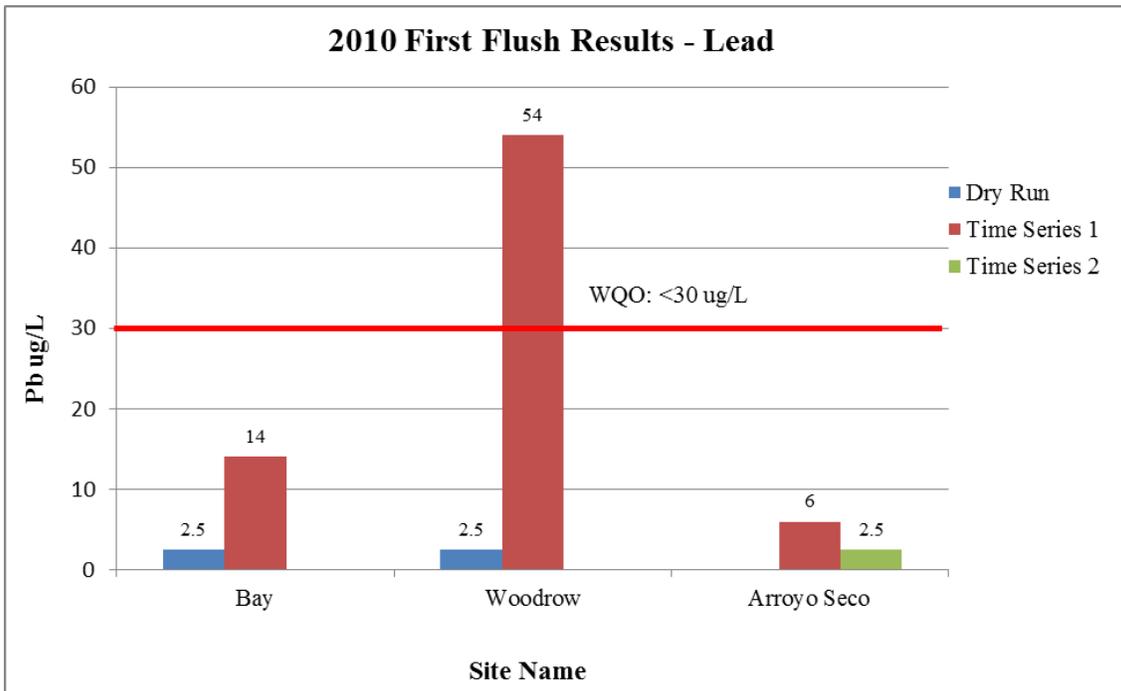


Figure 7: City of Santa Cruz Dry Run and First Flush Results: Lead levels at Bay, Woodrow & Arroyo Seco storm drain sites.

Zinc

The Basin Plan Water Quality Objective for zinc is $<200 \text{ }\mu\text{g/L}$. The minimum detection limit (MDL) is $10 \text{ }\mu\text{g/L}$. Figure 8 shows the zinc results for the First Flush.

During the First Flush samples taken at the Woodrow and Arroyo Seco sites exceeded the Basin Plan WQO.

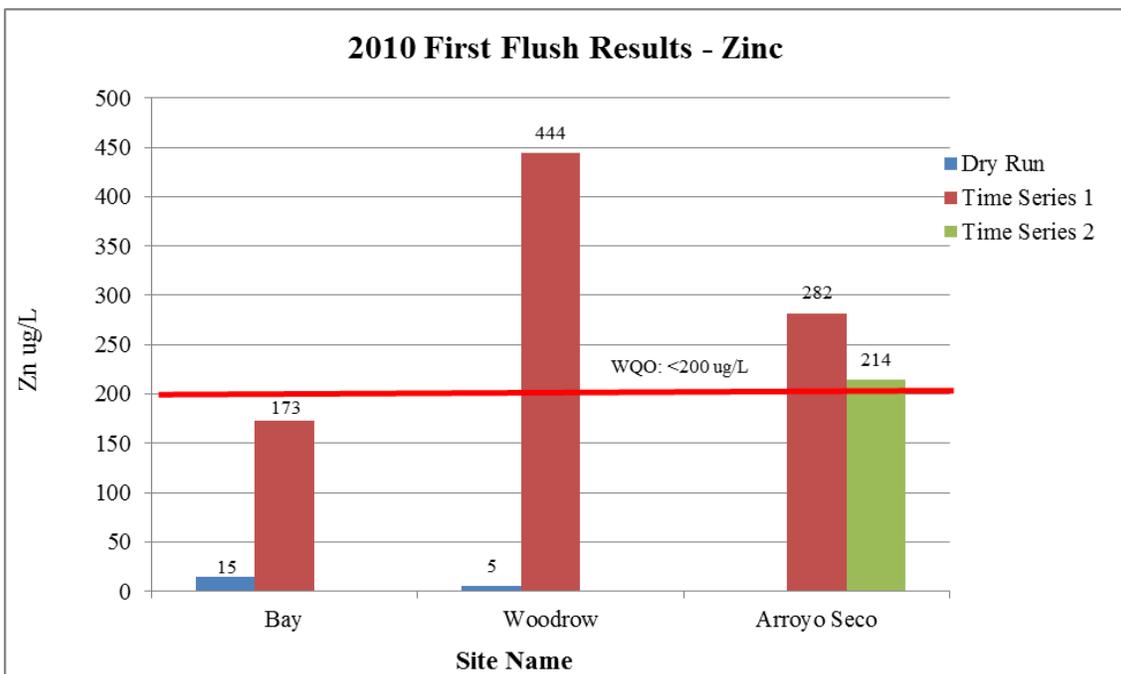


Figure 8: City of Santa Cruz Dry Run and First Flush Results: Zinc levels at Bay, Woodrow & Arroyo Seco storm drain sites.

Total Suspended Solids

Suspended solids include plankton, algae, fine organic and other particulate matter like silt and clay particles. Sources of total solids include sewage, fertilizers, road runoff, soil erosion and industrial discharges. Certain toxic compounds, including pesticides, adsorb to the surface of solid particles, making elevated total solids levels a concern for watershed health. During First Flush, hardness and total suspended solids (TSS) were measured. For TSS, the CCAMP attention level is 500 mg/L; the MDL is 5 mg/L. Figure 9 shows the TSS results for First Flush.

There were no exceedances of the CCAMP attention level for TSS during the Dry Run or First Flush.

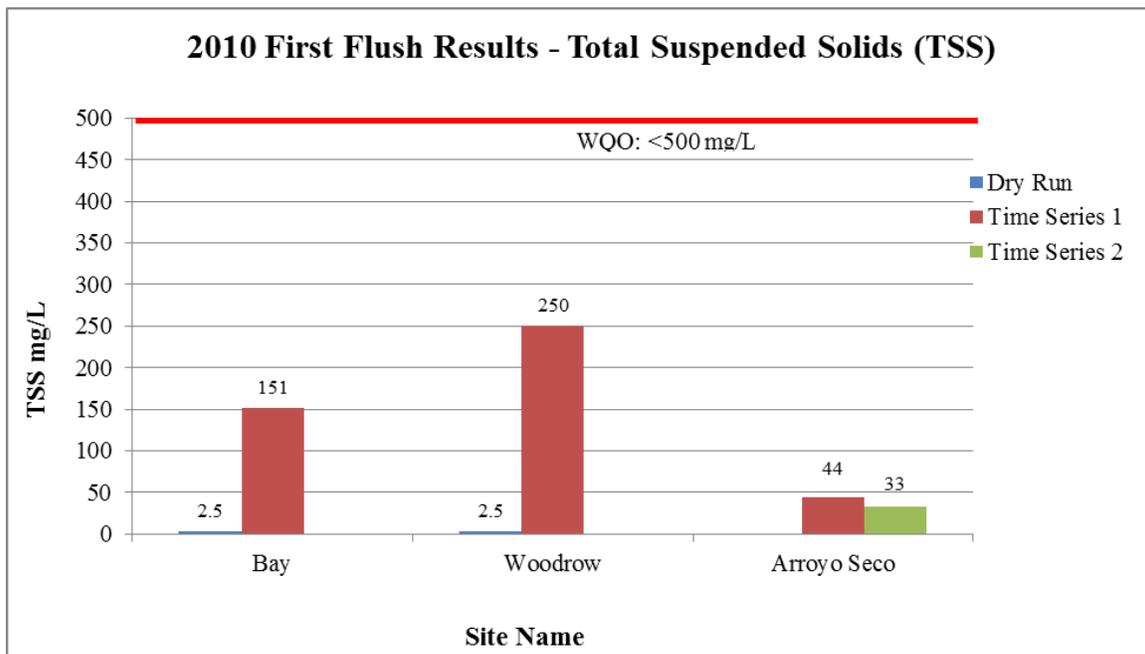


Figure 9: City of Santa Cruz Dry Run and First Flush Results: TSS levels at Bay, Woodrow & Arroyo Seco storm drain sites.

Hardness

Hardness is measured analytically as the sum of calcium and magnesium. Magnesium is necessary for photosynthesis and basic cell functions for living organisms and is found in both fresh and salt water. Sources of magnesium include fertilizers, water softeners and soaps/detergents that are not biodegradable. Calcium is abundant naturally in rocks and soil throughout much of the earth, providing healthy natural levels in many water sources of this vital mineral. No Basin Plan, CCAMP or other attention levels exist for calcium, magnesium, or hardness, though the toxicity of metals, such as copper, are dependent upon the hardness of water the metals are found in. The MDL for hardness is 1 µg/L. Figure 10 shows the hardness results for First Flush.

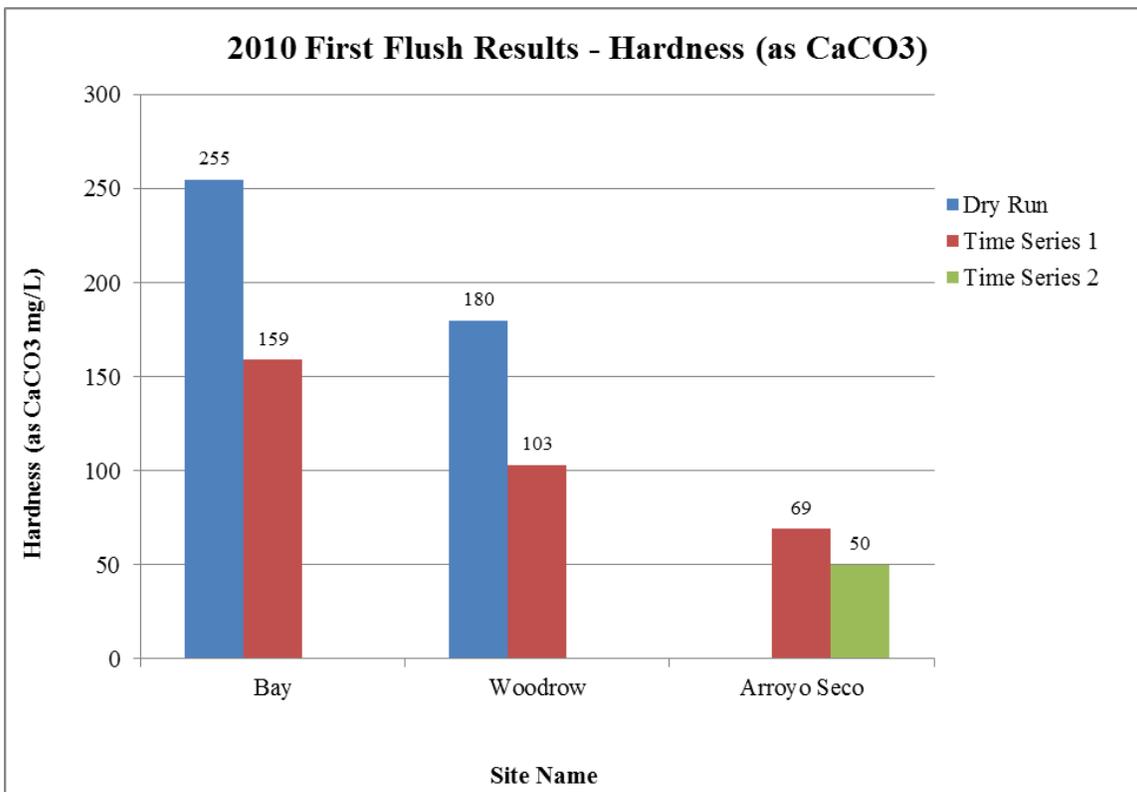


Figure 10: City of Santa Cruz Dry Run and First Flush Results: Hardness levels at Bay, Woodrow and Arroyo Seco storm drain sites.

Visual Observations

At each of the three sites monitored during First Flush 2010, volunteers observed and recorded whether there was any trash, sewage (sited or smelled), oil sheen, or scum present. Trash was recorded at the Bay and Woodrow sites. Only the Woodrow site recorded sewage smell during the second time series, oil sheen during the first time series and scum during each of the three time series. Flow levels at the Bay and Woodrow sites were recorded as “moderate” and “low” at the Arroyo Seco site.

Conclusion

This report summarizes results for the 2010 First Flush Program conducted in fall 2010 for the City of Santa Cruz. As a summary of the results section, exceedances of water quality objectives or attention levels were documented for nutrients (both nitrate and orthophosphate), bacteria (*E. coli*, total coliform and enterococcus) and metals (copper, lead and zinc) at the three City sites. These results indicate a mixed message about nutrients, which historically have been measured at excessive levels in this region. While the levels of phosphate far exceeded the CCAMP Attention Level at the Woodrow and Arroyo Seco sites, nitrate levels were well within safe levels at all three sites.

For pathogens, both indicator bacteria were measured at an order of magnitude far greater than the water quality objective at the Bay and Woodrow sites during the First Flush; Arroyo Seco also exceeded the WQO for both pathogens but at a lesser magnitude.

Results for metals show that all three City sites exceeded the WQO for copper; Woodrow exceeded the WQO for lead and both Woodrow and Arroyo Seco exceeded the WQO for zinc during the First Flush. There were no exceedances for metals during the Dry Run.

The First Flush results must be digested with the reminder that for all water quality objectives and attention levels, those values are intended to be applied to receiving waters. Discharges from storm drains will mix with the receiving waters as they enter the receiving waters, resulting in a dilution of the concentrations found in the storm drain discharge. No water quality objectives exist for storm drain discharges, per se. So while these target levels are the most appropriate use for this purpose, this qualification is important to remember when comparing actual results to target levels.

The City provides an exemplary model as a responsible steward of natural resources through its many efforts to reduce pollution associated with urban runoff. The City's financial support of the First Flush Program and its support of Snapshot Day and other dry weather monitoring activities, both by the City itself, CWC and other partners, are other examples of the City's leadership in pollution prevention. The fullest understanding of urban runoff issues requires this marriage of both wet and dry season water quality monitoring, as different parameters exhibit different levels according to the seasonal differences. Beyond monitoring, the City's efforts to educate and engage the public about sources and impacts of water pollution further demonstrate responsible municipal citizenship.

CWC greatly values our partnership with the City of Santa Cruz. It is our hope that the results in this report and from other monitoring programs will aid the City's prevention efforts by identifying which constituents are of greatest concern. Environmental data, by its very nature, is extremely variable, and conclusions are often difficult to make based on limited data points. Nonetheless, these results are of use in shaping the City's programs to inform the public about environmental stewardship. CWC's mission is to preserve and protect coastal watersheds through community stewardship, education and monitoring. CWC staff welcome every possible opportunity to assist the City in achieving our goals together and serving the community and we thank the City for their continued partnership with CWC to improve the health of local watersheds.