

2009 First Flush Program Final Report

City Purchase Order #25-10001

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 2009 First Flush Program in the Fall of 2009 in Santa Cruz County. As a partner to CWC, 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). Planned activities for the City included:

- Classroom training of volunteers
- Dry Run event for volunteer teams to visit sites & conduct water quality monitoring
- First Flush water quality monitoring during the first significant rainfall of the wet season

As the first significant storm arrived earlier than anticipated, in 2009 there was no opportunity for CWC to implement the Dry Run event for City sites, as contractual arrangements between the City and CWC had not yet been formalized. Along with storm drain and creek sites outside of the City limits monitored for other funding partners, three storm drain sites were monitored for the City: Bay Avenue, Woodrow and Arroyo Seco.

Rationale for Program: Pollutants have become abundant within the environment, often due to human activities. These can be everyday activities such as spraying pesticides, washing clothes with detergents, or driving extensively. 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 this 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, with the ideal impact being 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 their USEPA National Pollution Discharge Elimination System (NPDES) and MS4 General Permit requirements. Volunteers such as those trained by CWC engage in citizen science to assist communities and districts by increasing available human resources and monitoring abilities. 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.

Since 2000, the First Flush program has taken 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 including pH, electrical conductivity, transparency and the temperature of air and water. They also receive training for collecting water samples for delivery to laboratories for analysis of nutrients (nitrate, orthophosphate, and ammonia), bacteria (*Escherichia coli* and enterococcus), metals (copper, lead and zinc), and hardness. All training stresses the importance of volunteer safety above all other considerations. 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 or State Water Resources Control Board standards. Lastly, while citizen science efforts such as the First Flush Program are crucial 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.

Methods

Prior to First Flush, volunteers are trained in the classroom on overall monitoring techniques, including how to use a conductivity meter, pH strips, transparency tube, thermometers and how to properly collect and preserve water samples for laboratory analysis using appropriate containers and latex gloves. During a follow-up training, volunteers go out and perform field tests and collect water samples. Known as the First Flush Dry Run, this second training serves several purposes. One is 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(s) 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(s) 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 and Monterey County received training on September 16th, 2009. For the three City sites, CWC had fourteen trained volunteers prepared for the First Flush event; on event night, eleven volunteers participated in the actual event. The same equipment and protocols are used for both the Dry Run and First Flush events. Again, due to the early arrival of the First Flush storm, there was no Dry Run training for City sites in 2009; explanations of Dry Run activities offered in this report provide a context for normal operation of First Flush activities.

Having completed classroom and Dry Run training, volunteer teams are prepared for the arrival of the First Flush storm. CWC staff monitor the offshore storms through the U.S. Naval Research Laboratory in Monterey to anticipate when the first significant rainfall will occur in the Santa Cruz region. Using a phone tree, CWC staff then mobilize team leaders who activate all volunteers to meet on-site. Upon seeing that the rain is sheeting off of the street at their site, volunteer teams begin monitoring activities. When budgets permit this approach, 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 sample collection, usually during the rising limb of the rainfall hydrograph in order

to capture the heaviest pollution load and highest concentrations of measured constituents. For City sites, however, only one time series collection was planned.

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 field data sheet. Sample containers were filled with storm drain discharges for lab analysis of nitrate, orthophosphate, *E. coli*, enterococcus, total coliform, hardness and total suspended solids (TSS). All collected water samples were analyzed as a grab sample rather than a composite of samples.

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 such as these storm drain discharges, but 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 (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. These attention levels are set for 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 and/or mixing usually occurs in the receiving waters within a short distance of each storm drain outfall.

Minimum Detection Limits (MDL) are noted in Table 1 for each constituent. The MDL is the minimum concentration that a laboratory procedure can detect for a given analyte. For sites that have a non-detect listed, it is placed on the graphs at zero, although the value is not zero but instead somewhere between zero and the MDL.

Results/Discussion

The First Flush event in the City of Santa Cruz occurred on October 13, 2009, during a major storm system that extended the length of the monitored areas and beyond - from Napa Valley to south of Big Sur. First Flush teams were able to monitor fourteen sites starting around approximately 5:00 a.m.; three storm drain sites were monitored within the City.

For each parameter monitored, this section includes a brief narrative summary and a plot showing the results. 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. Also, all City sites were sampled at 5:10 a.m., but the Woodrow site was also sampled at 5:40 a.m. for the following reason: Some sites not funded by the City were sampled on a time-series basis, such as three samplings separated by thirty minutes each (the time-series approach describes in the Methods section). This approach provides a more useful set of composite results as the

levels of contaminants are measured over time rather than just once. The schedules and limited availability of certain volunteer teams required CWC staff to reassign certain team leaders and team members to cover the First Flush. This is common due to the nature of this event being unscheduled, dependent upon nature, and often in the middle of the night, as was again the case this year. As the Woodrow site team had been trained to collect samples on a time-series basis for another site, they collected samples at 5:10 a.m., and then repeated a collection at 5:40, per their training. This is the reason most plots indicate two results for the Woodrow site (5:10 results are consistently shown left of the 5:40 value). This second data point has been provided at no cost to the City for lab fees.

Storm water monitoring events like First Flush usually include analysis of metals, such as copper, lead and zinc. During the 2010 event, however, the contracted laboratory CWC employed for metals analysis failed to monitor the samples they received. The explanation provided to CWC was that CWC staff and volunteers followed all established protocol, and the samples were delivered intact to Monterey Bay Analytical Services (MBAS). Days after the event, MBAS discarded the samples rather than running the required analyses for metals. Per MBAS management, this was caused by issues of staff training, overworked staff, and management being out of town when the samples were received by the lab. CWC has taken steps to assure that if CWC contracts with MBAS again, measures have been implemented to prevent a repeat occurrence. No lab fees for metals analysis were paid using City funds.

Table 1: Water Quality Objectives (WQO)*

<u>Parameter</u>	<u>Water Quality Objectives</u>	<u>Source of Objective</u>
Orthophosphate as P	not exceed 0.12 mg-P/L	CCAMP Attention Level
Nitrate as N	not to exceed 2.25 mg-N/L	CCAMP Attention Level
<i>E.coli</i>	not to exceed 400 MPN/100 mL	EPA Ambient Water Quality Criteria
Enterococcus	not to exceed 104 MPN/100 mL	EPA Ambient Water Quality Criteria
Copper	<30 µg/L	CCRWQCB Basin Plan
Lead	<30 µg/L	CCRWQCB Basin Plan
Zinc	<200 µg/L	CCRWQCB Basin Plan
Total suspended solids (TSS)	<500 mg/L	CCAMP Attention Level
Water temperature	no more than 22°C	Basic Plan Objective for Cold Water Fish
pH	no lower than 6.5 and no greater than 8.5	CCRWQCB Basin Plan

*(Urea, Conductivity, Magnesium, Calcium, and Calcium Carbonate (CaCO₃) do not have a specific WQO or Attention Level).

Table 2: Range of results for Monitoring Events

<u>Parameter</u>	<u>First Flush 2009</u>
Orthophosphate as P	0.24 to 0.47 mg-P/L
Nitrate as N	0.4 to 1.2 mg-N/L
Urea	45-64 µg-N/L
<i>E.coli</i>	4132 to 72699 MPN/100mL

Enterococcus	6907 to 48844 MPN/100mL
Total suspended solids (TSS)	88 to 319 mg/L
Water temperature	14.5 to 16 °C
pH	6.0 to 7.0
Conductivity	0 to 210 µS
Calcium	7.1 to 34 mg/L
Magnesium	1.2 to 3.9 µg/L
(CaCO₃)	23 to 101 µg/L

Nutrients

Nitrate is a vital nutrient for plant growth and a healthy ecosystem. Normally nitrate is not found in elevated concentrations within aquatic environments unless there is an unnatural source. Elevated levels can cause algal blooms which decreases water quality, most notably decreased dissolved oxygen levels as algal blooms decay. Sources of nitrate may include runoff from fertilized lawns, farms, sewer systems and construction sites. The CCAMP attention level for N (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 1.2 mg-N/L at the Bay site.

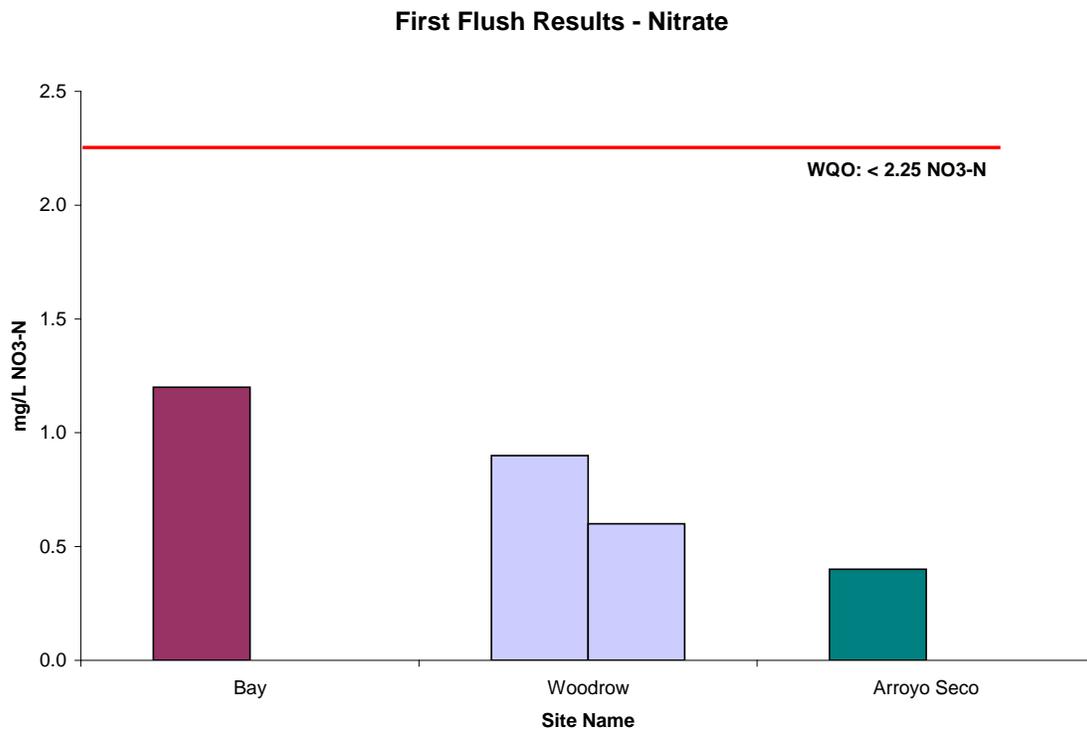


Figure 1: City of Santa Cruz First Flush Results: Nitrate as Nitrogen at Bay, Woodrow & Arroyo Seco storm drain sites.

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 unnatural source. The CCAMP attention level for orthophosphate ($\text{PO}_4\text{-P}$) is 0.12 mg-P/L. The MDL is 0.05mg-P/L. All four samples taken at City sites exceeded the CCAMP attention level, as shown in Figure 2.

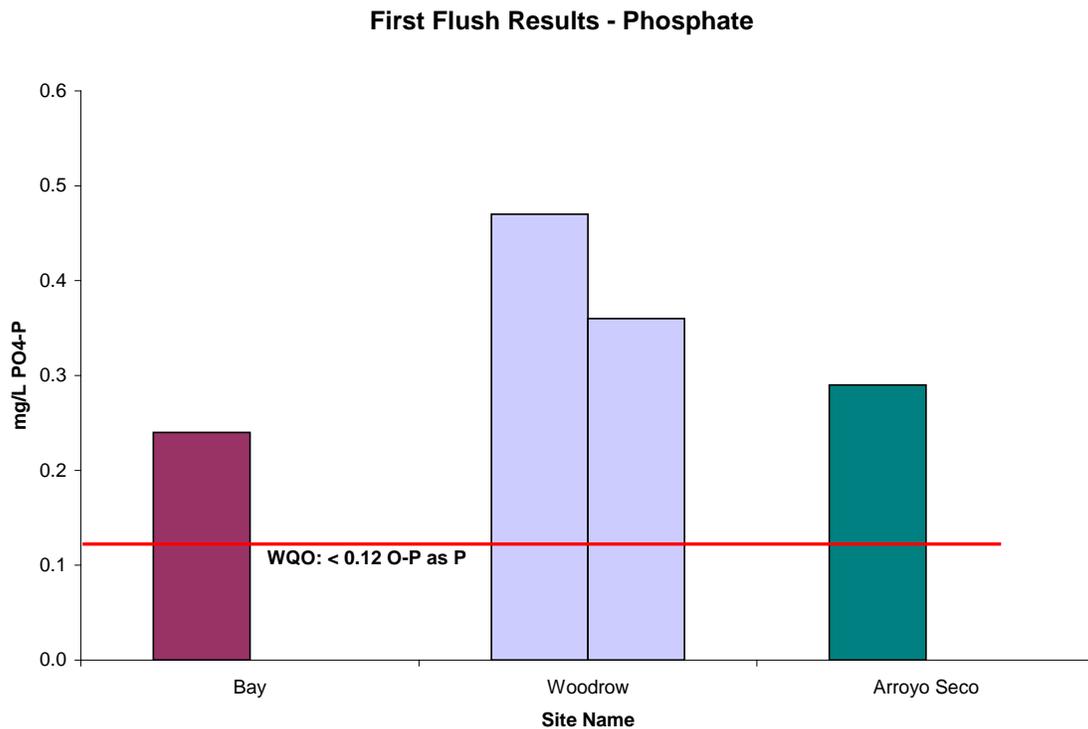


Figure 2: City of Santa Cruz First Flush Results: Orthophosphate as Phosphate at Bay, Woodrow & Arroyo Seco storm drain sites.

Urea is an organic compound containing nitrogen. As mammals metabolize nitrogen into urea and excrete it in urine, urea is one of the naturally occurring compounds found in nature as part of the nitrogen cycle. The toxicity of urea and ammonia on 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 $\mu\text{g-N/L}$. Figure 3 shows the urea results for First Flush.

First Flush Results - Urea

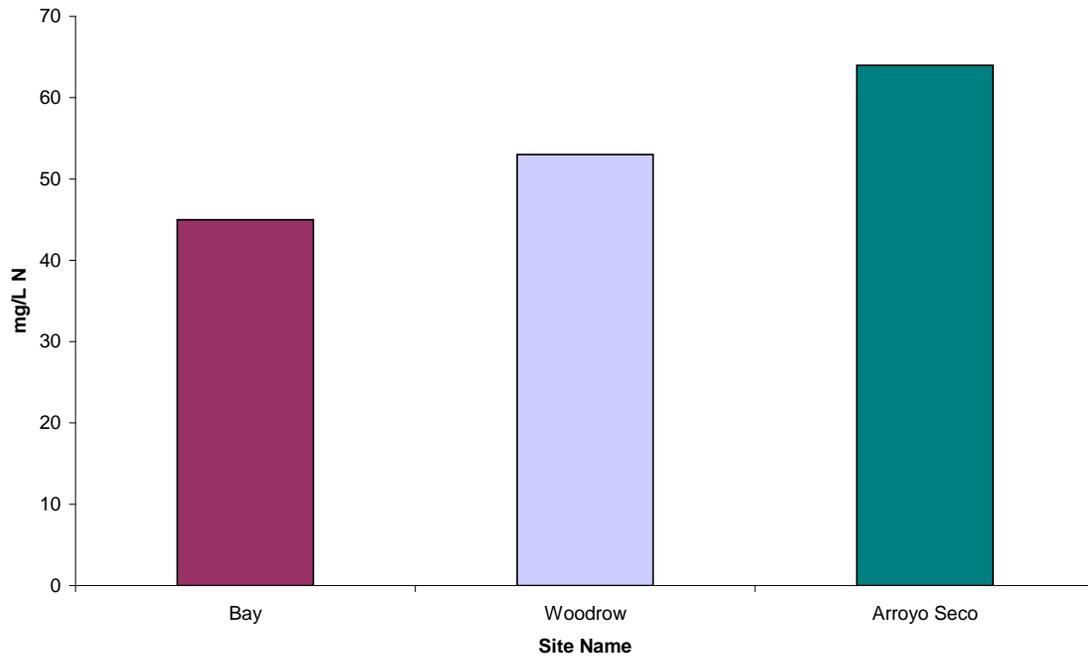


Figure 3: City of Santa Cruz First Flush Results: Urea as Nitrogen at Bay, Woodrow & Arroyo Seco storm drain sites. There is no established WQO for urea.

Bacteria

Bacteria are microscopic single-celled organisms that function as decomposers by breaking down plant and animal remains. Many bacteria are vital to the overall function of healthy natural systems, yet some forms of bacteria causes 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, storm water professionals and public health officials focus on these “indicator” bacteria, and measure them during events such as First Flush. The EPA’s Ambient Water Quality Criteria for *E.coli* is 400 MPN/100mL and the MDL is 1 MPN/100mL. For enterococcus, the WQO is 104 MPN/100mL and the MDL is 1 MPN/100mL. Figures 4 and 5 show the results for *E. Coli* and enterococcus, respectively, which show that all samples at all sites exceeded the WQO for both parameters. These elevated levels indicate contributions to storm water from possible 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.

First Flush Results - *E. Coli*

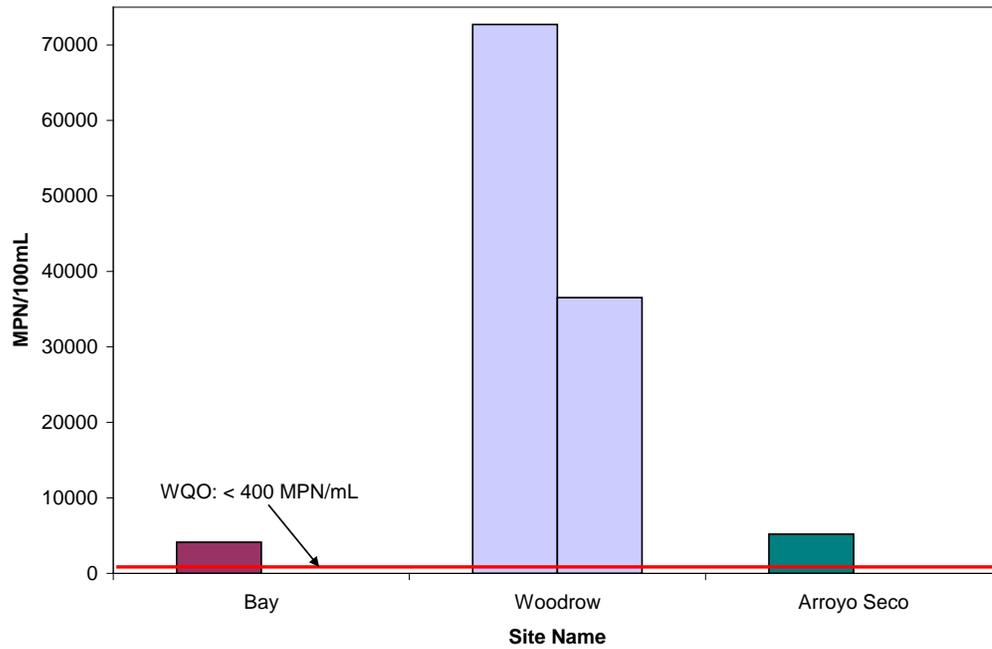


Figure 4: City of Santa Cruz First Flush Results: *E. Coli* levels at Bay, Woodrow & Arroyo Seco storm drain sites.

First Flush Results - Enterococcus

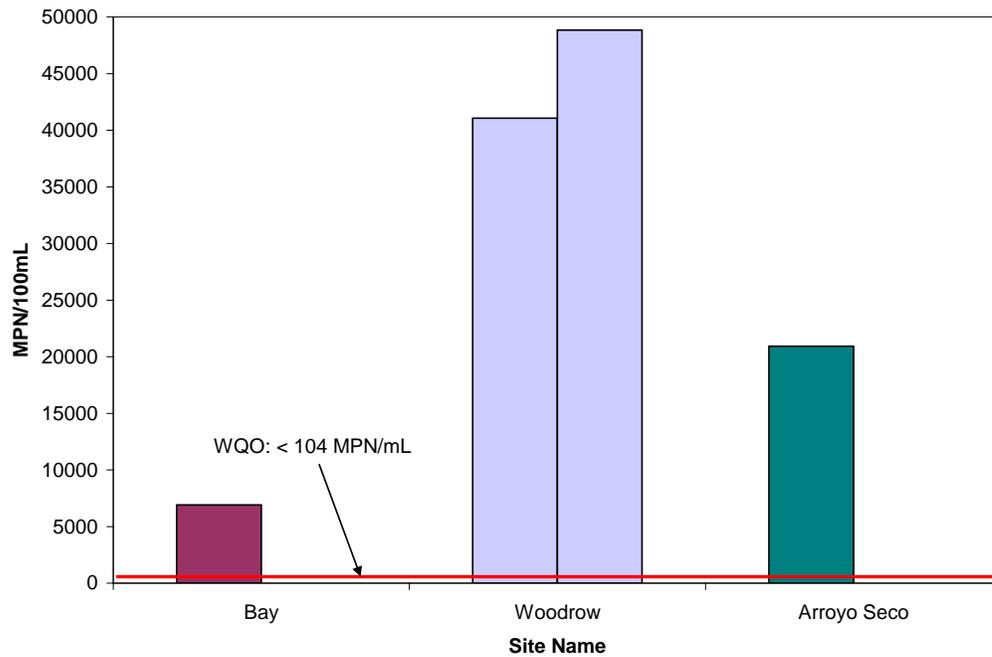


Figure 5: City of Santa Cruz First Flush Results: Enterococcus levels at Bay, Woodrow & Arroyo Seco storm drain sites.

Total Solids

Total solids are dissolved solids plus suspended and settleable solids in water. In stream water, dissolved solids consist of calcium, chlorides, nitrate, phosphorous, iron, sulfur and other ions. 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, magnesium, calcium and total suspended solids (TSS) were measured.

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. No CCAMP or other attention levels exist for magnesium; the MDL is 1 µg/L. Calcium is abundant naturally in rocks and soil throughout much of the earth, providing healthy natural levels in many water sources for this vital mineral. As with calcium, there is no CCAMP attention level specifically for calcium; the MDL is 1µg/L. For TSS, the CCAMP attention level is 500 mg/L; the MDL is 5 mg/L. Figure 6 shows the TSS results for First Flush.

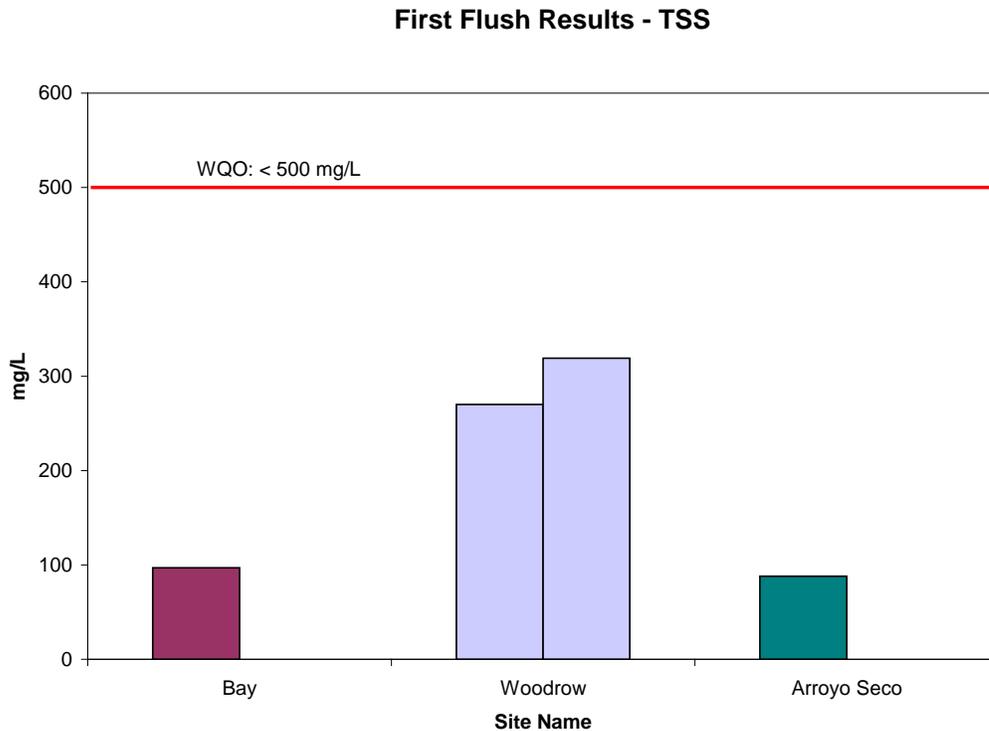


Figure 6: City of Santa Cruz First Flush Results: TSS levels at Bay, Woodrow & Arroyo Seco storm drain sites.

Visual Observations

At each of the three sites monitored during First Flush 2009, volunteers observed and recorded whether there was any trash, sewage (sited or smelled), oil sheen, or scum

present. No City sites had any documented observations of trash, sewage or oil sheen, and only Woodrow was found to have scum present. Flow levels at each site was recorded as “moderate.”

Conclusion

This report summarizes the results from the First Flush event conducted in Fall 2009. As a summary of the results section, exceedances of water quality objectives or attention levels were documented for only phosphate and bacteria (both *E. Coli* and enterococcus) 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 water quality objective, nitrate levels were well within safe levels. For pathogens, both indicator bacteria were measured at an order of magnitude or greater than the water quality objective or attention level. Also, these 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 First Flush 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 season at times. 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.