# CARLSBAD HYDROLOGIC UNIT (CHU)
# LAGOON MONITORING REPORT

June 2009

Prepared for:

City of Carlsbad, City of Encinitas, City of Escondido, City of Oceanside, City of San Marcos, City of Solana Beach, City of Vista, County of San Diego, California Department of Transportation (CalTrans), and the Hale Avenue Resource Recovery Facility (HARRF)

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# EXECUTIVE SUMMARY

## Background

The San Diego Regional Water Quality Control Board (RWQCB) issued Investigation Order (IO) No. R9-2006-076 to the dischargers to the creeks and lagoons in San Diego County that are 303(d) listed for bacteria, total dissolved solids (TDS), sediment, and nutrients. The IO required collection of monitoring data for the development of Total Maximum Daily Loads (TMDLs) as authorized by the Clean Water Act (CWA). According to the IO, the coastal lagoons in Southern California are heavily influenced by their urbanized watersheds. Runoff from these watersheds, coupled with reduced tidal influence from restricted inlets, has resulted in beneficial use impairments within Agua Hedionda Lagoon, Buena Vista Lagoon, Loma Alta Slough, and San Elijo Lagoon. All four lagoons and Agua Hedionda Creek are listed as impaired water bodies (303(d) list) for at least one of the following constituents: indicator bacteria, nutrients, sediment/siltation, TDS (Agua Hedionda Creek only), and/or eutrophic conditions. TMDLs must be developed for the critical constituents in each of the lagoons pursuant to CWA section 303(d).

To comply with the IO, the Carlsbad Hydrologic Unit's dischargers collected data in four lagoons: Aqua Hedionda Lagoon, Buena Vista Lagoon, Loma Alta Slough, and San Elijo Lagoon. The data were collected to support the development of TMDLs in one or more of these lagoons for bacteria, eutrophic conditions, and sedimentation. Additionally, data for TDS were collected for Aqua Hedionda Creek. Data collected during this monitoring program may be utilized in future efforts to develop TMDLs for these lagoons. This report documents the field methods, the data quality, and the results. Conclusions are presented.

## Monitoring Program

The monitoring program included the following three principal components:

1. Continuous monitoring of hydrologic and core water quality parameters such as flow, rainfall, specific conductivity, temperature, turbidity, and, if applicable, dissolved oxygen (DO) and pH.
2. Wet weather monitoring during and immediately following three storm events at the mass emission stations along the main tributaries of the lagoons, at targeted segment locations within the lagoons, and at the ocean inlets to the lagoons. After the first wet weather event only, post-storm sediment sampling was conducted.
3. Dry weather monitoring during four index period events designed to capture representative seasonal cycles of physical forcing, such as tides and currents acting on the lagoons, as well as biological activity within the lagoons. During each index period event, sampling was conducted at the mass emission stations along the main tributaries of the lagoons, at targeted segment locations within the lagoons, and at the ocean inlets to the lagoons. Index period events also included longitudinal transect sampling and targeted storm drain and tributary sampling.

Sample Locations at Each Lagoon

Agua Hedionda Lagoon:

- Mass Emission Station
- Lagoon Segment Site
- Ocean Inlet 1 Depth 1 (Surface) Site
- Ocean Inlet 1 Depth 2 (Bottom) Site
- Ocean Inlet 2 Depth 1 (Surface) Site
- Ocean Inlet 2 Depth 2 (Bottom) Site

Buena Vista Lagoon:

- Mass Emission Station
- Lagoon Segment 1 Site
- Lagoon Segment 2 Site

Loma Alta Slough:

- Mass Emission Station
- Lagoon Segment Site
- Ocean Inlet Site

San Elijo Lagoon:

- Mass Emission Station
- Lagoon Segment 1 Site
- Lagoon Segment 2 Site
- Ocean Inlet Site

Monitored Constituents

Constituents monitored at all Agua Hedionda Lagoon sampling locations were *Enterococcus* bacteria, total and fecal coliform bacteria, and total suspended solids (TSS). In addition to these constituents, total dissolved solids (TDS) were monitored at the mass emission station only.

Constituents monitored at all sampling locations at Buena Vista Lagoon, Loma Alta Slough, and San Elijo Lagoon were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as nitrogen (N), carbonaceous biochemical oxygen demand (CBOD), nitrate + nitrite (N+N), soluble reactive phosphorus (SRP), total and dissolved nitrogen (TN and TDN), and total and dissolved phosphorus (TP and TDP). Chlorophyll *a* was monitored at all lagoon segment and ocean inlet sites during wet weather events and all sampling locations during index period events.

Aqueous sediment grain size was analyzed from composite water samples generated from the mass emission station pollutagraph samples during each of the first two wet weather events. The samples were

analyzed for grain size distribution among the following size categories: clay < 0.0039 millimeters, silt 0.0039 to < 0.0625 millimeters, sand 0.0625 to < 2.0 millimeters, and granule 2.0 to < 4.0 millimeters.

Post-storm sediment samples were collected only after Wet Weather Event 1 at lagoon segment and ocean inlet sites. These samples were analyzed for percentage of organic carbon, percentage of sand, percentage of total nitrogen, and percentage of total phosphorus, with the exception of Agua Hedionda Lagoon sample locations, which were analyzed for percentage of sand only.

Monitoring Events

Two pollutagraph sampling events and one flow-weighted composite sampling event were sampled successfully at the mass emission station at each of the four lagoons as required by the IO. Time-weighted composite samples were collected at lagoon segment and ocean inlet sites during the following three wet weather events at all lagoons:

- Wet Weather Event 1 – January 5 to January 8, 2008.
- Wet Weather Event 2 – January 23 to January 24, 2008.
- Wet Weather Event 3 – February 3 to February 4, 2008.

Four index period events were successfully monitored at all four lagoons. Each index period event spanned six days and generally took place over a two-week period. Although events between lagoons were staggered, all events for each index period occurred during the same general time frame. Longitudinal transects within each lagoon were sampled once during each index period event. Index period events represented dry weather conditions during each of the four seasons and occurred as follows:

- Index Period Event 1 (winter) – January to February 2008.
- Index Period Event 2 (spring) – late March to April 2008.
- Index Period Event 3 (summer) – July 2008.
- Index Period Event 4 (fall) – September to October 2008.

Over 800 individual samples were collected throughout the entire monitoring program along with continuous data collected at 15-minute intervals.

**Quality Assurance/Quality Control (QA/QC) Summary**

The Quality Assurance Project Plan (QAPP) was developed to establish activities and procedures to assure both chemical and physical measurements would meet the Surface Water Ambient Monitoring

Program (SWAMP) requirements and provide the quality of data needed to calibrate and validate future TMDL models.

Field sampling and laboratory quality assurance activities and procedures were implemented to meet the objectives provided in the QAPP. Quality assurance activities began with field protocols designed to minimize errors introduced during field sampling and measurements. Field QA/QC processes included equipment calibration, field protocols to meet analytical holding times, field duplicates, and field blanks. Laboratory QA/QC samples were used to evaluate the analytical processes for contamination, accuracy, and precision (reproducibility).

All data are considered usable. No data were rejected. Data were qualified and flagged in the project database with the appropriate SWAMP QA codes. Flagged data are usable as qualified.

Monitoring Field Equipment

Calibration activities were conducted monthly on flow collection equipment, including flow-calibration measurements, stream level offset checks, and maintenance activities on an as-needed basis. Data comparison and correction activities were conducted to maintain consistent flow measurements. Maintenance and calibration were conducted twice monthly on the data sondes. Maintenance activities included calibration, removal of sediment accrued on the data sondes, and battery exchanges. Data sonde fouling and/or errors resulted in occasional data gaps or qualified data. Prior to each event, and throughout each event, flow meters, automated sampling equipment, and rain gauges were inspected, maintained, and volume-calibrated to ensure the collection of proportional aliquots for composite samples.

Sample Handling

Holding time requirements are established as part of the analytical method and require samples to be analyzed within a specified time to produce accurate results. The following 303(d) listed categories and individual analytes exceeded holding times on at least one occasion: bacteria (including *Enterococcus*, total and fecal coliforms), TDS, and nutrients/eutrophication (including ammonia, N+N, SRP, TN, TDN, TP, and TDP). However, the program met the Data Quality Objective (DQO) of 90 percent data completeness by attaining results for 99 percent of all scheduled analyses.

Field QA/QC Results

Field duplicates were analyzed for a minimum of 10 percent total samples per constituent. The percent of field duplicates that met the data quality objectives for individual constituents ranged between 48 percent and 100 percent, generally within the acknowledged range due to the heterogeneity of environmental samples.

High relative percent differences (RPDs) occurred as a result of small absolute differences at low concentrations (close to the reporting limit (RL)) that tended to amplify RPDs. This occurred for the following constituents collected during index period events: TSS, ammonia as nitrogen, CBOD, chlorophyll *a*, N+N, SRP, TN, TDN, TP, and TDP. High RPDs also reflected the heterogeneous nature of environmental samples, and are considered reasonable. The National Science Foundation, in a review of RPDs for various types of environmental samples, found that storm water samples routinely had RPDs between 60 and 100 percent. This was thought to be caused, in many instances, by the process of splitting samples (due to the potential for large variations in particle sizes and, therefore, constituent concentrations between the primary and duplicate samples).

Field blanks were analyzed on a minimum of five percent of total samples collected for all constituents. All sample results met the DQOs, except for the following:

- *Enterococcus*
- Total Coliform
- Total Dissolved Solids
- Total Phosphorous
- Total Dissolved Phosphorous

Laboratory QA/QA Results

Laboratory duplicates were analyzed for a minimum of five percent of the total number of samples analyzed per constituent. The percentage of duplicates that met the DQOs for individual constituents ranged between 66 percent and 100 percent, with all but one constituent in the range of 91 percent to 100 percent.

Laboratory control samples were analyzed for a minimum of six percent of the total samples collected for the following constituents: ammonia as nitrogen, N+N, SRP, TN, TDN, TP, and TDP. All results met the DQOs, except for two samples.

Matrix spikes/matrix spike duplicates were analyzed on a minimum of five percent of the total number of samples collected for the following constituents: TDS, ammonia as nitrogen, N+N, TN, TDN, TP, and TDP. All sample results met the DQOs, except for one TN sample tested during Index Period 1.

Laboratory blanks were analyzed on a minimum of five percent of the total number of samples collected. All sample results met the DQOs except for one of 79 total samples tested for chlorophyll *a*.

**Conclusions**

The following paragraphs summarize the key findings and conclusions of this report for each constituent category. These conclusions apply to the entire CHU watershed based on the lagoon-specific findings and overall patterns observed. It should be noted that these conclusions are preliminary and are based on tentative water quality objectives (WQO) and other assumptions stated herein. They may be revised and/or fine-tuned through the TMDL development process.

Bacteria

These conclusions apply to Agua Hedionda Lagoon, Buena Vista Lagoon, Loma Atla Slough, and San Elijo Lagoon, which are 303(d) listed for bacteria impairments. Fecal and total coliform and *Enterococcus* results for both dry and wet weather conditions at the mass emission stations exceeded their respective WQOs at all four lagoons. Bacteria results within the lagoons and at the ocean inlets also exceeded WQOs during wet weather conditions, indicating that beneficial uses may be impaired during wet weather conditions.

Wet Weather Event 1 concentrations generally exceeded Wet Weather Events 2 and 3 concentrations, possibly due to higher rainfall intensities, higher peak flows and/or a longer antecedent dry period, therefore, there was more bacteria build-up and wash-off.

In most cases, little or no concentration first-flush effects were found at the mass emission stations during wet weather events. Some events, however, had minor to moderate mass first-flush effects. Studies have shown that an absence of a first-flush effect for bacteria is more typical of less-developed, less-impervious (5 to 30 percent) watersheds. The CHU watershed averages about 18-percent imperviousness.

Wet weather samples had higher concentrations than dry weather sample concentrations at most locations within each lagoon, suggesting that non-point sources are the primary contributors to elevated bacteria concentrations and annual loadings. Also, wet weather flows contribute between 84 and 98 percent of the

total annual flow volume and nearly all of the bacteria loadings into the lagoons during wet weather storm events.

It should be noted that the bacteria concentrations at the mass emission stations were similar to concentrations measured by the Southern California Coastal Water Research Project (SCCWRP) from undeveloped watersheds. These natural sources may be contributing significant bacteria concentrations and a larger portion of the bacteria loads than anthropogenic sources, such as poorly-managed livestock operations, and/or improper handling of pet waste and should be taken into consideration. Also, due to the relatively low imperviousness of the CHU watershed (18-percent impervious), BMPs targeted to impervious areas only may have limited impact on downstream water quality. Ultimately, the development of a TMDL model can assist with assessing the relative contribution of bacteria concentrations and loads.

Dry weather periods do not generally appear to be associated with beneficial use impairments from bacteria for Agua Hedionda Lagoon, Buena Vista Lagoon, and San Elijo Lagoon, as all within-lagoon samples were below the dry weather WQOs. Buena Vista Lagoon's East Basin and Loma Alta Slough did, however, slightly exceed dry weather WQOs during dry weather conditions. The exceedance rate for these lagoons ranged from 12.5 percent to 14.6 percent, versus an allowable exceedance frequency of 10 and 20 percent for fecal and total coliform, respectively per the Basin Plan.

Concentrations during the summer and fall months were generally higher than concentrations during the fall and winter. However, within the lagoons, concentrations during the winter were the highest.

The highest WQO exceedance frequencies were associated with *Enterococcus* and fecal coliform. Studies by the United States Environmental Protection Agency (USEPA) have demonstrated that *Enterococcus* is a better predictor of the presence of gastrointestinal illness-causing pathogens than fecal and total coliform (RWQCB, 2007).

<u>Nutrients</u>

These conclusions apply to Buena Vista Lagoon, Loma Atla Slough, and San ElLijo Lagoon, which are 303(d) listed for nutrient/eutrophication impairments. Results for TN, TP, and ammonia nitrogens for both dry and wet weather conditions at the mass emission stations, lagoon segments, and ocean inlets exceeded their respective WQOs at all of the three lagoons 303(d) listed for nutrients/eutrophication. Concentrations for these constituents were, with some exceptions, only slightly greater than the WQOs. In

some instances, the mean concentration was lower than the WQO, but several samples that exceeded the WQO resulted in an exceedance rate that was slightly greater than the 10 percent allowable exceedance frequency.

Additionally, concentrations for TN and TP at Buena Vista and San Elijo Lagoons were below historical concentrations and site-specific TN and TP criteria proposed by the Regional Water Quality Control Board (RWQCB) in 1985 to prevent any further degradation in water (no historical concentrations for Loma Alta were readily available) by between approximately 50 and 100 percent. Although seasonal and/or spatial variations may have been responsible for this difference. Improvements in water quality since the time of the RWQCB study may also have led to this difference.

It should be noted that the WQO exceedances were based on comparisons to non site-specific nutrient WQOs. These WQOs may not be reflective of the San Diego coastal lagoon environment, as the objectives in the San Diego Basin Plan were originally developed based on non site-specific temperate, freshwater lake criteria. SCCWRP has been conducting a study to meet some of the requirements of the IO to help address the issue of appropriate nutrient criteria for the coastal lagoons in San Diego. Additionally, there is a state-wide effort to develop nutrient criteria for coastal water bodies (SCCWRP, 2009).

Two of the three lagoons (Loma Alta and San Elijo) had DO concentrations that fell below the single sample minimum concentration (5 mg/L) between 30 and 50 percent of the time. For Buena Vista, DO concentrations were below the single-sample minimum concentration only slightly more than 10 percent of the time. Most of the DO concentrations that fell below the single-sample minimum occurred during the summer and fall.

During the summer and fall, algal growth was observed by field crews at the Buena Vista Lagoon and Loma Alta Slough, and during the summer and spring at the San Elijo Lagoon. The extent of coverage was not recorded, but generally, it appeared to be less than 10 to 15 percent of the each of the lagoon's total surface area. During these periods, low DO concentrations (below the 5 mg/L single-sample minimum) occurred, which is a commonly observed symptom of eutrophic water bodies. Also during these periods, chlorophyll *a* concentrations (typically related to the overproduction of algae) and ammonia were generally above the WQOs of 20 ug/L and 0.025 mg/L, respectively. Conversely, at most locations, TN and TP during the summer and fall were below the WQOs, while the winter and spring concentrations were above the WQO. Although the highest nutrient concentrations did not coincide with observed algal

growth, ambient conditions in a water body can reflect biological processing and nutrient loading that has already occurred.

Wet Weather Event 1 nutrient concentrations and loadings exceeded the nutrient concentrations and loadings for Wet Weather Events 2 and 3, possibly due to a longer antecedent dry period and, therefore, there was more nutrient build-up and wash-off, higher rainfall intensities, and/or higher peak flows.

Generally, nutrient concentrations were similar throughout wet weather events. As a result, no or little first-flush effects were found for most constituents. Ammonia showed the greatest concentration and mass first-flush effects of the nutrients, however, the effects were still considered minor.

As indicated, the first step in the nutrient TMDL process should be the development of site-specific nutrient criteria that can be applied to each lagoon's unique environment. As seasonal differences were found, these criteria should be seasonally based. After these criteria are developed, the comparison of concentrations measured and loadings calculated in this study to the site-specific criteria should be reassessed. As multiple sources of nutrients can contribute to potential impairments of the lagoons, further source identification and/or characterization would help target the largest contributors, whether they are sediment, air deposition, urban runoff, and/or lagoon dynamics. Similar to bacteria, the development of a TMDL model can assist with assessing the relative contribution of nutrient concentrations and loads.

Total Dissolved Solids (TDS)

These conclusions apply to Agua Hedionda Creek, which is 303(d) listed for TDS. The WQO for TDS was exceeded during wet and dry weather conditions at the Agua Hedionda Lagoon Mass Emission Station. TDS samples were not required at the other lagoons, as they are not 303(d) listed for dissolved solids. Possible sources for relatively high salt loads (TDS) include agricultural runoff, urban run-off, wastewater, seepage of groundwater with a high salt content, imported drinking water, and natural sources such as leaves, silt, plankton, and rocks.

TDS concentrations at the mass emission stations were similar for Wet Weather Events 1 and 2 and slightly lower for Wet Weather Event 3, so it does not appear that any of the factors that may have contributed to higher bacteria and nutrient concentrations (e.g., antecedent dry period, higher rainfall intensities, and greater peak flows) contributed to higher TDS concentrations for Wet Weather Event 1.

Generally, inconsistent first-flush effects were found. The highest TDS concentrations tended to occur within the first six hours of each event prior to peak flow conditions. As a result, TDS had moderate to strong concentration-based first-flush effects. However, TDS did not have a mass-based first-flush effect. This was due to relatively high concentrations during the first six hours of discharge, but only on the early part of the rising limb of the hydrograph. As these concentrations occurred during a relatively low flow period, only minor loading occurred. Concentrations remained fairly consistent throughout the rest of the event.

During dry weather conditions, TDS concentrations were similar throughout the different seasons and flow regimes, with the lowest concentrations associated with higher flow regimes during the winter.

Sediment

These conclusions apply to Agua Hedionda Lagoon, Buena Vista Lagoon, Loma Atla Lagoon, and San Elijo Lagoon, which are 303(d) listed for sediment impairments. The San Diego Basin Plan only specifies narrative WQOs only for sediment. Therefore, no comparisons between TSS concentrations and WQOs could be made. TSS concentrations at the mass emission stations during Wet Weather Events 2 and 3 were higher than Wet Weather Event 1 concentrations. During wet weather events, TSS concentrations generally correlated with the flow rate, i.e., higher concentrations during higher flows and lower concentrations during lower flows. TSS had a moderate concentration-based first- flush effect during Wet Weather Event 1, but no concentration-based first- flush effect during Wet Weather Event 2. Little to no mass-based, first-flush effects were found.

Wet weather samples from mass emission stations were also analyzed for aqueous grain size distribution. The results of these samples indicated that greater than 80 percent of the sediment measured in most of the mass emission station samples was present in the silt size range and smaller (less than 62.5 um). This has potential implications in the feasibility of implementing source and/or treatment control BMPs to remove sediment (and other constituents, depending on their associated particle size distributions), as smaller colloidal and suspended particles (< 10 um) will generally remain suspended and not settle out of water as opposed to the larger suspended particles that settle fairly quickly.

Similar to sediment TMDLs developed for other regions and states for streams where the TMDLs have consisted of particle size range limits (or minimums) to protect habitat suitability for aquatic life (e.g., salmon), an appropriate grain sediment size distribution range could be developed for the four lagoons to protect beneficial uses.

During dry weather conditions, TSS concentrations were the highest for the high flow regime during the winter. TSS concentrations were relatively consistent throughout the rest of the year, with the lowest concentrations occurring during the spring.

# 1.0 INTRODUCTION AND PROJECT BACKGROUND

## 1.1 PROJECT BASIS AND SECTION 303(D) LISTING

To comply with San Diego Regional Water Quality Control Board Investigative Order (IO) No. 2006-076, the Carlsbad Watershed Hydrologic Unit's dischargers collected data in four lagoons: Aqua Hedionda Lagoon, Buena Vista Lagoon, Loma Alta Slough, and San Elijo Lagoon. The data were collected to support the development of TMDLs in one or more of these lagoons for bacteria, eutrophic conditions, and sedimentation. Additionally, data for total dissolved solids (TDS) was collected for Aqua Hedionda Creek. This report documents the field methods, the data quality, and the results and presents conclusions.

The Federal Clean Water Act (CWA) section 303(d) requires states to develop a list of water bodies that do not or are not expected to meet water quality standards after implementing technology-based controls and to schedule such waters for development of Total Maximum Daily Loads (TMDLs) (40 Code of Federal Regulations (CFR) Sections 130.7(c) and (d). TMDLs represent the loading capacity of a water body and define the maximum amount of a pollutant allowed to enter a water body so that the water body will meet and continue to meet the water quality standard (WQS) for a particular pollutant. TMDLs determine the waste load allocation (WLA) for point sources and load allocation (LA) for non-point sources of pollutants.

According to IO No. R9-2006-076, the coastal lagoons in Southern California are heavily influenced by their urbanized watersheds. Runoff from these watersheds, coupled with reduced tidal influence from restricted inlets, has reportedly resulted in beneficial use impairments of Agua Hedionda Lagoon, Buena Vista Lagoon, Loma Alta Slough, and San Elijo Lagoon located in San Diego County. All four lagoons are listed as impaired water bodies (303(d) list) for at least one of the following constituents: indicator bacteria, nutrients, sediment/siltation, TDS, and/or eutrophic conditions (Table 1-1). TMDLs must be developed for the critical constituents in each of the lagoons pursuant to CWA section 303(d). Water quality objectives for the critical constituents at the four Carlsbad Hydrologic Unit (CHU) lagoons are established by the Basin Plan.

**Table 1-1: Summary of 303(d) Listings by Lagoon**

| Lagoon | Tidal Regime | 303(d) Listing | | | |
|---|---|---|---|---|---|
| | | Sediments | Total Dissolved Solids (TDS) | Bacteria | Nutrients/ Eutrophication |
| Loma Alta Slough | Tidal | | | X | X |
| Agua Hedionda Creek | | | X | | |
| Agua Hedionda Lagoon | Tidal | X | | X | |
| Buena Vista Lagoon | Non-Tidal | X | | X | X |
| San Elijo Lagoon | Tidal | X | | X | X |

## 1.2 LAGOON BENEFICIAL USES, WATER QUALITY, AND REGULATORY CRITERIA

The CWA includes two basic approaches for protecting and restoring the nation's waters. One is a technology-based, end-of-pipe approach, whereby the United States Environmental Protection Agency (USEPA) promulgates effluent guidelines that rely on technologies available to remove pollutants from waste streams. The other approach is water-quality based and is designed to achieve the desired uses of a water body.

Water quality standards, the foundation of the water-quality based control program mandated by the CWA, define the goals for a water body by designating its uses, setting criteria to protect those uses, and establishing provisions to protect water quality from pollutants. A water quality standard consists of four basic elements:

- Designated uses of the water body (e.g., recreation, water supply, aquatic life, agriculture).
- Water quality criteria to protect designated uses (numeric pollutant concentrations and narrative requirements). Water quality criteria are elements of state water quality standards expressed as constituent concentrations, levels, or narrative statements representing a quality of water that supports a particular use. When criteria are met, water quality will generally protect the designated use.
- An anti-degradation policy to maintain and protect existing uses and high quality waters.
- General policies addressing implementation issues (e.g., low flows, variances, mixing zones).

Designated beneficial uses are defined as the uses of water necessary for the survival or well being of man, plants, and wildlife. Those uses, specified in water quality standards for each water body or segment, include: (1) recreational uses; (2) the propagation and growth of a balanced, indigenous population of aquatic life and wildlife; and (3) the production of edible and marketable natural resources are generally stated as "fishable and swimmable" uses. Other uses may be industrial water supply,

irrigation, and navigation. These uses serve to promote tangible and intangible economic, social, and environmental goals.

Once beneficial uses are designated, RWQCBs can establish the appropriate water quality objectives and implement regulatory program criteria to maintain or enhance water quality to protect beneficial uses. Table 1-2 defines the categories of beneficial use, and Table 1-3 presents the beneficial uses of the four lagoons monitored for the CHU Lagoon Monitoring Program as established in the Basin Plan.

Under section 303(d) of the CWA, monitoring data, as well as other information, must be used by the states to develop a list of "water-quality limited segments," or waters that will not meet water quality standards for a particular pollutant even after a technology-based permit is in place. States must develop TMDLs for every water body/pollutant combination on the 303(d) list. Table 1-4 presents the water quality objectives (WQO) that will be used for preliminary analysis of data collected during the CHU Lagoon Monitoring Program as established in the Basin Plan or supported by other references. Each WQO and its respective source are described further in the notes following Table 1-4. The purpose of a TMDL is to attain water quality objectives and restore the water body's beneficial uses.

**Table 1-2: Beneficial Uses Categories**

| Abbreviation | Beneficial Use |
|---|---|
| MUN | Municipal and Domestic Supply |
| AGR | Agricultural Supply |
| IND | Industrial Service Supply |
| REC-1 | Contact Water Recreation Including Body Contact with Water |
| REC-2 | Contact Water Recreation Including Activities in Proximity to Water but Generally without Body Contact |
| COMM | Commercial and Sport Fishing |
| BIOL | Preservation of Biological Habitats of Special Significance |
| EST | Estuarine Habitat |
| WILD | Wildlife Habitat |
| RARE | Rare, Threatened, or Endangered Species |
| MAR | Marine Habitat |
| AQUA | Aquaculture |
| MIGR | Migration of Aquatic Organisms |
| SPWN | Spawning, Reproduction, and/or Early Development |
| WARM | Warm Freshwater Habitat |
| SHELL | Shellfish Harvesting |

**Table 1-3: Beneficial Uses of CHU Lagoons**

| Water Body | Hydrologic Unit Basin Number | | | Beneficial Use | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MUN | AGR | IND | NAV | REC1 | REC2 | COMM | BIOL | EST | WILD | RARE | MAR | AQUA | MIGR | SPWN | WARM | SHELL |
| Freshwater Creek | | | | | | | | | | | | | | | | | | |
| Agua Hedionda Creek | 4.31 | ● | ● | ● | | ● | ● | | ● | | ● | | | | | | ● | |
| Coastal Lagoons | | | | | | | | | | | | | | | | | | |
| Agua Hedionda Lagoon | 4.31 | | | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● |
| Buena Vista Lagoon | 4.21 | | | | | ● | ● | | ● | ○ | ● | ● | ● | | | | ● | |
| Loma Alta Slough | 4.10 | | | | | ● | ● | | | ● | ● | ● | ● | | | | | |
| San Elijo Lagoon | 4.61 | | | | | ● | ● | | ● | ● | ● | ● | ● | | ● | ● | | |

● Existing Beneficial Use ○ Potential Beneficial Use

## 1.3 WATER QUALITY OBJECTIVES

Table 1-4 presents the WQO for each constituent by constituent category. Note that these WQO are intended for preliminary assessment purposes only. The use of different WQO during the TMDL development process could significantly alter the results and conclusions reached.

**Table 1-4: Water Quality Objectives**

| Category | Constituent | Units | Water Quality Objective | | |
|---|---|---|---|---|---|
| | | | Dry Weather Criteria | Wet Weather Criteria | Allowable Exeedance Frequency |
| General Parameters | pH | pH units | 6.5-9.0 | 6.5-9.0 | NA |
| | Specific Conductance | umhos/cm | None | None | NA |
| | Turbidity | NTU | 20 | 20 | NA |
| | Water Temperature | mg/L | Narrative | Narrative | NA |
| | Dissolved Oxygen | mg/L | 5 | 5 | NA |
| Bacteria | *Enterococcus* | CFU/100mL | 33/35 | 108/276 | 22%[a] |
| | Fecal Coliform | MPN/100 mL | 200 | 400 | 22%[a] |
| | Total Coliform | MPN/100 mL | 1,000 | 10,000 | 22%[a] |
| Dissolved Solids | TDS | mg/L | 500 | 500 | 10% |
| Sediment | TSS | mg/L | Narrative | Narrative | NA |
| | Sediment Grain Size | mm | None | None | NA |
| Nutrients | Total Phosphorus | mg/L | 0.1 | 0.1 | 10% |
| | Total Dissolved Phosphorus | mg/L | None | None | NA |
| | Total Reactive Phosphorus | mg/L | None | None | NA |
| | Total Nitrogen | mg/L | 1.0 | 1.0 | 10% |
| | Total Dissolved Nitrogen | mg/L | None | None | NA |
| | Ammonia as N | mg/L | 0.025 | 0.025 | NA |
| | Chlorophyll a | ug/L | 20[b] | 20[b] | NA |
| | Nitrate+Nitrite as N | mg/L | 10[b] | 10[b] | 10% |
| | CBOD | mg/L | None | None | NA |

(a) Allowable exceedance frequency applies to wet weather criteria only.
(b) Currently, the San Diego Basin Plan does not specify a WQO for this constituent; however, a value is proposed as a benchmark for preliminary analysis purposes.

The importance of each of these constituents and the source of their WQO are discussed in further detail for each constituent category.

General Parameters

pH: Acceptable pH levels are required to support aquatic life. A change in pH can also impact the bioavailability and toxicity of other pollutants, such as ammonia. The San Diego Basin Plan specifies an acceptable range of 6.5 to 9.0 pH units.

Specific Conductivity: There are currently no WQOs in the San Diego Basin Plan for conductivity. TDS and conductivity are closely related. Therefore, the WQO for TDS will be used to evaluate concentration exceedances in Agua Hedionda Creek, which is 303(d) listed for TDS.

Turbidity: High turbidity levels impede the penetration of light and adversely affect photosynthesis, thereby causing harm to aquatic life. An example is turbidity caused by high concentrations of particulate matter. The Basin Plan states: "Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses." A criteria of 20 NTU, published for inland surface waters in the San Diego Basin Plan, was used for both dry and wet weather conditions.

Water Temperature: Temperature is an important factor effecting plant and bacteria growth. In general, algal and bacteria growth increases with increasing temperature until some upper limit of temperature is reached, beyond which there is an abrupt decline in growth rates (RWQCB, 1985). Currently, there are no applicable numerical WQOs in the San Diego Basin Plan; however, there is the following narrative objective: "The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Board that such alteration in temperature does not adversely affect beneficial uses."

Dissolved Oxygen (DO): Acceptable dissolved oxygen levels are critical for aquatic life. Depressed oxygen levels can kill aquatic life and cause unpleasant odors from anaerobic decomposition. DO is a function of water temperature and salinity. The San Diego Basin Plan specifies that no single measurement be below 5.0 milligram-per-liter (mg/L) and an annual mean standard of 7.0 mg/L for all measurements. This objective applies to all inland surface waters designated for MAR or WARM beneficial uses (CHU lagoons have this beneficial use).

Indicator Bacteria

Indicator bacteria are surrogates used to measure the potential presence of bacteria, fecal material, and associated fecal pathogens. Indicator bacteria such as fecal coliform and *Enterococcus* are part of the intestinal flora of warm-blooded animals. Indicator organisms have been long used to protect swimmers from illnesses that may be contracted from recreational activities in surface waters contaminated by fecal pollution. These organisms often do not cause illness directly, but have demonstrated characteristics that make them good indicators of harmful pathogens that may be present in water bodies (RWQCB, 2007).

Under section 304(a) of the Clean Water Act, the USEPA is required to publish water quality criteria accurately reflecting the latest scientific knowledge for the protection of human health and aquatic life. Prior to 1986, the USEPA recommended bacteria criteria based on fecal coliforms to protect human health. In 1986, the USEPA recommended the use of criteria based on *Escheria (E.) coli* for fresh waters and *Enterococci* for fresh and marine waters rather than the use of criteria based on fecal coliform. The USEPA recommended this change in the use of bacteria indicator organisms because USEPA studies demonstrated that *E. coli* and *Enteroccocci* are better predictors of the presence of gastrointestinal illness-causing pathogens than fecal and total coliforms and, hence, provide a better means of protecting human health. Subsequent supporting research led the USEPA to reaffirm these findings in 2002. The USEPA strongly recommends the replacement of WQOs based on fecal or total coliforms with objectives based on *Enterococci* and *E. coli* (RWQCB, 2007).

Despite this recommendation, the SWRCB adopted an amendment to the Water Quality Control Plan for Ocean Waters of California (Ocean Plan) in January 2005 that maintained the total and fecal coliform WQO. Additionally, the SWRCB added provisions that required additional monitoring if the single sample maximum WQO are exceeded. WQO for *Enterococci* were also added to the Ocean Plan at that time.

The following dry and wet weather WQO (contained in the San Diego Basin Plan) are used for fecal and total coliform and *Enterococci*:

- *Enterococcus*: The criteria were published in the San Diego Basin Plan for freshwater/saltwater bodies designated for REC-1. The dry weather standards are the steady state criteria of 33 CFU/100mL for freshwater bodies and 35 CFU/100mL for saltwater bodies. The wet weather standards are the single sample maximums for "moderately to lightly used areas" of 108 CFU/100mL for freshwater bodies (Buena Vista Lagoon) and 276 CFU/100mL for saltwater bodies (Agua Hedionda, Loma Alta, and San Elijo Lagoons).

These criteria are specified in the USEPA Bacteriological criteria for Water Contact Recreation in Chapter 3, page 6 of the San Diego Basin Plan.

- Fecal Coliform: The criteria were published for water bodies designated for REC-1. The dry weather standard is based on the geometric mean of 200 MPN/100mL for a minimum of five samples in any 30-day period provided that less than 10 percent of samples exceed 400 MPN/100mL during any 30-day period. The wet weather standard is the single sample maximum of 400 MPN/100mL.
- Total Coliform: The criteria were published for bays and estuaries bodies designated for REC-1. The dry weather standard is 1,000 MPN/100mL, provided that less than 20 percent of samples in any 30-day period exceed 1,000 MPN/100mL. The wet weather standard is the single sample maximum of 10,000 MPN/100mL.

For preliminary analysis purposes, a proposed 22 percent exceedance allowance has been applied to the wet weather objectives for indicator bacteria. This condition was incorporated into the RWQCB Beaches and Creeks TMDL interim numeric targets for indicator bacteria and was based on the reference system in the Los Angeles region (SDRWQCB, 2007). A reference system is minimally impacted by anthropogenic sources that can affect levels of indicator bacteria in a lagoon. By using a reference system approach, natural sources of indicator bacteria can be accounted for when developing water quality objectives as part of the TMDL process. The natural (reference) system would establish the allowable exceedance based on either the probability of a single sample maximum exceedance at a monitored lagoon or reference system, whichever is most stringent. This reference system approach is a proposed revision to the San Diego Basin Plan. Natural systems as a source of bacteria is further supported in a study by SCCWRP, where samples collected from natural landscapes exceeded WQOs 40 to 50 percent of the time (Stein & Yoon, 2007).

Total Dissolved Solids

Dissolved solids in natural waters may include carbonates, bicarbonates, chlorides, sulfates, phosphates, nitrates, magnesium, sodium, iron, manganese, and others. High TDS can adversely affect surface waters. The San Diego Basin Plan specifies a numerical WQO of 500 mg/L for inland surface waters, which is based on Secondary Drinking Water Standards, with a 10 percent exceedance allowance for a one-year period. The TDS standard does not apply to tidally influenced saltwater lagoons.

Sediment

Currently, the San Diego Basin Plan does not specify a numerical WQO for sediment, including TSS. The San Diego Basin Plan does define the following narrative WQO, however: “Waters shall not contain suspended material in concentrations that cause nuisance or adversely affect beneficial uses.” To-date, most developed sediment TMDLs have been for other regions and states. In these instances, grain size

limits, instead of TSS, were used for the protection of habitat suitability for certain aquatic life species (e.g., salmon).

Nutrients

Nutrients include macronutrients, micronutrients, and trace organic growth factors. Typically, only the macronutrients nitrogen and phosphorus are at or near algae growth limiting levels. Nitrogen can exist in several chemical forms, including dissolved, particulate, organic, and inorganic. Primary external sources of nitrogen and phosphorus include stream inputs of urban and agricultural drainage, sewage spills/discharges, septic system failure, precipitation, atmospheric deposition, and ground water. In-lagoon sources include sediment release, nitrogen fixation, and biological recycling.

The primary impact of nutrients on surface water is to stimulate plant growth, particularly the growth of algae, which can impact beneficial uses by increasing the frequency of nuisance conditions for recreational purposes, as well as reduce the value of the water body as a habitat for intolerant forms of plants, fish, invertebrate, and other aquatic life.

As stated in the San Diego Region 9 Basin Plan:

> "Concentrations of nitrogen and phosphorus, by themselves or in combination with other nutrients, shall be maintained at levels below those which stimulate algae and emergent plant growth. Threshold Total Phosphorus (P) concentrations shall not exceed 0.05 mg/L in any stream at the point where it enters any standing body of water, nor 0.025 mg/L in any standing body of water. A desired goal in order to prevent plant nuisances in streams and other flowing waters appears to be 0.1 mg/L total P. These values are not to be exceeded more than 10% of the time unless studies of the specific body in question clearly show that water quality objective changes are permissible and changes are approved by the Regional Board. Analogous threshold values have not been set for nitrogen compounds; however, natural ratios of nitrogen to phosphorus are to be determined by surveillance and monitoring and upheld. If data are lacking, a ratio of N: P = 10:1 shall be used."

These objectives have not changed since the San Diego Basin Plan was first adopted in 1975. Believing that a narrative objective would not adequately prevent the continued degradation of surface water quality, the USEPA and SWRCB insisted on the inclusion of numerical nutrient objectives for all inland and coastal surface waters within the San Diego region. These objectives were values that could not be exceeded more than ten percent of the time based on a contractor's literature review of the nitrogen to phosphorus ratios in plant assimilation of inorganic nutrients (RWQCB, 1985).

Although the standing water and flowing water limits were based on extensive amounts of data, the data was for inland, temperate zone, freshwater lakes. A limited amount of information was available regarding the coastal lagoon habitat, particularly the nutrient and algae interactions within the water columns of these environments. Lake systems and other water bodies in the milder regions of the Southern United States have been shown to tolerate much higher levels of phosphorus (e.g., Texas uses a total phosphorus level of 0.4 mg/L to indicate when a lake with recreational uses will become impaired) (RWQCB, 1985).

Therefore, treating the lagoons as lakes and setting nutrient objectives to protect them from becoming eutrophic may not be realistic, since most of the lagoons already possess nutrient levels that would classify them as eutrophic or hypereutrophic, at least according to most popular state classification schemes (RWQCB, 1985). The existing limits in the San Diego Basin Plan may not only be unrealistically stringent for coastal lagoons in San Diego, they also do not take into account the site-specific chemical form of the nutrients necessary to protect beneficial uses (RWQCB, 1985).

Recognizing the lack of site-specific objectives for the coastal lagoons in San Diego, and to prevent conditions within the lagoons from further degradation, the RWQCB utilized five years of monitoring data to propose site-specific objectives in 1985 for six coastal lagoons based on 90 percent exceedance limits. Where seasonal differences were found, two objectives were proposed, one for summer and one for winter. The objectives proposed were:

- Agua Hedionda (saltwater) – 1.6 mg/L of total nitrogen and 0.14 mg/L of total phosphorus
- Buena Vista (freshwater) – 3.4 mg/L of total nitrogen and 0.36 mg/L of total phosphorus
- San Elijo West Basin (brackish water)
  - Winter (October to March) – 5.6 mg/L of total nitrogen and 0.46 mg/L total phosphorus
  - Summer (April to September) – 3.7 mg/L of total nitrogen and 0.69 mg/L of total phosphorus
- San Elijo East Basin (freshwater) – 3.5 mg/L of total nitrogen and 0.33 mg/L of total phosphorus

Although no objectives were proposed for Loma Alta, as it was not part of the study, the following non site-specific objectives were proposed for other coastal lagoons: 2.6 mg/L of total nitrogen (winter), 2.1 mg/L of total nitrogen (summer), and 0.25 mg/L of total phosphorus (annual). The proposed objectives discussed above were never incorporated into subsequent amendments to the Basin Plan.

More recently, SCCWRP in collaboration with SWRCB, USEPA, and other agencies are working to develop nutrient numeric endpoints to regulate nutrient levels in coastal lagoons statewide (SCCWRP, 2009).

Based on the limited availability of site-specific criteria, the following objectives are used as benchmark WQO for preliminary analysis purposes, pending the finding of the SCCWRP and statewide efforts:

- Total Phosphorus (TP): The Basin Plan specifies a biostimulatory substances WQO of 0.025 mg/L of total phosphorus for standing water and 0.1 mg/L for flowing waters for eutophication impairments, with the value not being exceeded more than ten percent of the time. In light of the current lack of site-specific nutrient objectives, a WQO of 0.1 mg/L is used as a benchmark for both standing and flowing waters. These values are also similar to historical data for Agua Hedionda (a mean concentration of 0.08 mg/L and a 90 percent concentration of 0.14 mg/L), which has not typically experienced algal blooms, and values used for trophic state classifications (levels below which generally help maintain a lake below the hypereutrophic state).
- Total Dissolved Phosphorus (TDP): The San Diego Basin Plan does not specify a WQO for total dissolved phosphorus, nor has it been used in existing TMDLs. This constituent will be used in relation with other parameters/constituents to evaluate the overall quality of the lagoon and to assist with future modeling efforts.
- Soluble Reactive Phosphorus (SRP): The San Diego Basin Plan does not specify a WQO for SRP, nor has it been used in existing TMDLs. This constituent will be used in relation with other parameters/constituents to evaluate the overall quality of the lagoon and to assist with future modeling efforts.
- Total Nitrogen (TN): Assuming total phosphorus WQO of 0.1 mg/L, and using the 10:1 ratio of nitrogen to phosphorus, the resulting WQO is 1.0 mg/L of total nitrogen.
- Total Dissolved Nitrogen (TDN): The San Diego Basin Plan does not specify a WQO for total dissolved nitrogen, nor has it been used in existing TMDLs. This constituent will be used in relation with other parameters/constituents to evaluate the overall quality of the lagoon and to assist with future modeling efforts.
- Ammonia: Ammonia is one of the most bioavailable forms of inorganic nitrogen and its concentration is a function of temperature and pH. Excess ammonia can result in excessive growth of algal and nuisance plants that can displace native plants. The San Diego Basin Plan specifies a numerical WQO of 0.025 mg/L for un-ionized ammonia.
- Chlorophyll *a*: Chlorophyll *a* is generally considered a good indicator of phytoplankton populations within a lagoon and, hence, is a biological measurement of biostimulation. Based on previous studies of San Diego County lagoons, general inverse relationships have been found between growth of algal mats and growth of phytoplankton. Additionally, measurements of chlorophyll *a* have not correlated well with total algae biomass or nutrient objectives in the lagoons. Therefore, this constituent has not been recommended as a biostimuluation objective for coastal lagoons in San Diego (RWQCB, 1985). Chlorophyl *a* is, nonetheless, important in helping to interpret the results of nutrient monitoring programs. Therefore, for the purposes of this study, a criteria of 20 ug/L was used as a benchmark for preliminary analysis purposes only. This criteria was applied to coastal estuaries by the

USEPA in the National Coastal Condition Report to evaluate the aquatic and human beneficial uses of West Coast estuaries (2005). Estuaries with concentrations greater than 20 ug/L were considered to have poor water quality with adverse impacts to beneficial uses.

- Nitrate+Nitrite (N+N): Nitrate is a form of inorganic nitrogen that can be immediately available for algal growth at excessive levels. Currently, there are no WQO in the San Diego Basin Plan for nitrate and/or nitrite. However, these constituents (in particular nitrate), are forms of nitrogen that can be immediately available for nitrogen growth. Therefore, to help evaluate factors that may be contributing to any high total nitrogen concentrations and possible algal growth in the lagoons, a criteria of 10 mg/L was used as a benchmark for preliminary analysis purposes only. This criterion was published in the Los Angeles Basin Plan for surface waters with a ten percent exceedance allowance for a one-year period. This criterion was also applied in the Malibu Creek Nutrient TMDL.
- Carbonaceous Biochemical Oxygen Demand (CBOD): CBOD is an important parameter (along with ammonia, biochemical oxygen demand, and others) because of its impact on dissolved oxygen (DO) levels. Currently, there are no WQO for CBOD in the San Diego Basin Plan. This constituent will be used in relation with other parameters/constituents to evaluate the overall quality of the lagoon and to assist with future modeling efforts.

## 1.4 MODELING DEVELOPMENT AND OUTCOMES

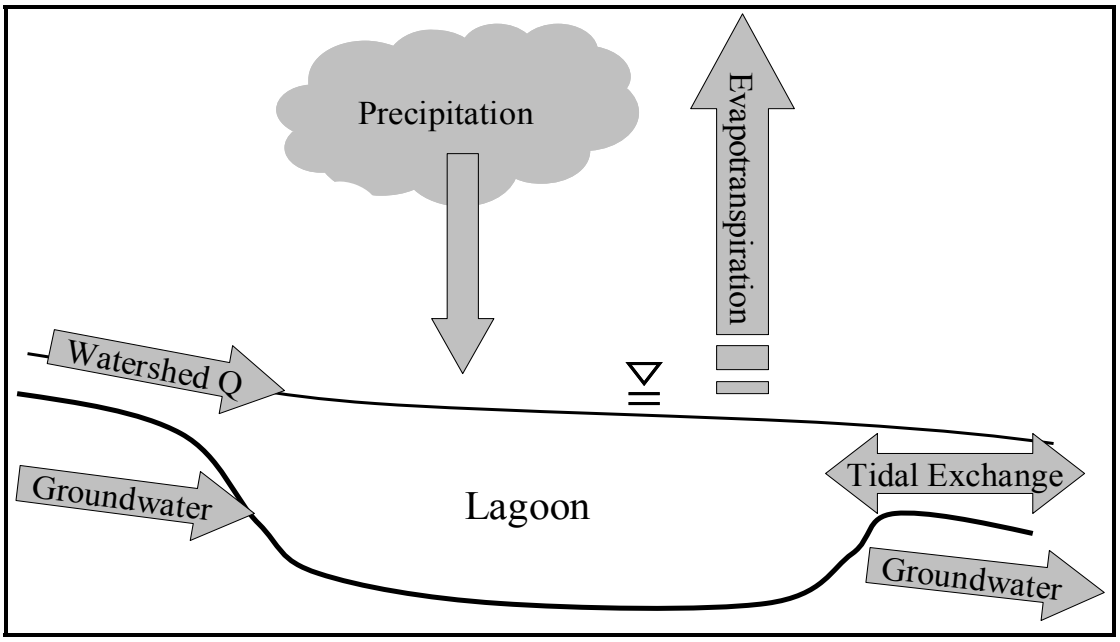
The San Diego RWQCB intends to develop TMDLs, LAs, WLAs, and reductions through the use of watershed and lagoon models. The TMDL development process as defined by the San Diego RWQCB includes the following steps (SDRWQCB website, 2007):

1. Involve Stakeholders: Stakeholders can be the general public, business interests, government entities, environmental groups, or anyone concerned with a particular water body. Stakeholders are involved at the beginning of the process in order to provide input to the RWQCBs on the development of TMDLs.
2. Assess Water Body: In this step, pollution sources and amounts, or "loads," are identified for various times of the year. Then the overall effect of these loads on the water body is determined.
3. Define the Total Load and Develop Allocations: To ensure water quality standards are met and beneficial uses are attained, allocations of pollutant load to all sources are established for the pollutant(s) in question. TMDLs can address single pollutants or combinations of pollutants. The sum of the allocations must result in the water body attaining the applicable water quality standards.
4. Develop Implementation Plan: This step is a description of the approach and activities to be undertaken to ensure the allocations are met and identification of parties responsible for carrying out the actions.
5. Amend the Basin Plan: Federal law requires that TMDLs be incorporated into the Basin Plans. The Basin Plan is a legal document that describes how a Regional Board would manage water quality. The TMDLs must be formally incorporated into the Basin Plan to be part of the basis for Regional Board actions. Basin Plan amendments are adopted through a public process that requires approval of the TMDLs by a Regional Board, the State Board, the Office of Administrative Law, and USEPA Region 9.

Conceptual models were developed in the Work Plan to describe the watershed and lagoon models in terms of sources and losses of targeted constituents to each lagoon. Four conceptual models including the hydrodynamic, sediment transport, bacteria water quality, and nutrient/eutrophication are briefly described and depicted below.

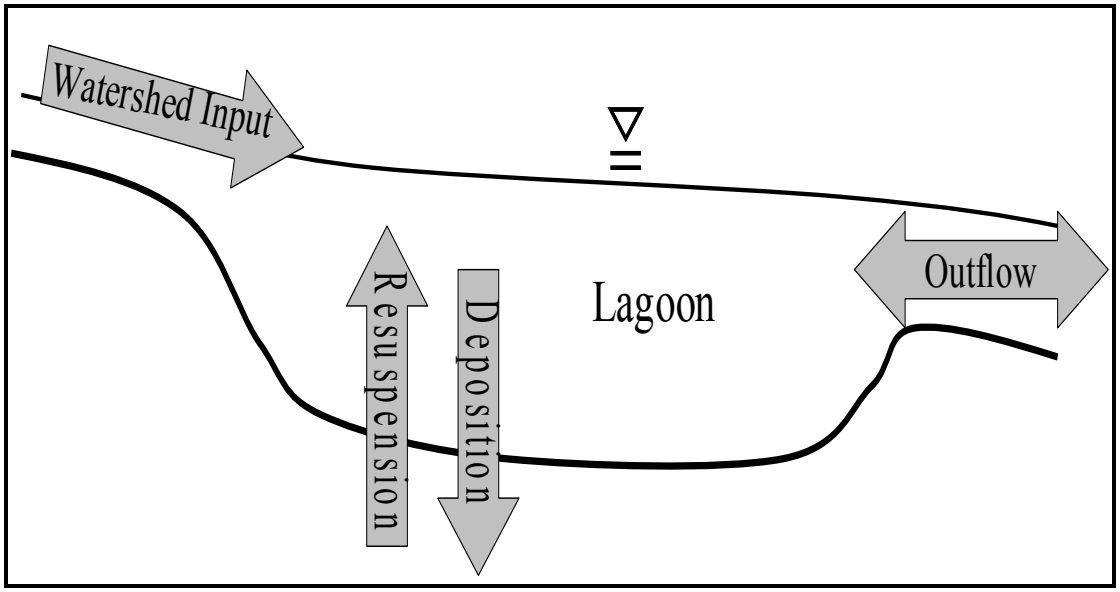
The hydrodynamic model describes the inputs and outputs of water within a watershed/lagoon/ocean system as shown in Figure 1-1. Inputs include flow from the watershed, precipitation, groundwater inflow, storm drains, and tidal inflow from the ocean. Outputs include evaporation/transpiration, groundwater outflow, and outflow to the ocean.

**Figure 1-1: Hydrodynamic Model**



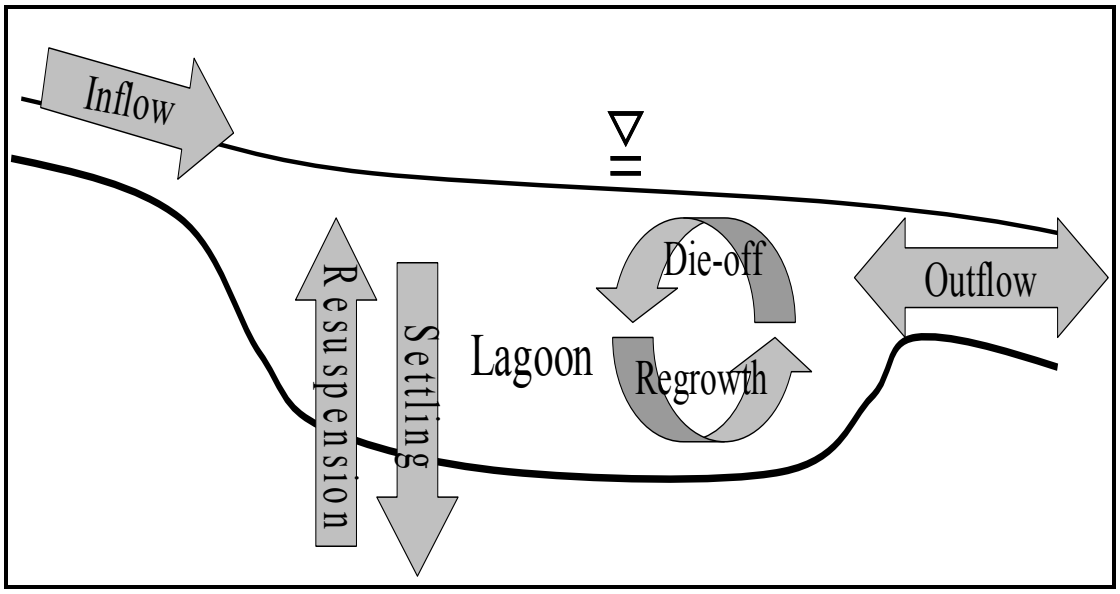

The sediment transport model, a component of the hydrodynamic model, describes the inputs and outputs to each lagoon, as well as, processes within the lagoon as shown in Figure 1-2. Sediment inputs into each lagoon are from the watershed and the ocean inlet. Sediment outputs are to the ocean.

**Figure 1-2: Sediment Transport Model**



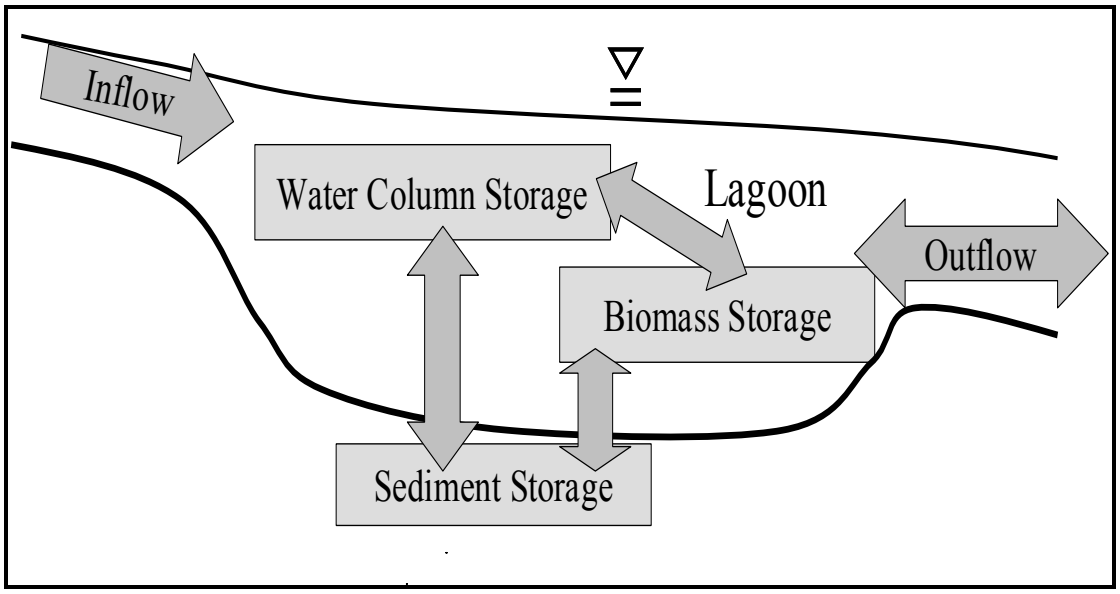

The bacteria water quality model describes the inputs, outputs, and processes affecting bacteria levels within a lagoon as shown in Figure 1-3. Bacteria sources are from the watershed and storm drains, as well as direct contribution to the lagoons via wildlife. The ocean outlet can serve as either a source or loss of bacteria from the lagoon. Within lagoon cycling of bacteria includes regrowth within the sediments and water column, die-off within sediments and water column, and settling and burial within the sediments.

**Figure 1-3: Bacteria Water Quality Model**



The nutrient/eutrophication model describes inputs, outputs, and process that affect nutrient concentrations and primary production within the lagoon as shown in Figure 1-4. Nutrient inputs into the lagoon are surface waters coming from the watershed, ocean, and storm drain inflow, flux from the sediments, leakage from plant or animal tissues, and decomposition of organic matter within the water column. Nutrient outputs from the lagoon are to the ocean, to growth and storage of biomass within the lagoon, burial and flux into the sediments, and storage in the water column.

**Figure 1-4: Nutrient/Eutrophication Model**



## 1.5 INVESTIGATION ORDER

The San Diego RWQCB issued IO No. R9-2006-076 to the dischargers to the creeks and lagoons in San Diego County that are 303(d) listed for bacteria, TDS, sediment, and nutrients. The IO required collection of monitoring data for the development of TMDLs as authorized by the CWA. The monitoring data included hydrologic and water quality data for lagoons, major tributaries, and major point sources to be used to calibrate and validate the lagoon and watershed models that will develop the TMDLs and allocations.

A total of seven lagoons were included in the IO, however, this monitoring program included only those in the CHU. The Responsible Parties (RPs) within the CHU as defined in the IO include the cities of Carlsbad, Encinitas, Escondido, Oceanside, San Marcos, Solana Beach, and Vista, the County of San Diego, the California Department of Transportation (Caltrans), and the Hale Avenue Resource Recovery Facility (HARRF) located in the City of Escondido. The City of Encinitas was the lead contracting agency among the RPs within the CHU that worked together on a watershed basis to implement the IO for four lagoons: Agua Hedionda Lagoon, Buena Vista Lagoon, Loma Alta Slough, and San Elijo Lagoon.

Through a group of meetings during spring 2007 with watershed stakeholders, the Southern California Coastal Water Research Project (SCCWRP), on behalf of the RWQCB developed the "San Diego Coastal Lagoons TMDL Monitoring Work Plan." This June 18, 2007 Work Plan was incorporated into the IO as part of Addendum No. 2 on June 21, 2007.

Prior to the implementation of the CHU Lagoon Monitoring Program, the San Diego RWQCB contracted Tetra Tech to assess the available data to that required for use in the TMDL modeling effort for the San Diego region. Partial data existed for the four lagoons of interest; however, complete data required to develop watershed loading and lagoon water quality models was not available for Southern California coastal lagoons. Therefore, the purpose of the monitoring program was to:

1. Quantify during both wet and dry weather the loading of constituents to the lagoons from watersheds and storm drains.
2. Collect data to calibrate and validate lagoon hydrodynamic and water quality models for each of the targeted constituents (indicator bacteria, total dissolved solids, sediment, and nutrients).

MACTEC Engineering and Consulting, Inc. (MACTEC), located in San Diego, California, was contracted by the Responsible Parties of the CHU for the overall organization and implementation of the monitoring program for the four lagoons and successful completion of the IO. MACTEC was to coordinate the sample collection, laboratory analysis, data management, data analysis, and reporting, as well as field sampling and logistics for the CHU Lagoon Monitoring Program. Merkel and Associates, Inc. (M&A) of San Diego, California, assisted MACTEC with the sampling program. Pacific REMS and Everest International provided support for sampling design and quality assurance in advisory roles.

## 1.6 KEY MANAGEMENT QUESTIONS

The general approach of the monitoring program was driven by a series of 18 management questions outlined in the work plan and Quality Assurance Project Plan (QAPP). The management questions were organized into the following three categories:

1. Questions that characterize sources of targeted contaminants to the lagoons or to Agua Hedionda Creek.
2. Questions that characterize within-lagoon hydrodynamics and water quality.
3. Questions that relate to the implementation of models to set load allocations.

The design of the monitoring program and preliminary data analysis conducted by MACTEC addressed questions related to the first two categories. These questions are:

- What are the concentrations of targeted contaminants at the base of each watershed before it enters an impaired lagoon?
- What is the daily rainfall in the watershed?
- What is the total annual (and daily) flow and mass loads of targeted contaminants from each watershed to each impaired lagoon?
- What is the total annual (and daily) flow and mass loads of total dissolved solids to Agua Hedionda Creek?
- What are the concentrations of targeted contaminants at the ocean inlet before it enters an impaired lagoon?
- What are the concentrations of TDS in Agua Hedionda Creek? Do they exceed water quality objectives?
- What are the concentrations of targeted contaminants within each impaired lagoon? Do they exceed water quality objectives?
- What are the dissolved oxygen concentrations in lagoons impaired for nutrients or eutrophication?

The following within lagoon management questions will be addressed by the Southern California Coastal Water Research Project (SCCWRP) special studies:

- What are the sediment flux rates for nutrients in these water bodies?
- What is the sediment oxygen demand in these water bodies?
- What are the standing crop totals and primary productivity rates for plant/macroalgae biomass in these water bodies?

Remaining source and implementation management questions will be addressed by the TMDL models portion of the program. These questions are:

- What are the relative contributions for targeted contaminants from each land use type or from regulated facilities?
- What is the total annual load reduction of nutrients needed so that beneficial uses and water quality objectives are met?
- What is the net annual flux of the targeted contaminants from the impaired lagoon to the coastal ocean?
- What are the physical factors that control lagoon hydrodynamics and sediment transport?
- What is the total annual load reduction of bacteria needed so that recreational beneficial uses and water quality objectives are met?
- What is the total annual load reduction of sediment needed so that sedimentation is reduced to meet water quality objectives, physical and geological habitat objectives?
- What is the total annual load reduction of total dissolved solids needed in Agua Hedionda Creek so that water quality objectives that support the MUN beneficial uses are met?

Data collected by MACTEC during the CHU Lagoon Monitoring Program and data collected by SCCWRP during the special studies portion of the program will be used in the development of these TMDL models.

## 1.7 WATERSHED DESCRIPTION

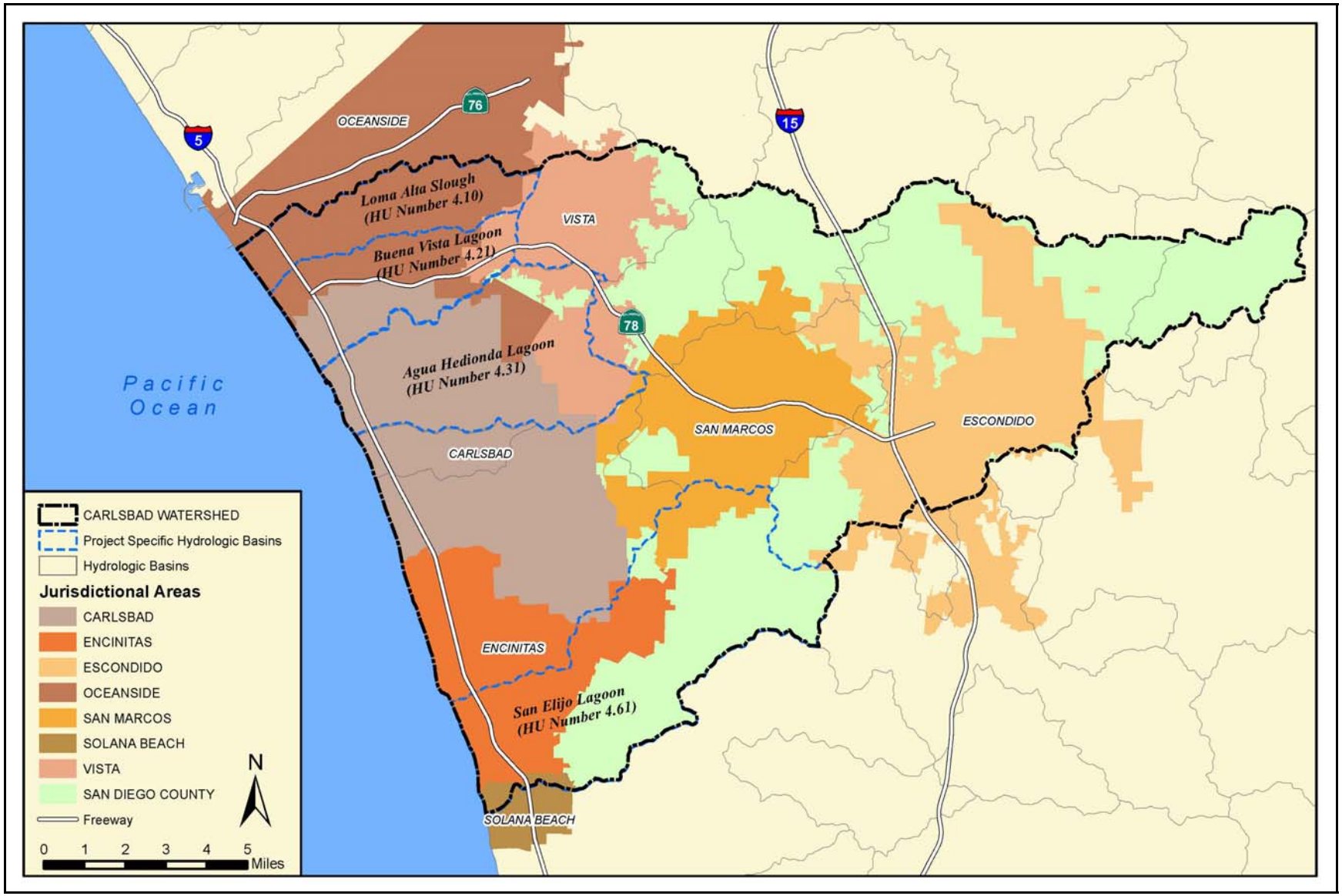
The CHU, approximately 210 square miles in area, extends from the headwaters above Lake Wohlford in the east to the Pacific Ocean in the west, and from the cities of Oceanside and Vista to the north to the cities of Escondido, Solana Beach, and the community of Rancho Santa Fe to the south. This hydrologic unit encompasses entirely the cities of Carlsbad, San Marcos, and Encinitas. Four unique coastal lagoons, three major creeks, and two large water storage reservoirs serve as the important surface hydrologic features within the CHU, which also contains four major, roughly parallel hydrologic areas (HAs). These hydrologic areas, from north to south, are designated as the the Loma Alta hydrologic area (7.29 square miles), the Buena Vista hydrologic area (10.6 square miles), Agua Hedionda hydrologic area (30 square miles), and the San Elijo hydrologic area (24.6 square miles). Figure 1-5 shows the hydrologic areas associated with the four lagoons monitored for the CHU Lagoon Monitoring Program, jurisdictional areas of the Responsible Parties, and freeways.

Unincorporated areas of San Diego County (66 square miles), the cities of Carlsbad and San Marcos (39 and 24 square miles, respectively), and a portion of the City of Escondido (approximately 27 square miles) are the largest jurisdictions in terms of land area in the CHU. Approximately 48 percent of the CHU is urbanized, and the dominant land uses are broken down as follows:

- Vacant/Undeveloped – 32 percent
- Residential – 29 percent
- Agriculture – 12 percent
- Freeways – 12 percent
- Roads – 10 percent
- Commercial/Industrial – 6 percent

Approximately 500,000 residents reside in the CHU, making it the third-most densely populated HU in San Diego County behind the Pueblo San Diego HU and the Penasquitos HU. The population in the CHU is projected to increase to over 700,000 residents by the year 2015.

**Figure 1-5: CHU Lagoon Hydrologic Areas**



# 2.0. METHODS AND INSTRUMENTATION

## 2.1 GENERAL APPROACH

The general approach of the CHU Lagoon Monitoring Program was driven by the series of management questions presented in Section 1.5 and was developed both to address those questions and to provide data to calibrate and validate watershed loading and water quality models. To accomplish this, three distinct monitoring components were designed to characterize the targeted constituents based on specific lagoon 303(d) listings, including overall water quality, seasonal and temporal variations, and constituents of possible concern.

The monitoring program included the following three principle components:

4. Continuous monitoring of hydrologic and core water quality parameters such as flow, rainfall, specific conductivity, temperature, turbidity, and, if applicable, dissolved oxygen (DO) and pH.
5. Wet weather monitoring during and immediately following three storm events at the mass emission (ME) stations along the main tributaries of the lagoons, at targeted segments locations within the lagoons, and at the ocean inlets to the lagoons, and, after the first wet weather event only, post-storm sediment sampling.
6. Dry weather monitoring during four index period events designed to capture representative seasonal cycles of physical forcing, such as tides and currents acting on the lagoons, as well as biological activity within the lagoons. During each index period event, sampling was conducted at the mass emission stations along the main tributaries of the lagoons, at targeted segment locations within the lagoons, and at the ocean inlets to the lagoons. Index period events also included longitudinal transect sampling and targeted storm drain and tributary sampling.

Various locations were monitored within each lagoon during the three monitoring components to collect data representative of the distinct regions within each lagoon. Table 2-1 shows GPS coordinates for the sampling sites within each lagoon. Figures 2-1 through 2-4 show the locations of sampling sites within each lagoon. For each lagoon the following sample locations were monitored: one mass emission station, one to two lagoon segments, and zero to two ocean inlets.

The mass emission stations were placed at a location above the upstream boundary of the estuaries of each lagoon to monitor the watershed inputs to the lagoons. The lagoon segment sites were established to monitor the baseline water quality of the lagoons and the response of the lagoons to watershed inputs. The number of segments per lagoon depended on the number of unique environments within a specific lagoon and did not include the mass emission stations or the ocean inlet sites. The actual number of monitoring

locations within each lagoon was a function of the number of segments agreed upon between the San Diego RWQCB and the stakeholders.

The ocean inlet sampling sites were established to monitor the lagoon-ocean interface. However, ocean inlet sites were not necessarily representative of incoming constituent loads from the ocean to the lagoon. At least one ocean inlet site was monitored at each lagoon when the lagoon mouths were open. Buena Vista Lagoon is never open to tidal exchange and, therefore, monitoring of the lagoon did not include an ocean inlet site. Agua Hedionda Lagoon had an additional ocean inlet site just upstream of the Interstate-5 Bridge during all sampling events to obtain boundary condition data. Agua Hedionda Lagoon was the only lagoon with this additional ocean inlet site.

**Table 2-1: Monitoring Site Locations**

| Type | GPS Points | Agua Hedionda Lagoon[a] | Buena Vista Lagoon[a] | Loma Alta Slough[a] | San Elijo Lagoon[a] |
|---|---|---|---|---|---|
| Mass Emission Station | Latitude | 33.14950 | 33.18080 | 33.18850 | 33.04818 |
| | Longitude | -117.29690 | -117.32670 | -117.36150 | -117.22670 |
| Lagoon Segment 1 | Latitude | 33.14430 | 33.17980 | 33.17740 | 33.01170 |
| | Longitude | -117.32640 | -117.34120 | -117.36880 | -117.27270 |
| Lagoon Segment 2 | Latitude | NA | 33.16820 | NA | 33.01340 |
| | Longitude | NA | -117.35620 | NA | -117.27750 |
| Ocean Inlet 1 | Latitude | 33.14568 | NA | 33.17930 | 33.01000 |
| | Longitude | -117.34345 | NA | -117.36720 | -117.26500 |
| Ocean Inlet 2 | Latitude | 33.14720 | NA | NA | NA |
| | Longitude | -117.33075 | NA | NA | NA |

(a) GPS locations are based on NAD 83 datum.

**Figure 2-1: Agua Hedionda Lagoon Sampling Locations**

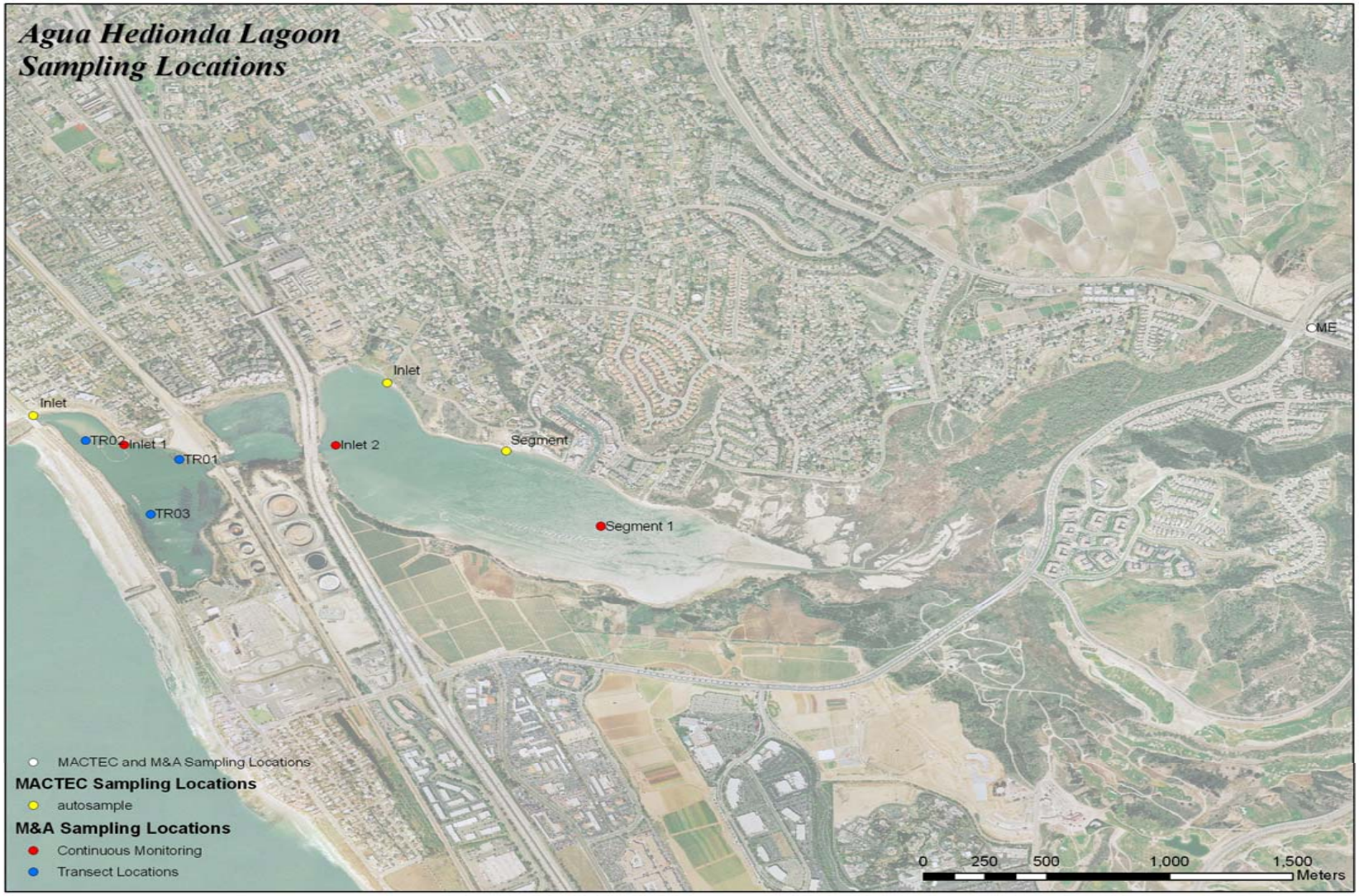


**Figure 2-2: Buena Vista Lagoon Sampling Locations**

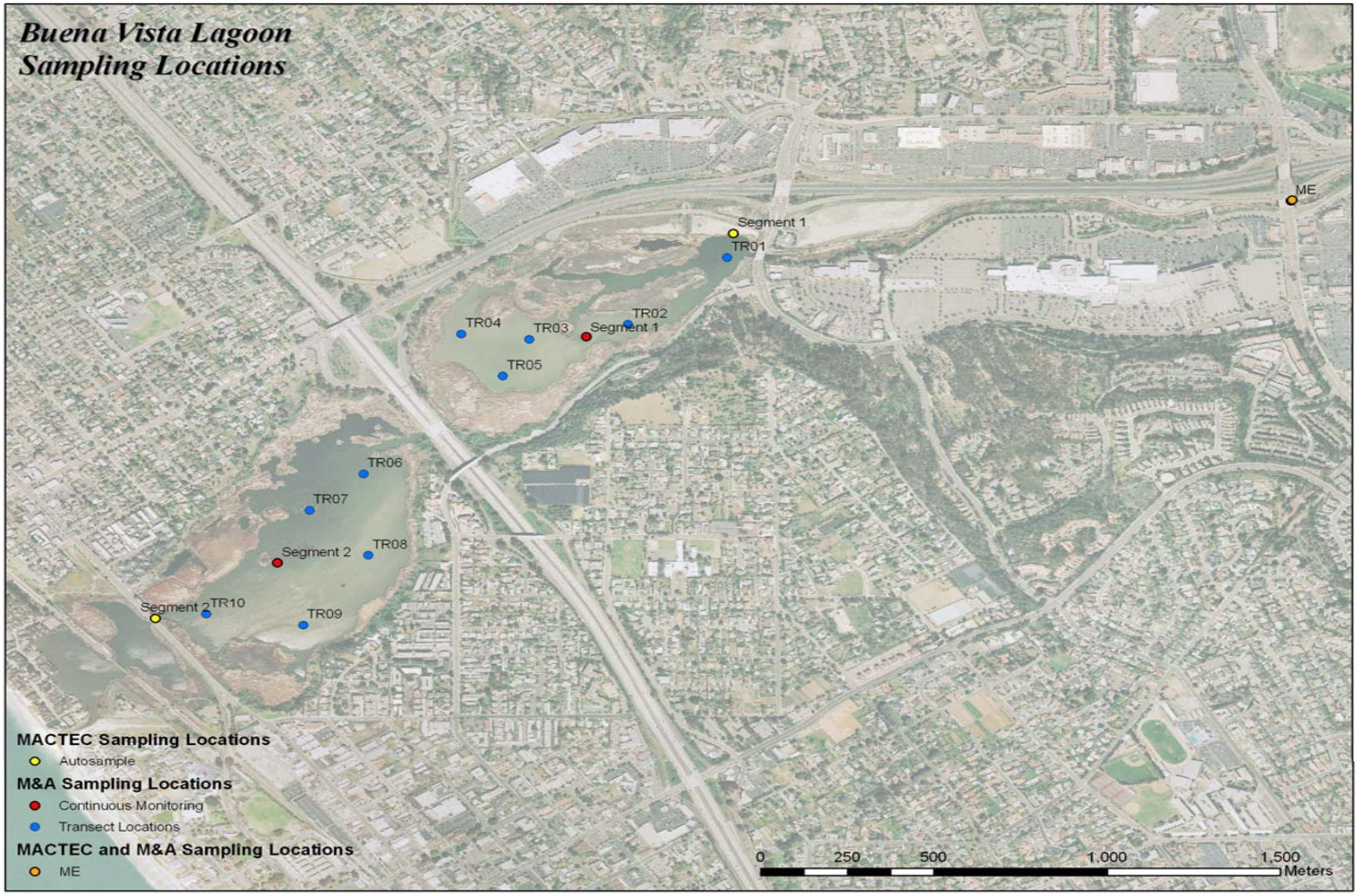
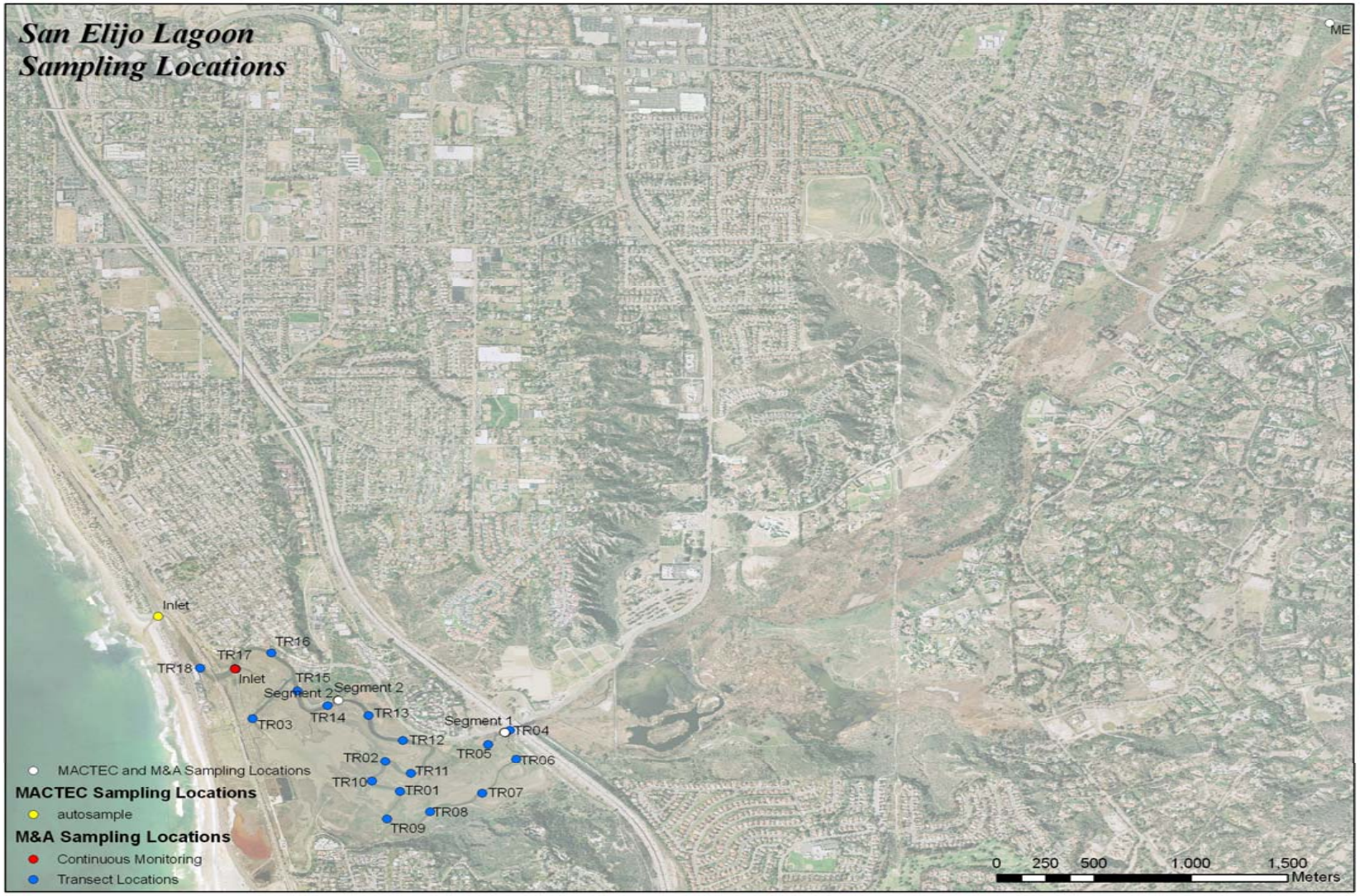


**Figure 2-3: Loma Alta Slough Sampling Locations**

**Figure 2-4: San Elijo Lagoon Sampling Locations**



## 2.2 SPECIFIC APPROACH

This section outlines the methods that were used in the monitoring program, laboratory analysis, data assessment, and QA/QC processes to meet the program objectives.

### 2.2.1 Continuous Monitoring for Hydrology and Chemical Parameters

In order to calibrate and validate the watershed hydrology and lagoon hydrodynamic models, monitoring of hydrologic and core chemical parameters (e.g., flow, specific conductance, temperature, turbidity, etc.) were measured via in-situ probes (data sondes) installed at discrete depths in each lagoon at the mass emission stations, lagoon segment sites, and at the ocean inlet sites. At lagoons 303(d) listed for nutrients/eutrophication, DO and pH also were measured. In each of the watersheds, rainfall and flow data were acquired at the mass emission stations. All meter specifications are outlined in Table 2-5 in Section 2.2.6.

#### 2.2.1.1 Mass Emission Stations

Continuous monitoring at the mass emission stations occurred throughout the monitoring program and consisted of the following parameters: flow, rainfall, specific conductivity, temperature, turbidity, and, if applicable, DO and pH. The mass emission stations were distinguished from the other sites as the only stations where continuous flow and rainfall data collection was to occur. Continuous flow data was calculated in real-time by measuring stage (water level) using a pressure transducer and applying the measured stages to existing stream flow rating tables that were generated by manual field measurements using USGS stream gauging protocol. This data was inputted to HEC-RAS modeling software along with channel measurements to generate the stream flow rating tables. Rainfall data was collected using a tipping bucket rain gauge installed at each mass emission station. Water quality parameters were measured and logged using a YSI 6600 multi-parameter water quality data sonde installed on-site. Regular maintenance and calibration of sensors was performed as-needed.

Per the QAPP, flow, rainfall, specific conductivity, and temperature monitoring was required from October 2007 to October 2008 at the Mass Emission Station. Monitoring of turbidity and, if applicable, DO and pH was required from January 2008 to October 2008.

#### 2.2.1.2 Lagoon Segment Sites

Continuous monitoring at the lagoon segment sites occurred throughout the monitoring program and consisted of the following parameters: specific conductivity, temperature, turbidity, water level, and, if

applicable, DO, and pH. Water quality parameters were measured and logged using a YSI 6600 multi-parameter water quality data sonde installed on-site. Regular maintenance and calibration of sensors was performed as-needed.

Per the QAPP, specific conductivity, temperature, turbidity, water level, and, if applicable, DO and pH monitoring at lagoon segments sites was required during a three-month wet weather period and a three to four-month dry weather period, covering all monitoring events. Continuous monitoring of these parameters was conducted from January 2008 to October 2008 resulting in a greater time period than required by the QAPP.

#### 2.2.1.3 Ocean Inlet Sites

Continuous monitoring at the ocean inlet sites occurred throughout the monitoring program and consisted of the following parameters: specific conductivity, temperature, turbidity, water level, and, if applicable, DO and pH. For all lagoons, except Buena Vista, ocean inlet monitoring occurred when the lagoon mouths were open. Water quality parameters were measured and logged using a YSI 6600 multi-parameter water quality data sonde installed on-site. Regular maintenance and calibration of sensors was performed as-needed.

Per the QAPP, specific conductivity, temperature, turbidity, water level, and, if applicable, DO and pH monitoring at ocean inlet sites was required during a three-month wet weather period and a three to four-month dry weather period, covering all monitoring events. Continuous monitoring of these parameters was conducted from January 2008 to October 2008 resulting in a greater time period than required by the QAPP.

### 2.2.2 Wet Weather Monitoring

Wet weather loading of the targeted constituents into the lagoons results from both atmospheric deposition and direct storm water runoff throughout the lagoons' watersheds. Watershed loading of the targeted constituents was estimated through a wet weather watershed model. Data collected for modeling purposes included pollutagraph samples (flow and concentration) at mass emission stations in the main tributaries of the lagoons, and composite samples collected at the lagoon segment and ocean inlet sites to capture impacts of storms on lagoon water quality.

Post-storm sediment sampling was conducted after one wet weather event to assess how wet-weather flows impact sediment transport and bulk characteristics. Although the analytical results are presented, the results and discussion of sediment transport and deposition associated with that study will be incorporated in a special study conducted by SCCWRP.

The QAPP required pollutagraph sampling for two wet weather events. The third wet weather event corresponded to one of the two storms monitored as part of the San Diego County Regional Monitoring Program, per the Municipal NPDES Permit No. 2007-01, and was a flow-weighted composite and not a pollutagraph sample. Prior to each wet weather event, pre-storm weather forecasts were utilized to ensure that only storms producing a minimum rainfall of 0.2 inches were sampled.

Analytical methods performed on collected samples are outlined in Table 2-4 in Section 2.2.5. Quality Assurance/Quality Control samples also were collected per Surface Water Ambient Monitoring Program (SWAMP) requirements in accordance with the QAPP.

#### 2.2.2.1 Pollutagraph Sampling

Pollutagraph sampling was conducted to characterize watershed loading during wet weather events. Pollutagraphs estimate the constituent discharge as a function of time. The data collected was used to determine the loading of constituents from the watershed to the lagoons over the course of a storm event. Pollutagraph sampling was required at the mass emission stations at all four lagoons during two wet weather events. Eleven to 12 discrete samples were collected throughout the hydrograph per event. Eight of these samples were required for analysis to represent the various flow regimes, specifically the rising limbs and peaks of the hydrograph. Eight pollutagraph samples were required for chemistry, and five samples were required for indicator bacteria. Automated sampling equipment was used for collection of chemistry samples while bacteria samples were to be collected as manual grab samples.

#### 2.2.2.2 Composite Sampling at Lagoon Segment Sites

The purpose of wet weather event sampling within the lagoons was to collect data to calibrate the lagoon water quality models with respect to their response over the course of a storm event. Lagoon sampling was conducted simultaneously with pollutagraph sampling at the mass emission stations and ocean inlet sampling during wet weather events.

The influence of a storm on the lagoon is delayed due to varying transit times throughout the water body. The anticipated lag time (the amount of transit time after a storm's onset before the lagoon is affected) was accounted for when preparing to initialize sampling. Sampling at the lagoon segments during the targeted period slack tide (high or low) after the onset of the storm in accordance with the QAPP and work plan. According to the QAPP, the anticipated lag time of the freshwater plume would be monitored by salinity probe to iniate sampling. However, this methodology was not deemed feasible to identify the freshwater plume therefore sampling was conducted based on the targeted period and estimated lag time. The work plan did not provide requirements regarding the timing of the lagoon storm sampling to provide stakeholders with maximum flexibility.

Time-weighted composite samples were collected over a three-hour duration at slack high tide and again at slack low tide. Automated sampling equipment was programmed to collect aliquots every 15 minutes into a composite jar. During the three wet weather events, microbiology grab samples were collected concurrently with the composite samples. Lagoon segment sampling occurred at all lagoon segment sites listed in Table 2-1 during all three required wet weather events.

#### 2.2.2.3 Composite Sampling at Ocean Inlet Sites

The purpose of the ocean inlet sampling was to collect data to calibrate the lagoon water quality model with respect to the net transport and exchange of the targeted constituents between the ocean and the lagoons during a storm event. One surface composite sample was collected at each ocean inlet, with the exception of Agua Hedionda Lagoon, where samples were collected at two depths for both ocean inlet sites. As mentioned previously, no ocean inlet samples were collected at Buena Vista Lagoon.

Time-weighted composite samples were collected over a three-hour duration at slack high tide and again at slack low tide. Automated sampling equipment was programmed to collect aliquots every 15 minutes into a composite jar. During the three wet weather events, microbiology grab samples were collected concurrently with the composite samples. Ocean inlet sampling occurred during three required wet weather events at ocean inlet sites listed in Table 2-1.

#### 2.2.2.4 Grain Size Analysis of Aqueous Sediment in Storm Samples

In addition to the chemical constituents, lagoons were monitored for particle size distribution of aqueous sediment (suspended sediment) at the mass emission stations during both required pollutagraph wet weather events of the season. The samples submitted to the laboratory consisted of one composite sample

per lagoon. Each sample was composited from the eight required pollutagraph samples collected over the course of the storm at each lagoon. The samples were analyzed for grain size distribution among the following size categories: clay < 0.0039 millimeters, silt 0.0039 to < 0.0625 millimeters, sand 0.0625 to < 2.0 millimeters, and granule 2.0 to < 4.0 millimeters.

2.2.2.5 Post-Wet Weather Event Sediment Sampling

Post-wet weather event sediment sampling provided data to calibrate the lagoon sediment transport and water quality models with respect to the impact of a storm event on sediment transport and the geomorphic characteristics within the lagoon. Post-wet weather event sediment sampling occurred within two weeks after the first wet weather event sampled. Sediment samples were collected from a small boat (or on foot at Loma Alta Slough) using a ponar or similar grab sampler, with only the top two centimeters retained. Each grab sample was observed to determine acceptability, defined as an intact sample with no blow out or other indications that the top layer had been disturbed.

### 2.2.3 Index Period Sampling

The dry weather program was designed to provide data to calibrate and validate the watershed and water quality models and to characterize the baseline conditions of the lagoons during the monitoring program. Dry weather monitoring occurred at the mass emission stations, lagoon segments, ocean inlets, storm drains, and longitudinal transect sites during four index period events. These index period events captured representative seasonal cycles of physical forcing and biological activity in the lagoon.

Each of the four index period events spanned two weeks. During those two weeks, the first three days of each week (Monday through Wednesday) were sampled for a total of six days sampled. Sampling occurred during both slack low and slack high tide each day for the tidal lagoons (Agua Hedionda Lagoon, Loma Alta Slough, and San Elijo Lagoon) and occurred once per day at the non-tidal lagoon (Buena Vista Lagoon). One sample per day was collected at each mass emission station. Longitudinal transect along with storm drain and tributary sampling occurred once at each lagoon during each index period event.

Analytical methods performed on collected samples are outlined in Table 2-4 in Section 2.2.5. Quality Assurance/Quality Control samples also were collected per SWAMP requirements in accordance with the QAPP.

#### 2.2.3.1 Mass Emission Site Sampling

Dry weather loading from the watershed was estimated by monitoring the mass emission stations over each of the index periods. Mass emission station sampling was conducted once daily during the same index periods as the lagoon segment and ocean inlet sampling. Daily time-weighted composite samples were collected by automated sampling equipment programmed to collect aliquots every 15 minutes for a 30-minute period. Microbiology grab samples were collected concurrently with the composite samples. Sampling occurred at four Mass Emission Stations during the four Index Period Events.

#### 2.2.3.2 Lagoon Segment Site Sampling

Sampling at each lagoon segment site was to characterize intra-lagoon variability in target constituents, as well as daily variations at each individual segment. Two time-weighted samples per day per segment were collected for the tidal lagoons (Agua Hedionda Lagoon, Loma Alta Slough, and San Elijo Lagoon) and one sample per segment per day was collected at the non-tidal lagoon (Buena Vista Lagoon). For tidal lagoons, one composite sample was collected during slack low tide and one composite sample was collected during slack high tide. Composite samples were collected using automated sampling equipment programmed to collect aliquots every 15 minutes for a 30-minute period. Microbiology grab samples were collected concurrently with the composite samples. Sampling occurred at four Lagoon Segment Sites during the four Index Period Events.

#### 2.2.3.3 Ocean Inlet Site Sampling

The ocean inlet sites were monitored over each index period event to characterize the tidal exchange across the inlets throughout the index periods. During the index period events, ocean inlet sampling occurred for all lagoons except Buena Vista Lagoon. Ocean inlet sampling occurred simultaneously with index period sampling of the mass emission stations and the lagoon segment sites. Daily sampling was conducted only if the mouth of the lagoon was open. Time-weighted composite samples were collected using automated sampling equipment programmed to collect aliquots every 15 minutes for a 30-minute period. During the composite sample collection periods, microbiology grab samples were collected simultaneously. Sampling occurred at all Ocean Inlet Sites during the four Index Period Events unless the inlets were closed to tidal exchange.

2.2.3.4 Transect Sampling

Transect sampling provided spatial data for calibrating and validating the water quality model within the lagoons. Whereas lagoon segment sampling conducted at fixed sites provided data on only one site within each segment, longitudinal transects sampling provided data showing the variation of targeted constituents within each segment.

Longitudinal transect sampling was conducted along a salinity gradient in each lagoon from a small boat (or on foot at Loma Alta Slough) at locations designated using GPS, during flood and ebb tide (morning and evening for Buena Vista), and during each index period. At each sampling location, discrete water samples were collected just below the water surface, along with specific conductivity, temperature, turbidity, and, if applicable, DO and pH measurements using hand-held probes. The number of sample locations at each lagoon was consistent during all index periods; however, the number of sample locations varied between lagoons. Table 2-2 below summarizes the number of transect sampling locations per lagoon and provides a brief description of the sampling locations. Sampling occurred at the locations listed in Table 2-2 during the four Index Period Events.

**Table 2-2: Number of Transect Samples per Lagoon per Index Period**

| Lagoon | Transect 1 Ebb Tide | Transect 2 Flood Tide | Location |
|---|---|---|---|
| Loma Alta Slough | 8 | 8 | Along salinity gradient |
| Agua Hedionda Lagoon | 3 | 3 | In western-most basin only[a] |
| Buena Vista Lagoon | 10[a] | 10[a] | 5 in eastern- most basin, 5 in central basin |
| San Elijo Lagoon | 18 | 18 | 3 in eastern-most basin, 15 in western-most basin |

(a) Buena Vista Lagoon samples were collected in the morning and evening and were not based on tide.

2.2.3.5 Storm Drain and Tributary Sampling

Storm drains and tributaries were not expected to be a significant source of constituent loading to each lagoon during dry weather due to relatively low flows. Two storm drains or tributaries were selected for each lagoon that represented 80 percent of the target constituent loading from storm drains directly into each lagoon. Storm drain or tributary sampling occurred at designated sites around each lagoon once during each of the index period events. Flow conditions were noted at each location during each sampling

event. Table 2-3 lists the storm drain and tributary locations where sampling occurred during the four Index Period Events.

**Table 2-3: Storm Drain and Tributary Sampling Sites for Each Lagoon**

| Lagoon | Storm Drain and Tributary Sites | | | |
|---|---|---|---|---|
| | **Description** | **ID** | **Latitude[a]** | **Longitude[a]** |
| Loma Alta Slough | Storm Drain | L054 | 33.18350 | -117.36476 |
| | Tributary | LA Trib | 33.18248 | -117.36512 |
| Buena Vista Lagoon | Storm Drain | BV Lag 1 | 33.18063 | -117.34251 |
| | Storm Drain | BV Lag 2 | 33.18058 | -117.34250 |
| Agua Hedionda Lagoon | Storm Drain | AH-006 | 33.14627 | -117.33790 |
| | Storm Drain | AH-25 | 33.13816 | -117.33578 |
| San Elijo Lagoon | Tributary- La Orilla Creek | LOR | 33.01056 | -117.24000 |
| | Storm Drain | CBS-2 | 33.01667 | -117.28139 |

(a) GPS locations are based on NAD 83 datum.

2.2.3.6 Water Level and Flow Monitoring

Data on water levels within the lagoons and data on flow entering the lagoons will be used to calibrate the hydrodynamic models throughout the varying tidal and flow regimes. Water level within the lagoons was measured and logged by the use of moored data sondes in each lagoon and will be correlated with the lagoon bathymetry during the TMDL modeling process. Flow was measured continuously at the mass emission stations and was calculated based on the water level measured by a pressure transducer and stream flow rating tables to be updated regularly by the project team.

### 2.2.4 Land Elevation Survey of Ocean Inlet Sites

Per Addendum No. 3 of IO No. R9-2006-0076, the RWQCB required cross-section surveys of land elevation at the ocean inlet at each lagoon prior to the first index period event. Thereafter, surveys were based on potential alterations in site conditions. A change in site condition existed if the width, depth, or shape of the inlet and its banks changed significantly between index period events. Ocean inlet surveys were conducted at Agua Hedionda Lagoon, Loma Alta Slough, and San Elijo Lagoon to capture the significant changes to the inlet cross-section between sampling events. This included Ocean Inlet Site 2 at Agua Hedionda Lagoon. The mouth of Buena Vista Lagoon is closed to tidal exchange, and, therefore, was not subject to this requirement.

The survey method used at the ocean inlet sites varied between lagoons. At Loma Alta Slough and San Elijo Lagoon, a wading/rod combination survey was conducted during a low tide. The inlet at Agua

Hedionda Lagoon was too deep and currents too swift to conduct a wading survey or to use a small boat. Instead, a transect measurement was taken from the top of the Carlsbad Boulevard Bridge using a lead line. For ocean inlet surveys, elevations were tied into a known benchmark as opposed to the water surface or tide level.

### 2.2.5 Analytical Methods

A "core" set of parameters/analytes were monitored in each lagoon to establish a dataset to calibrate the lagoon hydrodynamic model. Other analytes depended on specific lagoons' listings (bacteria, total dissolved solids, sediment, or nutrients/eutrophication). Table 2-4 provides the list of analytes by TMDL type and shows the analytical method, the target reporting limit, and the laboratory to perform the analysis per analyte. Each analytical method and target reporting limit were compatible with the SWAMP requirements.

The San Diego RWQCB determined that the stakeholders were not required to use only laboratories with state of California certification for this IO, as long as the data met the SWAMP-specified Measurement Quality Objectives (MQOs) for the target analytes. Stakeholders and SCCWRP were allowed to filter and freeze a subset of nutrient samples to increase the holding time to 28 days. The established SWAMP holding time requirement for ammonia was 28 days, nitrate+nitrite was 48 hours, and total phosphorus was 28 days. The SWAMP does not have standard requirements for soluble reactive phosphorus (SRP), total nitrogen, total dissolved nitrogen, or total dissolved phosphorus. Collected samples were put on ice immediately after collection, kept on ice until processed, filtered within six hours of sample collection, and frozen at the end of each day of sampling. During all events, filtering occurred in the field.

MACTEC served as the clearing house for samples collected by the project team, with the exception of the first wet weather event and first index period event where CRG Marine Laboratories completed this aspect of sample handling. Once samples were under MACTEC custody, MACTEC processed and distributed the samples to the appropriate laboratories based on the required analysis. See Table 2-4 for laboratories associated with the required analyses, analytical method numbers, and target reporting limits (RLs). The samples were analyzed for chemistry as indicated below. Samples collected were stored on ice at four degrees Celsius for processing prior to laboratory delivery and were kept stored at that temperature or frozen where applicable until delivered to the analytical laboratory. Samples were managed under Chain-of-Custody (COC) protocol from the time of collection to laboratory receipt.

**Table 2-4: Constituents, TMDL Type, Responsible Laboratory, and Analytical Methods**

| TMDL Type | Parameter/Analyte | Laboratory | Target Reporting Limit (RL) | Analytical Method | Modified for Method Yes/No |
|---|---|---|---|---|---|
| Core[1] | Temperature | Field Monitoring | 0.1 °C | Data Sonde | no |
| | Conductivity | Field Monitoring | 2.5 µS/cm | Data Sonde | no |
| | Turbidity | Field Monitoring | 0.5 NTU | Data Sonde | no |
| | Total Suspended Solids (TSS) | CRG | 5 mg/L | SM 2540D | no |
| Total Dissolved Solids | Total Dissolved Solids (TDS) | CRG | 5 mg/L | SM 2450C | no |
| Bacteria | Total Coliform[2] | CRG/EWA | 1 MPN/ 100 mL | SM 9221B/9222B | no |
| | Fecal Coliform[2] | CRG/EWA | 1 MPN/ 100 mL | SM 9221E/D/9222D | no |
| | Enterococcus | CRG/EWA | 1 CFU/ 100 mL | EPA 1600[3] | no |
| Eutrophication | pH | Field Monitoring | 0.2 | Data Sonde | no |
| | Dissolved Oxygen (DO) | Field Monitoring | 1.00 mg/L | Data Sonde | no |
| | Total Nitrogen (TN) | UGA | 0.1 mg/L | USGS I-4650-03 | yes |
| | Total Phosphorus (TP) | UGA | 0.05 mg/L | USGS I-4650-03 | yes |
| | Total Dissolved Nitrogen (TDN) | UGA | 0.1 mg/L | USGS I-2650-03 | yes |
| | Total Dissolved Phosphorus (TDP) | UGA | 0.05 mg/L | USGS I-2650-03 | yes |
| | Nitrate+Nitrite-N | UCSB MSI | 0.05 mg/L | SM 4500-NO3+NO2 F | yes |
| | Ammonia-N | UCSB MSI | 0.05 mg/L | SM 4500-NH3 G | yes |
| | Nitrite as N | UCSB MSI | 0.05 mg/L | 4500-NO2 B | yes |
| | Soluble Reactive Phosphorus (SRP) | UCSB MSI | 0.05 mg/L | SM4500P C | yes |
| | Chlorophyll *a* | CRG | 2 mg/m$^3$ | SM 10200H | no |
| | Carbonaceous Biological Oxygen Demand (CBOD[5]) | CRG | 2 mg/L | SM 5210B | no |
| Aqueous Sediment or Sediment | % Fines or % Sand/Silt/Clay | ABCL | 1 % | ASTM D-422 (1963)[4] | no |
| | | SCCWRP | | EPA (1995)[5] | |
| | % Organic Carbon (%OC) | UCSB MSI | 0.2 % | EPA 9060 | no |
| | % Total Nitrogen (%TN) | UCSB MSI | 0.2 % | EPA 9060 | no |
| | % Total Phosphorus (%TP) | UGA | 0.01 % | Nelson (1987)[6] | no |

1 Under "type", "Core" refers to parameters that were monitored at all lagoons regardless of 303(d) listing.
2 Suggested analytical methods from SWAMP, using membrane filtration technique.
3 This method was an option to SM9230C per authorization from SDRWQCB.
4 ASTM D-2216, 1980. Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures. American Society for Testing and Materials.
5 U.S. EPA, 1995. Environmental Monitoring and Assessment Program (EMAP): Laboratory Methods Manual – Estuaries, Volume 1: Biological and Physical Analyses. United States Environmental Protection Agency, Office of Research and Development, Narragansett, RI. EPA/620/R-95/008.
6 Nelson, N. S. 1987. An acid-persulfate digestion procedure for determination of phosphorus in sediments. Commun in Soil Sci. Plant Anal. v.18 no.4 p.359-69.

**Table 2-5: Data Sonde Probe Specifications**

| Parameter | Range | Resolution | Accuracy |
|---|---|---|---|
| Conductivity | 0 to 100 mS/cm | 0.001 to 0.1 mS/cm (range dependent) | ± 0.5% of reading + 0.001 mS/cm |
| Temperature | -5 to + 50°C | 0.01°C | ±0.15°C |
| Turbidity | 0 to 1,000 NTU | 0.1 NTU | ± 2% of reading or 0.3 NTU, whichever is greater |
| Optical DO (% Saturation) | 0 to 500% | 0.1% | 0 to 200%: ± 1% of reading or 1% air saturation, whichever is greater; 200 to 500%: ± 15% of reading |
| Optical DO (Concentration) | 0 to 50 mg/L | 0.01 mg/L | 0 to 20 mg/L: ± 0.1 mg/L or 1% of reading, whichever is greater; 20 to 50 mg/L: ± 15% of reading |
| pH | 0 to 14 units | 0.01 unit | ± 0.2 unit |

2.2.5.1 Specific Conductivity, Temperature, Turbidity, Dissolved Oxygen (DO), and pH

Data sondes deployed at the designated sampling locations measured specific conductivity, temperature, turbidity, and, if applicable, DO and pH. The data sondes logged these parameters and were downloaded at the specified two-week intervals. During the download activities, the probes were cleaned and calibrated as per manufacturer recommendations. See Table 2-5 for data sonde sensor range, resolution, and accuracy.

2.2.5.2 Total Dissolved Solids (TDS) and Total Suspended Solids (TSS)

Total dissolved solids in the water samples were analyzed by the laboratory using SM 2450C. Total suspended solids were analyzed using the gravimetric technique (SM 2540D).

2.2.5.3 Microbiology

Samples collected for bacteria analysis were delivered to the laboratory within six hours to meet the microbiological holding times. Samples were analyzed for total coliform bacteria using SM 9221B/9222B, fecal coliform bacteria using SM 9221D/E/9222D, and *Enterococcus* bacteria using USEPA Method 1600.

2.2.5.4 Nutrients/Eutrophication

Ammonia as N, nitrate+nitrite as N, and nitrite as N were analyzed using SM 4500-NH3 G, SM 4500-NO3+NO2 F, and 4500-NO2 B, respectively. Total nitrogen (TN) and total phosphorus (TP) were analyzed using USGS Method I-4650-03. Total dissolved nitrogen (TDN) and total dissolved phosphorus (TDP) also were analyzed using USGS Method I-2650-03. Additional details of analytical methods used for nutrient analysis are described below and summarized in Table 2-6.

Ammonia was analyzed using distillation and the automated phenate method (SM 4500-NH3 G) using a Lachat Instruments (division of Zelweger Analytics) Model QuikChem 8000 Flow Injection Analyzer, nitrate+nitrite was analyzed using the cadmium reduction method (SM 4500-NO3+NO2 F), and nitrite was analyzed using the colorimetric method (SM 4500-NO2 B).

For total nitrogen (TN) and total phosphorus (TP) (USGS Method I-4650-03) and total dissolved nitrogen (TDN) and total dissolved phosphorus (TDP) (USGS Method I-2650-03; Patton, C.J. and J.R. Kryskalla (2003)), persulfate was used to digest unfiltered and filtered water samples to convert the nitrogen from all nitrogen compartments into nitrate and the phosphorus from all phosphorus compartments into orthophosphate for the simultaneous determination of TN and TP. The resulting digests were analyzed by automated colorimetry for nitrate-N and orthophosphate using an Alpkem Colorimeter.

Soluble reactive phosphorus (SRP) was analyzed using the automated ascorbic acid reduction method (SM 4500-P C), using a Lachat Instruments Model QuikChem 8000 Flow Injection Analyzer.

Chlorophyll *a* in water samples was concentrated by filtering at low vacuum through a Whatman glass fiber filter (GF/F). Photosynthetic pigments were extracted from the algae in 90 percent acetone and allowed to steep overnight, but did not exceed 24 hours, to ensure thorough extraction of chlorophyll *a* (USEPA method 445). Using a self-calibrating Turner Designs Trilogy Laboratory fluorometer, the fluorescence of the sample then was measured before and after acidification with 0.1M HCl to determine the concentration of phaeophytin-corrected Chlorophyll *a*.

2.2.5.5 Suspended Sediment or Sediment Analysis

Sediment grain size (percentage of sand only) was determined by wet sieving the sample through a 62-micron sieve to separate the course and fine fractions (USEPA, 1995). Sediment organic carbon percentage and organic nitrogen percentage was determined on a CHN elemental analyzer (Exeter

Analytical model CEC 440HA) by means of high temperature (1,000 degrees Celsius) combustion (Dumas Method) in an oxygen- enriched helium atmosphere (USEPA Method 9060).

Total sediment phosphorus was determined by persulfate digestion, which converts all organic phosphorus to orthophosphate. Digests were then analyzed by automated colorimetry for nitrate-nitrogen and orthophosphate using an Alpkem Colorimeter (Nelson, 1987).

2.2.5.6 Flow Data

Flow data was measured using Doppler velocity sensors in combination with level sensors to estimate stage and calculate flow. The product of velocity and wetted cross-sectional area provided an estimate of total flow. All raw data was downloaded on a regular basis. Raw data was uploaded to the project database for storage and retrieval. Original raw data files also were archived at MACTEC. Velocity and stage data was manually collected approximately once per month when not sampling to help calculate changes in flow conditions and to calibrate the ratings table. During sampling, flow measurements were collected at 15-minute intervals.

For dry weather storm drain and tributary sampling, flow measurements were conducted by field staff from the Responsible Parties (cities). Alternative methods were employed to estimate flow rates for different types, such as an open channel, outfall, or drainage pipe. Potential methods are described below.

<u>Velocity-Area Method</u>

This method requires the physical measurement of the velocity (V), depth (D), and width (W) of flowing water. Discharge is determined as follows:

$$\text{Equation 1: Discharge } (ft^3/sec) = \text{Velocity } (ft/sec) \times \text{Depth } (ft) \times \text{Width } (ft)$$

The average velocity in feet-per-second of water flow was measured using the Global Flow Probe FP101 (Global Water, Gold River, CA). For calibration and measurement procedures, refer to the *Dry Weather Analytical and Field Screening Monitoring Procedures Manual* (County of San Diego, 2006), Appendix G of the QAPP. Flow velocity was measured at three locations across a creek/stream (left, center, and right). Stream depth and width, both in feet, were determined using the measurement marks on the probe pole. As the probe pole markings are in tenths of a foot, measurements were read directly from the markings and did not require any conversions. Measurement results on the Field Data Sheets and the discharge in cubic feet-per-second (cfs) were calculated using Equation 1.

If water flow was too slow or the water was too shallow to measure the velocity using the probe, which occurs frequently during dry weather monitoring, the velocity was estimated by timing the travel of a piece of floating debris (e.g., a leaf). The "apparent" velocity was calculated by dividing the travel distance (feet) by the recorded travel time (seconds). The "actual" velocity then was calculated by multiplying a correction constant – 0.8 for rough bottom and 0.9 for smooth bottom.

Fill-a-Bottle method

If water was flowing relatively slowly through an outfall, the fill-a-bottle method was used. The time taken to fill a bottle or a bucket of a known volume with water was recorded, and this result was used to calculate discharge by dividing the known volume by the time taken to fill the bottle or bucket. For example, if it took 20 seconds for an outfall to fill a 1-gallon bottle, since one gallon equals 0.1337 cubic feet, the discharge was: 0.1337 divided by 20, or 0.007 cfs.

Partially-Filled Pipe Method

This method was used when substantial water volume flowed through a drainage pipe. The method followed is similar to the velocity-area method, except that the determination of the cross-sectional area is different. The procedures are described in detail in Appendix G of the QAPP.

### 2.2.6 Data Analysis Methods

MACTEC conducted data analysis using a comprehensive set of diagnostic tools. This data analysis helped guide further in-depth examination of monitoring results to address the monitoring program objectives and answer many of the management questions. The following diagnostic tools were used to conduct the data analysis.

#### 2.2.6.1 Summary Statistics

To help understand the large data set, basic statistics, including mean, median, maximum (max), minimum (min), standard deviation (SD), and coefficient of variance (COV) were calculated for each event per site. Basic summary statistics were provided for preliminary comparisons of data by site, event, and constituent, and for identification of anomalies to guide further analysis with the other diagnostic tools.

2.2.6.2 Event Mean Concentration

Event mean concentrations (EMCs) were used to compare results by event, as well as to calculate first-flush effects and develop load duration curves.

EMCs were calculated using analytical results from the mass emission pollutagraph samples and discharge records using Equation 2 below.

Equation 2: $$EMC = \frac{\sum(Vi*Ci)}{\sum(Vi)}$$

Where $V_i$ represents volume in cubic feet (cf) for the ith interval and $C_i$ represents analyte concentration for the ith interval in the appropriate units associated with that specific analyte. The ith interval refers to the time interval associated with each discharge and concentration record. This methodology was based on techniques described by Kayhanian and Stenstrom (March/April 2008).

2.2.6.3 First-flush Ratio

The concentration first-flush ratio was used to determine if a concentration-based (versus a load-based) first-flush effect was present for a given constituent per event and the magnitude of the first-flush. Partial event mean concentrations (PEMCs) were calculated with the same method used to calculate EMCs; however, the PEMCs were based on time intervals throughout the storm event (e.g., the first 120 minutes). Event-specific, first-flush ratios were calculated based on the ratio of the PEMC to the entire event mean concentration. Evidence of a concentration first-flush was present if the PEMC/EMC was larger than one. This methodology was based on techniques described by Kayhanian and Stenstrom (March/April 2008).

2.2.6.4 Daily and Annual Load

Daily and annual loads were calculated to quantify the daily and annual input of constituents (in terms of mass) from the mass emission stations and storm drains (daily only) into the lagoons. Annual and daily dry and wet weather load estimates were calculated for each lagoon's applicable 303(d) listed categories and individual constituents.

These categories and individual constituents that had load calculations estimated for were:

- Bacteria
  - *Enterococcus*
  - Total Coliform
  - Fecal Coliform
- Total Dissolved Solids (TDS)
- Sediment (TSS)
- Nutrients/Eutrophication
  - Ammonium-N
  - CBOD
  - Chlorophyll *a*
  - Nitrate+Nitrite-N
  - Soluble Reactive Phosphorus (SRP)
  - Total Nitrogen (TN)
  - Total Dissolved Nitrogen (TDN)
  - Total Phosphorus (TP)
  - Total Dissolved Phosphorus (TDP)

Load calculations were not performed for the following constituents:

- Specific Conductivity
- Temperature
- Turbidity
- Dissolved Oxygen (DO)
- pH
- Particle Grain Size

Wet Weather Load Estimate

The daily and annual wet weather loads for each constituent were calculated based on flows measured during wet weather conditions and calculated daily EMCs. Average daily, median daily, minimum daily, maximum daily, and total annual wet weather flows were calculated from flow measurements obtained every 15 minutes at the mass emission stations. Days that had equal to or greater than 0.1 inches of rainfall over a 24-hour period and the following three days after the end of precipitation were categorized as wet weather flow days. Daily EMCs were calculated from the results of the individual pollutagraph samples collected during the first two sampled wet weather events. These calculated daily EMCs and the EMCs calculated from the flow-weighted composite samples collected during the third weather event were used in calculating wet weather load estimations.

For wet weather day when samples were collected, the daily wet weather loads were estimated by multiplying the daily EMC by the associated daily wet weather flows and then multiplying the result by a conversion factor, as shown in Equation 3:

Equation 3: Load (lbs/day, G-org/day, etc) = Daily Flow (cf) * [analyte] (mg/L, MPN/100mL, etc) * conversion factor

For wet weather days with no sampling data, the average of the three EMCs was multiplied by the daily wet weather flow and then by the conversion factor.

Dry Weather Load Estimate

The daily and annual dry weather loads for each constituent were calculated based on flows measured during dry weather conditions and the analytical results of samples collected during index periods. Average daily, median daily, minimum daily, maximum daily, and total annual dry weather flows were calculated from flow measurements obtained every 15 minutes at each mass emission station. Days that had less than 0.1 inches of rainfall over a 24-hour period and were not included in the three days following a rain event (as defined above) were categorized as dry weather flow days.

Average concentrations for each of the four index periods were calculated from the results of samples collected from each mass emission station. The daily dry weather loads were estimated by multiplying the results of index period samples by the daily dry weather flows measured on the days that those samples were collected and then multiplying the total by a conversion factor, as shown in Equation 3. Most days did not have sampling data; therefore, the average index period sample results were used to calculate loads for days occurring during the corresponding seasonal period.

2.2.6.5 Load Pollutagraphs and Concentration Pollutagraphs

Load and concentration pollutagraphs estimate the pollutant loads and concentrations, respectively, as a function of time during storm events. These graphs were developed to determine the pollutant load and concentration contribution from the watersheds to the lagoons and to assess pollutant changes during a storm event.

Concentration graphs depict the concentration fluctuation over time throughout a storm event. The graphs used for this data analysis display the concentrations of target analytes associated with each individual pollutagraph sample collected during a storm event. These graphs were created for the two wet weather events for which pollutagraph sample collection was required.

Load pollutagraphs characterize constituent-load distribution throughout the flow regimes of a storm event. In order to create these graphs, load values for each pollutagraph sample collected during a storm

event were calculated in the same manner described in Section 2.2.6.4. These results were plotted as a function of time. The pollutant load is the area under the resulting load curve. This area (load) was estimated by dividing the curve into discrete time intervals. Based on these time intervals, load values were interpolated at the beginning and endpoint of the interval. Those load values were averaged and multiplied by the average flow for the corresponding time interval to create the estimated load for that time interval. This process was repeated for all time intervals throughout the storm event and plotted along with the discharge curve associated with the event. This allowed for an understanding of how pollutant load varies throughout a storm event and provided insight as to how pollutant loading varies relative to the discharge throughout the storm event.

#### 2.2.6.6 Load Duration Curve

Load duration curves were developed to provide a correlation between water quality parameters and different flow conditions. Load duration curves identify flow conditions (high, moist, mid, dry, and low flows) when water quality parameters exceed a receiving water body's loading capacity, as well as the magnitude of these exceedances. Load duration curves were developed using stream flow rates, flow-weighted EMCs, San Diego Basin Plan WQOs, and a 10-percent margin of safety (MOS), based on techniques described by USEPA (August 2007) and the Nevada Division of Environmental Protection (April 2003). The 10 percent MOS is recommended to account for gauging errors when measuring stream flow.

This analysis technique first ranks daily average flow for a given stream or river, with a rank of one being associated with the highest stream flow rate in the dataset. Once ranked, the "Percent of Days Flow Exceeded" were calculated. This was done by dividing a given rank by the highest rank value in the dataset and then multiplying by 100:

Equation 4: Percent of Days Flow Exceeded = ((rankx/rankmax)*100)

This load duration curve was developed by multiplying the WQO for the desired analyte by the stream flow rate and conversion factor (Equation 5). Note that Equation 5 differs from Equation 3 as load duration curve calculations incorporates average daily stream flow (cfs) rather than a daily flow total (cf) used in basic daily and annual load calculations.

Equation 5: Load (lbs/day, G-org/day, etc) = average daily stream flow (cfs) * WQO (mg/L, MPN/100mL, etc) * conversion factor

The conversion factor in this equation varied based on the water quality standard units and the desired load units. This equation was applied to all records in the dataset. In creating load duration curves, it was appropriate to apply a ten-percent margin of safety in order to account for gauging errors. This was accomplished by simply dividing the result from the previous equation by 1.1.

Water quality sampling results were used to calculate daily loads for each sample data point using the same equation in Step 2, exchanging the analytical result for the WQO. The analytical result used for data calculation was the flow-weighted EMC for each given day. The dates associated with the calculated load values were then compared to the "Percent of Day Flow Exceeded" or the equivalent "Percent of Days Load Exceeded". These percent and load data points were plotted on the load duration curve for the final product.

These tools provided an understanding of the possible point and non-point sources, seasonal and temporal variations, and site variations within a lagoon. Exceedances associated with dry or low flows indicated a point-source influence whereas exceedances associated with moist or high flows indicated a stronger influence from non-point sources.

#### 2.2.6.7 Dissolved Oxygen Frequency and Instantaneous Distributions

Frequency distributions were used to analyze DO results from continuous monitoring data based on 15-minute data collected during this monitoring program. These distributions assess the frequency of events where DO concentrations occurred in the following concentration classes: 0 - 2.5 mg/L, 2.5 - 5 mg/L, 5 - 7.5 mg/L, 7.5 – 10 mg/L, 10 – 12.5 mg/L, and >12.5 mg/L. This analysis provides information on the frequency of events where DO concentrations dropped below the Basin Plan objective of 5 mg/L. This analysis was performed on data from lagoons listed for eutrophication and therefore was not performed on data from Agua Hedionda. Of those lagoons listed for eutrophication, this analysis was performed on data from the lagoon segment sites only.

DO instantaneous distributions were plotted for all monitored sites at lagoons listed for eutrophication. These plots are distributions of all DO concentration data collected at each monitored location during this monitoring program as they occurred in chronological order.

2.2.6.8 Mass First-Flush Percentage

The mass first flush percentage was calculated based on partial load at 30 percent of storm flow divided by total load over the storm duration. A start of storm and end of storm time and date were determined by analysis of the storm hydrograph. Start of storm times were chosen before all rainfall and sample times and generally attempted to begin at the end of base flow conditions. End of storm times were chosen after all rainfall and sample collection points and generally attempted to end at the tail (high base flow) of the hydrograph. The total storm flow for the event was calculated, and 30 percent of total storm flow was calculated for mass first flush.

The time and date that corresponded to the 30 percent storm flow was located and the closest corresponding time period from the Load Pollutagraph Histograms was used to determine the total load at approximately 30 percent (the mass first flush). The flow at the histogram determined time period was then back-calculated to determine the actual flow percentage used (i.e. usually between 25-35% total storm flow) at the mass first flush.

The total load for the hydrograph duration was determined from the daily loading calculations (see methodology 2.2.6.4). If the hydrograph included a full day, the calculated load for that day was used in the total load calculation. If the hydrograph included partial days the relative flow that the hydrograph included for that day was calculated. The load for the partial day was calculated by analyte concentration multiplied by the partial flow multiplied by the conversion factor (see Equation 6). The total storm load was calculated by addition of all partial loads over storm event duration (see Equation 7).

Equation 6: $Load_{partial}$ = [analyte] (mg/L, CFU/100mL, etc) * $Flow_{partial}$ (cf) * conversion factor

Equation 7: $Load_{Total} = Load_{Day\ 1} + Load_{Day\ 2} + L_{Day\ 3} \ldots$

The mass first flush percentage was calculated by dividing the partial load at approximately 30 percent of total storm flow by the total load over the entire storm duration. The mass first flush percentages were then categorized by first flush relevancy for discussion purposes as follows:

- Strong = > 80 percent
- Moderate = < 80 percent and > 60 percent
- Minor = < 60 percent and > 35 percent
- None = < 35 percent

## 2.3 QUALITY ASSURANCE/QUALITY CONTROL METHODS

The section summarizes the methods used to meet the objectives of the CHU Lagoon Monitoring Program, including sampling procedures, laboratory analysis, and Quality Assurance/Quality Control (QA/QC) procedures. Data collected as part of the monitoring program was required to be compatible with the SWAMP quality assurance standards. This required an additional 10 to 15 percent of samples collected for field and laboratory quality assurance samples.

Field QA/QC samples were used to evaluate potential contamination and sampling error occurring during sample collection. Field QA/QC processes included equipment calibration, field protocols to meet analytical holding times, field duplicates, and field blanks. Laboratory QA/QC samples were used to evaluate the analytical process for contamination, accuracy, and reproducibility. Internal laboratory quality control checks included method blanks, matrix spike/matrix spike duplicate (MS/MSDs), and duplicates.

### 2.3.1 Field Equipment Verification and Sampling Procedures

This section discusses the calibration, inspection, and maintenance requirements of the equipment used in the CHU Lagoon Monitoring Program monitoring effort, as well as the requirements governing sampling procedures for the program.

#### 2.3.1.1 Field Equipment Calibration, Inspection, and Maintenance

QA/QC activities for the monitoring equipment included calibration, inspection, and maintenance procedures. Table 2-6 summarizes the equipment used in the CHU Lagoon Monitoring Program and the required frequency of calibration, inspection, and/or maintenance of the equipment.

Continuous monitoring of water quality parameters via data sonde required biweekly maintenance and calibration of the YSI 6920V2. The acceptance limit was 20 percent and was calculated as follows:

Equation 8: Acceptance Limit = [(Value from Quanta – Value from Sonde)/Value from Quanta] x 100

Note: value may be negative number

When values exceeded 20 percent, equipment was calibrated according to manufacturer specifications and then retested. This process was repeated until measurements fell within acceptance limits.

American Sigma flow meters, automated sampling equipment, rain gauges, and stingrays used to collect composite and pollutagraph samples were required to be calibrated semi-annually or as-needed based on inspections.

The Responsible Parties (cities) utilized Horiba U – 10 instruments to record measurements in the field that required calibration prior to use. San Elijo Lagoon Conservancy (SELC) equipment calibration activities were not included in the project QAPP, and were conducted as part of their program.

**Table 2-6: Calibration, Inspection, and Maintenance Schedule of Field Equipment**

| Equipment | Activity[a] | Responsible Entity | Frequency | SOP Reference |
|---|---|---|---|---|
| Hydrolab Quanta, YSI 6920V2, pH, Conductivity, Temp. Meter | Calibration | MACTEC Technical Staff | Daily, before use | Hydrolab Quanta Series Instruments SOP |
| Horiba U-10 | Calibration | Responsible Parties' Technical Staff | Daily, before use | Horiba U-10 Instrument Manual |
| American Sigma 950 AVB Flowmeter | Inspection, calibration, and maintenance | MACTEC Technical Staff | Semi-annually | American Sigma 950 O&M Manual AS009 |
| American Sigma 900MAX Autosampler | Inspection, calibration, and maintenance | MACTEC Technical Staff | Semi-annually | American Sigma 900MAX Sampler O&M Manual AS005 |
| American Sigma Rain Gauge | Inspection, calibration, and maintenance | MACTEC Technical Staff | Semi-annually | NA |
| American Sigma S1000 Stingray | Inspection, calibration, and maintenance | MACTEC Technical Staff | Semi-annually | Sigma 1000 Instrument Manual 52287-89 |

(a) Inspection, calibration, or maintenance activity.

#### 2.3.1.2 Sampling Procedures

Holding Time Requirements

Holding time requirements were established as part of the analytical methods and required samples to be analyzed within a specified time. Samples were preserved, packaged, and transported within the designated holding times per the method requirements provided in Table 2-7. Specific protocols were required to meet the holding time requirements of the following constituents:

- *Enterococcus*, fecal coliform, and total coliform – Samples were required to be kept in the dark and delivered to the laboratory within six hours (analyzed within eight hours) of the sample collection time.
- Ammonium, nitrate+nitrite, nitrite, soluble reactive phosphorus (SRP), total dissolved nitrogen (TDN), and total dissolved phosphorus (TDP) – Samples were required to be field filtered and frozen within six hours of the sample collection time to provide laboratories with a 30-day holding time.
- Chlorophyll *a* – Samples were required to be filtered by the laboratory and frozen to provide a 30-day holding time.
- Total nitrogen (TN) and total phosphorus (TP) – Samples did not require field filtration, but were required to be frozen to provide laboratories with a 30-day holding time.

**Table 2-7: Analytical Holding Times**

| Matrix | Analytical Parameter | Number of Samples (Includes Field Duplicates) | Sampling SOP # | Sample Volume | Containers (Number, Size, Type) | Preservation (Chemical, Temperature, Light Protected) | Maximum Holding Time: Preparation/Analysis |
|---|---|---|---|---|---|---|---|
| Water | Dissolved Oxygen, pH, Temperature, Salinity, Turbidity, | 3 (triplicate) per site | Field SOPs | N/A | N/A | N/A | N/A |
| Water | Water column Chlorophyll *a* | 1 per site (duplicate 5%) | Field SOPs | 500 mL | 1, 0.7 µm filter Whatman GF/F glass fiber filter | Cool to 4°C, dark, freeze | 30 days |
| Water | Nitrate+Nitrite, Nitrite, SRP, Ammonium | 1 of each per site (duplicate 5%) | Field SOPs | 120 mL | 1, 120 mL polyethylene bottle | Cool to 4°C, dark, filter within 6h, freeze | 6 hours to filter, freeze; 30 days to analysis |
| Water | TDN and TDP | 1 of each per site (duplicate 5%) | Field SOPs | 120 mL | 1, 120 mL polyethylene bottle | Cool to 4°C, dark, filter within 6h, freeze | 6 hours to filter, freeze; 30 days to analysis |
| Water | TN and TP | 1 of each per site (duplicate 5%) | Field SOPs | 120 mL | 1, 120 mL polyethylene bottle | 4°C, dark, freeze | 30 days |
| Water | TSS/TDS | 1 per site (duplicate at 5% of sites) | Field SOPs | 1000 mL | 1, 0.7 µm filter Whatman GF/F glass fiber filter | 4°C, dark | 7 days to filter, freeze; 7 days to analysis |

**Table 2-7: Analytical Holding Times (continued)**

| Matrix | Analytical Parameter | Number of Samples (Includes Field Duplicates) | Sampling SOP # | Sample Volume | Containers (Number, Size, Type) | Preservation (Chemical, Temperature, Light Protected) | Maximum Holding Time: Preparation/Analysis |
|---|---|---|---|---|---|---|---|
| All surface transect sites | Water | 0.1 m below surface | CBOD5 | 4 L | 1, 4L cubitainer | 4°C, dark | 48 hours |
| All surface transect sites | Water | 0.1 m below surface | Total Coliform, Fecal Coliform | 100 mL | 1, sterile 120 mL HDPE bottle | Cool to 4°C, dark | 6 hours |
| All surface transect sites | Water | 0.1 m below surface | *Enterococcus* | 100 mL | 1, sterile 120 mL HDPE bottle | Cool to 4°C, dark | 6 hours |
| Post storm event sampling sites | Sediment | Top 2 cm of surface sediment | Percent Fines | ~500 g wet weight | 1, 500 mL amber jar | Cool to 4°C, dark, oven dry 50°C for 48h, room temp. | 30 days |
| Post storm event sampling sites | Sediment | Top 2 cm of surface sediment | % OC, %TN, % TP | ~500 g wet weight | 1, 500 mL amber jar | Cool to 4°C, dark, oven dry 50°C for 48h, room temp | 30 days |

Broken Sample Containers

Sample handling and delivery protocols were established to make sure samples were received intact by the laboratory for analysis; however, sample containers occasionally break during sample collection, handling, or delivery. To account for the possibility of broken sample containers, a 90-percent level of completeness requirement was established.

Field Duplicates

Field duplicates were utilized as part of a QA/QC program to assess sampling precision. The project goal for field duplicates was one for every 10 samples collected per sample type per lagoon. Field duplicate collection procedure requirements for the CHU Lagoon Monitoring Program were established as being the same as those used for the collection of standard field samples. Duplicates of manual grab samples were collected by filling two grab sample containers at the same time or in rapid sequence. Duplicates from automated sampling equipment were made by splitting a sample into two containers. Sample containers for duplicate samples were labeled, but were not identified as duplicates to the laboratories.

Duplicate results were evaluated by calculating the relative percent difference (RPD) between the two sets of results, which served as a measure of the reproducibility (precision) of the sample results. The acceptable RPD limits are shown in Table 2-8 below. The RPD was calculated as follows:

Equation 9: RPD = 100 x (sample 1 - sample 2) / ((sample 1 + sample 2)/2)

### 2.3.2 Laboratory Analysis Quality Control Procedures

Laboratory Duplicates

Laboratory duplicates were utilized as part of a QA/QC program to assess method precision. The project goal for laboratory duplicates was one for every 20 samples collected per event. Duplicate results were evaluated by calculating the relative percent difference (RPD) between the two sets of results, which served as a measure of the reproducibility (precision) of the sample results. The acceptable RPD limits are shown in Table 2-8. The RPD was calculated using Equation 9.

Standard Reference Material

Standard reference materials (SRMs) were used to evaluate the relative accuracy of a particular analysis. The project goal for SRMs was one for every 20 samples collected per event or one per batch. An SRM is a homogeneous matrix with a similar concentration as those expected in the samples analyzed. The results

should be within 95 percent of the confidence interval of the mean as stated by the provider of the material.

Laboratory Matrix Spikes

Laboratory matrix spikes were used to assess precision and accuracy of the laboratory analytical method, and to evaluate matrix interference. The project goal for matrix spikes was one for every 20 samples collected per event or one per batch. The matrix spike/matrix spike duplicate (MS/MSD) approach was used with the field samples. A matrix spike sample is an aliquot of a field sample into which the laboratory adds a known quantity of an analyte. Reported percent recovery of the known analyte in the sample indicates matrix effects on the analysis. A matrix spike duplicate sample is a duplicate aliquot of the matrix spike sample analyzed separately. Matrix spike duplicate results were compared to the matrix spike results to assess the precision of the laboratory analytical method.

Method Blanks

Laboratory method blanks were run by the analytical laboratory to determine the level of contamination associated with laboratory reagents and equipment. The project goal for method blanks was one for every 20 samples collected per event or one per batch. A method blank is a sample of a known matrix that has been subjected to the same complete analytical procedure as the submitted field samples to determine if contamination has been introduced into the samples by the laboratory during processing. Results of a method blank analysis should be less than the reporting limit for each analyte.

Field Blanks

Field blanks were used to determine if field sampling activities were a potential source for contamination. The project goal for field blanks was one for every 20 samples collected per event or one per batch. Field blanks were collected by pouring "blank water" (contaminant-free de-ionized water) into sampling equipment and containers in the field during a sampling event. The same equipment used for collection of the grab samples was used to transfer the blank water into the blank sample containers.

**Table 2-8: Data Quality Objectives (DQO)**

| Group | Parameter | Target Reporting Limit | Accuracy | Precision | Recovery | Completeness |
|---|---|---|---|---|---|---|
| Conventional Constituents in Storm Water and Estuary Waters | TSS | 0.5 mg/L | Standard Reference Materials (SRM, CRM) within 95% CI stated by provider of material. If not available then within 80% to 120% of true value | Laboratory duplicate, blind field duplicate, or MS/MSD; 25% RPD Laboratory duplicate minimum | Matrix spike 80% - 120% or control limits at + 3 standard deviations based on actual lab data | 90% |
| | TN | 0.1 mg/L | | | | |
| | TDN | 0.1 mg/L | | | | |
| | TP | 0.05 mg/L | | | | |
| | TDP | 0.05 mg/L | | | | |
| | SRP | 0.05 mg/L | | | | |
| | Nitrate | 0.05 mg/L | | | | |
| | Nitrite | 0.05 mg/L | | | | |
| | Ammonia | 0.05 mg/L | | | | |
| | Chlorophyll *a* | 2 µg/L 0.01 mg/m3 | | | | |
| | CBOD5 | 2 mg/L | | | | |
| | TDS | 0.2 mg/L | | | | |
| In-situ Sampling | Temperature | 0.1 °C | Calibration Standard (3-5 standards over the expected range of sample target analyte concentrations with the lowest concentration standard at or near the MDL | Field replicate | N/A | 90% |
| | Conductivity | 2.5 mS/cm | | | | |
| | Turbidity | 0.5 NTU | | | | |
| | pH | 0.2 | | | | |
| | DO | 1.00 mg/L | | | | |

**Table 2-8: Data Quality Objectives (continued)**

| Group | Parameter | Target Reporting Limit | Accuracy | Precision | Recovery | Completeness |
|---|---|---|---|---|---|---|
| Bacteria | Total Coliform | 2 MPN/100 mL | Field and Laboratory blanks>TRL | Laboratory duplicate, blind field duplicate, Rlog≤ 3.27•mean Rlog(* | N/A | 90% |
| | Fecal Coliform | 2 MPN/100 mL | | | | |
| | *Enterococcus* | 1 colonies/ 100 mL | | | | |
| Sediment and Suspended Solids | % Fines or %Sand/Silt/Clay | 1 % | Standard Reference Materials (SRM, CRM) within 95% CI stated by provider of material | Laboratory duplicate, blind field duplicate, <20% RSD | N/A | 90% |
| | % OC | 0.01 % | | | | |
| | % ON | 0.01 % | | | | |

NA = Not Applicable

# 3.0 QA/QC RESULTS

The Quality Assurance Project Plan (QAPP) was developed to establish activities and procedures to assure both chemical and physical measurements would meet the SWAMP requirements and provide the quality of data needed to validate and calibrate future TMDL models. Field sampling and laboratory quality assurance activities and procedures were implemented to objectives provided in the QAPP.

Quality assurance activities began with field protocols designed to minimize errors introduced during field sampling and measurements. Field procedures included calibration of field equipment as well as sample handling and processing procedures. Field QA/QC samples evaluated potential contamination and sampling error prior to sample delivery to the analytical laboratory. Field QA/QC processes included equipment calibration, field protocols to meet analytical holding times, field duplicates, and field blanks. Laboratory QA/QC samples were used to evaluate the analytical process for contamination, accuracy, and reproducibility.

The primary criteria used to evaluate the quality of data are precision, accuracy, completeness, and representativeness. These criteria are described below:

- Precision describes how well repeated measurements agree. Precision measurements were assessed on both field and laboratory duplicates. The results of the duplicate samples were compared to the original samples to estimate a relative percent difference (RPD) between the two samples.
- Accuracy describes how close the measurement is to its true value using calibration standards, reference samples, and spiked samples. The accuracy of chemical measurements was checked by performing LCS/LCSDs and MS/MSDs during each batch of sample analysis at the laboratory. Accuracy was quantified as the percent recovery of the measured value within established control limits. The recoveries of both LCS/LCSDs and MS/MSDs were evaluated.
- Completeness describes the fraction of collected data that is successfully analyzed in the laboratory. While no specific statistical criteria have been generated as part of this project, it is expected that 90 percent of all analyses should be completed when sampled. Completeness was quantified by comparing the number of measurements actually collected to the number of measurements planned to be collected.
- Representativeness describes the degree to which the results of analyses represent the samples collected, and the samples in turn represent natural variability and characteristics of the environmental conditions. The monitoring approach was designed to achieve representativeness by sampling from several locations throughout each lagoon. Sites were chosen to best represent distinctive processes or sections of the estuaries: mass emission sites above the upstream boundary of the estuary, lagoon segment sites based on distinct regions within each, and ocean inlet or lagoon mouth sites defining the boundary condition. Monitoring locations were chosen to be representative of the lagoon processes of interest.

## 3.1 FIELD EQUIPMENT CALIBRATION

### 3.1.1 Continuous Monitoring Field Equipment

The water quality instrumentation was maintained per manufacturer specifications to achieve precision and accuracy requirements.

#### 3.1.1.1 Mass Emission Stations

Continuous monitoring at the mass emission stations consisted of the following parameters: flow, rain, specific conductivity, temperature, turbidity, and, if applicable, DO and pH. The mass emission stations were distinguished from the other sites as the only sites at which to collect continuous flow and rain data. This section discusses flow and rain data. Section 3.1.1.2 discusses data parameters collected by the data sondes. In accordance with the QAPP, flow, rain, specific conductivity, and temperature were monitored from October 2007 to October 2008. From January 2008 to October 2008, turbidity and, if applicable, DO and pH were monitored resulting in a greater time period than required by the QAPP.

SELC equipment calibration activities were not covered in the QAPP; however, they were conducted as part of their program. Calibration activities were conducted monthly, including flow-validation measurements, stream level offset checks, and maintenance activities on an as-needed basis. Data validation or correction activities were conducted to maintain consistent flow measurements. A summary of these activities is provided below:

- Agua Hedionda Lagoon: In April 2008, the ratings table was revised for this location to reflect continued accretion of sediment. Accumulation of sediment on the stream bed results in continuous changes in the stage/discharge relationship. For the period April 2008 through June 2008, a systematic shift (+ 0.52 feet) was made in the October 2007 rating curve to account for the rising stream bed and maintain consistency with on-site flow measurements made on January 30, 2008 and March 28, 2008. This shift applied to discharges from December 1, 2007 to March 31, 2008, and, therefore, the dataset was amended for Agua Hedionda Lagoon.
- Buena Vista Lagoon: In April 2008, validating stream flow measurements were made to refine the stream rating table. The accuracy in determining volumetric flow depends on flow rates calculated for this location. During the monitoring period, the stage-discharge relationship at this location was influenced by vegetation and sediment accumulations, and an undetermined change in a downstream control section. This data was considered to be adequate during low flow conditions, and, therefore, the dry weather data were not impacted by this condition. During higher stream stages and discharges, as the water level increased, the vegetation growth exhibited increased impacts on the stream stage-discharge rating relationship. Wet weather events monitored for this program occurred in January and February 2008 prior to the bulk of vegetation and sediment accumulation, and, therefore, the data associated with those events is considered adequate.

- Loma Alta Slough: In April 2008, a new stream rating table was completed for Loma Alta Slough. The new rating table reflected stream flow calibration measurements made on March 28, 2008 and an adjustment in the water level sensor elevation.
- Loma Alta Mass Emission Station flow data: In November 2008, a preliminary assessment of Loma Alta Creek flow data from October 2007 to September 2008 initiated concern that the flows reported during dry weather conditions may have been overestimated flows. This overestimation may be attributable to a manufacturing defect of the pressure transducer. During wet weather events, the impact of higher storm flow appeared to offset the impact of the pressure transducer (PT) overestimation. This data is considered to be adequate as the hydrographs based on the SELC PT flow data were consistent with the hydrographs based on the MACTEC stage data. During dry weather conditions, including index period events, the impact of the PT overestimation relative to the low stream level appeared to result in a greater effect on the flow data. This data is considered to be overestimated because it exhibits daily fluctuations that appear to be driven by environmental factors other than stream level. The proposed approach to resolve this data for modeling purposes includes utilizing the data collected during this monitoring program and subsequent data collected by SELC. At the time of TMDL development for Loma Alta Slough, flow data collected by SELC will need to be requested. The following data sets are qualified in the databased as follows:
  - Flow data considered suspect as a result of instrument malfunction (IMS): October 2007 – December 2007, January 2008 (except during storm events 1/5/08-1/8/08 and 1/23/08 – 1/24/08), February 2008 (except during storm event 2/3/08-2/4/08), and March 2008 – June 21, 2008.
  - Flow data estimated (E): June 21, 2008 – August 13, 2008
- San Elijo Lagoon: In May 2008, the rating table was revised for this location. The new rating table reflected the results of stream channel cross-section surveys conducted on May 12, 2008. This new rating applied to reported stream discharges starting January 1, 2008. The original control location for this site was eroded during storm events in December 2007. The reduction of the stream control was confirmed by site surveys conducted on February 21, 2008 and May 12, 2008.

#### 3.1.1.2 All Monitoring Locations

Water quality parameters including specific conductivity, temperature, turbidity, DO, and pH were measured and logged using a YSI 6600 multi-parameter water quality data sonde installed on-site. Maintenance and calibration were conducted twice monthly on the data sondes. Maintenance activities included calibration, removal of sediment accrued on the data sonde, and battery exchanges. Occasionally, data sonde maintenance caused a spike in the measurements for a period of one to two hours. Data sonde fouling, errors and/or environmental conditions resulted in the following data gaps or qualified data. Continuous Monitoring data gaps for water quality parameters are summarized in Table 3-1.

**Table 3-1: Summary of Continuous Monitoring Data Gaps**

| Lagoon | Monitoring Location | Parameter(s) | Date Range | Approximate Duration | Corresponding Monitoring Event |
|---|---|---|---|---|---|
| Agua Hedionda | Mass Emission Station | Turbidity | 1/1/08 – 1/10/08 | 10 days | Wet Weather Event 1 (1/5/08 – 1/8/08) |
| | Segment | Specific conductivity, temperature, and turbidity | 4/10/ 2008 – 4/24/2008 | 14 days | Index Period Event 3 (4/14/08 – 4/16/08) |
| | | Specific conductivity, temperature, and turbidity | 7/9/08 – 7/14/08 | 5 days | NA |
| | Ocean Inlet 1 Depth 1 (Surface) | Specific conductivity, temperature, and turbidity | 1/31/08 – 2/13/08 | 14 days | Wet Weather Event 3 (2/4/08) and Index Period Event 1 (2/7/08 – 2/8/08, 2/11/08 – 2/13/08) |
| Buena Vista | Mass Emission Station | Turbidity and DO | 1/1/08 – 1/3/08 | 3 days | NA |
| | | pH | 9/17/08 – 9/30/08 | 13 days | Index Period Event 4 (9/22/08 – 9/24/08) |
| | Segment | pH | 1/9/08 – 2/4/08 | 26 days | Wet Weather Event 2 (2/23/08 – 2/24/08) and Index Period Event 1 (2/14/08 – 2/15/08) |
| | | Turbidity | 8/13/08 – 8/18/08 | 5 days | NA |
| Loma Alta | Mass Emission Station | Turbidity | 1/1/08 – 1/8/08 | 8 days | Wet Weather Event 1 (1/5/08 – 1/8/08) |
| | Segment | Specific conductivity, temperature, turbidity, DO, and pH | 1/6/08 – 1/8/08 | 2 days 1 | NA |
| | | Specific conductivity, temperature, turbidity, DO, and pH | 2/14/08 – 2/20/08 | 6 days | NA |
| | Ocean Inlet | Specific conductivity, temperature, turbidity, DO, and pH | 1/1/08 – 1/3/08 | 3 days1 | NA |
| | | Specific conductivity, temperature, turbidity, DO, and pH | 1/6/08 – 1/8/08 | 2 days1 | NA |
| | | Specific conductivity, temperature, turbidity, DO, and pH | 5/13/08 – 5/20/08 | 7 days | NA |
| | | Specific conductivity, temperature, turbidity, DO, and pH | 7/18/08 – 10/8/08 | Lagoon mouth was closed for 3 months1 | Index Period Event 3 - data was not required per QAPP. |

**Table 3-1: Summary of Continuous Monitoring Data Gaps (continued)**

| Lagoon | Monitoring Location | Parameter(s) | Date Range | Approximate Duration | Corresponding Monitoring Event |
|---|---|---|---|---|---|
| San Elijo | Mass Emission Station | Turbidity and DO | 1/1/08 – 1/10/08 | 10 days | Wet Weather Event 1 (1/5/08 – 1/8/08) |
| | Segment 2 | Specific conductivity, temperature, turbidity, DO, and pH | 2/16/08 – 2/21/08 | 5 days | NA |
| | | Specific conductivity, temperature, turbidity, DO, and pH | 5/2008 – 10/2008 | Intermittently over 5 months1 | Index Period Event 3 low tides only (7/8/08 – 7/9/08) |
| | Ocean Inlet | Specific conductivity, temperature, turbidity, DO, and pH | 2/16/08 – 2/21/08 | 5 days | NA |
| | | Specific conductivity, temperature, turbidity, DO, and pH | 5/2008 – 10/2008 | Intermittently over 5 months1 | Index Period Event 3 low tides only (7/8/08 – 7/10/08) |

[1] Data gaps were intermittent and caused by environmental conditions at the sample location. Refer to complete data set for additional detail.

Agua Hedionda Lagoon

- The turbidity probe was installed on January 10, 2008. No turbidity data was recorded at the Mass Emission Station from January 1, 20008 to January 10, 2008. This data gap coincided with Wet Weather Event 1 (January 5, 2008 to January 8, 2008).
- No data was recorded at the segment site from April 10, 2008 through April 24, 2008 as a result of apparent tampering of the equipment. This data gap coincided with the second week of Index Period Event 3 (April 14, 2008 to April 16, 2008).
- No data was recorded at the lagoon segment site from July 9, 2008 through July 14, 2008 as a result of a conductivity probe error. The sonde was removed for maintenance and re-deployed.
- No data was recorded at the ocean inlet 1 depth 1 (surface) from January 31, 2008 through February 13, 2008 as a result of low battery voltage. Maintenance activities occurred on January 10, 2008 and January 31, 2008 that did not indicate low voltage. This data gap coincided with Wet Weather Event 3 (February 4, 2008) and five out of six days of Index Period Event 1 (February 7, 8, 11, 12, and 13, 2008).
- No turbidity data was recorded at ocean inlet 1 depth 2 (bottom) from May 5, 2008 through May 25, 2008 as a result of a fouled probe. Although other short-term data gaps occurred for intervals of hours to 2 days, they did not coincide with a monitoring event.
- Turbidity was elevated in late June and early July due to an unexplained event during that period. This event occurred at the lagoon segment site and the ocean inlet site 2 at both depths 1 and 2, ruling out either fouling or sensor drift. All three data sondes were calibrated on July 9 and returned to a typical level below 20 NTU. Although these high values do not seem representative of the conditions in this area of the lagoon, data was left in the report as there is not a valid reason to have it removed or adjusted. This data anomaly affected data for Index Period Event 3.
- Elevated turbidity values at the lagoon segment site occurring in September and October were due to frequent probe fouling. Efforts were made in the field to manage this problem, however growth occurred very rapidly. Probe fouling affected data for Index Period Event 4.
- Elevated turbidity values at the ocean inlet 2 depth 2 (bottom) site occurred in late March and April as well as September and October and were due to frequent probe fouling. Efforts were made in the field to manage this problem, however growth occurred very rapidly. Probe fouling affected data for Index Period Event 2 and 4, respectively.

Buena Vista Lagoon

- The turbidity probe was installed on January 3, 2008. No turbidity data was recorded at the Mass Emission Station from January 1, 20008 to January 3, 2008. This data gap did not coincided with a monitoring event.
- No pH data was recorded at the mass emission station from September 17, 2008 to September 30, 2008 as a result of a cracked pH probe. This data gap coincided with the second week of Index Period Event 4 (September 22, 2008 to September 24, 2008). The pH probe was replaced.
- No turbidity data was recorded from August 13, 2008 to August 18, 2008 as a result of a fouled probe. This data gap did not coincide with a monitoring event.

- No pH data was recorded at the lagoon segment 1 site from January 9, 2008 to February 4, 2008 as a result of outliers. Calibration and maintenance activities were performed on January 9, 2008; January 22, 2008; and February 4, 2008 to resolve this issue. This data gap coincided with Wet Weather Event 2 (January 23 and 24, 2008) and the first week of Index Period Event 1 (January 14, 2008 to January 15, 2008).

Loma Alta Slough

- The turbidity probe was installed on January 8, 2008. No turbidity data was recorded at the Mass Emission Station from January 1, 20008 to January 8, 2008. This data gap coincided with Wet Weather Event 1 (January 5, 2008 to January 8, 2008).
- The segment and ocean inlet sites had temporary data gaps from January 6, 2008 through January 8, 2008. The data sondes were exposed to air as a result of reduced water levels. The ocean sand berm at Loma Alta was breached after the storm event on January 5, 2008 causing a reduction in water level at the Loma Alta Slough.
- June 17, 2008 the data sonde at the segment site was replaced as a result of unusual spikes in the data. From June 16, 2008 to June 17, 2008 calibrations and maintenance activities were performed in an attempt to resolve unusual spikes in the data including low DO and high turbidity.
- No turbidity data was recorded from August 13, 2008 to August 18, 2008 as a result of probe fouling. This data gap did not coincide with a monitoring event.
- The lagoon mouth was closed from January 1, 2008 to January 3, 2008. Per the terms of the QAPP, data was not collected at the ocean inlet while the mouth was closed.
- The lagoon mouth was closed from May 12, 2008 to May 21, 2008 as a result of an ocean sand berm constructed by the City of Oceanside. Per the terms of the QAPP, data was not collected at the ocean inlet while the mouth was closed.
- The lagoon mouth was closed from July 18, 2008 to October 8, 2008 as a result of a ocean sand berm constructed by the City of Oceanside. Per the terms of the QAPP, data was not collected at the ocean inlet while the mouth was closed.

San Elijo Lagoon

- The turbidity probe was installed on January 10, 2008. No turbidity data was recorded at the Mass Emission Station from January 1, 20008 to January 10, 2008. This data gap coincided with Wet Weather Event 1 (January 5, 2008 to January 8, 2008).
- Data was not recorded at Lagoon Segment Site 2 and the ocean inlet sites from February 16, 2008 to February 21, 2008 as a result of a low battery. The low battery was not detected during maintenance activities because of a faulty gauge.
- May 2008 through October 2008, Lagoon Segment Site 2 and the ocean inlet sites had temporary data gaps corresponding with low tides. The data sondes at these locations were exposed to air as a result of reduced water levels. This data gap coincided with two low tide samples collected at Lagoon Segment Site 2 during Index Period Event 3 (July 8 and 9, 2008). This data gap coincided with three low tide samples collected at the ocean inlet site during Index Period Event 3 (July 8, 2008 to July 10, 2008).

- Flow at the lagoon mouth was restricted from March 28, 2008 to April 4, 2008 and from April 15, 2008 to April 28, 2008 as a result of an accumulation of sand.

### 3.1.2 Wet Weather and Index Period Event Monitoring Equipment

American Sigma flow meters, automated sampling equipment, rain gauges, and Stingrays used during sample collection of composite and pollutagraph samples were calibrated semi-annually or as-needed based on inspections. American Sigma flow meters and rain gauges were utilized during the wet weather events to provide MACTEC with site-specific conditions such as an increase in rainfall and rise in flow to aid in the mobilization of field crews. Prior to each event and assessed through an event, flow meters, automated sampling equipment, and rain gauges were inspected, maintained and volume calibrated to ensure proportional aliquots were collected for composite samples. During Wet Weather Event 1, one sample location was not sampled which reduced the overall percent completeness for the event to 99 percent as presented in Table 3-2.

- During wet weather event 1, only one depth was monitored at ocean inlet site 2 at Agua Hedionda Lagoon.

The Responsible Parties calibrated Horiba U – 10 instruments on a daily basis prior to recording measurements in the field for storm drain sampling.

**Table 3-2: Summary of Completeness by Event**

| Event Category | Lagoon | Total Samples | Total Samples Required | Pecent Complete |
|---|---|---|---|---|
| Wet Weather Event 1 | Agua Hedionda Lagoon | 63 | 71 | 89 |
| | Buena Vista Lagoon | 142 | 139 | 102 |
| | Loma Alta Slough | 139 | 139 | 100 |
| | San Elijo Lagoon | 166 | 165 | 101 |
| | **Event Total** | **510** | **514** | **99** |
| Wet Weather Event 2 | Agua Hedionda Lagoon | 74 | 71 | 104 |
| | Buena Vista Lagoon | 151 | 139 | 109 |
| | Loma Alta Slough | 142 | 139 | 102 |
| | San Elijo Lagoon | 196 | 165 | 119 |
| | **Event Total** | **563** | **514** | **110** |
| Wet Weather Event 3 | Agua Hedionda Lagoon | 40 | 40 | 100 |
| | Buena Vista Lagoon | 52 | 52 | 100 |
| | Loma Alta Slough | 52 | 52 | 100 |
| | San Elijo Lagoon | 78 | 78 | 100 |
| | **Event Total** | **222** | **222** | **100** |
| Index Period Event 1 | Agua Hedionda Lagoon | 304 | 304 | 100 |
| | Buena Vista Lagoon | 476 | 476 | 100 |
| | Loma Alta Slough | 589 | 596 | 99 |
| | San Elijo Lagoon | 923 | 932 | 99 |
| | **Event Total** | **2292** | **2308** | **99** |
| Index Period Event 2 | Agua Hedionda Lagoon | 304 | 304 | 100 |
| | Buena Vista Lagoon | 475 | 475 | 100 |
| | Loma Alta Slough | 594 | 596 | 100 |
| | San Elijo Lagoon | 930 | 932 | 100 |
| | **Event Total** | **2303** | **2307** | **100** |
| Index Period Event 3 | Agua Hedionda Lagoon | 304 | 304 | 100 |
| | Buena Vista Lagoon | 476 | 476 | 100 |
| | Loma Alta Slough | 440 | 440 | 100 |
| | San Elijo Lagoon | 930 | 932 | 100 |
| | **Event Total** | **2150** | **2152** | **100** |
| Index Period Event 4 | Agua Hedionda Lagoon | 304 | 304 | 100 |
| | Buena Vista Lagoon | 476 | 476 | 100 |
| | Loma Alta Slough | 596 | 596 | 100 |
| | San Elijo Lagoon | 932 | 932 | 100 |
| | **Event Total** | **2308** | **2308** | **100** |

## Table 3-3: Data Quality Objectives and Levels Achieved for Analytical Results

| Constituent | Accuracy | | | | | Precision | | | Recovery | | Completeness | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DQO | Percent Achieved (LCS)[1] | DQO | Percent Achieved (FB)[2] | Percent Achieved (LB)[3] | DQO | Percent Achieved (FD)[4] | Percent Achieved (LD)[5] | DQO | Percent Achieved (MSS)[6] | DQO | Percent Achieved |
| *Enterococcus* | NA[7] | NA | <TRL[8] | 98.5 | 100 | 25% RPD[9] | 99 | 100 | NA | NA | 90% | 99 |
| Total Coliform | NA | NA | <TRL[8] | 98.5 | 100 | 25% RPD | 100 | 100 | NA | NA | 90% | 99 |
| Fecal Coliform | NA | NA | <TRL[8] | 100 | 100 | 25% RPD | 99 | 100 | NA | NA | 90% | 99 |
| TSS | NA | NA | <TRL[8] | 100 | 100 | 25% RPD | 54 | 91 | NA | NA | 90% | 99 |
| TDS | 80-120% | 100 | <TRL[8] | 33.3 | 100 | 25% RPD | 100 | 100 | NA | NA | 90% | 100 |
| Ammonia-N | 80-120% | 100 | <TRL[8] | 12.8[10] | 100 | 25% RPD | 59.3 | 98.4 | 80-120% | 100 | 90% | 99 |
| CBOD | NA | NA | <TRL[8] | 100 | 100 | 25% RPD | 64 | 100 | NA | NA | 90% | 100 |
| Chlorophyll *a* | NA | NA | <TRL[8] | 91.5 | 98.7 | 25% RPD | 53 | 66 | NA | NA | 90% | 100 |
| Nitrate+Nitrite-N | 80-120% | 100 | <TRL[8] | 93.6 | 100 | 25% RPD | 54.1 | 96.3 | 80-120% | 100 | 90% | 99 |
| Soluble Reactive Phosphorus (SRP) | 80-120% | 100 | <TRL[8] | 95.7 | 100 | 25% RPD | 67.0 | 98.3 | 80-120% | 100 | 90% | 99 |
| Total Nitrogen (TN) | 80-120% | 98.0 | <TRL[8] | 100 | 100 | 25% RPD | 48.4 | 93.9 | 80-120% | 97.9 | 90% | 99 |
| Total Dissolved Nitrogen (TDN) | 80-120% | 98.0 | <TRL[8] | 100 | 100 | 25% RPD | 59.1 | 98.0 | 80-120% | 100 | 90% | 99 |
| Total Phosphorus (TP) | 80-120% | 100 | <TRL[8] | 95.7 | 100 | 25% RPD | 48.3 | 97.9 | 80-120% | 100 | 90% | 99 |
| Total Dissolved Phosphorus (TDP) | 80-120% | 100 | <TRL[8] | 95.7 | 100 | 25% RPD | 50.6 | 97.7 | 80-120% | 100 | 90% | 99 |
| % Total Phosphorus | 80-120% | NA | NA | NA | NA | 25% RPD | 83.3 | 100 | 80-120% | 100 | 90% | 100 |
| %Organic Carbon | 80-120% | 100 | NA | NA | NA | 25% RPD | 100 | 100 | 80-120% | NA | 90% | 100 |
| % Total Nitrogen | 80-120% | 100 | NA | NA | NA | 25% RPD | 100 | 100 | 80-120% | NA | 90% | 100 |

[1]LCS - Laboratory Control [2]FB - Field Blank [3] LB - Laboratory Blank
[4] FD - Field Duplicate [5]LD - Laboratory Duplicate [6]Standard MSS – Matrix Spike Sample
[7] NA – Not Applicable [8]TRL – Target Reporting Limit [9] RPD – Relative Percent Difference
[10] Note: Ammonia as N: 12.8 percent of filed blanks analyzed had results below the laboratory reported limit of 0.004 mg/L. However, 100 percent of field blanks analyzed had results below the QAPP target reporting limit of 0.05 mg/L for ammonia as nitrogen.

## 3.2 HOLDING TIME REQUIREMENTS

Holding time requirements are established as part of the analytical method and require samples to be analyzed within a specified time to ensure accurate results. The following 303(d) listed categories and individual analytes exceeded holding times on at least one occasion; bacteria (including *Enterococcus*, total and fecal coliforms); total dissolved solids; and nutrients/eutrophication (including ammonia, nitrate+nitrite, SRP, TN, TDN, TP, and TDP). These data are flagged in the project database with a QA/QC code of "H".

### 3.2.1 Bacteria

Total and fecal coliform samples were transported in coolers with ice to the laboratory within six hours of sample collection. Sample runners and laboratory couriers were utilized to meet the six-hour holding time. However, three samples (*Enterococcus,* total coliform, and fecal coliform) collected during Wet Weather Events 1 and 2 exceeded holding times:

- The first pollutagraph sample collected at Loma Alta Lagoon for Wet Weather Event 1 exceeded the holding time limit.
- Pollutagraph samples 8 and 9 collected at Loma Alta Lagoon for Wet Weather Event 2 exceeded the holding time limit.

### 3.2.2 TDS

Total Dissolved Solids were transported in coolers with ice to the laboratory at the end of each sampling day. One sample collected during Index Period 4 exceeded the holding time:

- Index Period Event 4: The mass emission sample collected on day five of the index period (October 14, 2008) was submitted to the laboratory within the holding time limit on October 14, 2008. However, the sample was not analyzed by the laboratory until November 4, 2008. This exceeded the holding time limit by 21 days.

### 3.2.3 Nutrients/Eutrophication

Ammonia as nitrogen, nitrate+nitrite as nitrogen, SRP, TDN, and TP samples were field filtered within six hours of sample collection, kept on ice during the day, and frozen at the end of the sampling day. Samples for TN and TP did not require filtration, but were frozen to maintain the 30-day holding time requirement. The project team utilized dry ice to ship the samples to the appropriate laboratories.

Ammonia as nitrogen, nitrate+nitrite as nitrogen, and SRP samples collected during Wet Weather Event 1, and Index Period Events 1, 3, and 4 exceeded holding time limits. Additionally, TN, TDN, TP, and TDP samples collected during Wet Weather Event 1 exceeded holding time limits. These holding time exceedances are discussed below by event:

- Wet Weather Event 1: Lagoon and ocean inlet samples that exceeded holding time limits were the result of a laboratory distribution error. A total of 18 nutrient samples collected on January 5, 2008 for the first wet weather event from the ocean inlets and segments at Buena Vista Lagoon, Loma Alta Slough, and San Elijo Lagoon were submitted to the laboratory within the holding time limit. However, the laboratory did not distribute the frozen samples until 112 days after the holding time limit. After further discussion with SCCWRP and the laboratories, it was believed that the quality of the data had not been compromised as a result of the exceeded holding time limits because the samples were continuously frozen. For many research projects, nutrient samples are frozen for up to six months. The results are considered acceptable due to no appreciable decay in concentration. To verify that results were with an acceptable range, this data was compared to historical concentrations and found to be within expected ranges. MACTEC implemented the following corrective actions to prevent additional distribution errors from occurring:
  - MACTEC took over nutrient sample distribution from CRG on February 1, 2008.
  - Individual samples were checked against COCs prior to shipment to ensure all samples collected were accounted for and shipped to the correct laboratory (UGA/MSI) by MACTEC.
  - Samples were frozen and shipped by MACTEC with dry ice to keep the samples frozen during transit.
  - A SWAMP-compatible EDD was pre-populated for each lab by MACTEC to confirm there was a result for each sample submitted and to reduce the reporting effort of the laboratory.
  - SWAMP-compatible EDDs and lab reports were checked by MACTEC within 14 days of receipt.
- Index Period Event 3: For ammonia as nitrogen, nitrate+nitrite as nitrogen, and SRP, a total of 112 samples out of 156 exceeded the holding time limits of 28 days. MACTEC checked and delivered samples to the laboratory within 2 to 7 business days. However, the laboratory did not analyze these samples until 1 to 10 days after the holding time limit. A summary of samples impacted per lagoon is provided below:
  - Buena Vista Lagoon: At Buena Vista Lagoon, the mass emission, segment 1, segment 2, and field blank samples collected on days four through six of the index period (July 21 to 23, 2008) exceeded holding times by 2 to 3 days.
  - Loma Alta Slough: At Loma Alta Slough, the mass emission, segment, and transect samples collected on days one through three of the index period (July 7 to 9, 2008) exceeded holding times by 8 to 10 days. The ocean inlet site was not sampled during this index period because the lagoon mouth was closed.

- San Elijo Lagoon: At San Elijo Lagoon, the mass emission, segment 1, segment 2, ocean inlet, storm drain1, storm drain 2, and all transect samples collected on days one through three of the index period (July 7 to 9, 2008) exceeded holding times by 8 to 10 days.

## 3.3 BROKEN VIALS

Sample handling and delivery protocols were established to ensure samples were received intact by the laboratory for analysis. No sample containers were broken during this program. However, sample distribution errors occurred during Wet Weather Event 1 and Index Period Event 1. As a result, the following ammonia as nitrogen, nitrate+nitrite as nitrogen, and SRP samples were not analyzed.

- One ocean inlet sample collected during Index Period Event 1 at San Elijo Lagoon was not received by the appropriate laboratory for analysis.
- One transect sample collected during Index Period Event 1 at Loma Alta Slough was not received by the appropriate laboratory for analysis.

Despite these two missing samples, this program met the DQO of 90 percent completeness by attaining an overall 99 percent completeness for all events shown in Table 3-2 and a 99 percent of all scheduled analysis per constituent as presented in Table 3-3.

## 3.4 FIELD DUPLICATES

Field duplicates were analyzed for a minimum of 10 percent total samples per constituent. The percent of field duplicates that met the data quality objectives for individual constituents is presented in Table 3-3. For those samples that did not meet the DQOs, site variations were evaluated by constituent to reflect the sampling strategy.

High RPDs occurred as a result of small absolute differences at low concentrations that tended to amplify RPDs. This occurred for the following constituents collected during index period events: *Enterococcus*, TSS, ammonia as nitrogen, CBOD, nitrate+nitrite as nitrogen, SRP, TN, TDN, TP, and TDP. High RPDs also reflected the heterogeneous nature of environmental samples, and are considered reasonable. The National Science Foundation, in a review of RPDs for various types of environmental samples, found that storm water samples routinely had RPDs between 60 and 100 percent. This was thought to be caused, in many instances, by the process of splitting samples (due to the potential for large variations in particle sizes and, therefore, constituent concentrations between the primary and duplicate samples).

### 3.4.1 Bacteria

Field duplicates were analyzed for 12 percent of the total bacteria samples collected for this monitoring program. The percent of field duplicates for bacteria (*Enterococcus*, fecal coliform and total coliform) that met the DQOs are provided in Table 3-3. The breakdown by constituent of the field duplicates that met the DQO for precision is as follows:

- *Enterococcus:* Of 112, 111 field duplicates (99 percent) met the DQO for precision.
- Fecal Coliform: Of 112, 111 field duplicates (100 percent) met the DQO for precision.
- Total Coliform: Of 112, 111 field duplicates (99 percent) met the DQO for precision.

### 3.4.2 TDS

Field duplicates were analyzed for 10 percent of the total TDS samples collected at Agua Hedionda Lagoon for this monitoring program. Of 5 total field duplicates analyzed for TDS, 100 percent met the DQO for precision.

### 3.4.3 TSS

Field duplicates were analyzed for 12 percent of the total TSS samples collected for this monitoring program. Of 127, 68 field duplicates (54 percent) analyzed for TSS met the DQO objective.

### 3.4.4 Nutrients/Eutrophication

Field duplicates were analyzed for 12 percent of the total nutrient/eutrophication samples collected at Buena Vista Lagoon, Loma Alta Slough, and San Elijio Lagoon for this monitoring program. The percentages of field duplicates for each constituent that met the DQOs are provided in Table 3-3. The breakdown by constituent of the field duplicates that met the DQO for precision is as follows:

- Ammonia as N: Of 91, 54 field duplicates (59.3 percent) analyzed for ammonia as nitrogen met the DQO for precision.
- CBOD: Of 25, 16 field duplicates (64 percent) analyzed for CBOD met the DQO for precision.
- Chlorophyll *a*: Of 83, 44 field duplicates (53 percent) analyzed for chlorophyll *a,* met the DQO for precision.
- Nitrate+Nitrite: Of 54, 52 field duplicates (54.1 percent) analyzed for nitrate+nitrite met the DQO for precision.
- SRP: Of 88, 9 field duplicates (67 percent) analyzed for SRP, met the DQO for precision.

- TN: Of 93, 45 field duplicates (48.4 percent) analyzed for total nitrogen met the DQO for precision.
- TDN: Of 93, 55 field duplicates (59.1 percent) analyzed for TDN, met the DQO for precision.
- TP: Of 89, 43 field duplicates (48.3 percent) analyzed for total phosphorus met the DQO for precision.
- TDP: Of 77, 39 field duplicates (50.6 percent) analyzed for TDP, met the DQO for precision.

### 3.4.5 Post-storm Sediment

Field duplicates were analyzed for x percent of the total post-storm sediment samples collected at Buena Vista Lagoon, Loma Alta Slough, and San Elijio Lagoon for this monitoring program. The percentages of field duplicates for each constituent that met the DQOs are provided in Table 3-3. The breakdown of the field duplicates that did not meet the DQO for precision is summarized in the following subsections.

- % Total Organic Carbon: Of 6, 6 field duplicates (100 percent) analyzed for % organic carbon, met the DQO for precision.
- % Total Nitrogen: Of 4, 4 field duplicates (100 percent) analyzed for % total nitrogen, met the DQO for precision.
- % Total Phosphorus: Of 5, 6 field duplicates (83.3 percent) analyzed for % total phosphorus, met the DQO for precision.
- % Sand: Of 9, 7 field duplicates (77.8 percent) analyzed for % sand, met the DQO for precision.

## 3.5 LABORATORY DUPLICATES

Laboratory duplicates were analyzed for a minimum of 5 percent of the total number of samples analyzed per constituent. The percentage of duplicates that met the DQOs for individual constituents is presented in Table 3-3.

<u>Bacteria</u>

- *Enterococcus*: Of 12, 12 laboratory duplicates (100 percent) for bacteria met the DQO.
- Fecal Coliform: Of 12, 12 laboratory duplicates (100 percent) for bacteria met the DQO.
- Total Coliform: Of 12, 12 laboratory duplicates (100 percent) for bacteria met the DQO.

<u>TDS</u>

- Of 26, 26 laboratory duplicates (100 percent) for TDS met the DQO.

TSS

- Of 107, 97 laboratory duplicates (91 percent) analyzed for TSS, met the DQO.

Nutrients/Eutrophication

All of the laboratory duplicates for the individual constituents met the DQO, except for chlorophyll *a*. The breakdown is as follows:

- Ammonia as N: Of 61, 60 laboratory duplicates (98.4 percent) analyzed for ammonia as nitrogen met the DQO for precision.
- CBOD: Of 3, 3 laboratory duplicates (100 percent) analyzed for CBOD met the DQO for precision.
- Chlorophyll *a*: Of 64, 42 laboratory duplicates (66 percent) analyzed for chlorophyll *a,* met the DQO for precision.
- Nitrate+Nitrite: Of 54, 52 laboratory duplicates (96.3 percent) analyzed for nitrate+nitrite met the DQO for precision.
- SRP: Of 60, 59 laboratory duplicates (98.3 percent) analyzed for SRP, met the DQO for precision.
- TN: Of 49, 46 laboratory duplicates (93.9 percent) analyzed for total nitrogen met the DQO for precision.
- TDN: Of 49, 48 laboratory duplicates (98.0 percent) analyzed for TDN, met the DQO for precision.
- TP: Of 47, 46 laboratory duplicates (97.9 percent) analyzed for total phosphorus met the DQO for precision.
- TDP: Of 44, 43 laboratory duplicates (97.7 percent) analyzed for TDP, met the DQO for precision.

Post-Storm Sediment

Laboratory duplicates were analyzed for x percent of the total post-storm sediment samples collected at Buena Vista Lagoon, Loma Alta Slough, and San Elijio Lagoon for this monitoring program. The percentages of laboratory duplicates for each constituent that met the DQOs are provided in Table 3-3. The breakdown of the laboratory duplicates that met the DQO for precision is as follows.

- % Total Organic Carbon: Of 4, 4 laboratory duplicates (100 percent) analyzed for % organic carbon, met the DQO for precision.
- % Total Nitrogen: Of 2, 2 laboratory duplicates (100 percent) analyzed for % total nitrogen, met the DQO for precision.
- % Total Phosphorus: Of 4, 4 laboratory duplicates (100 percent) analyzed for % total phosphorus, met the DQO for precision.

## 3.6 STANDARD REFERENCE MATERIAL

Laboratory control samples were analyzed for a minimum of 6 percent of the total samples collected for the following constituents: TDS, ammonia as nitrogen, nitrate+nitrite as nitrogen, SRP, total nitrogen, total dissolved nitrogen, total phosphorus, total dissolved phosphorus, % total organic carbon and % nitrogen. All results met the DQO, except for two samples:

- TDS: Of 46, 46 laboratory control samples (100 percent) analyzed for TDS met the DQO for precision.
- Ammonia as N: Of 77, 77 laboratory control samples (100 percent) analyzed for ammonia as nitrogen met the DQO for precision.
- Nitrate+Nitrite: Of 77, 77 laboratory control samples (100 percent) analyzed for nitrate+nitrite met the DQO for precision.
- SRP: Of 77, 77 laboratory control samples (100 percent) analyzed for SRP met the DQO for precision.
- TN: Of 49, 48 laboratory control samples (98.0 percent) analyzed for total nitrogen met the DQO for precision.
- TDN: Of 49, 48 laboratory control samples (98.0 percent) analyzed for TDN met the DQO for precision.
- TP: Of 49, 49 laboratory control samples (100 percent) analyzed for total phosphorus met the DQO for precision.
- TDP: Of 49, 49 laboratory control samples (100 percent) analyzed for TDP met the DQO for precision.
- % Total Organic Carbon: Of 11, 11 laboratory control samples (100 percent) analyzed for % organic carbon met the DQO for precision.
- % Total Nitrogen: Of 11, 11 laboratory control samples (100 percent) analyzed for % total nitrogen met the DQO for precision.

## 3.7 LABORATORY MATRIX SPIKES

Matrix spikes/matrix spike duplicates were analyzed on a minimum of 5 percent of the total number of samples collected for the following constituents: TDS, ammonia as nitrogen, nitrate+nitrite as nitrogen, total nitrogen, total dissolved nitrogen, total phosphorus, total dissolved phosphorus and % total phosphorus. All sample results met the DQO, except for the following samples:

- Ammonia as N: Of 63, 63 matrix spikes (100 percent) analyzed for ammonia as nitrogen met the DQO for precision.
- Nitrate+Nitrite: Of 63, 63 matrix spikes (100 percent) analyzed for nitrate+nitrite met the DQO for precision.

- SRP: Of 63, 63 matrix spikes (100 percent) analyzed for SRP, met the DQO for precision.
- TN: Of 48, 47 matrix spikes (97.9 percent) analyzed for total nitrogen met the DQO for precision.
- TDN: Of 47, 47 matrix spikes (100 percent) analyzed for TDN, met the DQO for precision.
- TP: Of 48, 48 matrix spikes (100 percent) analyzed for total phosphorus met the DQO for precision.
- TDP: Of 47, 47 matrix spikes (100 percent) analyzed for TDP, met the DQO for precision.
- % Total Phosphorus: Of 4, 4 matrix spikes (100 percent) analyzed for % total phosphorus, met the DQO for precision.

## 3.8 LABORATORY BLANKS

Laboratory blanks were analyzed on a minimum of 5 percent of the total number of samples collected. All sample results met the DQO except for the following samples:

Bactreria

- *Enterococcus*: Of 4, 4 laboratory blanks (100 percent) met the DQO.
- Total Coliform: Of 4, 4 laboratory blanks (100 percent) analyzed for did not meet the DQO.
- Fecal Coliform: Of 4, 4 laboratory blanks (100 percent) analyzed for did not meet the DQO.

TDS

- Of 26, 26 laboratory blanks (100 percent) met the DQO.

TSS

- Of 100, 100 laboratory blanks (100 percent) met the DQO.

Nutrients/Eutrophication

- Ammonia as N: Of 92, 92 laboratory blanks (100 percent) analyzed for ammonia as nitrogen met the DQO for precision.
- CBOD: Of 68, 68 laboratory duplicates (100 percent) analyzed for CBOD met the DQO for precision.
- Chlorophyll *a*: Of 79, 78 laboratory blanks (98.7 percent) met the DQO.
- Nitrate+Nitrite: Of 92, 92 laboratory blanks (100 percent) analyzed for nitrate+nitrite met the DQO for precision.
- SRP: Of 92, 92 laboratory blanks (100 percent) analyzed for SRP met the DQO for precision.
- TN: Of 47, 47 laboratory blanks (100 percent) analyzed for total nitrogen met the DQO for precision.

- TDN: Of 47, 47 laboratory blanks (100 percent) analyzed for TDN met the DQO for precision.
- TP: Of 47, 47 laboratory blanks (100 percent) analyzed for total phosphorus met the DQO for precision.
- TDP: Of 47, 47 laboratory blanks (100 percent) analyzed for TDP met the DQO for precision.

## 3.9 FIELD BLANKS

Field blanks were analyzed on a minimum of 5 percent of total samples collected for all constituents. All sample results met the DQO, except for one Enterococcus, one total coliform, two TDS, five chlorophyll *a*, one TN, one TDN, one TP, and one TDP. The samples that did not meet the DQO are discussed in the follow subsections:

Bacteria

- *Enterococcus*: Of 66, 65 field blanks (98.5 percent) met the DQO.
- Fecal Coliform: Of 66, 66 field blanks (100 percent) met the DQO.
- Total Coliform: Of 66, 65 field blanks (98.5 percent) met the DQO.

TDS

- Of 3, 1 field blanks (33.3 percent) met the DQO.

TSS

- Of 67, 67 field blanks (100 percent) met the DQO.

Nutrients/Eutrophication

- Ammonia as N: Of 47, 6 field blanks (12.8 percent) analyzed had results greater than the laboratory reported limit of 0.004 mg/L for ammonia as nitrogen met the DQO for precision. However, Of 47, 47 field blanks (100 percent) analyzed had results greater than the QAPP target reporting limit of 0.05 mg/L for ammonia as nitrogen met the DQO for precision.
- Nitrate+Nitrite: Of 47, 44 field blanks (100 percent) analyzed for nitrate+nitrite met the DQO for precision.
- SRP: Of 47, 45 field blanks (95.7 percent) analyzed for SRP, met the DQO for precision.
- TN: Of 47, 47 field blanks (100 percent) analyzed for total nitrogen met the DQO for precision.
- TDN: Of 46, 46 field blanks (100 percent) analyzed for TDN, met the DQO for precision.
- TP: Of 47, 45 field blanks (95.7 percent) analyzed for total phosphorus met the DQO for precision.
- TDP: Of 46, 44 field blanks (95.7 percent) analyzed for TDP, met the DQO for precision.

### 3.9.1 TN/TDN and TP/TDP

Although field blanks analyzed for TN/TDN and TP/TDP had values reported greater than the laboratory MDL of 0.0028 and 0.0021 mg/L, respectively, only one sample per analyte had results greater than the target RL. Upon further review of this data, a number of total dissolved nitrogen and total dissolved phosphorus results were identified as greater than the paired total phosphorus and total nitrogen results. MACTEC conducted an assessment of the total nitrogen, total dissolved nitrogen, total phosphorus, and total dissolved phosphorus results to understand the extent and magnitude of this issue. The laboratory reported values below the MDL and those values used in the data assessment are described below:

- Analyzed equipment blanks on each type of sample processing equipment, including syringes, filters, vials, and glass containers.
- Calculated percent of samples, field blanks, and equipment blanks impacted.
- Calculated the difference between total and dissolved results and identified values greater than the MDL.
- Calculated RPD in terms of the MDL to distinguish laboratory analysis variability.
- Evaluated the difference between the average dissolved and average total results for field samples, field blanks, and equipment blanks.

<u>TDN/TN</u>

TDN results are greater by at least 0.0028 (MDL) than their paired TN results in 33 percent of the total samples collected.

- Field Blank samples: TDN results are greater than their paired TN results in 55 percent of total field blank samples.
- Equipment Blank samples: All TN/TDN results were below the target RL of 0.1 mg/L. TDN results are greater by at least 0.0028 than their paired TN results in 69 percent of total equipment blank samples.
- For TN, the average field blank result was 0.0226 and average equipment blank was 0.0369. For TDN, the average field blank result was 0.0284 and average equipment blank was 0.0420.

TDP/TP

TDP results are greater than their paired TP results in 20 percent of the total samples collected.

- Field Blank samples: TDP results are greater than their paired TP results in 47 percent of total samples field blank samples collected.
- Equipment Blank samples: All TN/TDN results were below the target RL of 0.05 mg/L. TDP results are greater by at least 0.0028 (MDL) than their paired TP results in 19 percent of total field blank samples collected.
- The average field blank result for TP was 0.0013 and average equipment blank was 0.0001. The average field blank result for TDP was 0.0016 and average equipment blank was 0.0002. These values are below the MDL and are considered non-detects for this program per SWAMP guidelines.

Most of the TN, TDN, TP, and TDP results evaluated were present in relatively small concentrations below the target RL and in some cases below the laboratory MDL. The majority of the nitrogen or phosphorus appears to be present in the dissolved state in these samples. The laboratory used an exceptionally low method detection limit that reduces the confidence in the results at the lower limits and increases the possibility of positive results in blank samples. High RPDs occur as a result of small, absolute differences at low concentrations that amplify RPDs. The occurrence of dissolved values greater than paired total values is more evident in the TN/TDN samples than the TP/TDP results. The TN/TDN field blank and equipment blank results show a more substantial difference between dissolved and total samples. The equipment appears to be contributing to the TN/TDN results. The TP/TDP field blank and equipment blank results are most likely a result of laboratory interference and not a likely contributor to the sample results.

## 3.10 ASSESSMENT OF QUALITY ASSURANCE/QUALITY CONTROL RESULTS

Overall, data quality met program QA/QC objectives. All laboratory and field data generated under this program were reviewed for accuracy, precision and completeness. Data were qualified and flagged in the project database with the appropriate SWAMP QA code. Data was required to be reported in a SWAMP compatible format. Following the review, data results were assigned data qualifiers, as appropriate. Data were qualified using Result Qualifier Codes and Quality Assurance Codes, which are detailed below.

Result Qualifier Codes (ResQualCode) were used in the database to qualify individual sample results. The following ResQualCodes were assigned to data:

- Non-Detect (ND): The result was below the MDL.
- Detected Not Quantifiable (DNQ): The result was between the MDL and the RL.
- Estimated (E): Estimated value (Note this value was only used for bacteria counts and Loma Alta flow data).

Any constituent reported as non-detect (Numerical Qualifier "<") received an overall qualification of "ND" in the absence of laboratory quality control qualification. Any constituent that reported a value below the RL but at or above the MDL (with a Numerical Qualifier "<") received an overall qualification of "<,DNQ" to identify that the result was report as a less than value and was qualified as a DNQ in the absence of laboratory quality control qualification.

The 2007-2008 monitoring effort resulted in 10,749 chemical measurements. Of these, 2,785 values (26 percent) required data qualifications. Of the 2,785 values, 388 were wet weather results and 2397 were dry weather results. Table 3–3 provides a summary of the ResQualCodes applied to wet weather data and Table 3-4 provides a summary of the ResQualCodes applied to the dry weather data.

QA Codes are used in the database to describe any special conditions or situation occurring during the analysis. No data points were rejected based on these qualifiers. QA Codes are as follows.

- X: The default code, indicating no special conditions, is "X".
- H: A holding time violation occurred. The majority of the "H" qualifiers were attributable to holding-time violations for nutrients as described in Section 3.2.3.
- DGT: Dissolved result was greater than paired Total result; therefore the dissolved result was considered suspect. The "DGT" qualifiers were attributable to the total dissolved nitrogen and phosphorus results as described in Section 3.9.4.
- IMS: Instrument malfunction occurred, data is considered suspect. At Loma Alta Slough, flow data is considered suspect as described in Section 3.1.1.

Based on a review of the project DQOs and the database data qualifiers, the data collected as part of this study was deemed appropriate for use in the CHU Lagoon TMDL Monitoring Program Data Analysis as qualified. No data was rejected. The flagged data was applicable as qualified and can be used considering the constraints placed by the qualifiers.

**Table 3-4: Summary of Wet Weather Qualified Data**

| Analyte/Constituent | Qualified Results | % Qualified | ND | % ND | DNQ | % DNQ | E | % E | Total Analyte Result Count |
|---|---|---|---|---|---|---|---|---|---|
| Clay <0.0039 mm | 0 | 0% | | 0.0% | | 0.0% | | 0.0% | 33 |
| Granule 2.0 to <4.0 mm | 0 | 0% | | 0.0% | | 0.0% | | 0.0% | 11 |
| Sand 0.0625 to <2.0 mm | 0 | 0% | | 0.0% | | 0.0% | | 0.0% | 55 |
| Silt 0.0039 to <0.0625 mm | 0 | 0% | | 0.0% | | 0.0% | | 0.0% | 44 |
| % Organic Carbon | 6 | 10% | | 0.0% | 6 | 10.0% | | 0.0% | 60 |
| % Sand | 0 | 0% | | 0.0% | | 0.0% | | 0.0% | 85 |
| % Total Nitrogen | 23 | 49% | | 0.0% | 23 | 48.9% | | 0.0% | 47 |
| % Total Phosphorus | 0 | 0% | | 0.0% | | 0.0% | | 0.0% | 60 |
| Enterococcus | 3 | 3% | | 0.0% | 3 | 2.6% | | 0.0% | 116 |
| Fecal Coliform | 0 | 0% | | 0.0% | | 0.0% | | 0.0% | 116 |
| Total Coliform | 0 | 0% | | 0.0% | | 0.0% | | 0.0% | 116 |
| TDS | 0 | 0% | | 0.0% | | 0.0% | | 0.0% | 16 |
| TSS | 5 | 4% | 1 | 0.7% | 4 | 2.9% | | 0.0% | 138 |
| Ammonia as N | 1 | 1% | 1 | 1.1% | | 0.0% | | 0.0% | 94 |
| CBOD | 39 | 42% | 39 | 41.9% | | 0.0% | | 0.0% | 93 |
| Chlorophyll *a* | 0 | 0% | | 0.0% | | 0.0% | | 0.0% | 43 |
| Nitrate + Nitrite as N | 5 | 5% | 1 | 1.1% | 4 | 4.3% | | 0.0% | 94 |
| Soluble Reactive Phosphorus | 0 | 0% | | 0.0% | | 0.0% | | 0.0% | 94 |
| Total Nitrogen (calc) | 0 | 0% | | 0.0% | | 0.0% | | 0.0% | 94 |
| TDN | 35 | 37% | | 0.0% | 35 | 37.2% | | 0.0% | 94 |
| TP | 92 | 98% | 5 | 5.3% | 87 | 92.6% | | 0.0% | 94 |
| TDP | 94 | 100% | 8 | 8.5% | 86 | 91.5% | | 0.0% | 94 |
| **Total Qualifiers** | **388** | **23%** | **55** | **3.3%** | **248** | **14.7%** | | **0.0%** | **1691** |

**Table 3-5: Summary of Dry Weather Qualified Data**

| Analyte | Qualified | % Qualified | ND | % ND | DNQ | % DNQ | E | % E | Total Analyte Result Count |
|---|---|---|---|---|---|---|---|---|---|
| Enterococcus | 148 | 18.8% | | 0.0% | 148 | 18.8% | | 0.0% | 788 |
| Fecal Coliform | 112 | 14.2% | | 0.0% | 112 | 14.2% | | 0.0% | 788 |
| Total Coliform | 85 | 10.8% | | 0.0% | 57 | 7.2% | 28 | 3.6% | 788 |
| TDS | 0 | 0.0% | | 0.0% | | 0.0% | | 0.0% | 24 |
| TSS | 176 | 18.4% | 10 | 1.0% | 166 | 17.4% | | 0.0% | 956 |
| Ammonia as N | 4 | 0.6% | | 0.0% | 4 | 0.6% | | 0.0% | 652 |
| CBOD | 308 | 68.3% | 308 | 68.3% | | 0.0% | | 0.0% | 451 |
| Chlorophyll *a* | 46 | 7.0% | 21 | 3.2% | 25 | 3.8% | | 0.0% | 657 |
| Nitrate + Nitrite as N | 200 | 30.7% | 40 | 6.1% | 160 | 24.5% | | 0.0% | 652 |
| Soluble Reactive Phosphorus | 129 | 19.8% | 10 | 1.5% | 119 | 18.3% | | 0.0% | 652 |
| Total Nitrogen (calc) | 8 | 1.2% | 1 | 0.2% | 7 | 1.1% | | 0.0% | 661 |
| TDN | 161 | 24.4% | 1 | 0.2% | 160 | 24.2% | | 0.0% | 660 |
| TP | 489 | 74.0% | 23 | 3.5% | 466 | 70.5% | | 0.0% | 661 |
| TDP | 531 | 80.5% | 101 | 15.3% | 430 | 65.2% | | 0.0% | 660 |
| Turbidity | 0 | 0.0% | | 0.0% | | 0.0% | | 0.0% | 8 |
| **Total Qualifiers** | **2397** | **26.5%** | **515** | **5.7%** | **1854** | **20.5%** | **28** | **0.3%** | **9058** |

# 4.0 MONITORING RESULTS

## 4.1 AGUA HEDIONDA LAGOON MONITORING RESULTS

This section summarizes results from the continuous monitoring as well as wet weather and index period events. Detailed discussion of the results is presented in section 6.1.

### 4.1.1 Agua Hedionda Continuous Monitoring

Continuous monitoring at Agua Hedionda Lagoon included the following parameters:

- Rainfall (Mass Emission Station only)
- Flow (Mass Emission Station only)
- Specific conductivity
- Temperature
- Turbidity
- Water level (Lagoon Segment and Ocean Inlet Sites)

In accordance with the QAPP, flow, rainfall, specific conductivity, and temperature monitoring was conducted from October 2007 to October 2008 and monitoring of turbidity was conducted from January 2008 to October 2008 at the Agua Hedionda Mass Emission Station. Monitoring of specific conductivity, temperature, turbidity, and water level at lagoon segment and ocean inlet sites was required during a three-month wet weather period and a three to four-month dry weather period, covering all monitoring events. However, continuous monitoring of these parameters was conducted from January 2008 to October 2008 resulting in a greater time period than required by the QAPP.

#### 4.1.1.1 Hydrology of the Lagoon

Table 4-1 summarizes the results statistically on a monthly basis, as well as by event, from continuous water level monitoring. Detailed continuous monitoring results for the entire monitoring period are presented in Appendix B-1.

Both of the Agua Hedionda Ocean Inlet Surface (Depth 1) data sondes were attached to buoys to maintain data collection near the water surface. Results from these sites are reported as sensor depth in Table 4-1. Water level was not recorded with the data sonde at the Agua Hedionda Mass Emission Station as other instrumentation was installed to measure stage and to calculate real-time flows. Lagoon depth measurements from the data sondes were tied to North American Vertical Datum, 1988 (NAVD 88).

**Table 4-1: Agua Hedionda Continuous Lagoon and Sensor Depth Monitoring Monthly and Event Summary**

| Month (2008) | Lagoon Segment Site[1] | | | Ocean Inlet 1 Surface (Depth 1)[2] | | | Ocean Inlet 1 Bottom (Depth 2) | | | Ocean Inlet 2 Surface (Depth 1) | | | Ocean Inlet 2 Bottom (Depth 2) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Lagoon Depth (m) | | | Sensor Depth (m) | | | Lagoon Depth (m) | | | Sensor Depth (m) | | | Lagoon Depth (m) | | |
| | Mean | Min | Max | Mean | Min | Max | Mean | Min | Max | Mean | Min | Max | Mean | Min | Max |
| January | 1.2 | 1.1 | 1.4 | 0.9 | 0.8 | 1.0 | 3.7 | 2.6 | 4.9 | 1.3 | 1.2 | 1.5 | 3.7 | 3.1 | 3.8 |
| February | 1.2 | 1.1 | 1.4 | 0.9 | 0.8 | 1.0 | 3.7 | 2.7 | 4.8 | 1.3 | 0.3 | 1.4 | 3.7 | 2.9 | 3.8 |
| March | 1.2 | 1.1 | 1.4 | 0.9 | 0.8 | 1.7 | 3.7 | 2.8 | 4.6 | 1.2 | 1.1 | 1.3 | 3.7 | 3.3 | 3.8 |
| April | 1.2 | 1.1 | 1.4 | 0.9 | 0.8 | 0.9 | 3.6 | 2.8 | 4.8 | 1.3 | 1.2 | 1.4 | 3.6 | 3.3 | 3.7 |
| May | 1.2 | 1.1 | 1.3 | 0.9 | 0.7 | 0.9 | 3.7 | 2.6 | 5.0 | 1.1 | 0.9 | 1.4 | 3.6 | 2.6 | 3.8 |
| June | 1.2 | 1.0 | 1.3 | 0.8 | 0.5 | 0.9 | 3.7 | 2.6 | 4.9 | 1.2 | 1.0 | 1.4 | 3.6 | 3.0 | 3.7 |
| July | 1.2 | 1.0 | 1.3 | 0.8 | 0.7 | 0.9 | 3.7 | 2.6 | 5.1 | 1.2 | 1.1 | 1.4 | 3.6 | 3.0 | 3.8 |
| August | 1.2 | 0.9 | 1.3 | 0.8 | 0.7 | 0.9 | 3.8 | 2.7 | 5.0 | 1.2 | 1.1 | 1.4 | 3.7 | 3.1 | 3.9 |
| September | 1.2 | 1.0 | 1.4 | 0.8 | 0.7 | 1.8 | 3.7 | 2.8 | 4.7 | 1.2 | 1.0 | 1.4 | 3.7 | 3.2 | 3.8 |
| October | 1.2 | 1.1 | 1.5 | 0.6 | 0.5 | 0.8 | 3.7 | 2.7 | 4.9 | 1.2 | 1.1 | 1.7 | 3.7 | 3.3 | 4.1 |
| Average | 1.2 | 1.1 | 1.4 | 0.8 | 0.7 | 1.1 | 3.7 | 2.7 | 4.9 | 1.2 | 1.0 | 1.4 | 3.6 | 3.1 | 3.8 |
| **Event** | **Lagoon Depth (m)** | | | **Sensor Depth (m)** | | | **Lagoon Depth (m)** | | | **Sensor Depth (m)** | | | **Lagoon Depth (m)** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 1.3 | 1.1 | 1.4 | 0.9 | 0.8 | 0.9 | 3.8 | 2.8 | 4.8 | 1.3 | 1.2 | 1.4 | 3.6 | 3.5 | 3.7 |
| Wet Weather 2 | 1.3 | 1.1 | 1.4 | 0.9 | 0.8 | 1.0 | 3.8 | 2.7 | 4.7 | 1.3 | 1.2 | 1.4 | 3.7 | 3.1 | 3.7 |
| Wet Weather 3 | 1.3 | 1.1 | 1.4 | *No Data* | *No Data* | *No Data* | 3.7 | 2.7 | 4.7 | 1.3 | 1.2 | 1.4 | 3.6 | 2.9 | 3.8 |
| Index Period 1 | 1.2 | 1.1 | 1.4 | 0.9 | 0.8 | 1.0 | 3.7 | 2.7 | 4.8 | 1.3 | 0.3 | 1.4 | 3.6 | 3.3 | 3.8 |
| Index Period 2 | 1.2 | 1.1 | 1.4 | 0.9 | 0.8 | 0.9 | 3.7 | 2.8 | 4.8 | 1.3 | 1.2 | 1.4 | 3.6 | 3.3 | 3.7 |
| Index Period 3 | 1.3 | 1.0 | 1.3 | 0.8 | 0.8 | 0.9 | 3.8 | 2.7 | 5.1 | 1.2 | 1.1 | 1.4 | 3.6 | 3.4 | 3.8 |
| Index Period 4 | 1.3 | 1.2 | 1.3 | 0.6 | 0.5 | 0.7 | 3.7 | 2.7 | 4.8 | 1.2 | 1.1 | 1.7 | 3.7 | 3.3 | 4.1 |

(1) Data sonde tampered with during Index Period Event 2 sampling. Data calculated from the first three days of sampling only.
(2) Data sonde malfunctioned due to low voltage. No data collected from 10:00 on January 31, 2008 to 13:30 on February 13, 2008. This period includes Wet Weather Event 3 entirely. Data for Index Period Event 1 calculated from 13:30 to 23:45 February 13, 2008 (day 5) and all of February 19, 2008 (day 6).

#### 4.1.1.2 Rainfall and Flow

Rainfall and flow both were continuously monitored at the Agua Hedionda Mass Emission Station throughout the monitoring period as required by the IO. Instrumentation installed at the mass emission station measured and logged rainfall and flow beginning October 1, 2007 through October 31, 2008.

Daily and monthly precipitation totals are summarized in Table 4-2. The total rainfall for the entire monitoring year was 11.29 inches. January had the most rainfall, totaling 3.62 inches. Detailed continuous rainfall results for the entire monitoring period are presented in Appendix A-1.

Daily and monthly discharge totals are summarized in Table 4-3. A total volume of 188,510,669 cubic feet was discharged into Agua Hedionda Lagoon over the entire monitoring period. January recorded the highest monthly discharge throughout the year with 51,477,237 cubic feet. Detailed continuous stage and flow results for the entire monitoring period are presented in Appendix A-1.

For a short period of time between February 26, 2008 through March 14, 2008 flow was not measured and logged. This was due to local construction in the area that likely would have caused permanent damage to the sensor. Therefore, per instruction from the RPs, the sensor was removed from the channel until construction was complete.

## Table 4-2: Agua Hedionda Mass Emission StationDaily and Monthly Precipitation Summary (inches)

| Day | 2007 | | | 2008 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **October** | **November** | **December** | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 0.00 | 0.00 | 0.00 | 0.98 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | 0.00 | 0.00 | 0.00 | 0.83 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | 0.00 | 0.00 | 0.52 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | 0.00 | 0.00 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 13 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19 | 0.00 | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20 | 0.00 | 0.00 | 0.08 | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22 | 0.00 | 0.00 | 0.00 | 0.00 | 1.85 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 23 | 0.00 | 0.00 | 0.00 | 0.31 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 24 | 0.00 | 0.00 | 0.00 | 0.08 | 0.28 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 26 | 0.00 | 0.00 | 0.00 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 27 | 0.00 | 0.00 | 0.00 | 0.79 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 28 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 30 | 0.00 | 2.92 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 31 | 0.00 | | 0.00 | 0.00 | | 0.00 | | 0.00 | | 0.00 | 0.00 | | 0.00 |
| **Totals** | **0.12** | **2.92** | **1.28** | **3.62** | **3.27** | **0.00** | **0.00** | **0.08** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |

**Table 4-3: Agua Hedionda Mass Emission Station Daily and Monthly Total Discharge Summary (cubic feet)**

| Day | 2007 | | | 2008 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **October** | **November** | **December** | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** |
| 1 | 97,768 | 27,317 | 7,001,184 | 134,885 | 266,930 | *Off-line* | 74,069 | 113,107 | 146,682 | 93,357 | 29,309 | 16,238 | 99,744 |
| 2 | 49,952 | 36,031 | 739,509 | 151,916 | 278,169 | *Off-line* | 128,938 | 116,269 | 43,861 | 75,370 | 26,014 | 12,742 | 84,171 |
| 3 | 43,345 | 36,810 | 581,421 | 223,091 | 4,159,989 | *Off-line* | 110,239 | 115,743 | 45,740 | 27,064 | 28,833 | 16,256 | 81,722 |
| 4 | 37,078 | 34,024 | 514,048 | 316,251 | 2,154,019 | *Off-line* | 106,546 | 92,266 | 26,370 | 31,573 | 32,764 | 81,109 | 68,091 |
| 5 | 34,296 | 31,042 | 496,799 | 12,093,710 | 552,406 | *Off-line* | 89,764 | 106,087 | 52,696 | 29,621 | 28,080 | 54,711 | 97,014 |
| 6 | 31,647 | 29,344 | 565,928 | 3,349,560 | 336,964 | *Off-line* | 96,471 | 81,264 | 65,300 | 26,178 | 27,329 | 50,042 | 104,837 |
| 7 | 35,798 | 26,449 | 4,425,547 | 14,842,361 | 389,909 | *Off-line* | 112,299 | 109,225 | 46,581 | 27,656 | 67,727 | 51,050 | 143,202 |
| 8 | 37,813 | 23,524 | 1,955,350 | 1,635,965 | 504,166 | *Off-line* | 93,663 | 115,332 | 48,263 | 23,693 | 26,423 | 52,004 | 115,673 |
| 9 | 34,653 | 25,369 | 1,346,201 | 1,073,612 | 452,010 | *Off-line* | 103,541 | 88,030 | 54,252 | 21,046 | 25,167 | 46,426 | 91,906 |
| 10 | 33,660 | 30,529 | 359,696 | 753,984 | 414,092 | *Off-line* | 109,237 | 127,339 | 54,019 | 25,121 | 25,346 | 35,358 | 105,104 |
| 11 | 34,688 | 40,328 | 294,518 | 489,122 | 434,548 | *Off-line* | 135,554 | 112,665 | 60,258 | 18,002 | 23,695 | 29,112 | 63,279 |
| 12 | 33,799 | 101,062 | 222,450 | 290,856 | 499,219 | *Off-line* | 136,617 | 64,489 | 64,191 | 26,887 | 21,613 | 22,398 | 52,346 |
| 13 | 833,699 | 98,271 | 170,904 | 280,267 | 477,967 | *Off-line* | 105,865 | 121,152 | 56,232 | 27,557 | 16,387 | 31,429 | 58,686 |
| 14 | 113,206 | 93,079 | 213,860 | 278,826 | 3,212,359 | *Off-line* | 93,353 | 111,896 | 63,231 | 27,137 | 23,401 | 30,869 | 62,658 |
| 15 | 37,304 | 85,725 | 104,521 | 315,040 | 700,588 | 347,858 | 89,706 | 119,350 | 67,928 | 25,492 | 26,153 | 36,749 | 65,909 |
| 16 | 44,842 | 76,973 | 148,313 | 282,522 | 451,159 | 311,144 | 96,745 | 157,977 | 74,741 | 29,554 | 24,086 | 21,441 | 62,796 |
| 17 | 48,724 | 78,837 | 342,768 | 168,943 | 428,835 | 265,944 | 116,464 | 164,734 | 77,252 | 23,879 | 22,169 | 27,098 | 63,576 |
| 18 | 47,804 | 73,667 | 431,981 | 154,887 | 451,862 | 279,444 | 105,882 | 170,032 | 79,728 | 28,727 | 23,355 | 30,273 | 64,584 |
| 19 | 46,562 | 71,260 | 2,106,159 | 145,845 | 563,696 | 308,205 | 87,251 | 172,986 | 83,049 | 18,797 | 16,068 | 27,387 | 67,817 |
| 20 | 41,775 | 69,192 | 340,848 | 153,813 | 1,522,594 | 311,237 | 50,749 | 109,881 | 93,539 | 22,460 | 16,125 | 20,350 | 66,140 |
| 21 | 39,912 | 79,370 | 1,326,392 | 376,632 | 777,798 | 303,744 | 58,002 | 103,439 | 102,794 | 22,215 | 16,221 | 20,492 | 58,375 |
| 22 | 35,346 | 81,942 | 181,946 | 189,937 | 21,356,745 | 306,741 | 66,272 | 82,552 | 100,236 | 30,500 | 15,948 | 18,978 | 70,930 |
| 23 | 31,155 | 76,851 | 160,173 | 2,033,744 | 2,510,915 | 324,321 | 71,019 | 751,555 | 92,810 | 29,726 | 18,197 | 20,408 | 64,895 |
| 24 | 41,518 | 84,772 | 168,068 | 2,047,373 | 3,595,550 | 295,624 | 73,614 | 437,702 | 67,495 | 30,468 | 19,314 | 23,905 | 54,984 |
| 25 | 33,354 | 75,105 | 140,206 | 450,458 | 1,484,424 | 289,286 | 86,689 | 157,622 | 64,650 | 27,197 | 18,708 | 24,624 | 50,279 |
| 26 | 35,165 | 91,508 | 125,263 | 330,905 | *Off-line* | 272,107 | 96,788 | 124,242 | 64,183 | 23,247 | 20,578 | 27,271 | 47,930 |
| 27 | 27,598 | 72,326 | 129,922 | 5,426,649 | *Off-line* | 284,054 | 125,308 | 126,568 | 74,158 | 22,490 | 16,403 | 24,055 | 53,778 |
| 28 | 50,304 | 90,569 | 184,036 | 1,876,145 | *Off-line* | 236,726 | 115,107 | 110,670 | 82,190 | 26,275 | 14,311 | 19,879 | 55,337 |
| 29 | 36,131 | 59,845 | 189,221 | 837,254 | *Off-line* | 231,515 | 110,986 | 116,941 | 94,297 | 24,339 | 13,122 | 172,914 | 63,089 |
| 30 | 34,770 | 40,212,470 | 186,449 | 454,325 | | 275,312 | 59,190 | 125,971 | 104,026 | 29,600 | 18,795 | 120,773 | 55,718 |
| 31 | 33,439 | | 139,814 | 318,360 | | 228,548 | | 124,691 | | 29,419 | 18,761 | | 66,094 |
| **Total** | **2,117,105** | **42,013,590** | **25,293,494** | **51,477,237** | **47,976,916** | **4,871,811** | **2,905,929** | **4,631,777** | **2,150,751** | **924,651** | **720,403** | **1,166,342** | **2,260,664** |

4.1.1.3 Continuous Monitoring of Water Quality Parameters

Tables 4-4 through 4-9 summarize the results statistically on a monthly basis, as well as by event, from continuous water quality monitoring. Detailed continuous monitoring results for the entire monitoring period are presented in Appendix B-1.

Data gaps occurred as a result of fouling, tampering, unexpected decrease in water level, equipment malfunction, and other unforeseen events and are discussed in Section 3.1.1.2.

**Table 4-4: Agua Hedionda Mass Emission Station Continuous Data Monthly and Event Summary**

| Month (2007/2008) | Temperature (°C) | | | Specific Conductance (mS/cm) | | | Turbidity (NTU) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| October | 17.6 | 11.8 | 26.8 | 3.30 | 1.89 | 3.95 | *No Data* | *No Data* | *No Data* |
| November | 15.6 | 9.6 | 21.8 | 3.39 | 0.47 | 3.92 | *No Data* | *No Data* | *No Data* |
| December | 11.9 | 7.5 | 15.8 | 2.54 | 0.63 | 4.37 | *No Data* | *No Data* | *No Data* |
| January | 11.9 | 7.8 | 15.6 | 2.5 | 0.3 | 4.0 | 17.6 | 0.0 | 708.6 |
| February | 12.8 | 8.4 | 18.9 | 2.3 | 0.3 | 3.3 | 21.0 | 0.0 | 409.1 |
| March | 15.5 | 10.3 | 23.4 | 3.1 | 2.7 | 3.3 | 0.9 | 0.0 | 6.6 |
| April | 17.7 | 12.0 | 27.1 | 3.2 | 2.4 | 3.4 | 0.5 | -0.2 | 7.0 |
| May | 19.2 | 14.1 | 30.7 | 3.2 | 2.0 | 3.5 | 1.5 | -0.2 | 51.4 |
| June | 22.2 | 15.7 | 32.0 | 3.3 | 3.2 | 3.5 | 0.6 | -0.1 | 4.0 |
| July | 23.5 | 17.4 | 32.0 | 3.4 | 3.0 | 3.6 | 0.6 | -0.1 | 9.7 |
| August | 24.0 | 19.4 | 32.7 | 3.4 | 2.6 | 3.6 | 0.4 | -0.1 | 6.6 |
| September | 22.3 | 17.4 | 30.9 | 3.4 | 2.9 | 3.6 | 0.4 | -0.2 | 5.2 |
| October | 18.6 | 11.6 | 27.3 | 3.3 | 3.0 | 3.4 | 0.4 | 0.0 | 3.8 |
| Average | 17.9 | 12.5 | 25.8 | 3.1 | 2.0 | 3.7 | 4.4 | -0.1 | 121.2 |
| **Event** | **Temperature (°C)** | | | **Specific Conductance (mS/cm)** | | | **Turbidity (NTU)** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 12.9 | 11.1 | 14.0 | 1.4 | 0.3 | 3.9 | no data | no data | no data |
| Wet Weather 2 | 11.3 | 10.2 | 12.9 | 1.6 | 0.5 | 3.3 | 98.1 | 1.4 | 294.2 |
| Wet Weather 3 | 12.0 | 10.5 | 14.6 | 1.6 | 0.5 | 3.2 | 47.5 | 0.1 | 265.9 |
| Index Period 1 | 12.5 | 8.4 | 18.0 | 2.7 | 1.4 | 3.3 | 3.7 | 0.0 | 63.6 |
| Index Period 2 | 17.8 | 12.1 | 26.6 | 3.2 | 3.1 | 3.3 | 0.7 | 0.0 | 4.1 |
| Index Period 3 | 23.5 | 17.4 | 32.0 | 3.4 | 3.2 | 3.5 | 0.8 | 0.1 | 6.0 |
| Index Period 4 | 17.6 | 11.6 | 25.7 | 3.3 | 3.2 | 3.4 | 0.4 | 0.0 | 1.2 |
| WQO | N/A | | | N/A | | | 20 NTU | | |

**Table 4-5: Agua Hedionda Lagoon Segment Site Continuous Data Monthly and Event Summary**

| Month (2008) | Temperature (°C) | | | Specific Conductance (mS/cm) | | | Turbidity (NTU) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| January | 13.6 | 12.2 | 14.9 | 48.4 | 34.9 | 52.5 | 3.7 | 0.0 | 26.1 |
| February | 14.3 | 12.9 | 15.8 | 47.2 | 29.1 | 51.0 | 4.1 | -0.2 | 43.2 |
| March | 16.7 | 14.7 | 19.2 | 50.0 | 41.6 | 51.6 | 5.0 | 0.2 | 17.0 |
| April | 17.3 | 16.2 | 18.9 | 50.9 | 50.3 | 51.4 | 6.6 | 0.0 | 22.0 |
| May | 20.7 | 18.0 | 24.7 | 51.0 | 50.4 | 51.7 | 5.6 | 1.0 | 29.8 |
| June | 22.6 | 20.0 | 26.2 | 51.5 | 49.0 | 53.1 | 48.8[2] | -0.4 | 711.9 |
| July | 22.7 | 19.2 | 25.2 | 50.9 | 49.6 | 51.9 | 132.0[2] | -0.6 | 754.6 |
| August | 23.7 | 21.1 | 27.1 | 50.8 | 48.5 | 52.0 | 5.3 | -0.3 | 20.0 |
| September | 22.6 | 18.8 | 25.7 | 50.6 | 49.1 | 51.6 | 19.7[2] | 0.0 | 143.5 |
| October | 19.8 | 17.0 | 22.4 | 50.6 | 49.5 | 51.2 | 27.3[2] | 0.0 | 295.4 |
| Average | 19.4 | 17.0 | 22.0 | 50.2 | 45.2 | 51.8 | 25.8 | 0.0 | 206.4 |
| **Event** | **Temperature (°C)** | | | **Specific Conductance (mS/cm)** | | | **Turbidity (NTU)** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 13.6 | 13.3 | 13.9 | 46.2 | 36.6 | 51.8 | 3.6 | 0.5 | 18.4 |
| Wet Weather 2 | 13.9 | 13.3 | 14.7 | 47.4 | 34.9 | 50.1 | 3.8 | 0.8 | 24.5 |
| Wet Weather 3 | 13.8 | 12.9 | 14.6 | 47.4 | 39.9 | 49.0 | 5.0 | 1.3 | 21.6 |
| Index Period 1 | 14.4 | 13.0 | 15.6 | 49.5 | 47.1 | 51.0 | 3.9 | 1.3 | 29.2 |
| Index Period 2[1] | 17.2 | 16.5 | 18.1 | 51.0 | 50.6 | 51.4 | 6.4 | 1.0 | 15.3 |
| Index Period 3 | 23.6 | 22.4 | 24.7 | 50.8 | 49.8 | 51.2 | 14.3[2] | 0.8 | 39.7 |
| Index Period 4 | 19.8 | 17.3 | 22.4 | 50.7 | 49.9 | 51.0 | 36.0[2] | 2.0 | 295.4 |
| WQO | N/A | | | N/A | | | 20 NTU | | |

(1) Data sonde tampered with during Index Period Event 2 sampling. Data calculated from the first three days of sampling only.
(2) Elevated turbidity data is discussed in Section 3.1.1.2.

**Table 4-6: Agua Hedionda Ocean Inlet 1 Surface (Depth 1) Continuous Data Monthly and Event Summary**

| Month (2008) | Temperature (°C) | | | Specific Conductance (ms/cm) | | | Turbidity (NTU) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Min | Max | Mean | Min | Max | Mean | Min | Max |
| January | 13.6 | 12.6 | 14.7 | 49.8 | 39.6 | 51.6 | 3.2 | -0.3 | 28.0 |
| February | 14.2 | 12.9 | 16.1 | 47.2 | 37.8 | 50.4 | 2.6 | 0.0 | 21.7 |
| March | 15.8 | 14.2 | 17.9 | 50.8 | 45.8 | 52.7 | 1.8 | -0.2 | 12.5 |
| April | 16.6 | 14.1 | 19.7 | 51.1 | 47.3 | 51.7 | 2.5 | 0.0 | 13.8 |
| May | 19.3 | 16.7 | 22.7 | 51.8 | 47.1 | 52.6 | 1.7 | -0.2 | 12.7 |
| June | 20.9 | 18.0 | 24.3 | 51.4 | 50.7 | 51.6 | 1.8 | 0.0 | 9.4 |
| July | 21.2 | 17.7 | 23.9 | 51.4 | 50.4 | 51.9 | 2.1 | 0.0 | 13.9 |
| August | 22.0 | 18.7 | 24.6 | 49.8 | 47.8 | 50.6 | 1.2 | -0.2 | 7.5 |
| September | 20.9 | 17.5 | 23.9 | 49.5 | 46.6 | 50.8 | 1.0 | -0.3 | 6.0 |
| October | 18.9 | 16.5 | 21.0 | 50.3 | 47.0 | 50.7 | 0.9 | 0.0 | 6.4 |
| Average | 18.3 | 15.9 | 20.9 | 50.3 | 46.0 | 51.5 | 1.9 | -0.1 | 13.2 |
| **Event** | **Temperature (°C)** | | | **Specific Conductance (mS/cm)** | | | **Turbidity (NTU)** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 13.8 | 13.4 | 14.1 | 47.5 | 39.6 | 51.4 | 3.6 | 0.7 | 8.8 |
| Wet Weather 2 | 13.9 | 13.3 | 14.7 | 49.2 | 45.8 | 51.4 | 4.4 | 0.7 | 28.0 |
| Wet Weather 3[1] | no data | no data | no data | no data | no data | no data | no data | no data | no data |
| Index Period 1[1] | 14.4 | 13.9 | 14.7 | 49.3 | 47.5 | 50.2 | 1.9 | 0.3 | 5.6 |
| Index Period 2 | 16.5 | 14.9 | 18.1 | 51.0 | 50.7 | 51.4 | 3.0 | 0.2 | 12.6 |
| Index Period 3 | 22.4 | 21.0 | 23.4 | 51.4 | 50.7 | 51.9 | 1.7 | 0.2 | 7.9 |
| Index Period 4 | 18.8 | 17.0 | 20.7 | 50.3 | 49.1 | 50.7 | 0.9 | 0.0 | 6.2 |
| WQO | N/A | | | N/A | | | 20 NTU | | |

(1) Data sonde malfunctioned due to low voltage. No data collected from 10:00 on January 31, 2008 to 13:30 on February 13, 2008. This period includes Wet Weather Event 3 entirely. Data for Index Period Event 1 calculated from 13:30 to 23:45 February 13, 2008 (day 5) and all of February 19, 2008 (day 6).

**Table 4-7: Agua Hedionda Ocean Inlet 1 Bottom (Depth 2) Continuous Data Monthly and Event Summary**

| Month (2008) | Temperature (°C) | | | Specific Conductance (mS/cm) | | | Turbidity (NTU) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Min | Max | Mean | Min | Max | Mean | Min | Max |
| January | 13.6 | 12.7 | 14.7 | 47.8 | 39.3 | 52.0 | 3.6 | -0.3 | 70.1 |
| February | 14.0 | 13.0 | 15.3 | 48.0 | 35.5 | 52.0 | 3.9 | -0.1 | 123.1 |
| March | 15.6 | 13.8 | 17.4 | 48.8 | 46.3 | 52.0 | 2.7 | -0.3 | 16.0 |
| April | 16.5 | 13.6 | 18.9 | 48.4 | 44.7 | 51.3 | 5.3 | 0.0 | 53.8 |
| May | 19.2 | 16.7 | 22.5 | 51.3 | 49.0 | 53.0 | 2.5 | -0.2 | 20.3 |
| June | 20.7 | 17.6 | 24.3 | 50.4 | 47.2 | 52.1 | 3.0 | -0.3 | 14.0 |
| July | 21.1 | 17.6 | 23.4 | 49.3 | 45.6 | 51.1 | 2.1 | -0.2 | 9.7 |
| August | 21.8 | 18.6 | 24.4 | 45.9 | 40.3 | 49.0 | 1.8 | -0.1 | 19.5 |
| September | 20.7 | 17.4 | 23.9 | 46.3 | 39.1 | 48.4 | 2.6 | -0.4 | 60.8 |
| October | 18.9 | 16.5 | 21.0 | 47.5 | 44.5 | 48.7 | 2.5 | -0.3 | 7.5 |
| Average | 18.2 | 15.7 | 20.6 | 48.4 | 43.2 | 50.9 | 3.0 | -0.2 | 39.5 |
| **Event** | **Temperature (°C)** | | | **Specific Conductance (mS/cm)** | | | **Turbidity (NTU)** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 13.8 | 13.5 | 14.0 | 45.9 | 39.3 | 48.4 | 4.7 | 0.7 | 70.1 |
| Wet Weather 2 | 13.8 | 13.4 | 14.7 | 46.9 | 44.7 | 48.3 | 3.2 | 0.3 | 16.5 |
| Wet Weather 3 | 13.6 | 13.2 | 14.1 | 50.2 | 48.1 | 51.7 | 8.0 | -0.1 | 123.1 |
| Index Period 1 | 14.0 | 13.4 | 14.7 | 50.0 | 47.7 | 51.4 | 2.7 | -0.1 | 14.9 |
| Index Period 2 | 16.4 | 14.5 | 17.9 | 47.5 | 44.7 | 50.6 | 4.1 | 0.1 | 16.7 |
| Index Period 3 | 22.4 | 21.0 | 23.4 | 48.5 | 45.6 | 49.5 | 1.4 | -0.1 | 9.3 |
| Index Period 4 | 18.8 | 17.1 | 20.7 | 47.3 | 46.3 | 48.0 | 2.2 | -0.2 | 7.5 |
| WQO | N/A | | | N/A | | | 20 NTU | | |

**Table 4-8: Agua Hedionda Ocean Inlet 2 Surface (Depth 1) Continuous Data Monthly and Event Summary**

| Month (2008) | Temperature (°C) | | | Specific Conductance (mS/cm) | | | Turbidity (NTU) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Min | Max | Mean | Min | Max | Mean | Min | Max |
| January | 13.6 | 12.3 | 14.6 | 48.0 | 33.3 | 51.5 | 2.6 | -0.1 | 11.6 |
| February | 14.2 | 12.1 | 16.3 | 46.7 | 24.0 | 51.0 | 3.8 | -0.3 | 73.0 |
| March | 16.4 | 14.4 | 18.8 | 51.0 | 44.1 | 52.9 | 3.3 | 0.0 | 16.7 |
| April | 17.5 | 15.6 | 21.0 | 52.0 | 49.5 | 52.8 | 4.5 | 0.0 | 16.1 |
| May | 19.9 | 17.4 | 23.3 | 52.1 | 50.3 | 53.6 | 2.7 | -0.2 | 19.7 |
| June | 21.8 | 19.2 | 25.4 | 50.4 | 48.0 | 51.5 | 37.8[1] | -0.4 | 275.3 |
| July | 22.1 | 18.6 | 24.2 | 49.8 | 48.0 | 50.7 | 49.4[1] | 0.0 | 283.6 |
| August | 23.0 | 19.8 | 26.1 | 50.2 | 43.3 | 51.6 | 1.5 | -0.1 | 9.7 |
| September | 21.8 | 18.0 | 25.0 | 50.6 | 49.4 | 51.3 | 3.9 | 0.0 | 28.8 |
| October | 19.4 | 16.7 | 21.8 | 50.9 | 50.1 | 51.7 | 1.5 | -0.1 | 6.2 |
| Average | 19.0 | 16.4 | 21.6 | 50.2 | 44.0 | 51.8 | 11.1 | -0.1 | 74.1 |
| **Event** | **Temperature (°C)** | | | **Specific Conductance (mS/cm)** | | | **Turbidity (NTU)** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 13.7 | 13.3 | 14.3 | 44.8 | 33.3 | 51.1 | 4.0 | 1.3 | 11.6 |
| Wet Weather 2 | 13.9 | 13.1 | 14.6 | 47.3 | 43.9 | 50.5 | 3.2 | 1.2 | 9.7 |
| Wet Weather 3 | 13.7 | 12.5 | 14.5 | 46.3 | 42.5 | 48.5 | 3.4 | 0.8 | 7.1 |
| Index Period 1 | 14.2 | 13.2 | 15.1 | 49.4 | 45.5 | 50.9 | 3.2 | 0.6 | 10.5 |
| Index Period 2 | 17.3 | 15.9 | 19.2 | 52.2 | 51.8 | 52.6 | 4.7 | 0.0 | 11.4 |
| Index Period 3 | 23.1 | 21.8 | 24.1 | 49.5 | 48.6 | 50.0 | 2.3 | 0.2 | 12.0 |
| Index Period 4 | 19.4 | 17.2 | 21.6 | 51.0 | 50.7 | 51.3 | 1.4 | 0.0 | 6.2 |
| WQO | N/A | | | N/A | | | 20 NTU | | |

(1) Elevated turbidity data is discussed in Section 3.1.1.2.

**Table 4-9: Agua Hedionda Ocean Inlet 2 Bottom (Depth 2) Continuous Data Monthly and Event Summary**

| Month (2008) | Temperature (°C) | | | Specific Conductance (mS/cm) | | | Turbidity (NTU) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | Min | Max | Mean | Min | Max | Mean | Min | Max |
| January | 13.5 | 12.3 | 14.5 | 48.9 | 41.0 | 51.6 | 3.9 | 0.0 | 20.9 |
| February | 14.1 | 13.1 | 15.5 | 47.5 | 37.9 | 50.2 | 3.9 | -0.5 | 26.3 |
| March | 16.1 | 14.4 | 18.0 | 50.8 | 46.6 | 52.2 | 14.8 | 0.0 | 78.7 |
| April | 17.3 | 15.4 | 19.9 | 51.4 | 48.7 | 52.9 | 20.2[1] | 0.0 | 417.5 |
| May | 19.7 | 17.2 | 23.0 | 51.1 | 49.3 | 52.3 | 5.0 | -1.9 | 84.6 |
| June | 21.6 | 18.9 | 24.8 | 50.1 | 47.7 | 50.8 | 13.8[1] | -0.3 | 50.2 |
| July | 21.8 | 18.5 | 24.0 | 49.2 | 47.2 | 50.6 | 24.1[1] | 0.0 | 125.8 |
| August | 22.6 | 19.7 | 25.7 | 49.3 | 48.4 | 50.3 | 3.9 | -0.1 | 21.4 |
| September | 21.5 | 18.0 | 24.5 | 49.5 | 48.8 | 50.2 | 3.9 | 0.0 | 30.3 |
| October | 19.3 | 16.7 | 21.5 | 50.1 | 49.1 | 50.6 | 26.2[1] | 1.5 | 99.4 |
| Average | 18.8 | 16.4 | 21.1 | 49.8 | 46.5 | 51.2 | 12.0 | -0.1 | 95.5 |
| **Event** | **Temperature (°C)** | | | **Specific Conductance (mS/cm)** | | | **Turbidity (NTU)** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 13.7 | 13.4 | 13.9 | 47.7 | 41.0 | 51.3 | 5.4 | 1.3 | 13.0 |
| Wet Weather 2 | 13.8 | 13.1 | 14.3 | 48.0 | 46.5 | 50.4 | 5.3 | 1.0 | 20.9 |
| Wet Weather 3 | 13.7 | 13.1 | 14.2 | 47.3 | 45.5 | 49.1 | 4.6 | 0.3 | 11.2 |
| Index Period 1 | 14.1 | 13.3 | 14.9 | 49.2 | 46.7 | 50.1 | 2.9 | -0.3 | 13.4 |
| Index Period 2 | 17.1 | 15.8 | 18.5 | 51.5 | 49.8 | 52.9 | 46.3[1] | 1.0 | 339.9 |
| Index Period 3 | 22.9 | 21.7 | 23.9 | 49.1 | 48.9 | 49.3 | 12.9[1] | 0.0 | 43.5 |
| Index Period 4 | 19.2 | 17.2 | 21.5 | 50.3 | 49.6 | 50.5 | 21.6[1] | 6.1 | 58.4 |
| WQO | N/A | | | N/A | | | 20 NTU | | |

(1) Elevated turbidity data is discussed in Section 3.1.1.2.

### 4.1.2 Agua Hedionda Wet Weather Event Monitoring

The following three wet weather events were successfully monitored at Agua Hedionda Lagoon:

- Wet Weather Event 1 occurred from January 5 to January 7, 2008. Rainfall began at 00:47 on January 5, 2008 and ended at 06:09 on January 7, 2008, totaling 2.05 inches.
- Wet Weather Event 2 occurred from January 23 to January 24, 2008. Rainfall began at 18:12 on January 23, 2008 and ended at 18:01 on January 24, 2008, totaling 0.39 inches.
- Wet Weather Event 3 occurred from February 3, 2008 to February 4, 2008. Rainfall began at 05:54 on February 3, 2008 and ended at 02:51 on February 4, 2008, totaling 0.55 inches of rainfall (0.58 inches as measured by agency performing sampling during this event).

All collected samples were placed on ice immediately after collection and stored at four degrees Celsius until delivery to the laboratory. Control of samples was maintained by Chain-of-Custody protocol from sample collection through sample analysis. All analytical methods performed on collected samples are outlined in Table 2-4 in Section 2.2.5. QA/QC samples also were collected per SWAMP requirements in accordance with the QAPP.

#### 4.1.2.1 Mass Emission Station

Two pollutagraph events and one flow-weighted composite sampling event were sampled successfully at the Agua Hedionda Mass Emission Station as required by the IO. Analytes monitored at this station were *Enterococcus* bacteria, total and fecal coliform bacteria, TDS, and TSS.

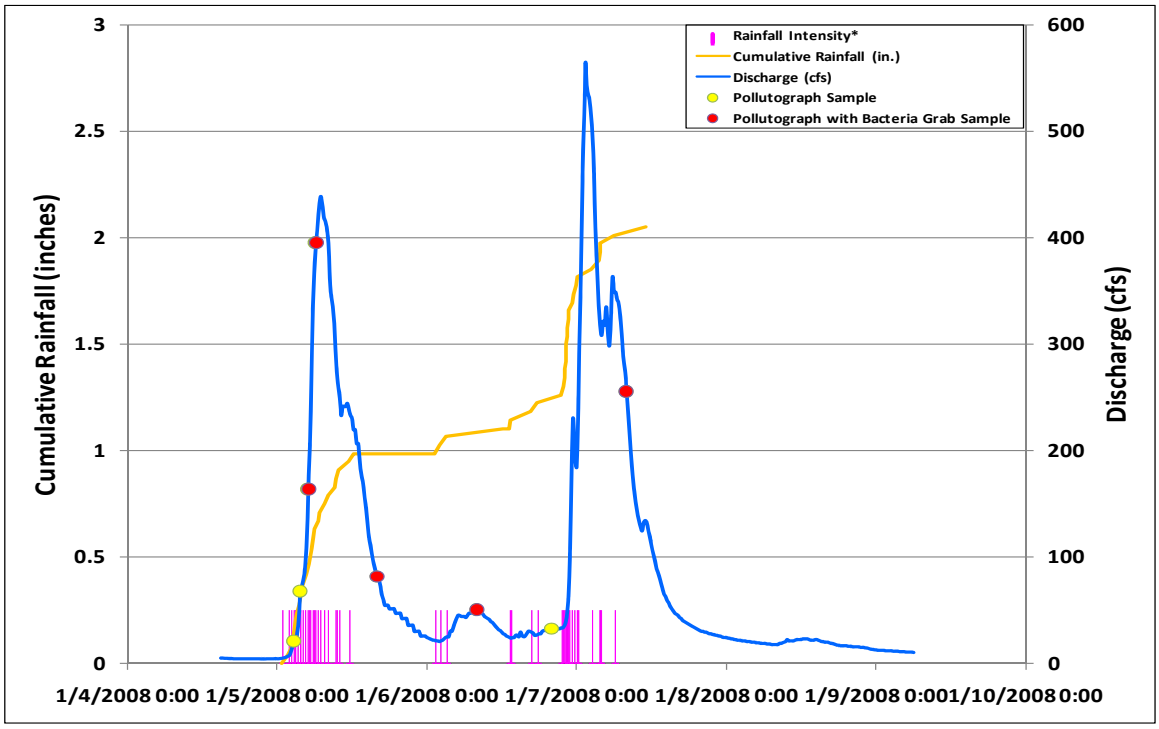
During Wet Weather Event 1, 12 pollutagraph samples were collected by the automated samplers. Eight of those 12 samples were submitted to the laboratory for TDS and TSS analysis. Samples that represented the various flow regimes, specifically the rising limbs and peaks of the hydrograph, were selected (Figure 4-1). Five microbiology grab samples were collected at targeted times during the storm event that corresponded to automated pollutagraph sample times. These samples were immediately submitted to the laboratory for analysis in order to meet the short hold time for bacteria analysis.

During Wet Weather Event 2, 12 pollutagraph samples were collected by the automated samplers. Eight of those 12 samples were submitted to the laboratory for TDS and TSS analysis. Samples that represented the various flow regimes, specifically the rising limbs and peaks of the hydrograph, were selected (Figure 4-2). Six microbiology grab samples were collected at targeted times during the storm event that corresponded to automated pollutagraph sample times. These samples were immediately submitted to the laboratory for analysis in order to meet the short holding time for bacteria analysis. Due to short holding

times for microbiology samples, a sample collected earlier in the event had to be analyzed before notice was given of a sixth collected sample that was to be included in the analyzed suite. Results for the six samples are reported.

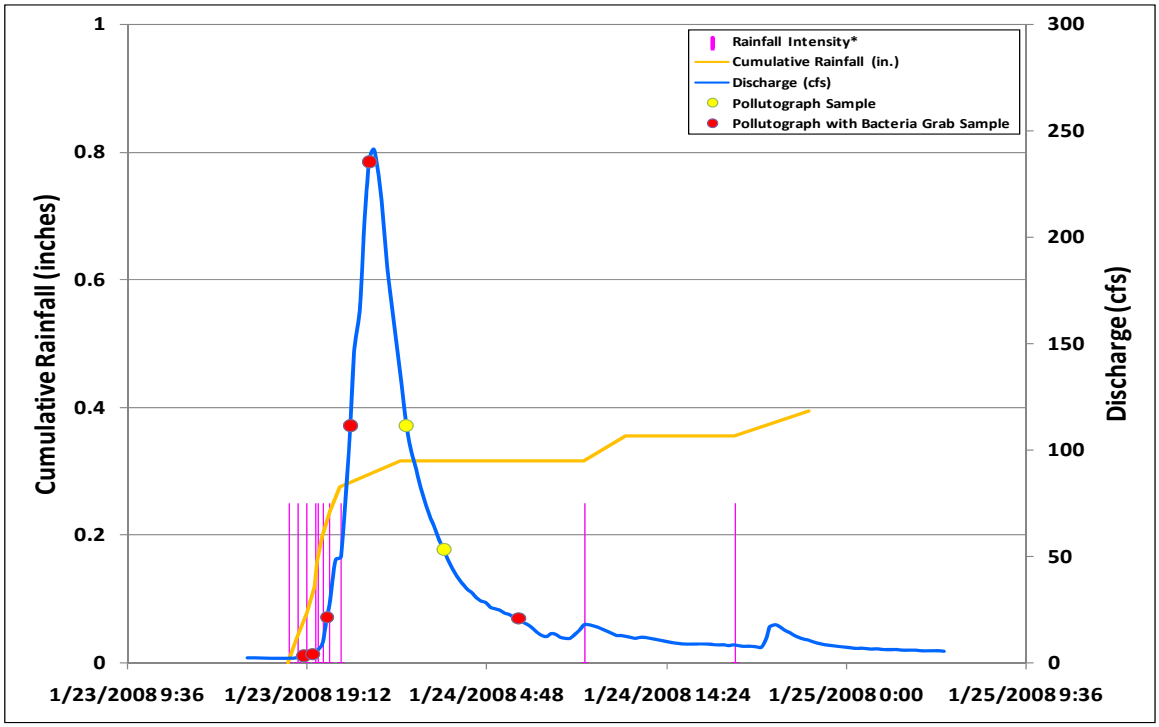
Wet Weather Event 3 was not required to be a pollutagraph sample. Instead, a flow-weighted composite sample was successfully monitored from February 3 to February 4, 2008 under the San Diego County Regional Monitoring Program, Order No. 2007-01. Rainfall began at 05:54 on February 3, 2008 and ended at 02:51 on February 4, 2008, totaling 0.55 inches of rainfall (0.58 inches as measured by agency performing sampling during this event). See Figure 4-3 for the rainfall, flow, and sampling that occurred during this event.

**Figure 4-1: Agua Hedionda Mass Emission Hydrograph and Hyetograph Wet Weather Event 1**



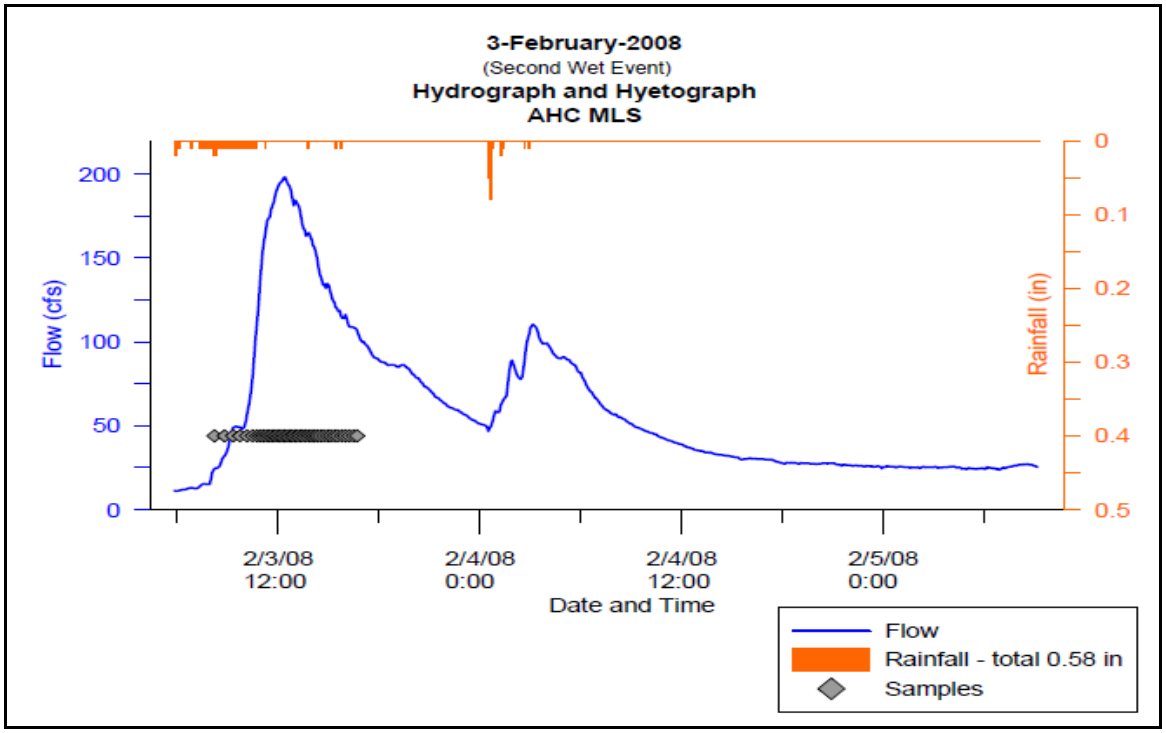

Note: Each vertical bar represents a one-millimeter rain gauge bucket tip.

**Figure 4-2: Agua Hedionda Mass Emission Hydrograph and Hyetograph Wet Weather Event 2**




Note: Each vertical bar represents a one-millimeter rain gauge bucket tip.

**Figure 4-3: Agua Hedionda Mass Emission Hydrograph and Hyetograph Wet Weather Event 3**




Note: Sampling for this event was conducted by an outside agency under the San Diego County Regional Monitoring Program, Order No. 2007-01.

Results from the two pollutagraph sampling events (Wet Weather Events 1 and 2) at the Agua Hedionda Mass Emission Station are summarized statistically in Table 4-10. The results from Wet Weather Event 3 are event mean concentrations (EMC) and those values are displayed in Table 4-11. Detailed analytical results for all wet weather events are presented in Appendix C-1.

**Table 4-10: Agua Hedionda Pollutagraph Summary Wet Weather Events 1-2**

| Event Category | Analyte | Units | Count | Mean | Median | Min | Max | WQO[1] | Percent Exceedance[2](%) |
|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 January 5-7, 2008 | *Enterococcus* | CFU/100mL | 5 | 12,520 | 10,200 | 6,100 | 26,000 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 5 | 6,700 | 7,000 | 2,200 | 14,000 | 400 | 100 |
| | Total Coliform | MPN/100mL | 5 | 55,400 | 50,000 | 17,000 | 130,000 | 10,000 | 100 |
| | TDS | mg/L | 8 | 650 | 612 | 308 | 1,354 | 500 | 63 |
| | TSS | mg/L | 8 | 92.6 | 88.5 | 32.0 | 188 | NA | NA |
| Wet Weather Event 2 January 23-25, 2008 | *Enterococcus* | CFU/100mL | 6 | 7,015 | 8,000 | 540 | 14,000 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 6 | 3,338 | 3,500 | 330 | 7,000 | 400 | 83 |
| | Total Coliform | MPN/100mL | 6 | 20,583 | 9,500 | 1,300 | 90,000 | 10,000 | 50 |
| | TDS | mg/L | 8 | 804 | 594 | 358 | 1,656 | 500 | 50 |
| | TSS | mg/L | 8 | 169 | 108 | 36.5 | 382 | NA | NA |

(1) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.
(2) The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

**Table 4-11: Agua Hedionda EMC Summary Wet Weather Event 3**

| Analyte | Units | EMC | WQO[1] | Exceedance |
|---|---|---|---|---|
| *Enterococci* | MPN/100mL | 3,000 | 276 | Yes |
| Fecal Coliform | MPN/100mL | 5,000 | 400 | Yes |
| Total Coliform | MPN/100mL | 30,000 | 10,000 | Yes |
| TDS | mg/L | 580 | 500 | Yes |
| TSS | mg/L | 215 | NA | NA |

(1) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.

#### 4.1.2.2 Lagoon Segment Site

Three events were successfully monitored at the Agua Hedionda Lagoon Segment Site as required by the IO. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, and TSS. Wet weather event sampling within the lagoon was conducted simultaneously with pollutagraph sampling and ocean inlet sampling during wet weather events. The anticipated lag time (the amount of transit time after a storm's onset before the lagoon is affected) was accounted for when preparing to initialize a sampling program.

During Wet Weather Event 1, the first composite sample was collected at the high tide that occurred at 06:41 on January 5, 2008 approximately six hours after rainfall began. The second composite sample was collected at the low tide that occurred at 14:01 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

During Wet Weather Event 2, the first composite sample was collected at the high tide that occurred at 09:49 on January 24, 2008 approximately 15 hours after rainfall began. Sampling was delayed for a longer period of time during this event for two reasons. Primarily, the rainfall was very light in intensity. This resulted in a slower transit time and therefore further delayed response within the lagoon. Secondly, the Health and Safety Plan for this project dictated that personnel cannot be out during non-daylight hours. The tide selected was the soonest possible time for sample collection to take place. The second composite sample was collected at the low tide that occurred at 16:35 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

During Wet Weather Event 3, the first composite sample was collected at the high tide that occurred at 07:03 on February 4, 2008 approximately 13 hours after rainfall began. Sampling was delayed during this event due to the timing of the storm and the Health and Safety requirements of this project. Rainfall began just before dawn on February 3, 2008. Sampling that morning would not have allowed for transit time from the watershed to the lagoon. The ideal sample time for this event would have resulted in personnel sampling during non-daylight hours, which is prohibited by the Health and Safety Plan for this project. The tide selected was the soonest possible time for sample collection to take place. The second composite sample was collected at the low tide that occurred at 14:00 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

Results from Wet Weather Events 1, 2, and 3 at the Agua Hedionda Lagoon Segment Site are summarized statistically in Table 4-12. Detailed analytical results for all wet weather events are presented in Appendix C-1.

**Table 4-12: Agua Hedionda Lagoon Segment Site Summary Wet Weather Events 1-3**

| Event | Analyte | Units | Count | Mean | Median | Min | Max | WQO | Percent Exceedance[1](%) |
|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 January 5-7, 2008 | *Enterococcus* | CFU/100mL | 2 | 1,864 | 1,864 | 27 | 3,700 | 276 | 50 |
| | Fecal Coliform | MPN/100mL | 2 | 1,565 | 1,565 | 130 | 3,000 | 400 | 50 |
| | Total Coliform | MPN/100mL | 2 | 4,065 | 4,065 | 130 | 8,000 | 10,000 | 0 |
| | TSS | mg/L | 2 | 13.1 | 13.1 | 0.3 | 26.0 | NA | NA |
| Wet Weather Event 2 January 23-24, 2008 | *Enterococcus* | CFU/100mL | 2 | 455 | 455 | 370 | 540 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 900 | 900 | 500 | 1,300 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 10,500 | 10,500 | 5,000 | 16,000 | 10,000 | 50 |
| | TSS | mg/L | 2 | 198 | 198 | 7.0 | 389 | NA | NA |
| Wet Weather Event 3 February 3-4, 2008 | *Enterococcus* | CFU/100mL | 2 | 169 | 169 | 28 | 310 | 276 | 50 |
| | Fecal Coliform | MPN/100mL | 2 | 175 | 175 | 80 | 270 | 400 | 0 |
| | Total Coliform | MPN/100mL | 2 | 1,315 | 1,315 | 230 | 2,400 | 10,000 | 0 |
| | TSS | mg/L | 2 | 57.7 | 57.7 | 17.7 | 97.7 | NA | NA |

(1) The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.1.2.4 Ocean Inlet Sites

Three events were successfully monitored at the Agua Hedionda Ocean Inlet Sites 1 and 2 as required by the IO. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, and TSS. There were two Ocean Inlet Sites (1 and 2) comprising four ocean inlet sampling locations at Agua Hedionda Lagoon (Table 2-1). Monitoring occurred at Ocean Inlet Sites 1 and 2. Both sites had a Surface (Depth 1) and a Bottom (Depth 2) sample point. As with the lagoon segment sampling, expected lag time was considered and the same protocol was followed for sampling program initiation.

During Wet Weather Event 1, the first composite samples were collected at the high tide that occurred at 06:41 on January 5, 2008 approximately six hours after rainfall began. The second composite samples were collected at the low tide that occurred at 14:01 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples. Samples were missed during this event from the Ocean Inlet 2 Bottom (Depth 2) location due to field error. The problem was resolved immediately and did not affect any further sampling events. The three other sample points were successfully sampled during this event.

During Wet Weather Event 2, the first composite samples were collected at the high tide that occurred at 09:49 on January 24, 2008 approximately 15 hours after rainfall began. Sampling was delayed for a longer period of time during this event for two reasons. Primarily, the rainfall was very light in intensity. This resulted in a slower transit time, and, therefore further delayed response within the lagoon. Secondly, the Health and Safety Plan for this project dictated that personnel could not be out during non-daylight hours. The tide selected was the soonest possible time for sample collection to take place. The second composite samples were collected at the low tide that occurred at 16:35 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples. The four sample points were successfully sampled during this event.

During Wet Weather Event 3, the first composite samples were collected at the high tide that occurred at 07:03 on February 4, 2008 approximately 3 hours after rainfall began. Sampling was delayed during this event due to the timing of the storm and the Health and Safety requirements of this project. Rainfall began just before dawn on February 3, 2008. Sampling that morning would not have allowed for transit time from the watershed to the lagoon. The ideal sample time for this event would have resulted in personnel sampling during non-daylight hours which was prohibited by the Health and Safety Plan for this project. The tide selected was the soonest possible time for sample collection to take place. The second composite samples were collected at the low tide that occurred at 14:00 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples. The four sample points were successfully sampled during this event.

Results from Wet Weather Events 1, 2, and 3 at the four Agua Hedionda Ocean Inlet locations are summarized statistically in Tables 4-13 and 4-14. Detailed analytical results for all wet weather events are presented in Appendix C-1.

**Table 4-13: Agua Hedionda Ocean Inlet 1 Summary Wet Weather Events 1-3**

| Event | Depth | Analyte | Units | Count | Mean | Median | Min | Max | WQO | Percent Exceedance[1](%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 January 5-7, 2008 | Surface (Depth 1) | *Enterococcus* | CFU/100mL | 2 | 197 | 197 | 174 | 220 | 276 | 0 |
| | | Fecal Coliform | MPN/100mL | 2 | 40 | 40 | 40 | 40 | 400 | 0 |
| | | Total Coliform | MPN/100mL | 2 | 800 | 800 | 300 | 1,300 | 10,000 | 0 |
| | | TSS | mg/L | 2 | 3.5 | 3.5 | 2.0 | 5.0 | NA | NA |
| | Bottom (Depth 2) | *Enterococcus* | CFU/100mL | 2 | 142 | 142 | 122 | 162 | 276 | 0 |
| | | Fecal Coliform | MPN/100mL | 2 | 150 | 150 | 70 | 230 | 400 | 0 |
| | | Total Coliform | MPN/100mL | 2 | 600 | 600 | 300 | 900 | 10,000 | 0 |
| | | TSS | mg/L | 2 | 6.5 | 6.5 | 4.0 | 9.0 | NA | NA |
| Wet Weather Event 2 January 23-24, 2008 | Surface (Depth 1) | *Enterococcus* | CFU/100mL | 2 | 36 | 36 | 1 | 70 | 276 | 0 |
| | | Fecal Coliform | MPN/100mL | 2 | 80 | 80 | 80 | 80 | 400 | 0 |
| | | Total Coliform | MPN/100mL | 2 | 1,100 | 1,100 | 500 | 1,700 | 10,000 | 0 |
| | | TSS | mg/L | 2 | 5.0 | 5.0 | 5.0 | 5.0 | NA | NA |
| | Bottom (Depth 2) | *Enterococcus* | CFU/100mL | 2 | 55 | 55 | 30 | 80 | 276 | 0 |
| | | Fecal Coliform | MPN/100mL | 2 | 45 | 45 | 20 | 70 | 400 | 0 |
| | | Total Coliform | MPN/100mL | 2 | 385 | 385 | 270 | 500 | 10,000 | 0 |
| | | TSS | mg/L | 2 | 13.0 | 13.0 | 3.3 | 22.7 | NA | NA |
| Wet Weather Event 3 February 3-4, 2008 | Surface (Depth 1) | *Enterococcus* | CFU/100mL | 2 | 119 | 119 | 58 | 180 | 276 | 0 |
| | | Fecal Coliform | MPN/100mL | 2 | 180 | 180 | 130 | 230 | 400 | 0 |
| | | Total Coliform | MPN/100mL | 2 | 665 | 665 | 230 | 1,100 | 10,000 | 0 |
| | | TSS | mg/L | 2 | 93.7 | 93.7 | 15.0 | 172.3 | NA | NA |
| | Bottom (Depth 2) | *Enterococcus* | CFU/100mL | 2 | 113 | 113 | 16 | 210 | 276 | 0 |
| | | Fecal Coliform | MPN/100mL | 2 | 75 | 75 | 20 | 130 | 400 | 0 |
| | | Total Coliform | MPN/100mL | 2 | 320 | 320 | 140 | 500 | 10,000 | 0 |
| | | TSS | mg/L | 2 | 109 | 109 | 24.7 | 194 | NA | NA |

(1) The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

**Table 4-14: Agua Hedionda Ocean Inlet 2 Summary Wet Weather Events 1-3**

| Event | Depth | Analyte | Units | Count | Mean | Median | Min | Max | WQO | Percent Exceedance[1](%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 January 5-7, 2008 | Surface (Depth 1) | *Enterococcus* | CFU/100mL | 2 | 895 | 895 | 290 | 1,500 | 276 | 100 |
| | | Fecal Coliform | MPN/100mL | 2 | 440 | 440 | 80 | 800 | 400 | 50 |
| | | Total Coliform | MPN/100mL | 2 | 4,650 | 4,650 | 300 | 9,000 | 10,000 | 0 |
| | | TSS | mg/L | 2 | 43.5 | 43.5 | 28.0 | 59.0 | NA | NA |
| | Bottom (Depth 2) | *Enterococcus* | CFU/100mL | Samples not collected | | | | | | |
| | | Fecal Coliform | MPN/100mL | | | | | | | |
| | | Total Coliform | MPN/100mL | | | | | | | |
| | | TSS | mg/L | | | | | | | |
| Wet Weather Event 2 January 23-24, 2008 | Surface (Depth 1) | *Enterococcus* | CFU/100mL | 2 | 400 | 400 | 390 | 410 | 276 | 100 |
| | | Fecal Coliform | MPN/100mL | 2 | 1,800 | 1,800 | 800 | 2,800 | 400 | 100 |
| | | Total Coliform | MPN/100mL | 2 | 9,000 | 9,000 | 9,000 | 9,000 | 10,000 | 0 |
| | | TSS | mg/L | 2 | 90.2 | 90.2 | 7.3 | 173 | NA | NA |
| | Bottom (Depth 2) | *Enterococcus* | CFU/100mL | 2 | 420 | 420 | 190 | 650 | 276 | 50 |
| | | Fecal Coliform | MPN/100mL | 2 | 550 | 550 | 300 | 800 | 400 | 50 |
| | | Total Coliform | MPN/100mL | 2 | 9,922 | 9,922 | 3,843 | 16,000 | 10,000 | 50 |
| | | TSS | mg/L | 2 | 79.4 | 79.4 | 31.7 | 127 | NA | NA |
| Wet Weather Event 3 February 3-4, 2008 | Surface (Depth 1) | *Enterococcus* | CFU/100mL | 2 | 150 | 150 | 100 | 200 | 276 | 0 |
| | | Fecal Coliform | MPN/100mL | 2 | 240 | 240 | 80 | 400 | 400 | 0 |
| | | Total Coliform | MPN/100mL | 2 | 2,650 | 2,650 | 1,300 | 4,000 | 10,000 | 0 |
| | | TSS | mg/L | 2 | 19.5 | 19.5 | 10.7 | 28.3 | NA | NA |
| | Bottom (Depth 2) | *Enterococcus* | CFU/100mL | 2 | 150 | 150 | 130 | 170 | 276 | 0 |
| | | Fecal Coliform | MPN/100mL | 2 | 32 | 32 | 23 | 40 | 400 | 0 |
| | | Total Coliform | MPN/100mL | 2 | 515 | 515 | 230 | 800 | 10,000 | 0 |
| | | TSS | mg/L | 2 | 23.2 | 23.2 | 18.3 | 28.0 | NA | NA |

(1) The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.1.2.5 Mass Emission Station Wet Weather Aqueous Sediment Grain Size

In addition to the chemical constituents required for a given impairment, all lagoons were monitored for grain size distribution of aqueous sediment (suspended sediment) at the mass emission site during both required pollutagraph monitoring events of the season. The samples submitted to the laboratory consisted of one composite sample per lagoon. Each sample was composited from the pollutagraph samples, based on event, collected over the course of the storm. The samples were analyzed for grain size distribution among the following size categories: clay < 0.0039 millimeters, silt 0.0039 to < 0.0625 millimeters, sand

0.0625 to < 2.0 millimeters, and granule 2.0 to < 4.0 millimeters. Results of the aqueous grain size distribution during both wet weather events are summarized in Table 4-15.

**Table 4-15: Agua Hedionda Aqueous Grain Size Distribution Wet Weather Events 1-2**

| Grain Size Classes | Units | Wet Weather Event 1 1/5-7/08 | Wet Weather Event 2 1/23-24/08 |
|---|---|---|---|
| Clay < 0.0039 mm | % | 18.4 | 22.6 |
| Silt 0.0039 to < 0.0625 mm | % | 72.9 | 63.9 |
| Sand 0.0625 to < 2.0 mm | % | 8.7 | 13.5 |
| Granule 2.0 to < 4.0 mm | % | 0.0 | 0.0 |

Note: Analysis was run on a composite of all pollutagraph samples collected for each storm.

4.1.2.6 Post-Storm Sediment

Post-storm event sediment sampling at Agua Hedionda Lagoon occurred on January 14, 2008, seven days after the end of the first sampled storm event. Sampling occurred at the Agua Hedionda Lagoon Segment Site and both Ocean Inlet 1 and 2 locations. These samples were analyzed for percentage of sand only. The analytical results are summarized statistically in Table 4-16. These data along with the associated sample locations will be used in a special study by SCCWRP to determine the characteristics of sediments and where they settle in the lagoon. Detailed analytical results for all wet weather events are presented in Appendix C-1.

**Table 4-16: Agua Hedionda Post-Storm Sediment Results (January 14, 2008)**

| Monitoring Location | % Analyte | Number of Samples | Mean | SD | CV | Median | Min | Max |
|---|---|---|---|---|---|---|---|---|
| Agua Hedionda Ocean Inlet 1 | % Sand | 9 | 90.46 | 3.96 | 0.044 | 92.4 | 82.9 | 96.0 |
| Agua Hedionda Ocean Inlet 2 | % Sand | 12 | 67.69 | 19.77 | 0.292 | 69.1 | 22.4 | 95.5 |
| Agua Hedionda Lagoon Segment Site | % Sand | 8 | 28.04 | 20.88 | 0.745 | 17.3 | 8.9 | 63.1 |

### 4.1.3 Agua Hedionda Index Period Monitoring

Four index period events were successfully monitored at all sample locations associated with Agua Hedionda Lagoon. Each index period event spanned six days and generally took place over a period of

two weeks. Index Period Events 1, 2, 3, and 4 at Agua Hedionda Lagoon occurred in February, April, July, and October 2008, respectively.

All samples collected were placed on ice immediately after collection and stored at four degrees Celsius until delivery to the laboratory. Control of samples was maintained by Chain-of-Custody protocol from sample collection through sample analysis. All analytical methods performed on collected samples are outlined in Table 2-4 in Section 2.2.5. QA/QC samples also were collected per SWAMP requirements in accordance with the QAPP.

#### 4.1.3.1 Mass Emission Station

Sampling at the Agua Hedionda Mass Emission Station was conducted once daily during the same index periods as the lagoon segment and ocean inlet sampling. Sampling at this station occurred between the tidally-regulated sample times at the lagoon segment and ocean inlet sites. Daily time-weighted composite samples were collected. Automated sampling equipment was programmed to collect aliquots every 15 minutes for a 30-minute period. Microbiology grab samples were collected concurrently with the composite samples.

All four events were sampled successfully at the Agua Hedionda Mass Emission Station. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, TDS, and TSS. Table 4-17 shows sampling schedule dates.

**Table 4-17: Agua Hedionda Mass Emission Station Index Period Sampling Schedule**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Index Period Event 1 | Day of the Week | Thursday | Friday | Monday | Tuesday | Wednesday | Tuesday |
| | Date | 2/7/2008 | 2/8/2008 | 2/11/2008 | 2/12/2008 | 2/13/2008 | 2/19/2008 |
| Index Period Event 2 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 4/7/2008 | 4/8/2008 | 4/09/2008 | 4/14/2008 | 4/15/2008 | 4/16/2008 |
| Index Period Event 3 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 7/21/2008 | 7/22/2008 | 7/23/2008 | 7/28/2008 | 7/29/2008 | 7/30/2008 |
| Index Period Event 4 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 10/07/2008 | 10/08/2008 | 10/09/2008 | 10/13/2008 | 10/14/2008 | 10/15/2008 |

Sampling during Index Period Event 1 was spread out over three different weeks as an unanticipated storm caused the last sample day to be pushed back. Per instructions from the RPs, dry weather sampling did not occur less than 72 hours after a rain event. All other index period events were sampled according to the general two-week approach.

Results from the four index period sampling events at the Agua Hedionda Mass Emission Station are summarized statistically in Table 4-18. Detailed analytical results for all wet weather events are presented in Appendix C-1.

**Table 4-18: Agua Hedionda Mass Emission Station Summary Index Period Events 1-4**

| Event | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO[2] | Exceedance[3] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 6 | 119 | 123 | 82 | 180 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 107 | 116 | 46 | 190 | 200 | No |
| | Total Coliform | CFU/100mL | 6 | 213 | 232 | 124 | 268 | 1,000 | No |
| | TDS | mg/L | 6 | 1,740 | 1,617 | 1,606 | 2,184 | 500 | 100% |
| | TSS | mg/L | 6 | 5.5 | 4.8 | 3.0 | 10.3 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 6 | 120 | 116 | 84 | 184 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 247 | 230 | 156 | 630 | 200 | Yes |
| | Total Coliform | CFU/100mL | 6 | 509 | 460 | 160 | 1,600 | 1,000 | No |
| | TDS | mg/L | 6 | 2,047 | 2,022 | 1,920 | 2,230 | 500 | 100% |
| | TSS | mg/L | 6 | 1.2 | 1.0 | 0.3 | 3.0 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | 6 | 270 | 262 | 104 | 536 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 834 | 585 | 480 | 3,940 | 200 | Yes |
| | Total Coliform | CFU/100mL | 6 | 2,129 | 1,820 | 1,660 | 3,960 | 1,000 | Yes |
| | TDS | mg/L | 6 | 2,021 | 2,011 | 1,960 | 2,074 | 500 | 100% |
| | TSS | mg/L | 6 | 6.7 | 3.8 | 1.2 | 17.0 | NA | NA |
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 6 | 199 | 201 | 128 | 360 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 651 | 565 | 360 | 1,820 | 200 | Yes |
| | Total Coliform | CFU/100mL | 6 | 1,415 | 1,510 | 620 | 2,420 | 1,000 | Yes |
| | TDS | mg/L | 6 | 2,199 | 2,136 | 1,840 | 2,586 | 500 | 100% |
| | TSS | mg/L | 6 | 5.7 | 4.2 | 3.0 | 15.0 | NA | NA |

(1) For general chemistry, means were calculated as arithmetic means. For bacteria (Enterococcus, fecal coliform, and total coliform), means were calculated as geometric means.
(2) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.
(3) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.1.3.2 Lagoon Segment Site

Two composite samples were collected per day at the Agua Hedionda Lagoon Segment Site. One sample was collected during slack low tide and one sample was collected during slack high tide. Composite samples were collected using automated sampling equipment programmed to collect aliquots every 15 minutes for a thirty-minute period. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

All four events were sampled successfully at the Agua Hedionda Lagoon Segment Site. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, and TSS. Sampling at the lagoon segment followed the same schedule as the ocean inlet sites. Refer to Table 4-19 for sampling schedule dates and tidal information.

Results from the four index period sampling events at the lagoon segment are summarized statistically in Table 4-20. Detailed analytical results for all wet weather events are presented in Appendix C-1.

**Table 4-19: Agua Hedionda Lagoon Segment/Ocean Inlet Sites Index Period Sampling Schedule**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Index Period Event 1 | Day of the Week | Thursday | Friday | Monday | Tuesday | Wednesday | Tuesday |
| | Date | 2/7/2008 | 2/8/2008 | 2/11/2008 | 2/12/2008 | 2/13/2008 | 2/19/2008 |
| | 1st Composite | High: 0848 | High: 0924 | Low: 0542 | Low: 0653 | Low: 0829 | High: 0738 |
| | 2nd Composite | Low: 1535 | Low: 1603 | High: 1134 | High: 1243 | High: 1443 | Low: 1429 |
| Index Period Event 2 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 4/7/2008 | 4/8/2008 | 4/09/2008 | 4/14/2008 | 4/15/2008 | 4/16/2008 |
| | 1st Composite | High: 1059 | High: 1154 | High: 1302 | Low: 1233 | High: 0641 | High: 0733 |
| | 2nd Composite | Low: 1618 | Low: 1651 | Low: 1728 | High: 0720 | Low: 1313 | Low: 1346 |
| Index Period Event 3 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 7/21/2008 | 7/22/2008 | 7/23/2008 | 7/28/2008 | 7/29/2008 | 7/30/2008 |
| | 1st Composite | High: 1222 | High: 1255 | Low: 0650 | High: 0759 | High: 0845 | High: 0922 |
| | 2nd Composite | Low: 1735 | Low: 1828 | High: 1333 | Low: 1149 | Low: 1259 | Low: 1357 |
| Index Period Event 4 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 10/07/2008 | 10/08/2008 | 10/09/2008 | 10/13/2008 | 10/14/2008 | 10/15/2008 |
| | 1st Composite | High: 1002 | High: 1136 | Low: 0718 | Low: 0836 | Low: 0904 | High: 0934 |
| | 2nd Composite | Low: 1553 | Low: 1715 | High: 1224 | High: 1453 | High: 1534 | Low: 1617 |

**Table 4-20: Agua Hedionda Lagoon Segment Site Summary Index Period Events 1-4**

| Event | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 12 | 4 | 3 | 2 | 56 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 3 | 2 | 2 | 22 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 11 | 12 | 4 | 48 | 1,000 | No |
| | TSS | mg/L | 12 | 18.7 | 11.9 | 3.3 | 89.0 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 12 | 3 | 3 | 2 | 12 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 6 | 4 | 4 | 12 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 11 | 10 | 4 | 50 | 1,000 | No |
| | TSS | mg/L | 12 | 44.6 | 29.0 | 11.0 | 108.0 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | 12 | 5 | 5 | 2 | 24 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 9 | 8 | 4 | 28 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 8 | 6 | 4 | 32 | 1,000 | No |
| | TSS | mg/L | 12 | 40.4 | 40.5 | 0.3 | 142.0 | NA | NA |
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 12 | 14 | 10 | 2 | 736 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 14 | 9 | 4 | 880 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 27 | 10 | 10 | 1,450 | 1,000 | No |
| | TSS | mg/L | 12 | 93.8 | 25.8 | 10.0 | 425.0 | NA | NA |

(1) For general chemistry, means were calculated as arithmetic means. For bacteria (Enterococcus, fecal coliform, and total coliform), means were calculated as geometric means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.1.3.3 Ocean Inlet Sites

Both Agua Hedionda Ocean Inlet Sites (1 and 2) had a Surface (Depth 1) and a Bottom (Depth 2) sample point (Table 2-1). Two composite samples were collected per day at each of the four ocean inlet sample points. One sample was collected during slack low tide and one sample was collected during slack high tide. Composite samples were collected using automated sampling equipment programmed to collect aliquots every 15 minutes for a 30-minute period. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples. Automated sampling equipment was used in manual mode in order to collect microbiology grab samples at both bottom sample points.

All four events were sampled successfully at the ocean inlet sites. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, and TSS. Sampling at the ocean inlets followed the same schedule as the lagoon segment. Table 4-19 shows sampling schedule dates and tidal information.

Results from the four index period sampling events at the two ocean inlet sites are summarized statistically in Tables 4-21 and 4-22. Detailed analytical results for all wet weather events are presented in Appendix C-1.

**Table 4-21: Agua Hedionda Ocean Inlet Site 1 Summary Index Period Events 1-4**

| Event | Depth | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | Surface (Depth 1) | *Enterococcus* | CFU/100mL | 12 | 3 | 2 | 2 | 16 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 2 | 2 | 2 | 16 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 7 | 8 | 4 | 12 | 1,000 | No |
| | | TSS | mg/L | 12 | 14.0 | 8.7 | 1.6 | 49.3 | NA | NA |
| | Bottom (Depth 2) | *Enterococcus* | CFU/100mL | 12 | 2 | 2 | 2 | 18 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 3 | 2 | 2 | 14 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 9 | 8 | 4 | 56 | 1,000 | No |
| | | TSS | mg/L | 12 | 26.1 | 16.2 | 1.7 | 131.3 | NA | NA |
| Index Period Event 2 | Surface (Depth 1) | *Enterococcus* | CFU/100mL | 12 | 2 | 2 | 2 | 2 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 8 | 7 | 4 | 36 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 14 | 20 | 4 | 48 | 1,000 | No |
| | | TSS | mg/L | 12 | 41.8 | 26.2 | 4.0 | 159.3 | NA | NA |
| | Bottom (Depth 2) | *Enterococcus* | CFU/100mL | 12 | 2 | 2 | 2 | 4 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 7 | 4 | 4 | 32 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 11 | 10 | 4 | 32 | 1,000 | No |
| | | TSS | mg/L | 12 | 51.3 | 12.5 | 4.3 | 419.3 | NA | NA |
| Index Period Event 3 | Surface (Depth 1) | *Enterococcus* | CFU/100mL | 12 | 2 | 2 | 2 | 4 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 7 | 4 | 4 | 64 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 7 | 4 | 4 | 64 | 1,000 | No |
| | | TSS | mg/L | 12 | 7.8 | 4.8 | 0.3 | 47.5 | NA | NA |
| | Bottom (Depth 2) | *Enterococcus* | CFU/100mL | 12 | 2 | 2 | 2 | 6 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 6 | 4 | 4 | 56 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 7 | 4 | 4 | 56 | 1,000 | No |
| | | TSS | mg/L | 12 | 10.4 | 4.5 | 0.3 | 71.3 | NA | NA |
| Index Period Event 4 | Surface (Depth 1) | *Enterococcus* | CFU/100mL | 12 | 2 | 2 | 2 | 6 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 5 | 4 | 4 | 12 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 10 | 10 | 10 | 10 | 1,000 | No |
| | | TSS | mg/L | 12 | 8.2 | 6.3 | 2.5 | 22.0 | NA | NA |
| | Bottom (Depth 2) | *Enterococcus* | CFU/100mL | 12 | 2 | 2 | 2 | 6 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 5 | 4 | 4 | 12 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 12 | 10 | 10 | 30 | 1,000 | No |
| | | TSS | mg/L | 12 | 14.3 | 8.5 | 3.0 | 59.5 | NA | NA |

(1) For general chemistry, means were calculated as arithmetic means. For bacteria (Enterococcus, fecal coliform, and total coliform), means were calculated as geometric means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

**Table 4-22: Agua Hedionda Ocean Inlet Site 2 Summary Index Period Events 1-4**

| Event | Depth | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | Surface (Depth 1) | *Enterococcus* | CFU/100mL | 12 | 4 | 5 | 2 | 10 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 3 | 3 | 2 | 8 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 13 | 16 | 4 | 24 | 1,000 | No |
| | | TSS | mg/L | 12 | 13.4 | 13.5 | 3.3 | 25.0 | NA | NA |
| | Bottom (Depth 2) | *Enterococcus* | CFU/100mL | 12 | 6 | 6 | 2 | 22 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 3 | 2 | 2 | 22 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 10 | 10 | 4 | 52 | 1,000 | No |
| | | TSS | mg/L | 12 | 29.7 | 12.2 | 4.0 | 137.3 | NA | NA |
| Index Period Event 2 | Surface (Depth 1) | *Enterococcus* | CFU/100mL | 12 | 3 | 2 | 2 | 8 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 7 | 4 | 4 | 44 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 13 | 10 | 4 | 52 | 1,000 | No |
| | | TSS | mg/L | 12 | 132.9 | 24.5 | 7.0 | 774.0 | NA | NA |
| | Bottom (Depth 2) | *Enterococcus* | CFU/100mL | 12 | 5 | 6 | 2 | 16 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 9 | 6 | 4 | 60 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 16 | 16 | 4 | 64 | 1,000 | No |
| | | TSS | mg/L | 12 | 102.7 | 101.0 | 14.0 | 244.0 | NA | NA |
| Index Period Event 3 | Surface (Depth 1) | *Enterococcus* | CFU/100mL | 12 | 8 | 4 | 2 | 76 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 5 | 4 | 4 | 48 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 7 | 4 | 4 | 48 | 1,000 | No |
| | | TSS | mg/L | 12 | 11.2 | 10.3 | 0.7 | 22.4 | NA | NA |
| | Bottom (Depth 2) | *Enterococcus* | CFU/100mL | 12 | 7 | 3 | 2 | 222 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 9 | 8 | 4 | 44 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 7 | 4 | 4 | 36 | 1,000 | No |
| | | TSS | mg/L | 12 | 27.9 | 25.3 | 1.0 | 60.2 | NA | NA |
| Index Period Event 4 | Surface (Depth 1) | *Enterococcus* | CFU/100mL | 12 | 2 | 2 | 2 | 8 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 6 | 4 | 4 | 16 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 17 | 20 | 10 | 40 | 1,000 | No |
| | | TSS | mg/L | 12 | 43.2 | 19.2 | 10.5 | 185.0 | NA | NA |
| | Bottom (Depth 2) | *Enterococcus* | CFU/100mL | 12 | 2 | 2 | 2 | 4 | 35 | No |
| | | Fecal Coliform | CFU/100mL | 12 | 7 | 6 | 4 | 16 | 200 | No |
| | | Total Coliform | CFU/100mL | 12 | 14 | 15 | 10 | 20 | 1,000 | No |
| | | TSS | mg/L | 12 | 44.8 | 29.5 | 11.5 | 162.7 | NA | NA |

(1) For general chemistry, means were calculated as arithmetic means. For bacteria (Enterococcus, fecal coliform, and total coliform), means were calculated as geometric means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.1.3.4 Transect Sampling

Longitudinal transect sampling was conducted at three designated locations along a salinity gradient within the eastern-most basin of Agua Hedionda Lagoon. Sampling events occurred once during each index period event and included sampling once during the flood tide and once during the ebb tide on the same day. Specific conductivity, temperature, turbidity, DO, and pH water quality parameters also were measured concurrent to sample collection at each site and results are presented in Appendix C-1. Results from transect sampling events are summarized statistically in Table 4-23. Detailed analytical results for all wet weather events are presented in Appendix C-1.

**Table 4-23: Agua Hedionda Longitudinal Transect Data Summary Index Period Events 1-4**

| Event | Analyte Name | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | 6 | 3 | 3 | 2 | 8 | 35 | No |
| | Fecal Coliform | 6 | 3 | 2 | 2 | 12 | 200 | No |
| | Total Coliform | 6 | 9 | 10 | 4 | 24 | 1,000 | No |
| | TSS | 6 | 7.1 | 7.3 | 5.3 | 8.7 | NA | NA |
| Index Period Event 2 | *Enterococcus* | 6 | 2 | 2 | 2 | 6 | 35 | No |
| | Fecal Coliform | 6 | 8 | 6 | 4 | 32 | 200 | No |
| | Total Coliform | 6 | 23 | 30 | 10 | 60 | 1,000 | No |
| | TSS | 6 | 8.1 | 6.3 | 3.8 | 15.8 | NA | NA |
| Index Period Event 3 | *Enterococcus* | 6 | 3 | 2 | 2 | 18 | 35 | No |
| | Fecal Coliform | 6 | 10 | 4 | 4 | 184 | 200 | No |
| | Total Coliform | 6 | 13 | 6 | 4 | 220 | 1,000 | No |
| | TSS | 6 | 3.2 | 3.5 | 1.7 | 4.0 | NA | NA |
| Index Period Event 4 | *Enterococcus* | 6 | 3 | 2 | 2 | 10 | 35 | No |
| | Fecal Coliform | 6 | 6 | 4 | 4 | 16 | 200 | No |
| | Total Coliform | 6 | 17 | 15 | 10 | 40 | 1,000 | No |
| | TSS | 6 | 3.0 | 3.0 | 2.5 | 4.0 | NA | NA |

Note: Transects were sampled at high and low tides each index period within Agua Hedionda Lagoon.
(1) For general chemistry, means were calculated as arithmetic means. For bacteria (Enterococcus, fecal coliform, and total coliform), means were calculated as geometric means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.1.3.5 Specific Conductivity

Specific conductivity was continuously measured at all sample locations during the four index periods. Specific conductivity was lowest at all stations during Index Period Event 1, which occurred in the wet season and experienced a higher input of freshwater from the watershed. The Agua Hedionda Mass Emission Station consistently reported low specific conductivity values close to the typical freshwater

range (less than 1.072 mS/cm) as the station is beyond the range of tidal influence. All other sites reported specific conductivity values that generally were near the range of normal seawater (50 mS/cm to 56 mS/cm), with the exception of occasional wet weather events (United States Office of Naval Research).

Tables 4-4 through 4-9 summarize statistically, by both month and monitoring event, results for all continuously-monitored parameters at all sites. Detailed continuous monitoring results from the entire monitoring period are presented in Appendix B-1.

#### 4.1.3.6 Temperature

Temperature was continuously measured at all sample locations during the four index periods. Seasonal variation in temperature was reflected at all sample locations. Temperature averages and ranges were very similar at all sites with the exception of the Agua Hedionda Mass Emission Station. Although the average was roughly the same as the other sites, the mass emission site experienced a much larger range in temperature, likely due to the lack of tidal influence maintaining a tighter temperature range. Seasonal differences in flow at the mass emission site allow for more extreme cooling and heating of the water column as well. Temperature was lowest at all sites during Index Period Event 1, which occurred in the wet season and experienced a higher input of freshwater from the watershed.

Tables 4-4 through 4-9 summarize statistically, by both month and monitoring event, results for all continuously-monitored parameters at all sites. Detailed continuous monitoring results from the entire monitoring period are presented in Appendix B-1.

#### 4.1.3.7 Turbidity

Turbidity was measured at all sample locations during the four index periods. Turbidity was generally low during the index period sampling events. Turbidity was highest at all sites during Index Period Event 1, which occurred in the wet season and experienced a higher input of freshwater transporting sediment from the watershed. Turbidity spikes associated with storm events were most profound at the mass emission station and dampened through the lagoon and ocean inlet sites.

Tables 4-4 through 4-9 summarize statistically, by both month and monitoring event, results for all continuously-monitored parameters at all sites. Detailed continuous monitoring results from the entire monitoring period are presented in Appendix B-1.

4.1.3.8 Storm Drain and Tributary Sampling

Storm drain and tributary sampling occurred at the two designated locations once during each of the index period sampling events. Flow conditions were noted at each location during each sampling event. Sample dates and analytical results are summarized in Table 4-24.

**Table 4-24: Agua Hedionda Storm Drain Sampling Results Index Period Events 1-4**

| Analyte Name | Units | Index Period Event 1 | | Index Period Event 2 | | Index Period Event 3 | | Index Period Event 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2/7/2008 | 2/8/2008 | 4/8/2008 | | 7/21-23/2008[1] | | 10/8/2008 | |
| | | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 |
| *Enterococcus* | CFU/100mL | 200 | 160 | 5,100 | 240 | 3,300 | 700 | 5,000 | 400 |
| Fecal Coliform | CFU/100mL | 900 | 350 | 3,400 | 300 | 6,500 | 1,600 | 85,000 | 2,050 |
| Total Coliform | CFU/100mL | 2,000 | 3,800 | 38,400 | 4,600 | 25,600 | 8,000 | 12,8000 | 22,000 |
| TSS | mg/L | 1 | 2.4 | 4 | 3.2 | 4.8 | 1.2 | 3 | 2.5 |
| Turbidity | NTU | 0.593 | 7.82 | 1.79 | 2.81 | 4.13 | 1.38 | 1.55 | 2.11 |
| Flow | cfs | 3,080 | 3,369 | 9,625 | 3,273 | 2,695 | 2,888 | 963 | 3,273 |

(1) TSS and turbidity samples were collected July 21, 2008, and bacteria samples were collected July 23, 2008.

### 4.1.4 Agua Hedionda Land Elevation Survey of Ocean Inlet Sites

Land elevation surveys were conducted at two locations at the Agua Hedionda Ocean Inlet Site 1 prior to all index periods. Figure 4-4 depicts the locations of the two cross-sections at Ocean Inlet Site 1. The surveys of the ocean inlet locations were conducted in January, March, July, and September 2008. Results from land elevation surveys are presented in Appendix J-1.

### 4.1.5 Agua Hedionda Open Ocean Inlet Days

The Agua Hedionda Ocean Inlet Site 1 is located at the mouth of the lagoon that opens to the ocean, and was open throughout the entire monitoring period associated with this program.

**Figure 4-4: Agua Hedionda Ocean Inlet Land Elevation Survey Locations**

## 4.2 BUENA VISTA LAGOON MONITORING RESULTS

This section summarizes results from the continuous monitoring as well as wet weather and index period events. Detailed discussion of the results is presented in section 6.1.

### 4.2.1 Buena Vista Continuous Monitoring

Continuous monitoring at Buena Vista Lagoon included the following parameters:

- Rainfall (mass emission station only)
- Flow (mass emission station only)
- Specific conductivity
- Temperature
- Turbidity
- Dissolved Oxygen (DO)
- pH
- Water level (lagoon segment sites)

In accordance with the QAPP, flow, rainfall, specific conductivity, and temperature monitoring was conducted from October 2007 to October 2008 at the Buena Vista Mass Emission Station and monitoring of turbidity and DO was conducted from January 2008 to October 2008. Although monitoring of pH was required from January 2008 to October 2008, it was monitored from October 2007 to October 2008 at the Mass Emission Station. Monitoring of specific conductivity, temperature, turbidity, DO, pH, and water level at lagoon segment sites was required during a three-month wet weather period and a three to four-month dry weather period, covering all monitoring events. However, continuous monitoring of these parameters was conducted from January 2008 to October 2008 resulting in a greater time period than required by the QAPP.

#### 4.2.1.1 Hydrology of the Lagoon

Table 4-25 summarizes results from the continuous water level monitoring statistically on a monthly basis, as well as by event. Detailed continuous monitoring results for the entire monitoring period are presented in Appendix B-2.

Water level was not recorded with the data sonde at the mass emission station as other instrumentation was installed to measure stage and to calculate real-time flows. Lagoon depth measurements from the data sondes were tied to North American Vertical Datum, 1988 (NAVD 88).

**Table 4-25: Buena Vista Continuous Lagoon Depth Monitoring Monthly and Event Summary**

| Month (2008) | Lagoon Segment 1 Site | | | Lagoon Segment 2 Site | | |
|---|---|---|---|---|---|---|
| | Lagoon Depth (m) | | | Lagoon Depth (m) | | |
| | Mean | Min | Max | Mean | Min | Max |
| January | 2.6 | 0.6 | 5.7 | 2.5 | 2.3 | 3.0 |
| February | 2.6 | 2.4 | 3.4 | 2.5 | 2.3 | 3.1 |
| March | 2.5 | 2.4 | 2.5 | 2.4 | 2.3 | 2.5 |
| April | 2.5 | 2.4 | 2.5 | 2.4 | 2.2 | 2.4 |
| May | 2.4 | 2.3 | 2.5 | 2.4 | 2.2 | 2.4 |
| June | 2.4 | 2.4 | 2.5 | 2.4 | 2.3 | 2.5 |
| July | 2.5 | 2.4 | 2.5 | 2.5 | 2.4 | 2.6 |
| August | 2.5 | 2.5 | 2.6 | 2.6 | 2.5 | 2.6 |
| September | 2.5 | 2.4 | 2.6 | 2.4 | 2.3 | 2.7 |
| October | 2.4 | 2.4 | 2.5 | 2.4 | 2.3 | 2.4 |
| Average | 2.5 | 2.2 | 2.9 | 2.4 | 2.3 | 2.6 |
| **Event** | **Lagoon Depth (m)** | | | **Lagoon Depth (m)** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 2.6 | 0.6 | 5.7 | 2.6 | 2.4 | 3.0 |
| Wet Weather 2 | 2.7 | 2.4 | 3.3 | 2.5 | 2.3 | 2.8 |
| Wet Weather 3 | 2.6 | 2.4 | 2.9 | 2.5 | 2.4 | 2.6 |
| Index Period 1 | 2.6 | 2.5 | 2.9 | 2.4 | 2.3 | 2.5 |
| Index Period 2 | 2.5 | 2.4 | 2.5 | 2.4 | 2.3 | 2.4 |
| Index Period 3 | 2.5 | 2.5 | 2.5 | 2.6 | 2.5 | 2.6 |
| Index Period 4 | 2.4 | 2.4 | 2.5 | 2.3 | 2.3 | 2.4 |

#### 4.2.1.2 Rainfall and Flow

Rainfall and flow were both continuously monitored at the Buena Vista mass emission station throughout the monitoring period as required by the IO. Instrumentation installed at the mass emission station measured and logged rainfall and flow beginning October 1, 2007 through October 31, 2008.

Daily and monthly precipitation totals are summarized in Table 4-26. The total rainfall for the entire monitoring year was 11.58 inches. January had the most rainfall in one month, totaling 4.09 inches. Detailed continuous rainfall results for the entire monitoring period are presented in Appendix A-2.

Daily and monthly discharge totals are summarized in Table 4-27. A total volume of 640,319,759 cubic feet was discharged into Buena Vista Lagoon over the entire monitoring period. January recorded the highest monthly discharge throughout the year with 205,688,703 cubic feet. Detailed continuous stage results and flow results for the entire monitoring period are presented in Appendix A-2.

## Table 4-26: Buena Vista Mass Emission Station Daily and Monthly Precipitation Summary (inches)

| Day | 2007 | | | 2008 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **October** | **November** | **December** | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.39 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 0.00 | 0.00 | 0.00 | 0.94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | 0.00 | 0.00 | 0.00 | 1.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | 0.00 | 0.00 | 0.43 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | 0.00 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 13 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18 | 0.00 | 0.00 | 0.39 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19 | 0.00 | 0.00 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22 | 0.00 | 0.00 | 0.00 | 0.04 | 1.97 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 23 | 0.00 | 0.00 | 0.00 | 0.35 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 24 | 0.00 | 0.00 | 0.00 | 0.04 | 0.35 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 26 | 0.00 | 0.00 | 0.00 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 27 | 0.00 | 0.00 | 0.00 | 1.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 |
| 30 | 0.00 | 2.56 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 31 | 0.00 | | 0.00 | 0.00 | | 0.00 | | 0.00 | | 0.00 | 0.00 | | 0.00 |
| **Totals** | **0.16** | **2.56** | **1.30** | **4.09** | **3.35** | **0.00** | **0.00** | **0.08** | **0.00** | **0.00** | **0.00** | **0.04** | **0.00** |

## Table 4-27: Buena Vista Mass Emission Station Daily and Monthly Total Discharge Summary (cubic feet)

| Day | 2007 | | | 2008 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | October | November | December | January | February | March | April | May | June | July | August | September | October |
| 1 | 227,639 | 271,550 | 33,208,819 | 185,175 | 877,131 | 1,453,656 | 245,534 | 189,283 | 199,303 | 307,548 | 206,081 | 219,447 | 191,259 |
| 2 | 197,780 | 280,516 | 1,027,681 | 177,392 | 970,416 | 1,389,111 | 220,304 | 193,393 | 198,929 | 319,811 | 198,915 | 220,426 | 190,213 |
| 3 | 193,187 | 282,435 | 381,303 | 183,588 | 22,649,749 | 1,192,856 | 230,908 | 195,485 | 200,531 | 301,117 | 195,879 | 218,975 | 202,512 |
| 4 | 247,361 | 307,756 | 283,135 | 201,534 | 6,930,109 | 1,126,225 | 244,073 | 202,073 | 204,306 | 288,171 | 227,572 | 272,519 | 199,917 |
| 5 | 206,155 | 333,564 | 261,992 | 34,686,746 | 1,457,106 | 1,303,248 | 252,190 | 195,267 | 203,224 | 309,231 | 252,315 | 261,880 | 1,211,401 |
| 6 | 173,143 | 340,972 | 272,344 | 15,612,786 | 1,021,767 | 1,210,144 | 236,341 | 189,708 | 199,198 | 323,633 | 210,821 | 253,393 | 193,253 |
| 7 | 118,077 | 343,421 | 16,691,506 | 62,079,155 | 931,647 | 1,109,309 | 235,982 | 190,622 | 201,929 | 309,265 | 209,504 | 270,562 | 181,289 |
| 8 | 139,639 | 366,687 | 3,626,264 | 2,099,969 | 917,504 | 1,161,081 | 242,555 | 189,145 | 211,349 | 332,213 | 207,088 | 254,527 | 177,965 |
| 9 | 103,316 | 376,677 | 3,578,950 | 1,064,230 | 917,340 | 1,155,431 | 244,782 | 195,474 | 209,151 | 408,656 | 208,987 | 238,747 | 180,850 |
| 10 | 162,480 | 312,830 | 324,851 | 901,125 | 922,231 | 1,101,074 | 226,317 | 193,442 | 192,711 | 337,093 | 204,851 | 230,204 | 187,868 |
| 11 | 175,091 | 271,478 | 233,807 | 911,441 | 917,998 | 1,072,849 | 221,132 | 198,645 | 192,938 | 329,682 | 212,938 | 221,216 | 183,487 |
| 12 | 212,833 | 303,935 | 165,015 | 820,299 | 963,545 | 1,154,651 | 219,203 | 200,491 | 192,535 | 332,017 | 200,026 | 231,930 | 169,870 |
| 13 | 1,788,324 | 239,697 | 162,567 | 765,347 | 1,083,387 | 1,222,138 | 213,146 | 195,105 | 196,725 | 336,794 | 203,201 | 235,405 | 161,464 |
| 14 | 328,815 | 219,368 | 166,412 | 625,183 | 14,766,726 | 1,322,406 | 224,159 | 195,238 | 207,722 | 349,022 | 216,522 | 240,151 | 159,050 |
| 15 | 284,892 | 203,842 | 157,775 | 577,812 | 2,022,533 | 1,241,219 | 237,751 | 200,541 | 219,264 | 314,400 | 235,123 | 264,408 | 164,002 |
| 16 | 271,966 | 259,445 | 158,202 | 678,665 | 1,086,237 | 1,305,520 | 222,249 | 201,836 | 223,757 | 370,520 | 224,596 | 244,133 | 230,619 |
| 17 | 233,822 | 290,102 | 162,316 | 525,772 | 1,055,640 | 1,028,326 | 196,980 | 196,600 | 281,071 | 396,997 | 215,572 | 243,547 | 281,411 |
| 18 | 208,607 | 294,300 | 411,976 | 450,771 | 1,060,843 | 1,086,128 | 202,868 | 194,339 | 283,918 | 411,315 | 211,216 | 248,503 | 344,583 |
| 19 | 200,553 | 294,905 | 12,966,628 | 413,413 | 1,093,799 | 1,070,147 | 202,415 | 208,667 | 237,737 | 417,690 | 250,434 | 228,676 | 441,007 |
| 20 | 213,210 | 261,986 | 549,611 | 433,784 | 7,298,796 | 1,141,578 | 197,864 | 202,393 | 236,953 | 348,667 | 264,690 | 215,417 | 506,053 |
| 21 | 191,481 | 260,811 | 3,406,224 | 569,991 | 1,618,064 | 1,054,375 | 197,553 | 199,679 | 246,924 | 332,832 | 208,661 | 252,188 | 443,810 |
| 22 | 107,148 | 234,246 | 193,313 | 690,745 | 58,363,613 | 1,065,230 | 195,718 | 193,818 | 240,214 | 296,548 | 213,319 | 198,612 | 469,457 |
| 23 | 113,796 | 236,974 | 165,760 | 5,719,153 | 3,877,046 | 996,556 | 193,532 | 1,179,470 | 276,816 | 226,790 | 219,255 | 194,998 | 353,075 |
| 24 | 174,798 | 158,696 | 167,998 | 5,609,788 | 13,709,933 | 1,046,239 | 202,526 | 1,204,837 | 272,235 | 225,791 | 219,902 | 197,778 | 309,450 |
| 25 | 190,013 | 142,625 | 159,853 | 989,199 | 2,871,553 | 1,081,166 | 202,126 | 189,076 | 252,868 | 224,512 | 224,220 | 201,744 | 321,859 |
| 26 | 192,062 | 159,979 | 155,392 | 1,260,619 | 1,852,784 | 1,119,244 | 195,654 | 186,179 | 243,306 | 216,357 | 241,172 | 210,187 | 351,959 |
| 27 | 213,151 | 160,089 | 144,854 | 49,943,402 | 1,618,496 | 1,167,321 | 188,741 | 189,093 | 254,534 | 217,886 | 228,763 | 225,388 | 361,282 |
| 28 | 219,019 | 174,108 | 111,509 | 12,917,746 | 1,560,107 | 730,477 | 183,663 | 194,840 | 257,399 | 218,801 | 244,078 | 280,569 | 331,971 |
| 29 | 229,942 | 178,590 | 176,135 | 2,209,842 | 1,522,977 | 443,496 | 188,724 | 189,694 | 294,529 | 231,163 | 237,482 | 377,787 | 338,951 |
| 30 | 247,964 | 95,502,393 | 165,656 | 1,375,675 | | 587,639 | 197,202 | 189,336 | 299,647 | 247,890 | 226,988 | 207,576 | 344,056 |
| 31 | 229,487 | | 165,018 | 1,008,352 | | 418,438 | | 193,125 | | 232,382 | 227,834 | | 333,663 |
| **Total** | **7,795,747** | **103,063,979** | **79,802,867** | **205,688,703** | **155,939,077** | **33,557,277** | **6,462,191** | **8,036,896** | **6,931,724** | **9,514,797** | **6,848,004** | **7,160,894** | **9,517,604** |

#### 4.2.1.3 Continuous Monitoring of Water Quality Parameters

Results from the continuous monitoring are summarized statistically on a monthly basis, as well as by event, in Tables 4-28 through 4-30. Detailed continuous monitoring results for the entire monitoring period are presented in Appendix B-2.

Data gaps occurred as a result of fouling, tampering, unexpected decrease in water level, equipment malfunction, and other unforeseen events and are discussed in Section 3.1.1.2.

**Table 4-28: Buena Vista Mass Emission Station Continuous Data Monthly and Event Summary**

| Month (2007/2008) | Specific Conductance (mS/cm) | | | Temperature (°C) | | | Turbidity (NTU)[1] | | | Dissolved Oxygen (mg/L)[1] | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| October | 2.5 | 1.6 | 2.9 | 17.1 | 13.3 | 20.9 | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | 8.0 | 7.8 | 8.3 |
| November | 2.5 | 0.3 | 2.9 | 15.4 | 10.7 | 18.4 | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | 8.1 | 7.5 | 8.3 |
| December | 1.9 | 0.4 | 2.6 | 11.9 | 7.9 | 15.8 | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | 7.8 | 7.4 | 8.1 |
| January | 2.0 | 0.2 | 2.7 | 11.9 | 8.4 | 15.2 | 38.2 | -0.2 | 1000.2 | 9.6 | 8.3 | 13.2 | 7.9 | 7.5 | 8.2 |
| February | 1.9 | 0.2 | 2.5 | 12.8 | 8.7 | 16.9 | 17.8 | -0.1 | 455.5 | 9.5 | 7.9 | 12.7 | 7.9 | 7.3 | 8.2 |
| March | 2.5 | 2.3 | 2.8 | 15.4 | 11.5 | 19.9 | 1.0 | -0.2 | 9.4 | 9.4 | 7.2 | 13.8 | 8.0 | 7.9 | 8.3 |
| April | 2.5 | 2.3 | 2.6 | 17.3 | 13.1 | 22.6 | 1.0 | 0.0 | 114.3 | 9.2 | 5.8 | 15.1 | 8.0 | 7.8 | 8.4 |
| May | 2.4 | 1.3 | 2.6 | 18.7 | 15.2 | 24.5 | 2.2 | 0.0 | 119.1 | 8.0 | 4.8 | 12.8 | 8.0 | 7.5 | 8.4 |
| June | 2.5 | 2.4 | 2.7 | 21.0 | 17.0 | 25.8 | 2.2 | 0.0 | 13.0 | 8.1 | 4.8 | 12.2 | 8.0 | 7.7 | 8.4 |
| July | 2.5 | 2.4 | 2.6 | 22.0 | 18.7 | 24.9 | 5.1 | -0.1 | 48.8 | 7.9 | 5.5 | 11.6 | 7.9 | 7.7 | 8.2 |
| August | 2.5 | 2.3 | 2.7 | 22.6 | 20.2 | 25.5 | 1.9 | -0.3 | 13.6 | 7.5 | 4.1 | 10.9 | 7.9 | 7.7 | 8.2 |
| September | 2.6 | 2.3 | 2.9 | 21.3 | 18.2 | 24.7 | 1.4 | 0.0 | 14.2 | 7.5 | 5.2 | 11.3 | 7.1 | 6.0 | 8.2 |
| October | 2.4 | 1.9 | 2.9 | 18.3 | 12.8 | 22.8 | 2.9 | 0.0 | 89.9 | 8.0 | 5.3 | 12.1 | 8.0 | 7.7 | 8.4 |
| Average | 2.4 | 1.5 | 2.7 | 17.4 | 13.5 | 21.4 | 7.4 | -0.1 | 187.8 | 8.5 | 5.9 | 12.6 | 7.9 | 7.5 | 8.3 |
| **Event** | **Specific Conductance (mS/cm)** | | | **Temperature (°C)** | | | **Turbidity (NTU)** | | | **Dissolved Oxygen (mg/L)** | | | **pH** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 1.1 | 0.2 | 2.5 | 13.0 | 11.4 | 14.3 | 149.9 | 0.7 | 982.7 | 9.3 | 8.3 | 10.7 | 7.8 | 7.6 | 8.1 |
| Wet Weather 2 | 1.2 | 0.3 | 2.7 | 12.7 | 10.7 | 15.2 | 40.7 | 0.3 | 1000.2 | 9.3 | 8.3 | 11.2 | 7.7 | 7.5 | 8.2 |
| Wet Weather 3 | 1.4 | 0.3 | 2.5 | 11.6 | 9.8 | 13.1 | 23.5 | 0.4 | 455.5 | 9.7 | 8.7 | 10.9 | 7.8 | 7.6 | 8.0 |
| Index Period 1 | 2.5 | 2.2 | 2.6 | 11.9 | 9.7 | 15.3 | 2.1 | 0.0 | 16.3 | 9.7 | 8.3 | 12.0 | 8.0 | 8.0 | 8.1 |
| Index Period 2 | 2.5 | 2.3 | 2.6 | 16.2 | 13.1 | 19.7 | 1.0 | 0.2 | 6.9 | 9.2 | 6.9 | 12.5 | 8.0 | 7.9 | 8.2 |
| Index Period 3 | 2.4 | 2.4 | 2.6 | 22.3 | 18.7 | 24.9 | 2.3 | -0.1 | 20.2 | 8.0 | 5.8 | 11.4 | 7.9 | 7.7 | 8.2 |
| Index Period 4 | 2.6 | 2.4 | 2.7 | 20.6 | 18.2 | 23.3 | 1.4 | 0.0 | 5.3 | 7.6 | 5.6 | 11.1 | 6.9 | 6.0 | 8.1 |
| WQO | N/A | | | N/A | | | 20 NTU | | | < 5 mg/L | | | 6.5 – 8.5 | | |

(1) Per the QAPP, turbidity and DO were not required to be monitored prior to January 2008.

**Table 4-29: Buena Vista Lagoon Segment 1 Continuous Data Monthly and Event Summary**

| Month (2008) | Specific Conductance (mS/cm) | | | Temperature (°C) | | | Turbidity (NTU) | | | Dissolved Oxygen (mg/L) | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| January | 1.9 | 0.3 | 3.1 | 12.4 | 8.6 | 15.1 | 23.0 | 0.0 | 285.3 | 11.5 | 3.3 | 27.0 | 8.0 | 7.0 | 8.8 |
| February | 1.5 | 0.2 | 2.7 | 13.5 | 8.9 | 18.3 | 22.9 | 7.2 | 147.1 | 9.2 | 5.8 | 21.0 | 7.7 | 7.3 | 8.4 |
| March | 2.8 | 1.9 | 3.1 | 17.7 | 12.9 | 22.6 | 20.5 | -0.4 | 108.7 | 16.9 | 6.4 | 28.9 | 8.2 | 7.6 | 8.7 |
| April | 2.1 | 0.3 | 3.2 | 19.9 | 15.3 | 26.0 | 53.1 | 21.1 | 187.1 | 14.9 | 4.2 | 27.4 | 8.1 | 7.6 | 8.4 |
| May | 1.6 | 0.0 | 3.2 | 21.6 | 17.1 | 29.9 | 38.3 | 6.1 | 432.9 | 9.9 | 3.0 | 23.1 | 8.0 | 7.5 | 8.6 |
| June | 2.9 | 1.4 | 3.4 | 24.8 | 19.9 | 31.0 | 21.1 | 3.1 | 78.5 | 6.7 | 2.3 | 12.8 | 7.7 | 7.4 | 8.2 |
| July | 3.5 | 3.3 | 3.6 | 25.5 | 22.4 | 29.6 | 21.1 | 5.6 | 59.6 | 6.5 | 2.0 | 15.2 | 7.6 | 7.3 | 8.0 |
| August | 3.5 | 3.3 | 3.7 | 26.2 | 23.6 | 29.6 | 13.8 | 3.6 | 47.8 | 5.7 | 2.3 | 10.5 | 7.6 | 7.5 | 7.8 |
| September | 3.4 | 3.2 | 3.7 | 24.6 | 20.4 | 27.9 | 20.3 | 5.5 | 51.6 | 7.7 | 2.0 | 16.1 | 7.9 | 7.5 | 8.2 |
| October | 3.1 | 2.8 | 3.4 | 20.5 | 14.3 | 26.8 | 31.4 | 11.7 | 79.2 | 11.8 | 3.7 | 22.8 | 8.2 | 7.8 | 8.6 |
| Average | 2.6 | 1.7 | 3.3 | 20.7 | 16.3 | 25.7 | 26.6 | 6.4 | 147.8 | 10.1 | 3.5 | 20.5 | 7.9 | 7.4 | 8.4 |
| **Event** | **Specific Conductance (mS/cm)** | | | **Temperature (°C)** | | | **Turbidity (NTU)** | | | **Dissolved Oxygen (mg/L)** | | | **pH** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 1.0 | 0.3 | 2.8 | 13.1 | 11.7 | 14.5 | 47.4 | 6.9 | 285.3 | 7.2 | 3.3 | 17.2 | 7.4 | 7.0 | 8.5 |
| Wet Weather 2 | 1.1 | 0.3 | 3.0 | 13.0 | 11.0 | 15.1 | 41.1 | 5.3 | 200.7 | 7.3 | 3.5 | 16.0 | *No Data* | *No Data* | *No Data* |
| Wet Weather 3 | 1.0 | 0.4 | 2.4 | 12.2 | 9.8 | 14.1 | 31.4 | 8.6 | 67.3 | 7.9 | 6.6 | 10.2 | 7.5 | 7.4 | 7.7 |
| Index Period 1 | 2.2 | 1.3 | 2.8 | 12.9 | 10.2 | 16.4 | 11.0 | 0.6 | 39.5 | 11.6 | 6.9 | 19.4 | 7.8 | 7.5 | 8.2 |
| Index Period 2 | 2.9 | 2.6 | 3.1 | 18.7 | 15.3 | 22.8 | 55.2 | 26.7 | 153.9 | 16.5 | 8.6 | 26.3 | 8.1 | 7.8 | 8.4 |
| Index Period 3 | 3.5 | 3.3 | 3.6 | 26.3 | 22.4 | 29.6 | 16.4 | 6.4 | 39.7 | 5.8 | 2.8 | 9.9 | 7.6 | 7.4 | 7.9 |
| Index Period 4 | 3.3 | 3.2 | 3.5 | 23.9 | 21.2 | 26.6 | 25.7 | 10.3 | 47.3 | 8.7 | 4.6 | 16.1 | 8.0 | 7.7 | 8.2 |
| WQO | N/A | | | N/A | | | 20 NTU | | | < 5 mg/L | | | 6.5 – 8.5 | | |

**Table 4-30: Buena Vista Lagoon Segment 2 Continuous Data Monthly and Event Summary**

| Month (2008) | Specific Conductance (mS/cm) | | | Temperature (°C) | | | Turbidity (NTU) | | | Dissolved Oxygen (mg/L) | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| January | 1.3 | 0.5 | 2.0 | 12.8 | 10.2 | 15.1 | 13.2 | -0.7 | 93.7 | 7.9 | 3.2 | 18.6 | 7.8 | 7.1 | 8.9 |
| February | 1.1 | 0.5 | 1.7 | 14.0 | 9.4 | 18.3 | 13.7 | -0.5 | 120.4 | 9.5 | 4.3 | 19.2 | 7.9 | 7.2 | 8.9 |
| March | 2.0 | 1.0 | 2.8 | 18.7 | 14.2 | 22.9 | 12.5 | 0.9 | 85.2 | 9.5 | 3.8 | 15.8 | 8.1 | 7.6 | 8.8 |
| April | 3.1 | 2.7 | 6.5 | 20.8 | 17.3 | 25.5 | 20.4 | 2.2 | 51.1 | 6.7 | 1.4 | 14.3 | 7.8 | 7.0 | 8.3 |
| May | 3.6 | 3.4 | 3.7 | 22.4 | 17.1 | 29.9 | 10.2 | 1.2 | 61.0 | 9.0 | 0.8 | 26.0 | 8.1 | 7.5 | 8.7 |
| June | 3.9 | 3.6 | 4.2 | 25.0 | 21.2 | 29.9 | 11.9 | 0.3 | 40.4 | 8.0 | 3.3 | 11.4 | 8.2 | 7.6 | 8.7 |
| July | 4.3 | 4.0 | 4.7 | 25.3 | 23.0 | 28.2 | 9.5 | 1.0 | 39.9 | 6.6 | 3.1 | 9.6 | 8.2 | 7.5 | 8.7 |
| August | 4.6 | 4.5 | 4.8 | 26.3 | 24.1 | 28.9 | 2.8 | -0.2 | 16.1 | 5.0 | 1.2 | 8.2 | 8.0 | 7.4 | 8.4 |
| September | 4.5 | 4.2 | 4.9 | 24.8 | 21.4 | 27.9 | 5.1 | -0.2 | 33.5 | 3.4 | 0.2 | 8.8 | 7.4 | 6.9 | 7.9 |
| October | 4.1 | 4.0 | 4.3 | 21.2 | 15.7 | 26.7 | 12.3 | 2.5 | 36.3 | 7.3 | 1.8 | 16.8 | 7.9 | 7.4 | 8.7 |
| Average | 3.3 | 2.8 | 4.0 | 21.1 | 17.3 | 25.3 | 11.2 | 0.7 | 57.8 | 7.3 | 2.3 | 14.9 | 7.9 | 7.3 | 8.6 |
| **Event** | **Specific Conductance (mS/cm)** | | | **Temperature (°C)** | | | **Turbidity (NTU)** | | | **Dissolved Oxygen (mg/L)** | | | **pH** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 1.0 | 0.5 | 2.0 | 12.9 | 11.7 | 14.3 | 33.4 | 2.2 | 93.7 | 5.5 | 3.3 | 8.1 | 7.5 | 7.2 | 7.9 |
| Wet Weather 2 | 1.4 | 0.6 | 2.0 | 13.4 | 11.9 | 15.1 | 16.4 | 0.1 | 57.7 | 7.6 | 3.2 | 12.2 | 7.7 | 7.1 | 8.3 |
| Wet Weather 3 | 1.1 | 0.9 | 1.5 | 12.5 | 11.0 | 13.7 | 14.6 | 5.7 | 55.3 | 7.7 | 5.6 | 11.8 | 7.6 | 7.4 | 8.2 |
| Index Period 1 | 1.2 | 1.0 | 1.3 | 13.6 | 11.1 | 16.9 | 6.4 | -0.4 | 37.9 | 11.7 | 5.9 | 19.2 | 8.2 | 7.5 | 8.9 |
| Index Period 2 | 2.8 | 2.6 | 3.0 | 19.6 | 17.3 | 22.4 | 23.9 | 17.2 | 39.1 | 9.2 | 4.3 | 14.9 | 8.0 | 7.8 | 8.3 |
| Index Period 3 | 4.4 | 4.2 | 4.6 | 25.8 | 23.2 | 28.2 | 7.3 | 2.2 | 21.7 | 7.4 | 5.4 | 9.2 | 8.2 | 7.8 | 8.5 |
| Index Period 4 | 4.5 | 4.3 | 4.7 | 24.2 | 22.1 | 26.6 | 4.5 | 0.5 | 13.9 | 4.6 | 1.0 | 8.8 | 7.5 | 7.3 | 7.8 |
| WQO | N/A | | | N/A | | | 20 NTU | | | < 5 mg/L | | | 6.5 – 8.5 | | |

### 4.2.2 Buena Vista Wet Weather Monitoring

The following three wet weather events were successfully monitored at Buena Vista Lagoon:

- The first event occurred from January 5 to January 7, 2008. Rainfall began at 00:34 on January 5, 2008 and ended at 05:18 on January 7, 2008, totaling 2.32 inches.
- The second event occurred from January 23 to January 24, 2008. Rainfall began at 18:13 on January 23, 2008 and ended at 10:05 on January 24, 2008, totaling 0.39 inches.
- The third event occurred from February 3, 2008 to February 4, 2008. Rainfall began at 04:44 on February 3, 2008 and ended at 02:58 on February 4, 2008, totaling 0.43 inches of rainfall (0.40 inches as measured by agency performing sampling during this event).

All collected samples were placed on ice immediately after collection and stored at four degrees Celsius until delivery to the laboratory. Control of samples was maintained by Chain-of-Custody protocol from sample collection through sample analysis. All analytical methods performed on collected samples are outlined in Table 2-4 in Section 2.2.5. Quality Assurance/Quality Control samples were also collected per SWAMP requirements in accordance with the QAPP.

#### 4.2.2.1 Mass Emission Station

Two pollutagraph events and one flow-weighted composite sampling event were sampled successfully at the Buena Vista mass emission station as required by the IO. Analytes monitored at this station were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus.

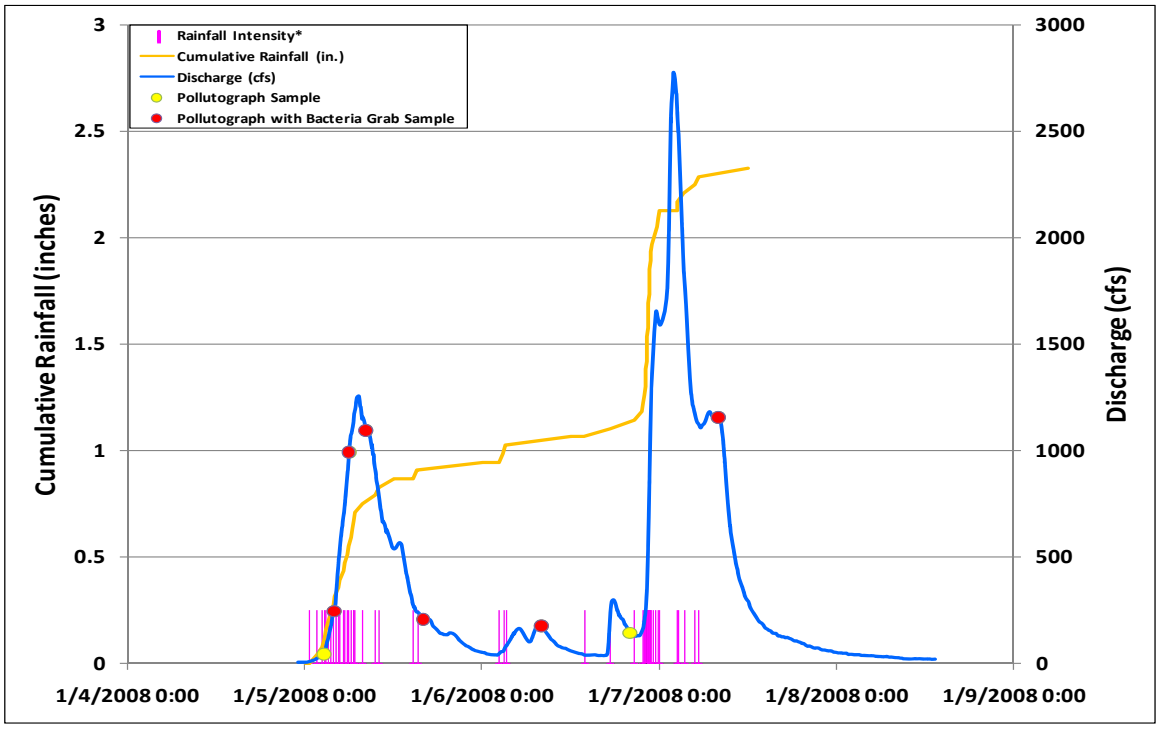
During the first monitored event, 12 pollutagraph samples were collected by the automated samplers. Eight of those 12 samples were submitted to the laboratory for analysis. Samples that represented the various flow regimes, specifically the rising limbs and peaks of the hydrograph, were selected. (Figure 4-5). Five microbiology grab samples were collected at targeted times during the storm event that corresponded to automated pollutagraph sample times. These samples were immediately submitted to the laboratory for analysis in order to meet the short hold time for bacteria analysis.

During the second monitored event, 12 pollutagraph samples were collected by the automated samplers. Nine of those 12 samples were submitted to the laboratory for analysis. Samples that represented the various flow regimes, specifically the rising limbs and peaks of the hydrograph, were selected (Figure 4-6). Six microbiology grab samples were collected at targeted times during the storm event that corresponded to automated pollutagraph sample times. These samples were immediately submitted to the

laboratory for analysis in order to meet the short hold time for bacteria analysis. Due to short holding times for microbiology samples, a sample collected earlier in the event had to be analyzed before notice was given of a sixth collected sample that was to be included in the analyzed suite. A ninth pollutagraph sample was also analyzed beyond the required 8. Results for any samples analyzed but not required are reported.

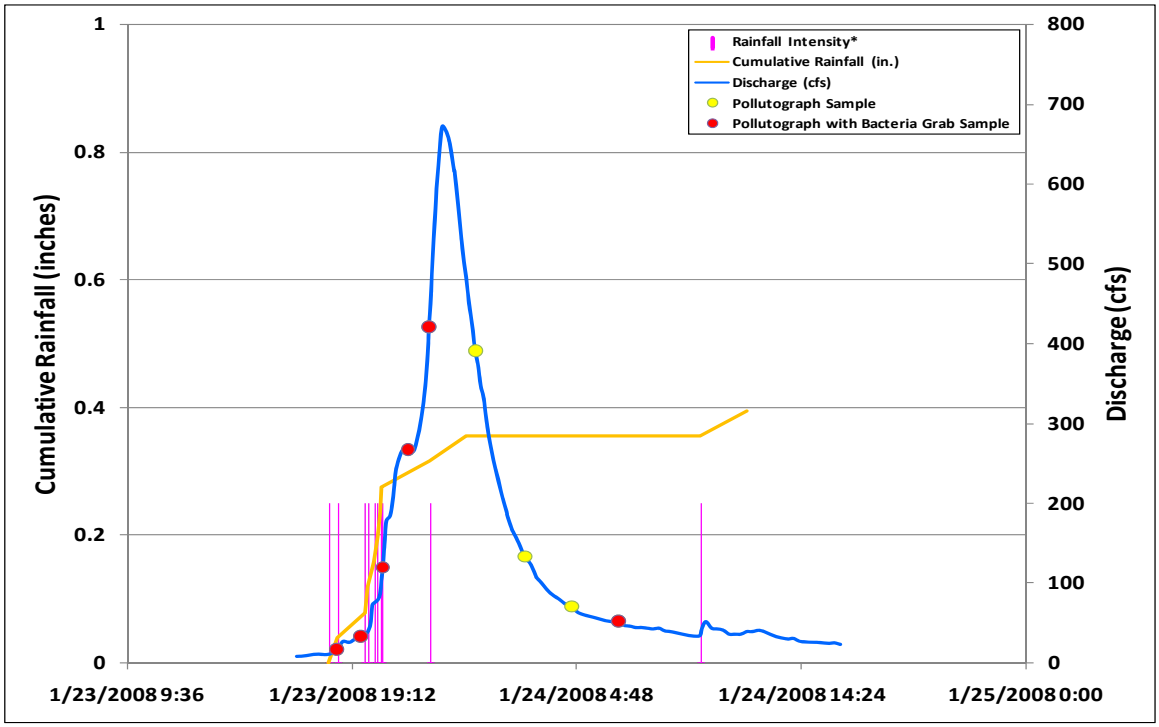
The third wet weather sampling event was not required to be a pollutagraph sample. Instead, a flow-weighted composite sample was successfully monitored from February 3 to February 4, 2008 under the San Diego County Regional Monitoring Program, Order No. 2007-01. See Figure 4-7 for the rainfall, flow, and sampling that occurred during this event.

**Figure 4-5: Buena Vista Mass Emission Hydrograph and Hyetograph Wet Weather Event 1**



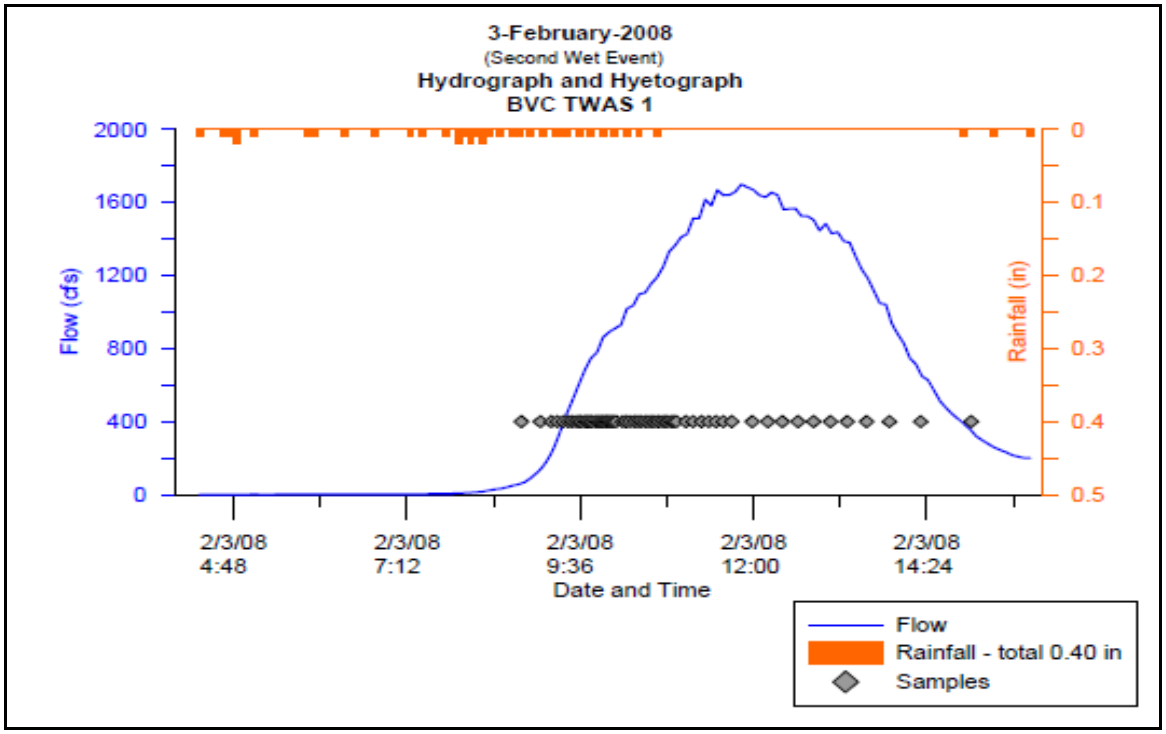

Note: Each vertical bar represents a one-millimeter rain gauge bucket tip.

**Figure 4-6: Buena Vista Mass Emission Hydrograph and Hyetograph Wet Weather Event 2**




Note: Each vertical bar represents a one-millimeter rain gauge bucket tip.

**Figure 4-7: Buena Vista Mass Emission Hydrograph and Hyetograph Wet Weather Event 3**




Note: Sampling for this event was conducted by an outside agency under the San Diego County Regional Monitoring Program, Order No. 2007-01.

Results from the two pollutagraph sampling events at the mass emission station are summarized statistically in Table 4-31. The results from the third monitoring event are event mean concentrations (EMC) and those values are displayed in Table 4-32. Detailed analytical results for all wet weather events are presented in Appendix C-2.

**Table 4-31: Buena Vista Wet Weather Events 1 and 2 Pollutagraph Summary**

| Event Category | Analyte | Units | Count | Mean | Median | Min | Max | WQO | Percent Exceedance[1] (%) |
|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 January 5-7, 2008 | *Enterococcus* | CFU/100mL | 6 | 17,050 | 13,750 | 6,800 | 38,000 | 108 | 100 |
| | Fecal Coliform | MPN/100mL | 6 | 7,667 | 6,500 | 3,000 | 14,000 | 400 | 100 |
| | Total Coliform | MPN/100mL | 6 | 79,833 | 60,000 | 9,000 | 160,000 | 10,000 | 83 |
| | TSS | mg/L | 8 | 94.3 | 76.0 | 30.0 | 190.0 | NA | NA |
| | Ammonia as N | mg/L | 8 | 0.11 | 0.07 | 0.02 | 0.26 | 0.025 | 71 |
| | CBOD | mg/L | 8 | 4.06 | 3.60 | 1.00 | 8.70 | NA | NA |
| | Nitrate+Nitrite | mg/L | 8 | 0.99 | 0.83 | 0.35 | 1.90 | 10 | 0 |
| | SRP | mg/L | 8 | 0.17 | 0.15 | 0.10 | 0.34 | NA | NA |
| | Total Nitrogen | mg/L | 8 | 1.79 | 1.62 | 0.77 | 2.67 | 1 | 88 |
| | Total Dissolved Nitrogen | mg/L | 8 | 1.43 | 1.29 | 0.67 | 2.16 | NA | NA |
| | Total Phosphorus | mg/L | 8 | 0.25 | 0.23 | 0.12 | 0.46 | 0.1 | 100 |
| | Total Dissolved Phosphorus | mg/L | 8 | 0.19 | 0.19 | 0.11 | 0.31 | NA | NA |
| Wet Weather Event 2 January 23-25, 2008 | *Enterococcus* | CFU/100mL | 6 | 9,907 | 12,000 | 240 | 17,000 | 108 | 100 |
| | Fecal Coliform | MPN/100mL | 6 | 19,596 | 8,000 | 200 | 90,000 | 400 | 67 |
| | Total Coliform | MPN/100mL | 6 | 30,486 | 17,500 | 2400 | 90,000 | 10,000 | 67 |
| | TSS | mg/L | 9 | 177.3 | 99.0 | 32.5 | 585.0 | NA | NA |
| | Ammonia as N | mg/L | 9 | 0.19 | 0.19 | 0.10 | 0.25 | 0.025 | 100 |
| | CBOD | mg/L | 9 | 3.28 | 2.80 | 1.00 | 5.10 | NA | NA |
| | Nitrate+Nitrite | mg/L | 9 | 1.64 | 1.51 | 0.94 | 3.01 | 10 | 0 |
| | SRP | mg/L | 9 | 0.13 | 0.14 | 0.06 | 0.15 | NA | NA |
| | Total Nitrogen | mg/L | 9 | 1.64 | 1.57 | 1.33 | 2.16 | 1 | 100 |
| | Total Dissolved Nitrogen | mg/L | 9 | 1.54 | 1.52 | 0.70 | 2.23 | NA | NA |
| | Total Phosphorus | mg/L | 9 | 0.14 | 0.16 | 0.03 | 0.18 | 0.1 | 78 |
| | Total Dissolved Phosphorus | mg/L | 9 | 0.12 | 0.13 | 0.06 | 0.16 | NA | NA |

(1) The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

**Table 4-32: Buena Vista Wet Weather Event 3 EMC Summary**

| Analyte | Units | EMC | WQO | Exceedance |
|---|---|---|---|---|
| *Enterococcus* | MPN/100mL | 17,000 | 108 | Yes |
| Fecal Coliform | MPN/100mL | 5,000 | 400 | Yes |
| Total Coliform | MPN/100mL | 80,000 | 10,000 | Yes |
| TSS | mg/L | 290 | NA | NA |
| Ammonia as N | mg/L | 0.13 | 0.025 | Yes |
| Nitrate + Nitrite as N | mg/L | 1.09 | 10 | No |
| TP | mg/L | 0.43 | 0.1 | Yes |
| TDP | mg/L | 0.18 | NA | NA |

4.2.2.2 Lagoon Segment Sites

Three events were successfully monitored at the two lagoon segment sites at Buena Vista Lagoon as required by the IO. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, chlorophyll *a*, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus. Wet weather event sampling within the lagoon was conducted simultaneously with pollutagraph sampling and ocean inlet sampling during wet weather events. The anticipated lag time (i.e., the amount of transit time after a storm's onset before the lagoon is affected) was accounted for when preparing to initialize a sampling program. Buena Vista Lagoon is not tidally influenced, however samples were collected based on tides, similar to other lagoons, after each wet weather event.

During the first event, the first composite sample was collected at the high tide that occurred at 06:41 on January 5, 2008 approximately six hours after rainfall began. The second composite sample was collected at the low tide that occurred at 14:01 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

During the second event, the first composite sample was collected at the high tide that occurred at 09:49 on January 24, 2008 approximately 15 hours after rainfall began. Sampling was delayed for a longer period of time during this event for two reasons. Primarily, the rainfall was very light in intensity. This resulted in a slower transit time and therefore further delayed response within the lagoon. Secondly, the Health and Safety Plan for this project dictated that personnel cannot be out during non-daylight hours. Therefore the tide selected was the soonest possible time for sample collection to take place. The second

composite sample was collected at the low tide that occurred at 16:35 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

During the third event, the first composite sample was collected at the high tide that occurred at 07:03 on February 4, 2008 approximately 13 hours after rainfall began. Sampling was delayed during this event due timing of the storm and the Health and Safety requirements of this project. Rainfall began just before dawn on February 3, 2008. Sampling that morning would not have allowed for transit time from the watershed to the lagoon. The ideal sample time for this event would have resulted in personnel sampling during non-daylight hours, which is prohibited by the Health and Safety Plan for this project. Therefore the tide selected was the soonest possible time for sample collection to take place. The second composite sample was collected at the low tide that occurred at 14:00 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

Results from the three wet weather sampling events at the two lagoon segment sites are summarized statistically in Table 4-33 and Table 4-34. Detailed analytical results for all wet weather events are presented in Appendix C-2.

#### 4.2.2.4 Ocean Inlet Sites

Buena Vista Lagoon is closed to tidal influence and therefore there was not an ocean inlet sample location in this monitoring program.

**Table 4-33: Buena Vista Wet Weather Events 1-3 Lagoon Segment 1 Summary**

| Event Category | Analyte | Units | Count | Mean | Median | Min | Max | WQO | Percent Exceedance[1](%) |
|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 January 5-7, 2008 | *Enterococcus* | CFU/100mL | 2 | 11,100 | 11,100 | 9,200 | 13,000 | 108 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 15,000 | 15,000 | 13,000 | 17,000 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 150,000 | 150,000 | 80,000 | 220,000 | 10,000 | 100 |
| | TSS | mg/L | 2 | 89.0 | 89.0 | 46.0 | 132.0 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.12 | 0.12 | 0.10 | 0.14 | 0.025 | 100 |
| | CBOD | mg/L | 2 | 3.90 | 3.90 | 3.70 | 4.10 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 8.00 | 8.00 | 5.30 | 10.70 | 20 | 0 |
| | Nitrate+Nitrite | mg/L | 2 | 0.54 | 0.54 | 0.32 | 0.76 | 10 | 0 |
| | SRP | mg/L | 2 | 0.11 | 0.11 | 0.07 | 0.16 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 1.75 | 1.75 | 1.35 | 2.15 | 1 | 100 |
| | Total Dissolved Nitrogen | mg/L | 2 | 1.41 | 1.41 | 1.33 | 1.49 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.25 | 0.25 | 0.24 | 0.26 | 0.1 | 100 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.22 | 0.22 | 0.14 | 0.29 | NA | NA |
| Wet Weather Event 2 January 23-25, 2008 | *Enterococcus* | CFU/100mL | 2 | 6,270 | 6,270 | 540 | 12,000 | 108 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 3,500 | 3,500 | 2,000 | 5,000 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 93,000 | 93,000 | 26,000 | 160,000 | 10,000 | 100 |
| | TSS | mg/L | 2 | 33.0 | 2.8 | 0.09 | 33.0 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.14 | 0.03 | 0.21 | 0.14 | 0.025 | 100 |
| | CBOD | mg/L | 2 | 2.80 | 0.00 | 0.00 | 2.80 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 14.75 | 3.46 | 0.23 | 14.75 | 20 | 0 |
| | Nitrate+Nitrite | mg/L | 2 | 1.41 | 0.11 | 0.08 | 1.41 | 10 | 0 |
| | SRP | mg/L | 2 | 0.14 | 0.00 | 0.02 | 0.14 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 1.80 | 0.28 | 0.15 | 1.80 | 1 | 100 |
| | Total Dissolved Nitrogen | mg/L | 2 | 1.88 | 0.02 | 0.01 | 1.88 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.17 | 0.00 | 0.02 | 0.17 | 0.1 | 100 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.15 | 0.01 | 0.04 | 0.15 | NA | NA |

**Table 4-33: Buena Vista Wet Weather Events 1-3 Lagoon Segment 1 Summary (continued)**

| Event Category | Analyte | Units | Count | Mean | Median | Min | Max | WQO | Percent Exceedance[1](%) |
|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 3 February 3-4, 2008 | *Enterococcus* | CFU/100mL | 2 | 9,050 | 9,050 | 7,300 | 10,800 | 108 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 2,350 | 2,350 | 1,700 | 3,000 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 29,500 | 29,500 | 9,000 | 50,000 | 10,000 | 50 |
| | TSS | mg/L | 2 | 37.6 | 8.3 | 0.22 | 37.6 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.06 | 0.00 | 0.02 | 0.06 | 0.025 | 100 |
| | CBOD | mg/L | 2 | 1.00 | 0.00 | 0.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 10.70 | 0.00 | 0.00 | 10.70 | 20 | 0 |
| | Nitrate+Nitrite | mg/L | 2 | 1.01 | 0.00 | 0.00 | 1.01 | 10 | 0 |
| | SRP | mg/L | 2 | 0.22 | 0.00 | 0.01 | 0.22 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 1.99 | 0.10 | 0.05 | 1.99 | 1 | 100 |
| | Total Dissolved Nitrogen | mg/L | 2 | 2.00 | 0.16 | 0.08 | 2.00 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.26 | 0.09 | 0.36 | 0.26 | 0.1 | 100 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.31 | 0.05 | 0.15 | 0.31 | NA | NA |

(1) The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

**Table 4-34: Buena Vista Wet Weather Events 1-3 Lagoon Segment 2 Summary**

| Event Category | Analyte | Units | Count | Mean | Median | Min | Max | WQO | Percent Exceedance[1](%) |
|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 January 5-7, 2008 | *Enterococcus* | CFU/100mL | 2 | 1,485 | 1,485 | 370 | 2,600 | 108 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 600 | 600 | 500 | 700 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 2,600 | 2,600 | 2,200 | 3,000 | 10,000 | 0 |
| | TSS | mg/L | 2 | 5.0 | 5.0 | 3.0 | 7.0 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.07 | 0.07 | 0.00 | 0.13 | 0.025 | 50 |
| | CBOD | mg/L | 2 | 2.55 | 2.55 | 0.29 | 4.80 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 2.70 | 2.70 | 2.70 | 2.70 | 20 | 0 |
| | Nitrate+Nitrite | mg/L | 2 | 0.06 | 0.06 | 0.01 | 0.11 | 10 | 0 |
| | SRP | mg/L | 2 | 0.10 | 0.10 | 0.03 | 0.18 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 0.94 | 0.94 | 0.77 | 1.12 | 1 | 50 |
| | Total Dissolved Nitrogen | mg/L | 2 | 0.45 | 0.45 | 0.42 | 0.48 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.14 | 0.14 | 0.11 | 0.17 | 0.1 | 100 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.07 | 0.07 | 0.06 | 0.07 | NA | NA |
| Wet Weather Event 2 January 23-25, 2008 | *Enterococcus* | CFU/100mL | 2 | 25 | 25 | 20 | 30 | 108 | 0 |
| | Fecal Coliform | MPN/100mL | 2 | 120 | 120 | 70 | 170 | 400 | 0 |
| | Total Coliform | MPN/100mL | 2 | 1,500 | 1,500 | 800 | 2,200 | 10,000 | 0 |
| | TSS | mg/L | 2 | 8.0 | 8.0 | 7.0 | 8.9 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.02 | 0.02 | 0.02 | 0.03 | 0.025 | 50 |
| | CBOD | mg/L | 2 | 4.65 | 4.65 | 4.60 | 4.70 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 47.00 | 47.00 | 44.20 | 49.80 | 20 | 100 |
| | Nitrate+Nitrite | mg/L | 2 | 0.01 | 0.01 | 0.01 | 0.01 | 10 | 0 |
| | SRP | mg/L | 2 | 0.07 | 0.07 | 0.07 | 0.07 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 0.98 | 0.98 | 0.92 | 1.05 | 1 | 50 |
| | Total Dissolved Nitrogen | mg/L | 2 | 0.59 | 0.59 | 0.50 | 0.67 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.18 | 0.18 | 0.17 | 0.19 | 0.1 | 100 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.10 | 0.10 | 0.09 | 0.11 | NA | NA |

**Table 4-34: Buena Vista Wet Weather Events 1-3 Lagoon Segment 2 Summary (continued)**

| Event Category | Analyte | Units | Count | Mean | Median | Min | Max | WQO | Percent Exceedance[1](%) |
|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 3 February 3-4, 2008 | *Enterococcus* | CFU/100mL | 2 | 2,450 | 2,450 | 1,800 | 3,100 | 108 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 1,050 | 1,050 | 800 | 1,300 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 13,500 | 13,500 | 3,000 | 24,000 | 10,000 | 50 |
| | TSS | mg/L | 2 | 24.4 | 24.4 | 17.3 | 31.5 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.13 | 0.13 | 0.12 | 0.13 | 0.025 | 100 |
| | CBOD | mg/L | 2 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 27.75 | 27.75 | 27.50 | 28.00 | 20 | 100 |
| | Nitrate+Nitrite | mg/L | 2 | 0.82 | 0.82 | 0.80 | 0.83 | 10 | 0 |
| | SRP | mg/L | 2 | 0.15 | 0.15 | 0.15 | 0.15 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 1.90 | 1.90 | 1.79 | 2.00 | 1 | 100 |
| | Total Dissolved Nitrogen | mg/L | 2 | 1.86 | 1.86 | 1.61 | 2.10 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.26 | 0.26 | 0.25 | 0.26 | 0.1 | 100 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.24 | 0.24 | 0.21 | 0.27 | NA | NA |

(1) The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.2.2.5 Mass Emission Station Wet Weather Aqueous Sediment Grain Size

In addition to the chemical constituents required for a given impairment, all lagoons were monitored for grain size distribution of aqueous sediment (i.e., suspended sediment) at the mass emission station during both required pollutagraph monitoring events of the season. The samples submitted to the laboratory consisted of one composite sample per lagoon. Each sample was composited from the pollutagraph samples, based on event, collected over the course of the storm. The samples were analyzed for grain size distribution among the following size categories: clay < 0.0039 millimeters, silt 0.0039 to < 0.0625 millimeters, sand 0.0625 to < 2.0 millimeters, and granule 2.0 to < 4.0 millimeters. Results of the aqueous grain size distribution during both wet weather events are summarized in Table 4-35.

**Table 4-35: Buena Vista Wet Weather Events 1-2 Aqueous Grain Size Distribution**

| Grain Size Classes | Units | Wet Weather Event 1 1/5-7/08 | Wet Weather Event 2 1/23-24/08 |
|---|---|---|---|
| Clay < 0.0039 mm | % | 13.1 | 12.0 |
| Silt 0.0039 to < 0.0625 mm | % | 70.2 | 45.6 |
| Sand 0.0625 to < 2.0 mm | % | 16.7 | 42.4 |
| Granule 2.0 to < 4.0 mm | % | 0.0 | 0.0 |

Note: Analysis was run on a composite of all pollutagraph samples collected for each storm.

#### 4.2.2.6 Post-Storm Sediment

Post-storm event sediment sampling at Buena Vista Lagoon occurred on January 16, 2008, nine days after the end of the first sampled storm event. Sampling occurred at the two lagoon segment sites. These samples were analyzed for percentage of organic carbon, percentage of sand, percentage of total nitrogen, and percentage of total phosphorus. The analytical results are summarized statistically in Table 4-36. These data along with the associated sample locations will be used in a special study by SCCWRP to determine the characteristics of sediments and where they settle in the lagoon. Detailed analytical results for all wet weather events are presented in Appendix C-2.

**Table 4-36: Buena Vista Post-Storm Sediment Results (January 16, 2008)**

| Monitoring Location | % Analyte | Number of Samples | Mean | SD | CV | Median | Min | Max |
|---|---|---|---|---|---|---|---|---|
| Buena Vista Lagoon Segment 1 | % Organic Carbon | 8 | 3.59 | 0.38 | 0.107 | 3.5 | 3.0 | 4.4 |
| | % Sand | 8 | 35.95 | 9.85 | 0.274 | 32.4 | 21.6 | 51.2 |
| | % Total Nitrogen | 8 | 0.36 | 0.02 | 0.061 | 0.4 | 0.3 | 0.4 |
| | % Total Phosphorus | 8 | 0.07 | 0.01 | 0.118 | 0.1 | 0.1 | 0.1 |
| Buena Vista Lagoon Segment 2 | % Organic Carbon | 12 | 4.44 | 1.14 | 0.257 | 3.2 | 0.3 | 11.0 |
| | % Sand | 7 | 68.79 | 7.61 | 0.111 | 64.4 | 46.2 | 97.0 |
| | % Total Nitrogen | 11 | 0.54 | 0.12 | 0.226 | 0.4 | 0.1 | 1.2 |
| | % Total Phosphorus | 12 | 0.09 | 0.00 | 0.041 | 0.1 | 0.0 | 0.1 |

### 4.2.3 Buena Vista Index Period Monitoring

Four index period events were successfully monitored at all sample locations associated with Buena Vista Lagoon. Each index period event spanned six days and generally took place over two weeks. Index periods at Buena Vista Lagoon occurred in late January to early February 2008, late March to early April 2008, July 2008, and September to October 2008. Buena Vista Lagoon is closed to tidal influence and therefore only one sample per day was collected at the Mass Emission Station and the Lagoon Segment Sites.

All samples collected were placed on ice immediately after collection and stored at four degrees Celsius until delivery to the laboratory. Control of samples was maintained by Chain-of-Custody protocol from sample collection through sample analysis. All analytical methods performed on collected samples are outlined in Table 2-4 in Section 2.2.5. Quality Assurance/Quality Control samples were also collected per SWAMP requirements in accordance with the QAPP.

#### 4.2.3.1 Mass Emission Station

Mass emission station sampling was conducted once daily during the same index periods as the lagoon segment sites. Time-weighted composite samples were collected using automated sampling equipment programmed to collect aliquots every 15 minutes for a 30-minute period. Microbiology grab samples were collected concurrently with the composite samples.

Four index period events were sampled successfully at the mass emission station. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD,

chlorophyll *a*, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus. Table 4-37 shows sampling schedule dates.

**Table 4-37: Buena Vista Index Period Sampling Schedule**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Index Period Event 1 | Day of the Week | Monday | Tuesday | Wednesday | Thursday | Friday | Monday |
| | Date | 1/14/2008 | 1/15/2008 | 1/16/2008 | 2/07/2008 | 2/08/2008 | 2/11/2008 |
| Index Period Event 2 | Day of the Week | Monday | Tuesday | Monday | Tuesday | Wednesday | Thursday |
| | Date | 3/31/2008 | 4/01/2008 | 4/07/2008 | 4/8/2008 | 4/09/2008 | 4/10/2008 |
| Index Period Event 3 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 7/14/2008 | 7/15/2008 | 7/16/2008 | 7/21/2008 | 7/22/2008 | 7/23/2008 |
| Index Period Event 4 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 9/15/2008 | 9/16/2008 | 9/17/2008 | 9/22/2008 | 9/23/2008 | 9/24/2008 |

Sampling during Index Period Event 1 was spread out over three different weeks as two unanticipated storms caused a delay in the proposed schedule. Per instruction from the RPs, dry weather sampling did not occur less than 72 hours after a rain event. Index Period Event 2 was sampled over a two week period, however two days were sampled the first week and four the following as rain was predicted but never occurred during the latter part of the first week. All other index period events were sampled according to the general two-week approach.

Results from the four index period sampling events at the mass emission station are summarized statistically in Table 4-38. Detailed analytical results for all wet weather events are presented in Appendix C-2.

**Table 4-38: Buena Vista Index Periods 1-4 Mass Emission Station Summary**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 6 | 137 | 168 | 60 | 269 | 33 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 154 | 152 | 52 | 648 | 200 | No |
| | Total Coliform | CFU/100mL | 6 | 709 | 714 | 328 | 1,260 | 1,000 | No |
| | TSS | mg/L | 6 | 5.4 | 5.2 | 2.0 | 11.2 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.03 | 0.03 | 0.02 | 0.04 | 0.025 | 67% |
| | CBOD | mg/L | 6 | 0.76 | 1.00 | 0.29 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 6.78 | 5.60 | 2.70 | 13.9 | 20 | 0% |
| | Nitrate+Nitrite | mg/L | 6 | 1.80 | 2.07 | 0.04 | 3.11 | 10 | 0% |
| | SRP | mg/L | 6 | 0.07 | 0.07 | 0.01 | 0.11 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 1.90 | 1.83 | 0.96 | 2.90 | 1 | 83% |
| | Total Dissolved Nitrogen | mg/L | 6 | 2.60 | 2.60 | 2.06 | 3.10 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.07 | 0.07 | 0.03 | 0.10 | 0.1 | 17% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.10 | 0.11 | 0.05 | 0.14 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 6 | 54 | 58 | 22 | 102 | 33 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 128 | 101 | 56 | 370 | 200 | No |
| | Total Coliform | CFU/100mL | 6 | 464 | 450 | 370 | 650 | 1,000 | No |
| | TSS | mg/L | 6 | 46.4 | 37.0 | 17.7 | 109.5 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.03 | 0.03 | 0.03 | 0.04 | 0.025 | 100% |
| | CBOD | mg/L | 5 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 45.4 | 34.3 | 9.80 | 134.8 | 20 | 67% |
| | Nitrate+Nitrite | mg/L | 6 | 1.87 | 1.74 | 1.54 | 2.30 | 10 | 0% |
| | SRP | mg/L | 6 | 0.05 | 0.05 | 0.04 | 0.06 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 2.53 | 2.60 | 1.84 | 3.17 | 1 | 100% |
| | Total Dissolved Nitrogen | mg/L | 6 | 2.63 | 2.82 | 1.51 | 2.96 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.20 | 0.10 | 0.09 | 0.70 | 0.1 | 33% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.08 | 0.08 | 0.06 | 0.09 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | 6 | 218 | 235 | 128 | 284 | 33 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 602 | 600 | 260 | 1,230 | 200 | Yes |
| | Total Coliform | CFU/100mL | 6 | 877 | 924 | 452 | 1,620 | 1,000 | No |
| | TSS | mg/L | 6 | 35.7 | 24.9 | 5.2 | 86.0 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.04 | 0.02 | 0.02 | 0.09 | 0.025 | 50% |
| | CBOD | mg/L | 6 | 1.27 | 1.00 | 1.00 | 2.60 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 16.1 | 7.50 | 1.10 | 64.6 | 20 | 17% |
| | Nitrate+Nitrite | mg/L | 6 | 0.58 | 0.57 | 0.01 | 1.30 | 10 | 0% |
| | SRP | mg/L | 6 | 0.04 | 0.04 | 0.03 | 0.05 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 0.90 | 0.87 | 0.66 | 1.25 | 1 | 33% |
| | Total Dissolved Nitrogen | mg/L | 6 | 1.02 | 1.04 | 0.91 | 1.11 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.03 | 0.03 | 0.01 | 0.06 | 0.1 | 0% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.03 | 0.03 | 0.02 | 0.05 | NA | NA |

**Table 4-38: Buena Vista Index Periods 1-4 Mass Emission Station Summary (continued)**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 6 | 154 | 152 | 92 | 288 | 33 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 370 | 465 | 140 | 610 | 200 | Yes |
| | Total Coliform | CFU/100mL | 6 | 889 | 940 | 580 | 1,120 | 1,000 | No |
| | TSS | mg/L | 6 | 10.5 | 6.9 | 3.7 | 28.3 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.03 | 0.03 | 0.03 | 0.05 | 0.025 | 100% |
| | CBOD | mg/L | 6 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 10.4 | 5.35 | 2.20 | 28.0 | 20 | 17% |
| | Nitrate+Nitrite | mg/L | 6 | 0.63 | 0.55 | 0.42 | 0.91 | 10 | 0% |
| | SRP | mg/L | 6 | 0.05 | 0.05 | 0.04 | 0.06 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 1.49 | 1.48 | 1.13 | 1.73 | 1 | 100% |
| | Total Dissolved Nitrogen | mg/L | 6 | 1.18 | 1.19 | 0.86 | 1.49 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.08 | 0.08 | 0.06 | 0.11 | 0.1 | 17% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.07 | 0.07 | 0.04 | 0.11 | NA | NA |

(1) Enterococcus, fecal coliform, and total coliform were calculated as geometric means whereas all other constituents were calculated as arithmetic means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.2.3.2 Lagoon Segment Sites

One composite sample was collected per day at the two Buena Vista Lagoon segment sites. Composite samples were collected using automated sampling equipment programmed to collect aliquots every 15 minutes for a thirty-minute period. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

Four index period events were sampled successfully at the lagoon segment sites. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, chlorophyll *a*, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus. Sampling at the lagoon segment sites followed the same daily schedule as the mass emission station. Table 4-37 shows the sampling schedule dates.

Results from the four index period sampling events at the lagoon segment sites are summarized statistically in Tables 4-39 and 4-40. Detailed analytical results for all wet weather events are presented in Appendix C-2.

**Table 4-39: Buena Vista Index Period Events 1-4 Lagoon Segment 1 Site Summary**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 6 | 68 | 67 | 16 | 228 | 33 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 112 | 123 | 40 | 234 | 200 | No |
| | Total Coliform | CFU/100mL | 6 | 414 | 442 | 80 | 2,200 | 1,000 | No |
| | TSS | mg/L | 6 | 75.1 | 38.8 | 6.0 | 291.3 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.05 | 0.03 | 0.01 | 0.11 | 0.025 | 67% |
| | CBOD | mg/L | 6 | 0.95 | 1.00 | 0.29 | 2.10 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 21.18 | 13.95 | 3.10 | 49.50 | 20 | 33% |
| | Nitrate+Nitrite | mg/L | 6 | 1.59 | 1.76 | 0.54 | 2.10 | 10 | 0% |
| | SRP | mg/L | 6 | 0.09 | 0.08 | 0.02 | 0.15 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 2.42 | 2.31 | 1.28 | 4.48 | 1 | 100% |
| | Total Dissolved Nitrogen | mg/L | 6 | 1.79 | 1.91 | 0.73 | 2.73 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.19 | 0.16 | 0.11 | 0.42 | 0.1 | 100% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.13 | 0.14 | 0.04 | 0.18 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 6 | 12 | 12 | 6 | 30 | 33 | No |
| | Fecal Coliform | CFU/100mL | 6 | 105 | 136 | 36 | 250 | 200 | No |
| | Total Coliform | CFU/100mL | 6 | 305 | 355 | 160 | 450 | 1,000 | No |
| | TSS | mg/L | 6 | 53.4 | 45.8 | 42.7 | 92.2 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.02 | 0.02 | 0.01 | 0.03 | 0.025 | 17% |
| | CBOD | mg/L | 6 | 11.97 | 9.25 | 6.80 | 28.70 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 409.23 | 373.30 | 220.30 | 710.20 | 20 | 100% |
| | Nitrate+Nitrite | mg/L | 6 | 0.20 | 0.16 | 0.01 | 0.45 | 10 | 0% |
| | SRP | mg/L | 6 | 0.02 | 0.01 | 0.01 | 0.06 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 2.43 | 2.41 | 1.64 | 3.12 | 1 | 100% |
| | Total Dissolved Nitrogen | mg/L | 6 | 0.91 | 1.00 | 0.61 | 1.08 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.26 | 0.25 | 0.20 | 0.36 | 0.1 | 100% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.04 | 0.03 | 0.01 | 0.14 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | 6 | 57 | 62 | 16 | 134 | 33 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 106 | 116 | 20 | 444 | 200 | No |
| | Total Coliform | CFU/100mL | 6 | 217 | 265 | 72 | 500 | 1,000 | No |
| | TSS | mg/L | 6 | 12.6 | 11.8 | 3.5 | 22.5 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.09 | 0.03 | 0.01 | 0.34 | 0.025 | 67% |
| | CBOD | mg/L | 6 | 2.00 | 1.00 | 1.00 | 4.80 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 36.00 | 31.15 | 5.20 | 71.80 | 20 | 50% |
| | Nitrate+Nitrite | mg/L | 6 | 0.03 | 0.02 | 0.01 | 0.07 | 10 | 0% |
| | SRP | mg/L | 6 | 0.07 | 0.03 | 0.02 | 0.19 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 0.89 | 0.87 | 0.67 | 1.12 | 1 | 33% |
| | Total Dissolved Nitrogen | mg/L | 6 | 0.70 | 0.56 | 0.38 | 1.11 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.07 | 0.06 | 0.05 | 0.11 | 0.1 | 17% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.03 | 0.03 | 0.01 | 0.07 | NA | NA |

**Table 4-39: Buena Vista Index Period Events 1-4 Lagoon Segment 1 Site Summary (continued)**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 6 | 9 | 11 | 2 | 22 | 33 | No |
| | Fecal Coliform | CFU/100mL | 6 | 132 | 146 | 48 | 344 | 200 | No |
| | Total Coliform | CFU/100mL | 6 | 311 | 255 | 110 | 890 | 1,000 | No |
| | TSS | mg/L | 6 | 20.3 | 17.7 | 13.7 | 38.3 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.02 | 0.02 | 0.01 | 0.05 | 0.025 | 33% |
| | CBOD | mg/L | 6 | 5.15 | 4.35 | 2.70 | 8.20 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 102.30 | 82.10 | 63.40 | 192.20 | 20 | 100% |
| | Nitrate+Nitrite | mg/L | 6 | 0.03 | 0.01 | 0.01 | 0.08 | 10 | 0% |
| | SRP | mg/L | 6 | 0.01 | 0.01 | 0.01 | 0.01 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 0.82 | 0.74 | 0.59 | 1.22 | 1 | 17% |
| | Total Dissolved Nitrogen | mg/L | 6 | 0.54 | 0.55 | 0.30 | 0.78 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.06 | 0.06 | 0.03 | 0.12 | 0.1 | 17% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.02 | 0.02 | 0.01 | 0.04 | NA | NA |

(1) Enterococcus, fecal coliform, and total coliform were calculated as geometric means whereas all other constituents were calculated as arithmetic means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

**Table 4-40: Buena Vista Index Period Events 1-4 Lagoon Segment 2 Site Summary**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 6 | 17 | 17 | 10 | 32 | 33 | No |
| | Fecal Coliform | CFU/100mL | 6 | 110 | 100 | 84 | 180 | 200 | No |
| | Total Coliform | CFU/100mL | 6 | 351 | 356 | 228 | 520 | 1,000 | No |
| | TSS | mg/L | 6 | 10.2 | 8.9 | 6.0 | 20.0 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.05 | 0.02 | 0.01 | 0.18 | 0.025 | 50% |
| | CBOD | mg/L | 6 | 2.27 | 1.55 | 0.29 | 6.10 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 55.27 | 57.25 | 4.80 | 104.40 | 20 | 83% |
| | Nitrate+Nitrite | mg/L | 6 | 0.40 | 0.39 | 0.01 | 0.74 | 10 | 0% |
| | SRP | mg/L | 6 | 0.17 | 0.16 | 0.07 | 0.29 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 1.38 | 1.34 | 0.93 | 1.98 | 1 | 83% |
| | Total Dissolved Nitrogen | mg/L | 6 | 1.32 | 1.11 | 0.51 | 2.56 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.29 | 0.27 | 0.17 | 0.49 | 0.1 | 100% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.23 | 0.16 | 0.10 | 0.46 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 6 | 12 | 19 | 2 | 44 | 33 | No |
| | Fecal Coliform | CFU/100mL | 6 | 48 | 48 | 34 | 70 | 200 | No |
| | Total Coliform | CFU/100mL | 6 | 113 | 105 | 60 | 250 | 1,000 | No |
| | TSS | mg/L | 6 | 27.4 | 28.1 | 21.5 | 32.7 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.02 | 0.02 | 0.02 | 0.03 | 0.025 | 17% |
| | CBOD | mg/L | 6 | 5.20 | 5.20 | 3.30 | 7.40 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 102.10 | 114.10 | 25.80 | 147.70 | 20 | 100% |
| | Nitrate+Nitrite | mg/L | 6 | 0.02 | 0.01 | 0.01 | 0.03 | 10 | 0% |
| | SRP | mg/L | 6 | 0.05 | 0.06 | 0.01 | 0.06 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 1.60 | 1.60 | 1.09 | 2.13 | 1 | 100% |
| | Total Dissolved Nitrogen | mg/L | 6 | 0.82 | 0.80 | 0.58 | 1.05 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.23 | 0.21 | 0.18 | 0.32 | 0.1 | 100% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.09 | 0.10 | 0.01 | 0.14 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | 6 | 13 | 15 | 2 | 38 | 33 | No |
| | Fecal Coliform | CFU/100mL | 6 | 94 | 96 | 40 | 240 | 200 | No |
| | Total Coliform | CFU/100mL | 6 | 145 | 159 | 80 | 210 | 1,000 | No |
| | TSS | mg/L | 6 | 7.1 | 8.1 | 3.7 | 8.9 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.05 | 0.02 | 0.00 | 0.22 | 0.025 | 33% |
| | CBOD | mg/L | 6 | 1.87 | 1.75 | 1.00 | 2.90 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 13.72 | 13.10 | 4.30 | 24.40 | 20 | 33% |
| | Nitrate+Nitrite | mg/L | 6 | 0.02 | 0.01 | 0.01 | 0.09 | 10 | 0% |
| | SRP | mg/L | 6 | 0.04 | 0.02 | 0.01 | 0.17 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 0.87 | 0.90 | 0.42 | 1.20 | 1 | 33% |
| | Total Dissolved Nitrogen | mg/L | 6 | 0.85 | 0.87 | 0.33 | 1.24 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.04 | 0.04 | 0.02 | 0.07 | 0.1 | 0% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.03 | 0.03 | 0.01 | 0.04 | NA | NA |

**Table 4-40: Buena Vista Index Period Events 1-4 Lagoon Segment 2 Site Summary (continued)**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 6 | 25 | 13 | 2 | 98 | 33 | No |
| | Fecal Coliform | CFU/100mL | 6 | 91 | 88 | 36 | 140 | 200 | No |
| | Total Coliform | CFU/100mL | 6 | 105 | 80 | 50 | 180 | 1000 | No |
| | TSS | mg/L | 6 | 8.1 | 4.7 | 2.3 | 26.3 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.02 | 0.02 | 0.01 | 0.03 | 0.025 | 17% |
| | CBOD | mg/L | 6 | 1.67 | 1.60 | 1.00 | 2.40 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 15.20 | 15.90 | 4.00 | 28.50 | 20 | 33% |
| | Nitrate+Nitrite | mg/L | 6 | 0.01 | 0.01 | 0.01 | 0.01 | 10 | 0% |
| | SRP | mg/L | 6 | 0.00 | 0.00 | 0.00 | 0.01 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 0.96 | 0.97 | 0.61 | 1.25 | 1 | 50% |
| | Total Dissolved Nitrogen | mg/L | 6 | 0.78 | 0.76 | 0.66 | 0.95 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.04 | 0.04 | 0.02 | 0.06 | 0.1 | 0% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.02 | 0.02 | 0.01 | 0.03 | NA | NA |

(1) Enterococcus, fecal coliform, and total coliform were calculated as geometric means whereas all other constituents were calculated as arithmetic means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.2.3.3 Ocean Inlet Sites

Buena Vista Lagoon is closed to tidal influence and therefore there was not an ocean inlet sample location in this monitoring program.

#### 4.2.3.4 Transect Sampling

Longitudinal transect sampling was conducted at ten designated locations along a salinity gradient at Buena Vista Lagoon; five within the eastern-most basin and five within the central basin. Sampling events occurred once during each index period event and included sampling once during the morning and once during the evening on the same day. Specific conductivity, temperature, turbidity, DO, and pH water quality parameters were also measured concurrent to sample collection at each site and results are presented in Appendix B-2. Results from transect sampling events are summarized statistically in Table 4-41. Detailed analytical results for all wet weather events are presented in Appendix C-2.

**Table 4-41: Buena Vista Longitudinal Transect Data Summary Index Period Events 1-4**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 10 | 32 | 42 | 8 | 80 | 33 | No |
| | Fecal Coliform | CFU/100mL | 10 | 109 | 124 | 44 | 252 | 200 | No |
| | Total Coliform | CFU/100mL | 10 | 408 | 430 | 208 | 660 | 1,000 | No |
| | TSS | mg/L | 20 | 21.5 | 15.5 | 6.0 | 62.5 | NA | NA |
| | Ammonia as N | mg/L | 20 | 0.02 | 0.02 | 0.01 | 0.03 | 0.025 | 15% |
| | CBOD | mg/L | 6 | 2.76 | 0.29 | 0.29 | 14.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 20 | 132.05 | 99.70 | 61.50 | 569.60 | 20 | 100% |
| | Nitrate+Nitrite | mg/L | 20 | 0.73 | 0.57 | 0.14 | 2.02 | 10 | 0% |
| | SRP | mg/L | 20 | 0.09 | 0.09 | 0.01 | 0.20 | NA | NA |
| | Total Nitrogen | mg/L | 20 | 1.63 | 1.52 | 1.14 | 3.25 | 1 | 100% |
| | Total Dissolved Nitrogen | mg/L | 20 | 1.40 | 1.21 | 0.80 | 2.39 | NA | NA |
| | Total Phosphorus | mg/L | 20 | 0.18 | 0.22 | 0.04 | 0.31 | 0.1 | 65% |
| | Total Dissolved Phosphorus | mg/L | 20 | 0.13 | 0.12 | 0.01 | 0.28 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 10 | 8 | 6 | 2 | 78 | 33 | No |
| | Fecal Coliform | CFU/100mL | 10 | 177 | 250 | 36 | 500 | 200 | No |
| | Total Coliform | CFU/100mL | 10 | 282 | 410 | 40 | 1020 | 1,000 | No |
| | TSS | mg/L | 20 | 78.1 | 61.0 | 32.7 | 184.0 | NA | NA |
| | Ammonia as N | mg/L | 20 | 0.02 | 0.02 | 0.01 | 0.04 | 0.025 | 30% |
| | CBOD | mg/L | 6 | 6.45 | 6.30 | 2.80 | 11.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 20 | 238.58 | 199.80 | 87.70 | 524.70 | 20 | 100% |
| | Nitrate+Nitrite | mg/L | 20 | 0.07 | 0.01 | 0.00 | 0.72 | 10 | 0% |
| | SRP | mg/L | 20 | 0.02 | 0.01 | 0.00 | 0.05 | NA | NA |
| | Total Nitrogen | mg/L | 20 | 1.26 | 1.05 | 0.66 | 2.21 | 1 | 65% |
| | Total Dissolved Nitrogen | mg/L | 20 | 0.60 | 0.59 | 0.35 | 1.33 | NA | NA |
| | Total Phosphorus | mg/L | 20 | 0.13 | 0.10 | 0.03 | 0.27 | 0.1 | 50% |
| | Total Dissolved Phosphorus | mg/L | 20 | 0.02 | 0.01 | 0.00 | 0.04 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | 10 | 2 | 2 | 2 | 6 | 33 | No |
| | Fecal Coliform | CFU/100mL | 10 | 122 | 140 | 4 | 1324 | 200 | No |
| | Total Coliform | CFU/100mL | 10 | 151 | 146 | 10 | 1324 | 1,000 | No |
| | TSS | mg/L | 20 | 30.0 | 13.9 | 2.5 | 90.2 | NA | NA |
| | Ammonia as N | mg/L | 20 | 0.02 | 0.02 | 0.01 | 0.10 | 0.025 | 20% |
| | CBOD | mg/L | 6 | 3.07 | 3.65 | 1.00 | 4.80 | NA | NA |
| | Chlorophyll *a* | ug/L | 20 | 28.63 | 19.95 | 0.50 | 73.20 | 20 | 50% |
| | Nitrate+Nitrite | mg/L | 20 | 0.01 | 0.01 | 0.00 | 0.07 | 10 | 0% |
| | SRP | mg/L | 20 | 0.01 | 0.01 | 0.00 | 0.01 | NA | NA |
| | Total Nitrogen | mg/L | 20 | 0.65 | 0.63 | 0.28 | 1.03 | 1 | 10% |
| | Total Dissolved Nitrogen | mg/L | 20 | 0.68 | 0.74 | 0.34 | 0.97 | NA | NA |
| | Total Phosphorus | mg/L | 20 | 0.03 | 0.03 | 0.00 | 0.08 | 0.1 | 0% |
| | Total Dissolved Phosphorus | mg/L | 20 | 0.01 | 0.01 | 0.52 | 0.01 | NA | NA |

**Table 4-41: Buena Vista Longitudinal Transect Data Summary Index Period Events 1-4 (continued)**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 10 | 3 | 2 | 2 | 18 | 33 | No |
| | Fecal Coliform | CFU/100mL | 10 | 45 | 42 | 8 | 440 | 200 | No |
| | Total Coliform | CFU/100mL | 10 | 166 | 245 | 20 | 1,150 | 1,000 | No |
| | TSS | mg/L | 20 | 35.2 | 17.4 | 0.5 | 190.4 | NA | NA |
| | Ammonia as N | mg/L | 20 | 0.01 | 0.01 | 0.01 | 0.03 | 0.025 | 10% |
| | CBOD | mg/L | 6 | 7.97 | 8.75 | 1.00 | 15.30 | NA | NA |
| | Chlorophyll *a* | ug/L | 20 | 78.18 | 72.10 | 8.50 | 235.00 | 20 | 75% |
| | Nitrate+Nitrite | mg/L | 20 | 0.01 | 0.01 | 0.01 | 0.02 | 10 | 0% |
| | SRP | mg/L | 20 | 0.01 | 0.01 | 0.00 | 0.01 | NA | NA |
| | Total Nitrogen | mg/L | 20 | 1.01 | 0.97 | 0.66 | 1.55 | 1 | 45% |
| | Total Dissolved Nitrogen | mg/L | 20 | 0.74 | 0.65 | 0.50 | 1.46 | NA | NA |
| | Total Phosphorus | mg/L | 20 | 0.08 | 0.07 | 0.01 | 0.19 | 0.1 | 35% |
| | Total Dissolved Phosphorus | mg/L | 20 | 0.04 | 0.03 | 0.00 | 0.17 | NA | NA |

(1) Enterococcus, fecal coliform, and total coliform were calculated as geometric means whereas all other constituents were calculated as arithmetic means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.2.3.5 Specific Conductivity

Specific conductivity was continuously measured at all sample locations during the four index periods. Specific conductivity remained generally low at less than 5 mS/cm, at the three monitoring locations associated with Buena Vista Lagoon as the lagoon is closed to tidal influence. Although specific conductance remained low throughout the monitoring period, values reached their the lowest points during Index Period 1, which occurred in the wet season and experienced a higher input of freshwater from the watershed. Specific conductance at these sites was close to accepted freshwater values which are near 1.0 mS/cm. In contrast, seawater ranges from 50 mS/cm to 56 mS/cm (United States Office of Naval Research).

Results for all parameters continuously monitored at all sites are summarized statistically in Tables 4-28 through 4-30. Results are summarized both monthly and by monitoring event. Detailed continuous monitoring results from the entire monitoring period are presented in Appendix B-2.

#### 4.2.3.6 Temperature

Temperature was continuously measured at all sample locations during the four index periods. Seasonal variation in temperature was reflected at all sample locations. The magnitude of temperature ranges was very similar at all sites; however, the Mass Emission Station recorded lower averages in general than the two segment sites. Input from the watershed is a factor in cooler waters at the mass emission station when compared to the lagoon segment sites, which have very little flow due to the lagoon mouth closure. Temperature was lowest at all locations during Index Period 1, which occurred in the wet season and experienced a higher input of freshwater from the watershed.

Results for all parameters continuously monitored at all sites are summarized statistically in Tables 4-28 through 4-30. Results are summarized both monthly and by monitoring event. Detailed continuous monitoring results from the entire monitoring period are presented in Appendix B-2.

#### 4.2.3.7 Turbidity

Turbidity was measured at all sample locations during the four index periods. Turbidity was generally low during the Index Period Events. Turbidity was low during index period events at the mass emission station, however were higher at the lagoon segment sites. Turbidity spikes associated with storm events were most profound at the mass emission station and dampened through the lagoon segment sites.

Results for all parameters continuously monitored at all sites are summarized statistically in Tables 4-28 through 4-30. Results are summarized both monthly and by monitoring event. Detailed continuous monitoring results from the entire monitoring period are presented in Appendix B-2.

#### 4.2.3.8 Storm Drain Sampling

Storm drain sampling occurred at the two designated locations once during each of the index sampling events. Flow conditions were noted at each location during each sampling event. Sample dates and analytical results are summarized in Table 4-42.

**Table 4-42: Buena Vista Index Period Storm Drain Sampling Results**

| Analyte Name | Units | Index Period Event 1 | | Index Period Event 2 | | Index Period Event 3 | | Index Period Event 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1/15/2008 | | 3/31/2008 | | 7/14-17/2008[1] | | 9/23/2008 | |
| | | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 |
| *Enterococcus* | CFU/100mL | 1,200 | 200 | 2,228 | 1,274 | 4,050 | 400 | 5,800 | 200 |
| Fecal Coliform | CFU/100mL | 1,000 | 800 | 1,444 | 1992 | 7,400 | 3,050 | 8,800 | 1,300 |
| Total Coliform | CFU/100mL | 3,000 | 9,300 | 3,740 | 1,430 | 12,000 | 3,750 | 10,800 | 1,200 |
| TSS | mg/L | 7.2 | 28.8 | 9.6 | 43.2 | 7.6 | 13.2 | 13 | 22.5 |
| Ammonia as N | mg/L | 0.04 | 0.02 | 0.07 | 0.05 | 0.04 | 0.06 | 0.06 | 0.24 |
| CBOD | mg/L | 0.29 | 5.6 | 0.29 | 1.5 | 0.29 | 2.8 | 0.29 | 0.29 |
| Chlorophyll *a* | ug/L | 3.2 | 169 | 3.3 | 4 | 0.5 | 43.2 | 18.7 | 36.7 |
| Nitrate+Nitrite as N | mg/L | 4.40 | 0.01 | 7.90 | 0.01 | 8.91 | 0.02 | 13.1 | 0.02 |
| SRP | mg/L | 0.03 | 0.01 | 0.03 | 0.01 | 0.03 | 0.01 | 0.04 | 0.00 |
| TN | mg/L | 30.0 | 0.72 | 5.30 | 0.58 | 7.40 | 0.63 | 14.7 | 1.15 |
| TDN | mg/L | 21.2 | 1.23 | 5.67 | 0.72 | 7.97 | 0.93 | 15.3 | 0.92 |
| TP | mg/L | 0.07 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.04 | 0.03 |
| TDP | mg/L | 0.11 | 0.07 | 0.01 | 0.01 | 0.03 | 0.00 | 0.06 | 0.01 |
| Flow | cfs | 0.011 | 0.011 | 0.006 | 0.008 | 0.069 | 0.005 | 0.023 | 0.004 |

(1) Microbiology samples were collected July 17, 2008 and the remaining samples were collected July 14, 2008.

### 4.2.4 Buena Vista Land Elevation Survey of Ocean Inlet Site

Land elevation surveys were not a requirement at Buena Vista Lagoon as the ocean inlet is closed.

### 4.2.5 Buena Vista Open Ocean Inlet Days

The Buena Vista Lagoon is continuously closed to the ocean.

## 4.3 LOMA ALTA SLOUGH MONITORING RESULTS

This section summarizes results from continuous monitoring as well as wet weather and index period events. Detailed discussion of the results is presented in section 6.1.

### 4.3.1 Loma Alta Continuous Monitoring

Continuous monitoring at Loma Alta Slough included the following parameters:

- Rainfall (Mass Emission Station only)
- Flow (Mass Emission Station only)
- Specific conductivity
- Temperature
- Turbidity
- Dissolved Oxygen (DO)
- pH
- Water level (Lagoon Segment and Ocean Inlet Sites)

In accordance with the QAPP, flow, rainfall, specific conductivity, and temperature monitoring was conducted from October 2007 to October 2008 at the Loma Alta Mass Emission Station and monitoring of turbidity and DO was conducted from January 2008 to October 2008. Although monitoring of pH was required from January 2008 to October 2008, it was monitored from October 2007 to October 2008 at the Mass Emission Station. Monitoring of specific conductivity, temperature, turbidity, DO, pH, and water level at lagoon segment and ocean inlet sites was required during a three-month wet weather period and a three to four-month dry weather period, covering all monitoring events. However, continuous monitoring of these parameters was conducted from January 2008 to October 2008 resulting in a greater time period than required by the QAPP.

#### 4.3.1.1 Hydrology of the Lagoon

Table 4-43 summarizes results from the continuous water level monitoring statistically on a monthly basis as well as by event. Detailed continuous monitoring results for the entire monitoring period are presented in Appendix B-3.

Water level was not recorded with the data sonde at the mass emission station as other instrumentation was installed to measure stage and to calculate real-time flows. Depth measurements from the data sondes were tied to North American Vertical Datum, 1988 (NAVD 88).

**Table 4-43: Loma Alta Continuous Lagoon Depth Monitoring Monthly and Event Summary**

| Month (2008) | Lagoon Segment 1 Site | | | Ocean Inlet 1 Site | | |
|---|---|---|---|---|---|---|
| | Lagoon Depth (m) | | | Lagoon Depth (m) | | |
| | Mean | Min[1] | Max | Mean | Min | Max |
| January | 0.0 | -0.5 | 1.0 | 0.9 | 0.5 | 1.8 |
| February | 0.1 | -0.3 | 2.0 | 0.9 | 0.4 | 1.6 |
| March | 0.2 | -0.2 | 0.7 | 1.0 | 0.6 | 1.5 |
| April | 0.2 | 0.0 | 0.7 | 1.0 | 0.5 | 1.5 |
| May | 0.3 | 0.0 | 0.9 | 1.1 | 0.8 | 1.7 |
| June | 0.4 | 0.2 | 0.5 | 1.2 | 1.0 | 1.3 |
| July | 0.4 | 0.3 | 0.7 | 1.2 | 1.1 | 1.5 |
| August | 0.4 | 0.3 | 0.6 | Lagoon mouth closed. No data collected. | | |
| September | 0.4 | 0.2 | 0.8 | Lagoon mouth closed. No data collected. | | |
| October | 0.7 | 0.4 | 1.0 | 1.4 | 1.2 | 1.8 |
| Average | 0.3 | 0.0 | 0.9 | 1.1 | 0.8 | 1.6 |
| **Event** | **Lagoon Depth (m)** | | | **Lagoon Depth (m)** | | |
| | **Mean[1]** | **Min[1]** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | -0.1 | -0.5 | 0.6 | 0.8 | 0.5 | 1.4 |
| Wet Weather 2 | 0.0 | -0.2 | 0.8 | 0.8 | 0.5 | 1.6 |
| Wet Weather 3 | 0.0 | -0.2 | 0.6 | 0.8 | 0.5 | 1.4 |
| Index Period 1 | 0.1 | -0.2 | 0.5 | 1.0 | 0.7 | 1.4 |
| Index Period 2 | 0.2 | 0.0 | 0.6 | 0.9 | 0.6 | 1.4 |
| Index Period 3 | Lagoon mouth closed. No samples collected during Index Period Event 3. | | | | | |
| Index Period 4 | 0.6 | 0.4 | 0.8 | 1.2 | 1.2 | 1.2 |

(1) Negative depth measurements are due to a very shallow channel during the winter months. Due to high storm flows, the channel was washed out, therefore during non-storm flows the measurement area around the data sonde remained very shallow making it difficult to keep the depth sensor (which is higher on the sonde body than the other sensors) submerged.

#### 4.3.1.2 Rainfall and Flow

Rainfall and flow were both continuously monitored at the Loma Alta mass emission station throughout the monitoring period as required by the IO. Instrumentation installed at the mass emission station measured and logged rainfall and flow beginning October 1, 2007 through October 31, 2008.

Daily and monthly precipitation totals are summarized in Table 4-44. The total rainfall for the entire monitoring year was 12.41 inches. January had the most rainfall in one month, totaling 4.49 inches. Detailed continuous rainfall results for the entire monitoring period are presented in Appendix A-3.

Daily and monthly discharge totals are summarized in Table 4-45. A total volume of 179,167,679 cubic feet was discharged into Loma Alta Lagoon over the entire monitoring period. January recorded the highest monthly discharge throughout the year with 45,616,334 cubic feet. Detailed continuous stage results and flow results for the entire monitoring period are presented in Appendix A-3.

## Table 4-44: Loma Alta Mass Emission Station Daily and Monthly Precipitation Summary (inches)

| Day | 2007 | | | 2008 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **October** | **November** | **December** | **January** | **February** | **March** | **April** | **May** | **June** | **July** | **August** | **September** | **October** |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 0.00 | 0.00 | 0.00 | 1.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | 0.00 | 0.00 | 0.00 | 1.22 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | 0.00 | 0.00 | 0.39 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | 0.00 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 13 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18 | 0.00 | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19 | 0.00 | 0.00 | 0.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22 | 0.00 | 0.00 | 0.00 | 0.12 | 2.72 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 23 | 0.00 | 0.00 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 24 | 0.00 | 0.00 | 0.00 | 0.04 | 0.35 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 26 | 0.00 | 0.00 | 0.00 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 27 | 0.00 | 0.00 | 0.00 | 1.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 |
| 30 | 0.00 | 2.28 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 31 | 0.00 | | 0.00 | 0.00 | | 0.00 | | 0.00 | | 0.00 | 0.00 | | 0.00 |
| **Totals** | **0.12** | **2.28** | **1.22** | **4.49** | **3.98** | **0.00** | **0.00** | **0.28** | **0.00** | **0.00** | **0.00** | **0.04** | **0.00** |

**Table 4-45: Loma Alta Mass Emission Station Daily and Monthly Total Discharge Summary (cubic feet)**

| Day | 2007 | | | 2008 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | October | November | December | January | February | March | April | May | June | July | August | September | October |
| 1 | 26,199 | 76,908 | 5,154,896 | 45,621 | 311,829 | 242,336 | 613,401 | 268,742 | 78,849 | 8,467 | 6,323 | 4,178 | 4,680 |
| 2 | 30,969 | 61,659 | 617,367 | 53,082 | 579,902 | 261,717 | 575,906 | 315,760 | 91,593 | 8,398 | 6,253 | 4,109 | 3,762 |
| 3 | 30,735 | 54,963 | 218,465 | 52,992 | 3,521,903 | 288,368 | 592,069 | 407,472 | 87,993 | 8,329 | 6,184 | 4,040 | 2,961 |
| 4 | 33,588 | 45,459 | 159,843 | 45,927 | 1,542,899 | 273,167 | 755,496 | 596,519 | 90,666 | 8,259 | 6,115 | 3,971 | 2,871 |
| 5 | 32,544 | 50,670 | 121,347 | 7,208,467 | 520,246 | 250,623 | 797,316 | 729,724 | 93,393 | 8,190 | 6,046 | 4,880 | 12,807 |
| 6 | 32,904 | 67,077 | 85,095 | 3,770,743 | 398,592 | 271,514 | 814,572 | 881,133 | 99,162 | 8,121 | 5,977 | 4,410 | 6,480 |
| 7 | 36,036 | 62,010 | 2,529,469 | 12,606,929 | 337,135 | 209,705 | 990,151 | 1,054,402 | 85,716 | 8,052 | 5,908 | 5,661 | 4,050 |
| 8 | 44,730 | 92,691 | 1,118,029 | 814,842 | 284,489 | 253,914 | 1,194,430 | 1,126,687 | 90,531 | 7,983 | 5,838 | 5,427 | 3,195 |
| 9 | 85,653 | 78,478 | 997,784 | 415,879 | 228,664 | 253,786 | 1,210,779 | 1,267,517 | 57,668 | 7,914 | 5,769 | 4,500 | 3,078 |
| 10 | 60,687 | 55,143 | 276,861 | 333,240 | 219,036 | 231,164 | 1,369,129 | 1,225,092 | 38,961 | 7,844 | 5,700 | 5,562 | 3,087 |
| 11 | 48,870 | 36,855 | 189,048 | 254,640 | 245,762 | 243,825 | 1,379,895 | 1,217,976 | 34,479 | 7,775 | 5,631 | 6,363 | 2,736 |
| 12 | 46,098 | 39,420 | 139,185 | 209,557 | 230,284 | 307,332 | 1,179,721 | 1,452,438 | 38,808 | 7,706 | 5,562 | 6,831 | 2,061 |
| 13 | 291,299 | 33,228 | 135,144 | 182,913 | 230,296 | 286,812 | 1,142,675 | 1,223,271 | 33,507 | 7,637 | 5,063 | 7,758 | 2,322 |
| 14 | 129,267 | 27,495 | 98,298 | 159,372 | 1,766,837 | 300,540 | 1,449,206 | 1,225,435 | 30,249 | 7,568 | 6,525 | 5,418 | 2,034 |
| 15 | 70,947 | 46,534 | 83,430 | 140,436 | 813,454 | 311,246 | 1,573,704 | 1,277,178 | 43,002 | 7,498 | 7,875 | 4,068 | 2,205 |
| 16 | 55,971 | 38,025 | 73,926 | 159,714 | 297,032 | 462,037 | 1,527,948 | 1,104,559 | 43,038 | 7,429 | 8,469 | 4,383 | 2,763 |
| 17 | 67,392 | 41,832 | 73,521 | 142,068 | 218,097 | 374,126 | 1,242,685 | 2,221,613 | 52,569 | 7,360 | 5,184 | 3,717 | 3,060 |
| 18 | 75,591 | 46,260 | 138,249 | 170,696 | 174,015 | 337,480 | 1,154,699 | 499,440 | 61,110 | 7,291 | 5,075 | 4,437 | 3,861 |
| 19 | 59,121 | 56,286 | 2,754,297 | 150,075 | 140,337 | 264,080 | 942,985 | 516,656 | 52,290 | 7,222 | 5,077 | 5,085 | 4,851 |
| 20 | 72,810 | 58,266 | 264,424 | 146,772 | 1,191,165 | 300,649 | 723,610 | 500,814 | 30,078 | 7,153 | 5,008 | 3,996 | 8,802 |
| 21 | 54,009 | 49,698 | 606,582 | 97,551 | 478,572 | 360,153 | 685,429 | 413,061 | 22,566 | 7,083 | 4,939 | 4,212 | 3,438 |
| 22 | 33,219 | 51,165 | 260,196 | 278,174 | 18,787,253 | 342,122 | 639,198 | 443,652 | 9,089 | 7,014 | 4,870 | 4,653 | 3,519 |
| 23 | 27,783 | 61,344 | 108,234 | 634,106 | 1,199,673 | 266,548 | 532,952 | 734,597 | 9,020 | 6,945 | 4,801 | 3,933 | 2,484 |
| 24 | 31,932 | 64,629 | 81,666 | 1,681,656 | 3,726,703 | 281,018 | 469,575 | 371,897 | 8,951 | 6,876 | 4,732 | 4,311 | 2,079 |
| 25 | 54,558 | 42,309 | 89,163 | 264,843 | 984,599 | 343,912 | 389,449 | 98,847 | 8,882 | 6,807 | 4,662 | 4,851 | 2,331 |
| 26 | 102,876 | 31,347 | 78,219 | 266,680 | 529,469 | 343,118 | 253,964 | 139,877 | 8,813 | 6,738 | 4,593 | 4,275 | 2,313 |
| 27 | 59,274 | 29,907 | 83,322 | 9,810,014 | 333,328 | 386,347 | 159,834 | 157,660 | 8,744 | 6,668 | 4,524 | 4,833 | 3,213 |
| 28 | 66,474 | 33,912 | 64,566 | 4,069,259 | 354,165 | 444,648 | 186,350 | 81,360 | 8,674 | 6,599 | 4,455 | 4,293 | 3,816 |
| 29 | 62,325 | 21,636 | 68,022 | 714,235 | 263,634 | 428,882 | 236,739 | 89,397 | 8,605 | 6,530 | 4,386 | 31,572 | 3,636 |
| 30 | 85,257 | 14,690,052 | 79,866 | 417,004 | | 435,555 | 262,757 | 96,597 | 8,536 | 6,461 | 4,317 | 8,919 | 3,699 |
| 31 | 71,415 | | 69,282 | 318,848 | | 446,895 | | 81,864 | | 6,392 | 4,247 | | 4,113 |
| **Total** | **1,980,533** | **16,145,257** | **16,817,798** | **45,616,334** | **39,909,369** | **9,803,618** | **25,046,623** | **21,821,236** | **1,335,543** | **230,308** | **170,108** | **174,645** | **116,307** |

4.3.1.3 Continuous Monitoring of Water Quality Parameters

Results from the continuous monitoring are summarized statistically on a monthly basis as well as by event in Tables 4-46 through 4-48. Detailed continuous monitoring results for the entire monitoring period are presented in Appendix B-3.

Data gaps occurred as a result of fouling, tampering, unexpected decrease in water level, equipment malfunction, and other unforeseen events and are discussed in Section 3.1.1.2.

**Table 4-46: Loma Alta Mass Emission Station Continuous Data Monthly and Event Summary**

| Month (2007/2008) | Specific Conductance (mS/cm) | | | Temperature (°C) | | | Turbidity (NTU)[1] | | | Dissolved Oxygen (mg/L)[1] | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| October | 4.2 | 1.8 | 5.0 | 17.8 | 12.4 | 24.5 | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | 7.9 | 7.7 | 8.4 |
| November | 4.4 | 0.4 | 5.0 | 15.4 | 9.1 | 20.2 | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | 7.9 | 7.6 | 8.2 |
| December | 2.8 | 0.6 | 4.3 | 11.1 | 6.1 | 15.6 | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | 7.9 | 7.6 | 8.4 |
| January | 3.1 | 0.2 | 4.5 | 11.4 | 6.8 | 16.1 | 15.3 | 0.0 | 764.1 | 10.9 | 7.8 | 20.8 | 8.0 | 7.6 | 8.5 |
| February | 2.7 | 0.2 | 4.3 | 12.6 | 7.5 | 19.4 | 14.5 | 0.0 | 433.8 | 10.9 | 7.0 | 20.0 | 8.0 | 7.6 | 8.8 |
| March | 4.1 | 3.3 | 4.4 | 16.0 | 9.9 | 22.0 | 0.6 | -0.1 | 3.9 | 11.5 | 4.9 | 23.1 | 8.0 | 7.6 | 8.5 |
| April | 4.4 | 4.2 | 4.6 | 18.1 | 12.9 | 23.6 | 0.5 | 0.0 | 6.0 | 10.6 | 2.6 | 23.2 | 7.6 | 7.3 | 8.1 |
| May | 4.3 | 1.1 | 4.7 | 20.1 | 14.8 | 27.2 | 1.4 | 0.0 | 94.7 | 8.3 | 0.1 | 22.4 | 7.6 | 7.2 | 8.1 |
| June | 4.4 | 3.9 | 4.5 | 22.8 | 18.1 | 29.1 | 1.1 | 0.0 | 10.9 | 7.8 | 0.1 | 21.7 | 7.5 | 7.2 | 8.1 |
| July | 4.4 | 4.2 | 4.6 | 23.7 | 19.5 | 28.0 | 0.9 | 0.0 | 3.8 | 6.6 | 0.5 | 18.5 | 7.5 | 7.1 | 8.0 |
| August | 4.6 | 4.1 | 4.8 | 24.5 | 21.0 | 29.0 | 1.3 | -0.1 | 600.6 | 5.8 | 0.4 | 16.7 | 7.5 | 7.2 | 8.0 |
| September | 4.6 | 1.1 | 4.9 | 22.7 | 18.3 | 27.2 | 1.8 | 0.0 | 323.4 | 6.4 | 0.6 | 16.3 | 7.5 | 7.0 | 7.9 |
| October | 4.1 | 2.9 | 4.6 | 18.9 | 12.2 | 25.2 | 1.6 | 0.0 | 93.5 | 6.0 | 1.3 | 13.1 | 7.6 | 7.3 | 7.9 |
| Average | 4.0 | 2.2 | 4.6 | 18.1 | 13.0 | 23.6 | 3.9 | 0.0 | 233.5 | 8.5 | 2.5 | 19.6 | 7.7 | 7.4 | 8.2 |
| **Event** | **Specific Conductance (mS/cm)** | | | **Temperature (°C)** | | | **Turbidity (NTU)** | | | **Dissolved Oxygen (mg/L)** | | | **pH** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 1.6 | 0.2 | 4.3 | 12.6 | 10.3 | 14.7 | 3.2 | 1.1 | 9.0 | 10.1 | 9.4 | 11.4 | 7.9 | 7.7 | 8.2 |
| Wet Weather 2 | 1.7 | 0.2 | 4.2 | 12.3 | 9.5 | 16.1 | 46.7 | 0.4 | 764.1 | 10.3 | 8.4 | 17.1 | 8.0 | 7.6 | 8.5 |
| Wet Weather 3 | 2.0 | 0.5 | 3.9 | 11.2 | 7.9 | 14.8 | 13.6 | 0.0 | 90.6 | 10.7 | 8.4 | 15.6 | 8.0 | 7.7 | 8.5 |
| Index Period 1 | 3.9 | 3.2 | 4.3 | 11.3 | 8.0 | 17.0 | 1.4 | 0.1 | 7.4 | 11.4 | 8.5 | 19.5 | 8.1 | 7.9 | 8.5 |
| Index Period 2 | 4.3 | 4.2 | 4.4 | 17.4 | 12.9 | 22.0 | 0.5 | 0.0 | 1.6 | 12.0 | 4.8 | 23.2 | 7.8 | 7.4 | 8.1 |
| Index Period 3 | 4.3 | 4.3 | 4.4 | 24.0 | 21.0 | 28.0 | 1.0 | 0.0 | 3.5 | 6.3 | 0.6 | 16.8 | 7.4 | 7.1 | 7.9 |
| Index Period 4 | 4.1 | 1.1 | 4.7 | 20.6 | 17.2 | 25.2 | 5.6 | 0.2 | 323.4 | 5.0 | 1.0 | 11.9 | 7.5 | 7.0 | 7.7 |
| WQO | N/A | | | N/A | | | 20 NTU | | | < 5 mg/L | | | 6.5 – 8.5 | | |

(1) Per the QAPP, turbidity and DO were not required to be monitored prior to January 2008.

**Table 4-47: Loma Alta Lagoon Segment 1 Continuous Data Monthly and Event Summary**

| Month (2008) | Specific Conductance (mS/cm) | | | Temperature (°C) | | | Turbidity (NTU) | | | Dissolved Oxygen (mg/L) | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| January | 26.5 | 0.2 | 48.2 | 13.6 | 9.6 | 17.4 | 21.0 | 0.0 | 878.4 | 10.6 | 2.3 | 22.0 | 8.1 | 7.6 | 8.6 |
| February | 18.6 | 0.2 | 46.7 | 13.9 | 8.4 | 20.5 | 12.9 | -0.1 | 383.7 | 10.7 | 4.5 | 21.3 | 8.1 | 7.6 | 8.6 |
| March | 39.9 | 4.1 | 45.2 | 18.9 | 13.8 | 24.4 | 2.1 | 0.0 | 20.6 | 11.1 | 0.2 | 21.9 | 8.1 | 7.6 | 8.5 |
| April | 43.3 | 36.6 | 46.5 | 25.6 | 16.9 | 32.8 | 2.1 | 0.0 | 35.2 | 10.7 | 0.5 | 20.2 | 7.9 | 7.1 | 8.2 |
| May | 42.6 | 31.7 | 48.2 | 25.6 | 19.7 | 33.4 | 19.6 | -0.1 | 161.2 | 7.0 | 0.1 | 19.4 | 7.9 | 7.3 | 8.3 |
| June | 23.0 | 14.6 | 33.3 | 26.2 | 23.7 | 29.7 | 143.2 | 13.1 | 365.2 | 0.1 | 0.1 | 0.6 | 7.2 | 6.9 | 7.4 |
| July | 9.8 | 5.7 | 15.2 | 24.8 | 22.6 | 26.9 | 31.2 | -1.0 | 124.2 | 2.3 | 0.1 | 17.4 | 7.2 | 6.9 | 7.9 |
| August | 5.8 | 5.2 | 6.5 | 24.1 | 22.3 | 26.2 | 8.1 | -8.7 | 23.3 | 0.7 | 0.1 | 6.4 | 7.3 | 7.2 | 7.6 |
| September | 5.9 | 5.5 | 6.2 | 22.9 | 19.8 | 25.3 | 8.7 | -12.7 | 27.1 | 0.6 | 0.2 | 4.4 | 7.3 | 7.2 | 7.5 |
| October | 7.9 | 5.3 | 13.7 | 19.3 | 14.3 | 22.2 | 24.7 | 0.0 | 96.5 | 0.7 | 0.2 | 5.7 | 7.3 | 7.0 | 7.7 |
| Average | 22.3 | 10.9 | 31.0 | 21.5 | 17.1 | 25.9 | 27.4 | -1.0 | 211.5 | 5.5 | 0.8 | 13.9 | 7.6 | 7.2 | 8.0 |
| **Event** | **Specific Conductance (mS/cm)** | | | **Temperature (°C)** | | | **Turbidity (NTU)** | | | **Dissolved Oxygen (mg/L)** | | | **pH** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 2.7 | 0.2 | 41.4 | 12.9 | 10.3 | 16.5 | 58.3 | 0.8 | 802.9 | 9.8 | 8.5 | 12.1 | 8.0 | 7.7 | 8.3 |
| Wet Weather 2 | 12.1 | 0.2 | 47.3 | 12.8 | 10.1 | 16.7 | 48.5 | 0.1 | 878.4 | 9.6 | 4.7 | 14.5 | 7.9 | 7.6 | 8.4 |
| Wet Weather 3 | 12.1 | 0.5 | 46.7 | 11.7 | 8.4 | 15.5 | 15.8 | 2.2 | 98.9 | 10.0 | 5.4 | 13.4 | 8.0 | 7.7 | 8.6 |
| Index Period 1 | 38.8 | 12.4 | 43.0 | 14.4 | 9.8 | 16.6 | 1.8 | -0.1 | 31.8 | 12.9 | 7.2 | 21.8 | 8.3 | 8.1 | 8.5 |
| Index Period 2 | 42.9 | 38.7 | 45.2 | 21.3 | 17.3 | 24.2 | 2.1 | 0.1 | 13.8 | 9.9 | 2.5 | 16.9 | 7.9 | 7.4 | 8.2 |
| Index Period 3 | 11.5 | 9.4 | 13.4 | 25.7 | 23.5 | 26.6 | 26.9 | 0.0 | 62.6 | 1.7 | 0.1 | 15.7 | 7.1 | 6.9 | 7.6 |
| Index Period 4 | 6.3 | 5.5 | 7.3 | 20.3 | 18.9 | 21.8 | 15.1 | -8.9 | 76.8 | 0.3 | 0.2 | 2.2 | 7.3 | 7.2 | 7.5 |
| WQO | N/A | | | N/A | | | 20 NTU | | | <5 mg/L | | | 6.5 – 8.5 | | |

**Table 4-48: Loma Alta Ocean Inlet 1 Continuous Data Monthly and Event Summary**

| Month (2008) | Specific Conductance (mS/cm) | | | Temperature (°C) | | | Turbidity (NTU) | | | Dissolved Oxygen (mg/L) | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| January | 30.9 | 0.3 | 49.6 | 13.6 | 9.9 | 16.4 | 26.0 | -0.1 | 1192.9 | 9.5 | 4.0 | 20.8 | 8.0 | 7.6 | 8.7 |
| February | 31.0 | 0.2 | 50.1 | 14.3 | 9.5 | 19.3 | 19.0 | 0.0 | 983.3 | 9.7 | 3.5 | 20.0 | 8.0 | 7.5 | 8.6 |
| March | 46.7 | 29.8 | 50.3 | 17.1 | 12.9 | 24.5 | 2.0 | 0.0 | 60.4 | 9.6 | 0.0 | 25.1 | 8.1 | 7.2 | 8.7 |
| April | 47.2 | 39.3 | 51.0 | 19.1 | 13.9 | 32.2 | 3.5 | 0.0 | 47.5 | 6.6 | -0.1 | 23.3 | 8.0 | 7.1 | 8.8 |
| May | 33.3 | 14.1 | 50.7 | 25.4 | 16.8 | 32.7 | 34.0 | 0.0 | 375.1 | 4.1 | 0.0 | 24.7 | 7.9 | 7.3 | 8.7 |
| June | 14.6 | 6.4 | 30.5 | 24.5 | 20.9 | 26.8 | 61.9 | 0.0 | 329.9 | 0.1 | 0.0 | 4.3 | 7.3 | 6.9 | 7.9 |
| July | 20.0 | 9.2 | 28.9 | 23.8 | 21.1 | 25.9 | 57.3 | -0.3 | 170.7 | 0.2 | 0.0 | 7.6 | 7.2 | 6.9 | 7.8 |
| August[1] | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* |
| September[1] | *No Data* | *No Data* | *N Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* |
| October | 25.3 | 15.2 | 34.0 | 22.1 | 16.4 | 25.9 | 30.2 | 0.0 | 171.7 | 2.4 | 0.1 | 10.1 | 7.9 | 7.0 | 8.5 |
| Average | 31.1 | 14.3 | 43.1 | 20.0 | 15.2 | 25.4 | 29.2 | -0.1 | 416.4 | 5.3 | 0.9 | 17.0 | 7.8 | 7.2 | 8.5 |
| **Event** | **Specific Conductance (mS/cm)** | | | **Temperature (°C)** | | | **Turbidity (NTU)** | | | **Dissolved Oxygen (mg/L)** | | | **pH** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 9.6 | 0.3 | 43.5 | 12.9 | 10.3 | 15.7 | 70.2 | 0.1 | 795.5 | 9.5 | 8.3 | 15.9 | 8.0 | 7.7 | 8.4 |
| Wet Weather 2 | 18.4 | 0.3 | 49.0 | 13.3 | 10.5 | 16.4 | 58.8 | 0.1 | 1192.9 | 8.8 | 4.0 | 13.9 | 7.9 | 7.6 | 8.4 |
| Wet Weather 3 | 19.2 | 0.4 | 50.1 | 12.8 | 10.4 | 16.1 | 18.6 | 1.3 | 101.8 | 9.9 | 6.5 | 15.6 | 8.0 | 7.6 | 8.5 |
| Index Period 1 | 42.6 | 39.0 | 46.7 | 14.6 | 12.3 | 17.4 | 1.7 | 0.0 | 10.2 | 10.3 | 6.6 | 18.4 | 8.1 | 8.0 | 8.4 |
| Index Period 2 | 48.1 | 41.6 | 50.3 | 17.7 | 14.3 | 23.0 | 4.6 | 0.3 | 60.4 | 6.1 | 0.0 | 17.2 | 7.9 | 7.2 | 8.4 |
| Index Period 3 | Lagoon mouth closed. No samples collected during Index Period Event 3. | | | | | | | | | | | | | | |
| Index Period 4 | 18.1 | 17.0 | 18.5 | 24.5 | 23.9 | 25.3 | 31.7 | 5.2 | 54.4 | 0.1 | 0.1 | 0.2 | 7.6 | 7.0 | 7.8 |
| WQO | N/A | | | N/A | | | 20 NTU | | | < 5 mg/L | | | 6.5 – 8.5 | | |

(1) Continuous monitoring data was not collected when the lagoon mouth was closed, per the QAPP.

### 4.3.2 Loma Alta Wet Weather Monitoring

The following three wet weather events were successfully monitored at Loma Alta Lagoon:

- The first event occurred from January 5 to January 7, 2008. Rainfall began at 00:42 on January 5, 2008 and ended at 04:50 on January 7, 2008, totaling 2.52 inches.
- The second event occurred from January 23 to January 24, 2008. Rainfall began at 18:05 on January 23, 2008 and ended at 10:03 on January 24, 2008, totaling 0.24 inches.
- The third event occurred from February 3, 2008 to February 4, 2008. Rainfall began at 04:23 on February 3, 2008 and ended at 02:40 on February 4, 2008, totaling 0.39 inches of rainfall (0.35 inches as measured by agency performing sampling during this event).

All collected samples were placed on ice immediately after collection and stored at four degrees Celsius until delivery to the laboratory. Control of samples was maintained by Chain-of-Custody protocol from sample collection through sample analysis. All analytical methods performed on collected samples are outlined in Table 2-4 in Section 2.2.5. Quality Assurance/Quality Control samples were also collected per SWAMP requirements in accordance with the QAPP.

#### 4.3.2.1 Mass Emission Station

Two pollutagraph events and one flow-weighted composite sampling event were sampled successfully at the Loma Alta Mass Emission Station as required by the IO. Analytes monitored at this station were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus.

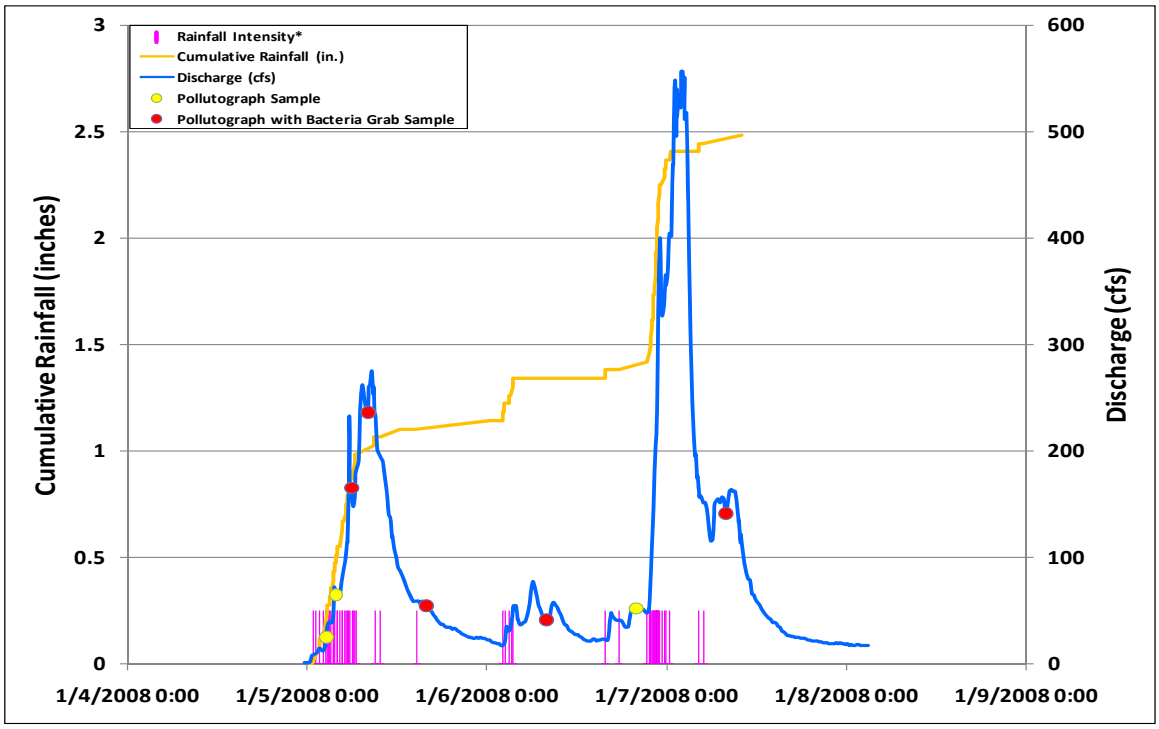
During the first monitored event, 12 pollutagraph samples were collected by the automated samplers. Eight of those 12 samples were submitted to the laboratory for analysis. Samples that represented the various flow regimes, specifically the rising limbs and peaks of the hydrograph, were selected. (Figure 4-8). Five microbiology grab samples were collected at targeted times during the storm event that corresponded to automated pollutagraph sample times. These samples were immediately submitted to the laboratory for analysis in order to meet the short hold time for bacteria analysis.

During the second monitored event, 12 pollutagraph samples were collected by the automated samplers. Eight of those 12 samples were submitted to the laboratory for analysis. Samples that represented the various flow regimes, specifically the rising limbs and peaks of the hydrograph, were selected (Figure 4-9). Six microbiology grab samples were collected at targeted times during the storm event that corresponded to automated pollutagraph sample times. These samples were immediately submitted to the

laboratory for analysis in order to meet the short hold time for bacteria analysis. Due to short holding times for microbiology samples, a sample collected earlier in the event had to be analyzed before notice was given of a sixth collected sample that was to be included in the analyzed suite. Results for any samples analyzed but not required are reported.

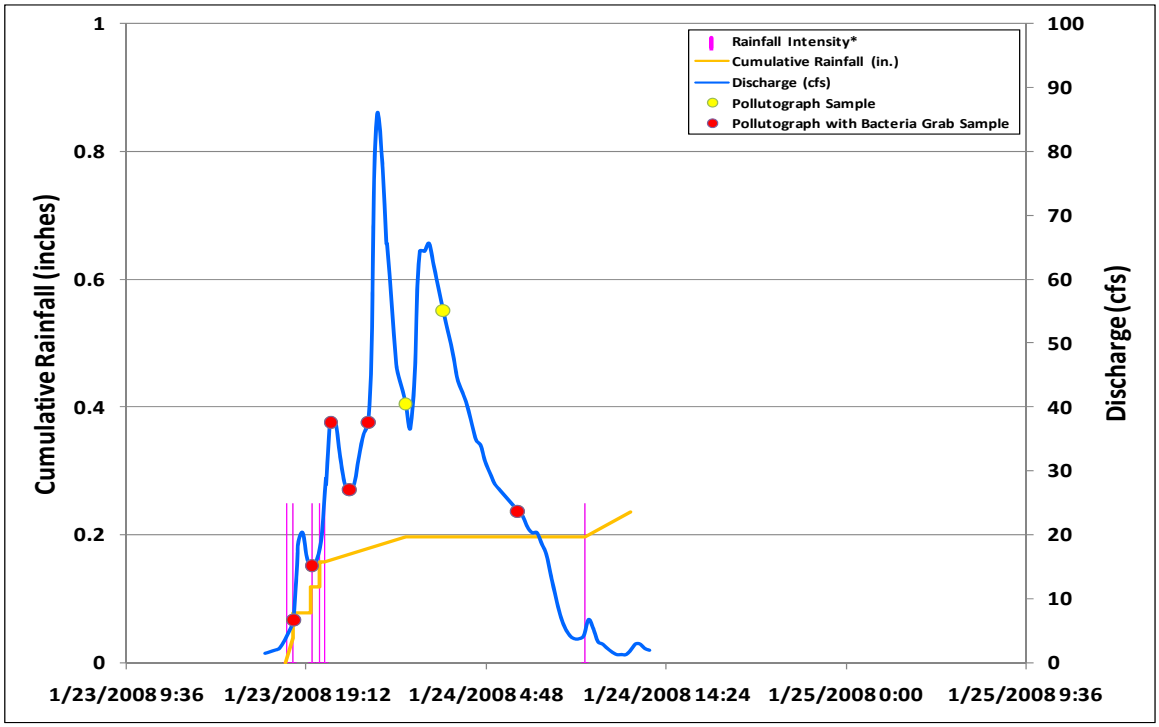
The third wet weather sampling event was not required to be a pollutagraph sample. Instead, a flow-weighted composite sample was successfully monitored from February 3 to February 4, 2008 under the San Diego County Regional Monitoring Program, Order No. 2007-01. See Figure 4-10 for the rainfall, flow, and sampling that occurred during this event.

**Figure 4-8: Loma Alta Mass Emission Hydrograph and Hyetograph Wet Weather Event 1**



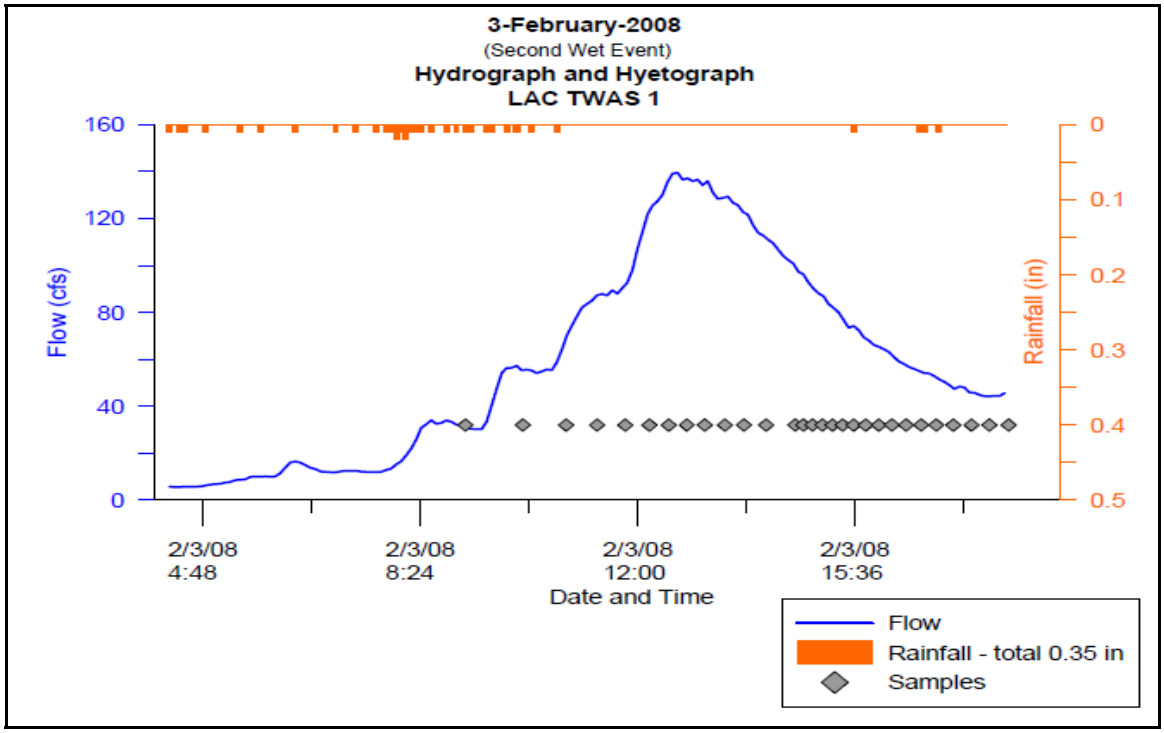

Note: Each vertical bar represents a one-millimeter rain gauge bucket tip.

**Figure 4-9: Loma Alta Mass Emission Hydrograph and Hyetograph Wet Weather Event 2**




Note: Each vertical bar represents a one-millimeter rain gauge bucket tip.

**Figure 4-10: Loma Alta Mass Emission Hydrograph and Hyetograph Wet Weather Event 3**




Note: Sampling for this event was conducted by an outside agency under the San Diego County Regional Monitoring Program, Order No. 2007-01

Results from the two pollutagraph sampling events at the Mass Emission Station are summarized statistically in Table 4-49. The results from the third monitoring event are event mean concentrations (EMC) and those values are displayed in Table 4-50. Detailed analytical results for all wet weather events are presented in Appendix C-3.

**Table 4-49: Loma Alta Wet Weather Events 1 and 2 Pollutagraph Summary**

| Event Category | Analyte | Units | Count | Mean | Median | Min | Max | WQO[1] | Percent Exceedance[2] (%) |
|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 January 5-7, 2008 | *Enterococcus* | CFU/100mL | 5 | 21,240 | 25,000 | 10,200 | 30,000 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 5 | 12,880 | 11,000 | 2,400 | 30,000 | 400 | 100 |
| | Total Coliform | MPN/100mL | 5 | 61,000 | 50,000 | 11,000 | 130,000 | 10,000 | 100 |
| | TSS | mg/L | 8 | 125.7 | 114.0 | 38.0 | 235.0 | NA | NA |
| | Ammonia as N | mg/L | 8 | 0.11 | 0.08 | 0.01 | 0.33 | 0.025 | 75 |
| | CBOD | mg/L | 8 | 4.33 | 3.50 | 1.00 | 8.20 | NA | NA |
| | Nitrate+Nitrite | mg/L | 8 | 0.55 | 0.56 | 0.21 | 1.00 | 10 | 0 |
| | SRP | mg/L | 8 | 0.25 | 0.26 | 0.14 | 0.44 | NA | NA |
| | Total Nitrogen | mg/L | 8 | 1.46 | 1.46 | 0.83 | 2.22 | 1 | 75 |
| | Total Dissolved Nitrogen | mg/L | 8 | 1.08 | 1.10 | 0.67 | 1.72 | NA | NA |
| | Total Phosphorus | mg/L | 8 | 0.36 | 0.35 | 0.24 | 0.61 | 0.1 | 100 |
| | Total Dissolved Phosphorus | mg/L | 8 | 0.29 | 0.29 | 0.13 | 0.47 | NA | NA |
| Wet Weather Event 2 January 23-25, 2008 | *Enterococcus* | CFU/100mL | 6 | 11,500 | 9,500 | 7,000 | 20,000 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 6 | 30,333 | 22,000 | 5,000 | 90,000 | 400 | 100 |
| | Total Coliform | MPN/100mL | 6 | 68,047 | 27,141 | 8,000 | 240,000 | 10,000 | 83 |
| | TSS | mg/L | 8 | 127.2 | 124.0 | 35.0 | 214.0 | NA | NA |
| | Ammonia as N | mg/L | 8 | 0.16 | 0.14 | 0.03 | 0.30 | 0.025 | 100 |
| | CBOD | mg/L | 8 | 8.70 | 6.05 | 2.10 | 22.20 | NA | NA |
| | Nitrate+Nitrite | mg/L | 8 | 0.53 | 0.56 | 0.30 | 0.67 | 10 | 0 |
| | SRP | mg/L | 8 | 0.13 | 0.12 | 0.07 | 0.26 | NA | NA |
| | Total Nitrogen | mg/L | 8 | 1.35 | 1.31 | 1.13 | 1.63 | 1 | 100 |
| | Total Dissolved Nitrogen | mg/L | 8 | 0.93 | 0.92 | 0.72 | 1.22 | NA | NA |
| | Total Phosphorus | mg/L | 8 | 0.21 | 0.19 | 0.16 | 0.34 | 0.1 | 50 |
| | Total Dissolved Phosphorus | mg/L | 8 | 0.15 | 0.14 | 0.07 | 0.33 | NA | NA |

(1) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.
(2) The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

**Table 4-50: Loma Alta Wet Weather Event 3 EMC Summary**

| Analyte | Units | EMC | WQO[1] | Exceedance |
|---|---|---|---|---|
| *Enterococcus* | MPN/100mL | 13,000 | 276 | Yes |
| Fecal Coliform | MPN/100mL | 1,700 | 400 | Yes |
| Total Coliform | MPN/100mL | 35,000 | 10,000 | Yes |
| TSS | mg/L | 101 | NA | NA |
| Ammonia as N | mg/L | 0.45 | 0.025 | Yes |
| Nitrate+Nitrite as N | mg/L | 0.27 | 10 | No |
| TP | mg/L | 0.30 | 0.1 | Yes |
| TDP | mg/L | 0.19 | NA | NA |

(1) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.

#### 4.3.2.2 Lagoon Segment Site

Three events were successfully monitored at the Loma Alta Slough Lagoon Segment Site as required by the IO. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, chlorophyll *a*, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus. Wet weather event sampling within the lagoon was conducted simultaneously with pollutagraph sampling and ocean inlet sampling during wet weather events. The anticipated lag time (i.e., the amount of transit time after a storm's onset before the lagoon is affected) was accounted for when preparing to initialize a sampling program.

During the first event, the first composite sample was collected at the high tide that occurred at 06:41 on January 5, 2008 approximately six hours after rainfall began. The second composite sample was collected at the low tide that occurred at 14:01 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

During the second event, the first composite sample was collected at the high tide that occurred at 09:49 on January 24, 2008 approximately 5 hours after rainfall began. Sampling was delayed for a longer period of time during this event for two reasons. Primarily, the rainfall was very light in intensity. This resulted in a slower transit time and therefore further delayed response within the lagoon. Secondly, the Health and Safety Plan for this project dictated that personnel cannot be out during non-daylight hours. Therefore the tide selected was the soonest possible time for sample collection to take place. The second composite sample was collected at the low tide that occurred at 16:35 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the

two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

During the third event, the first composite sample was collected at the high tide that occurred at 07:03 on February 4, 2008 approximately 13 hours after rainfall began. Sampling was delayed during this event due timing of the storm and the Health and Safety requirements of this project. Rainfall began just before dawn on February 3, 2008. Sampling that morning would not have allowed for transit time from the watershed to the lagoon. The ideal sample time for this event would have resulted in personnel sampling during non-daylight hours, which is prohibited by the Health and Safety Plan for this project. Therefore the tide selected was the soonest possible time for sample collection to take place. The second composite sample was collected at the low tide that occurred at 14:00 the same day. Sample aliquots were collected every 5 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

Results from the three wet weather sampling events at the lagoon segment site are summarized statistically in Table 4-51. Detailed analytical results for all wet weather events are presented in Appendix C-3.

**Table 4-51: Loma Alta Wet Weather Events 1-3 Lagoon Segment 1 Summary**

| Event Category | Analyte | Units | Count | Mean | Median | Min | Max | WQO | Percent Exceedance[1] (%) |
|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 January 5-7, 2008 | *Enterococcus* | CFU/100mL | 2 | 18,500 | 18,500 | 17,000 | 20,000 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 9,000 | 9,000 | 5,000 | 13,000 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 295,000 | 295,000 | 90,000 | 500,000 | 10,000 | 100 |
| | TSS | mg/L | 2 | 155.4 | 155.4 | 122.7 | 188.0 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.19 | 0.19 | 0.10 | 0.29 | 0.025 | 67 |
| | CBOD | mg/L | 2 | 5.80 | 5.80 | 4.70 | 6.90 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 79.20 | 79.20 | 23.10 | 135.30 | 20 | 100 |
| | Nitrate+Nitrite | mg/L | 2 | 0.50 | 0.50 | 0.45 | 0.54 | 10 | 0 |
| | SRP | mg/L | 2 | 0.18 | 0.18 | 0.16 | 0.21 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 1.23 | 1.23 | 1.06 | 1.40 | 1 | 100 |
| | Total Dissolved Nitrogen | mg/L | 2 | 1.49 | 1.49 | 1.44 | 1.54 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.25 | 0.25 | 0.25 | 0.25 | 0.1 | 100 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.31 | 0.31 | 0.23 | 0.39 | NA | NA |
| Wet Weather Event 2 January 23-25, 2008 | *Enterococcus* | CFU/100mL | 2 | 2,900 | 2,900 | 2,000 | 3,800 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 1,700 | 1,700 | 1,400 | 2,000 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 93,500 | 93,500 | 17,000 | 170,000 | 10,000 | 100 |
| | TSS | mg/L | 2 | 20.3 | 20.3 | 16.5 | 24.0 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.03 | 0.03 | 0.02 | 0.03 | 0.025 | 50 |
| | CBOD | mg/L | 2 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 16.10 | 16.10 | 15.90 | 16.30 | 20 | 0 |
| | Nitrate+Nitrite | mg/L | 2 | 0.51 | 0.51 | 0.40 | 0.61 | 10 | 0 |
| | SRP | mg/L | 2 | 0.09 | 0.09 | 0.09 | 0.10 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 0.84 | 0.84 | 0.46 | 1.21 | 1 | 50 |
| | Total Dissolved Nitrogen | mg/L | 2 | 0.69 | 0.69 | 0.62 | 0.75 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.11 | 0.11 | 0.07 | 0.15 | 0.1 | 50 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.09 | 0.09 | 0.09 | 0.09 | NA | NA |
| Wet Weather Event 3 February 3-4, 2008 | *Enterococcus* | CFU/100mL | 2 | 7,000 | 7,000 | 2,000 | 12,000 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 1,550 | 1,550 | 800 | 2,300 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 5,744 | 5,744 | 3,487 | 8,000 | 10,000 | 0 |
| | TSS | mg/L | 2 | 35.4 | 35.4 | 25.0 | 45.7 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.04 | 0.04 | 0.04 | 0.04 | 0.025 | 100 |
| | CBOD | mg/L | 2 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 9.35 | 9.35 | 8.00 | 10.70 | 20 | 0 |
| | Nitrate+Nitrite | mg/L | 2 | 0.73 | 0.73 | 0.72 | 0.74 | 10 | 0 |
| | SRP | mg/L | 2 | 0.19 | 0.19 | 0.18 | 0.19 | NA | 100 |
| | Total Nitrogen | mg/L | 2 | 1.59 | 1.59 | 1.53 | 1.65 | 1 | 100 |
| | Total Dissolved Nitrogen | mg/L | 2 | 1.21 | 1.21 | 1.01 | 1.41 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.28 | 0.28 | 0.26 | 0.30 | 0.1 | 100 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.23 | 0.23 | 0.19 | 0.26 | NA | NA |

(1) The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.3.2.4 Ocean Inlet Sites

Three events were successfully monitored at the Loma Alta Slough Ocean Inlet Site as required by the IO. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, chlorophyll *a*, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus. As with the lagoon segment sampling, expected lag time was considered and the same protocol was followed for sampling program initiation.

During the first event, the first composite samples were collected at the high tide that occurred at 06:41 on January 5, 2008 approximately six hours after rainfall began. The second composite samples were collected at the low tide that occurred at 14:01 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

During the second event, the first composite samples were collected at the high tide that occurred at 09:49 on January 24, 2008 approximately 15 hours after rainfall began. Sampling was delayed for a longer period of time during this event for two reasons. Primarily, the rainfall was very light in intensity. This resulted in a slower transit time and therefore further delayed response within the lagoon. Secondly, the Health and Safety Plan for this project dictated that personnel could not be out during non-daylight hours. Therefore the tide selected was the soonest possible time for sample collection to take place. The second composite samples were collected at the low tide that occurred at 16:35 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

During the third event, the first composite samples were collected at the high tide that occurred at 07:03 on February 4, 2008 approximately 3 hours after rainfall began. Sampling was delayed during this event due timing of the storm and the Health and Safety requirements of this project. Rainfall began just before dawn on February 3, 2008. Sampling that morning would not have allowed for transit time from the watershed to the lagoon. The ideal sample time for this event would have resulted in personnel sampling during non-daylight hours which was prohibited by the Health and Safety Plan for this project. Therefore the tide selected was the soonest possible time for sample collection to take place. The second composite samples were collected at the low tide that occurred at 14:00 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide.

During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

Results from the three wet weather sampling events at the four Loma Alta Slough Ocean Inlet Sites are summarized statistically in Tables 4-52. Detailed analytical results for all wet weather events are presented in Appendix C-3.

## Table 4-52: Loma Alta Wet Weather Events 1-3 Ocean Inlet 1 Summary

| Event Category | Analyte | Units | Count | Mean | Median | Min | Max | WQO | Percent Exceedance[1] (%) |
|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 January 5-7, 2008 | *Enterococcus* | CFU/100mL | 2 | 19,500 | 19,500 | 15,000 | 24,000 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 8,000 | 8,000 | 5,000 | 11,000 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 235,000 | 235,000 | 170,000 | 300,000 | 10,000 | 100 |
| | TSS | mg/L | 2 | 89.0 | 89.0 | 88.0 | 90.0 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.11 | 0.11 | 0.04 | 0.18 | 0.025 | 100 |
| | CBOD | mg/L | 2 | 4.10 | 4.10 | 3.40 | 4.80 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 22.25 | 22.25 | 21.40 | 23.10 | 20 | 100 |
| | Nitrate+Nitrite | mg/L | 2 | 0.49 | 0.49 | 0.47 | 0.50 | 10 | 0 |
| | SRP | mg/L | 2 | 0.20 | 0.20 | 0.20 | 0.20 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 1.06 | 1.06 | 0.77 | 1.34 | 1 | 50 |
| | Total Dissolved Nitrogen | mg/L | 2 | 0.95 | 0.95 | 0.69 | 1.22 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.27 | 0.27 | 0.19 | 0.36 | 0.1 | 100 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.27 | 0.27 | 0.19 | 0.35 | NA | NA |
| Wet Weather Event 2 January 23-25, 2008 | *Enterococcus* | CFU/100mL | 2 | 3,280 | 3,280 | 560 | 6,000 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 12,650 | 12,650 | 2,300 | 23,000 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 100,000 | 100,000 | 30,000 | 170,000 | 10,000 | 100 |
| | TSS | mg/L | 2 | 37.8 | 37.8 | 31.0 | 44.5 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.03 | 0.03 | 0.02 | 0.03 | 0.025 | 50 |
| | CBOD | mg/L | 2 | 3.00 | 3.00 | 2.80 | 3.20 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 18.20 | 18.20 | 14.10 | 22.30 | 20 | 50 |
| | Nitrate+Nitrite | mg/L | 2 | 0.35 | 0.35 | 0.15 | 0.54 | 10 | 0 |
| | SRP | mg/L | 2 | 0.07 | 0.07 | 0.04 | 0.09 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 0.83 | 0.83 | 0.49 | 1.17 | 1 | 50 |
| | Total Dissolved Nitrogen | mg/L | 2 | 0.64 | 0.64 | 0.36 | 0.93 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.11 | 0.11 | 0.07 | 0.15 | 0.1 | 50 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.07 | 0.07 | 0.03 | 0.11 | NA | NA |
| Wet Weather Event 3 February 3-4, 2008 | *Enterococcus* | CFU/100mL | 2 | 5,350 | 5,350 | 1,700 | 9,000 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 4650 | 4650 | 1300 | 8000 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 35,500 | 35,500 | 21,000 | 50,000 | 10,000 | 100 |
| | TSS | mg/L | 2 | 77.5 | 77.5 | 11.7 | 143.3 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.05 | 0.05 | 0.03 | 0.07 | 0.025 | 100 |
| | CBOD | mg/L | 2 | 2.40 | 2.40 | 1.00 | 3.80 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 12.00 | 12.00 | 5.30 | 18.70 | 20 | 0 |
| | Nitrate+Nitrite | mg/L | 2 | 0.40 | 0.40 | 0.20 | 0.59 | 10 | 0 |
| | SRP | mg/L | 2 | 0.14 | 0.14 | 0.10 | 0.18 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 1.17 | 1.17 | 0.73 | 1.61 | 1 | 50 |
| | Total Dissolved Nitrogen | mg/L | 2 | 1.14 | 1.14 | 0.56 | 1.72 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.20 | 0.20 | 0.16 | 0.24 | 0.1 | 100 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.18 | 0.18 | 0.10 | 0.26 | NA | NA |

(1) The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.3.2.5 Wet Weather Aqueous Sediment Grain Size at Loma Alta Mass Emission Station

In addition to the chemical constituents required for a given impairment, all lagoons were monitored for grain size distribution of aqueous sediment (i.e., suspended sediment) at the Mass Emission Station during both required pollutagraph monitoring events of the season. The samples submitted to the laboratory consisted of one composite sample per lagoon. Each sample was composited from the pollutagraph samples, based on event, collected over the course of the storm. The samples were analyzed for grain size distribution among the following size categories: clay < 0.0039 millimeters, silt 0.0039 to < 0.0625 millimeters, sand 0.0625 to < 2.0 millimeters, and granule 2.0 to < 4.0 millimeters. Results of the aqueous grain size distribution during both wet weather events are summarized in Table 4-53.

**Table 4-53: Loma Alta Wet Weather Events 1-2 Aqueous Grain Size Distribution**

| Grain Size Classes | Units | Wet Weather Event 1 1/5-7/08 | Wet Weather Event 2 1/23-24/08 |
|---|---|---|---|
| Clay < 0.0039 mm | % | 15.0 | 12.1 |
| Silt 0.0039 to < 0.0625 mm | % | 53.8 | 46.3 |
| Sand 0.0625 to < 2.0 mm | % | 31.1 | 41.6 |
| Granule 2.0 to < 4.0 mm | % | 0.0 | 0.0 |

Note: Analysis was run on a composite of all pollutagraph samples collected for each storm.

#### 4.3.2.6 Post-Storm Sediment

Post-storm event sediment sampling at Loma Alta Slough occurred on January 14, 2008, seven days after the end of the first sampled storm event. Sampling took place at the lagoon segment site and ocean inlet site. These samples were analyzed for percentage of organic carbon, percentage of sand, percentage of total nitrogen, and percentage of total phosphorus. The analytical results are summarized statistically in Table 4-54. These data along with the associated sample locations will be used in a special study by SCCWRP to determine the characteristics of sediments and where they settle in the lagoon. Detailed analytical results for all wet weather events are presented in Appendix C-3.

**Table 4-54: Loma Alta Post-Storm Sediment Results (January 14, 2008)**

| Monitoring Location | % Analyte | Number of Samples | Mean | SD | CV | Median | Min | Max |
|---|---|---|---|---|---|---|---|---|
| Loma Alta Lagoon Segment 1 | % Organic Carbon | 4 | 0.54 | 0.58 | 1.067 | 0.4 | 0.1 | 1.3 |
| | % Sand | 3 | 89.00 | 15.51 | 0.174 | 97.8 | 71.1 | 98.1 |
| | % Total Nitrogen | 2 | 0.10 | 0.05 | 0.521 | 0.1 | 0.1 | 0.1 |
| | % Total Phosphorus | 4 | 0.02 | 0.01 | 0.762 | 0.0 | 0.0 | 0.0 |
| Loma Alta Ocean Inlet 1 | % Organic Carbon | 1 | 1.60 | NA | NA | NA | NA | NA |
| | % Sand | 1 | 68.10 | NA | NA | NA | NA | NA |
| | % Total Nitrogen | 1 | 0.12 | NA | NA | NA | NA | NA |
| | % Total Phosphorus | 1 | 0.03 | NA | NA | NA | NA | NA |

### 4.3.3 Loma Alta Index Period Monitoring

Four index period events were successfully monitored at all sample locations associated with Loma Alta Slough. Each index period event spanned six days and generally took place over two weeks. Index periods at Loma Alta Slough occurred in late January to early February 2008, late March to early April 2008, July 2008, and late September to early October 2008.

All samples collected were placed on ice immediately after collection and stored at four degrees Celsius until delivery to the laboratory. Control of samples was maintained by Chain-of-Custody protocol from sample collection through sample analysis. All analytical methods performed on collected samples are outlined in Table 2-4 in Section 2.2.5. Quality Assurance/Quality Control samples were also collected per SWAMP requirements in accordance with the QAPP.

#### 4.3.3.1 Mass Emission Station

Mass emission station sampling was conducted once daily during the same index periods as the lagoon segment and ocean inlet sampling. Sampling at this station occurred between the tidally-regulated sample times at the lagoon segment and ocean inlet sites. Daily time-weighted composite samples were collected. Automated sampling equipment programmed to collect aliquots every 15 minutes for a 30-minute period. Microbiology grab samples were collected concurrently with the composite samples.

All four events were sampled successfully at the mass emission station. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, chlorophyll *a*,

nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus. Table 4-55 shows sampling schedule dates.

**Table 4-55: Loma Alta Mass Emission Station Index Period Sampling Schedule**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Index Period Event 1 | Day of the Week | Monday | Tuesday | Wednesday | Thursday | Friday | Monday |
| | Date | 1/14/2008 | 1/15/2008 | 1/16/2008 | 2/07/2008 | 2/08/2008 | 2/11/2008 |
| Index Period Event 2 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Monday |
| | Date | 3/24/2008 | 3/25/2008 | 3/26/2008 | 3/31/2008 | 4/01/2008 | 4/07/2008 |
| Index Period Event 3 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 7/07/2008 | 7/08/2008 | 7/09/2008 | 7/14/2008 | 7/15/2008 | 7/16/2008 |
| Index Period Event 4 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 10/07/2008 | 10/08/2008 | 10/09/2008 | 10/13/08 | 10/14/08 | 10/15/08 |

Sampling during Index Period Event1 was spread out over three different weeks as two unanticipated storms caused a delay in the proposed schedule. Dry weather sampling did not occur less than 72 hours after a rain event. Index Period Event 2 was spread out over three weeks as rain was predicted during the last week but never occurred. This delayed the last day of sampling. On September 29, 2008, during Index Period Event 4, 0.04 inches of rain was recorded by the Loma Alta rain gauge. Index Period Event 4 sampling was conducted seven days after this trace amount of rainfall was recorded. All other index period events were sampled according to the general two-week approach.

Results from the four index period sampling events at the mass emission station are summarized statistically in Table 4-56. Detailed analytical results for all wet weather events are presented in Appendix C-3.

**Table 4-56: Loma Alta Index Periods 1-4 Mass Emission Station Summary**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO[2] | Exceedance[3] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 6 | 162 | 146 | 116 | 256 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 218 | 248 | 96 | 528 | 200 | Yes |
| | Total Coliform | CFU/100mL | 6 | 655 | 664 | 500 | 820 | 1,000 | No |
| | TSS | mg/L | 6 | 2.7 | 3.0 | 0.3 | 4.5 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.02 | 0.02 | 0.02 | 0.03 | 0.025 | 33% |
| | CBOD | mg/L | 6 | 0.76 | 1.00 | 0.29 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 2.87 | 2.95 | 1.10 | 4.70 | 20 | 0% |
| | Nitrate+Nitrite | mg/L | 6 | 0.71 | 0.76 | 0.37 | 0.93 | 10 | 0% |
| | SRP | mg/L | 6 | 0.06 | 0.05 | 0.03 | 0.12 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 1.21 | 1.14 | 0.86 | 1.59 | 1 | 83% |
| | Total Dissolved Nitrogen | mg/L | 6 | 1.31 | 1.33 | 0.99 | 1.64 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.07 | 0.07 | 0.02 | 0.12 | 0.1 | 33% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.09 | 0.10 | 0.03 | 0.13 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 6 | 68 | 72 | 24 | 190 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 163 | 172 | 56 | 590 | 200 | No |
| | Total Coliform | CFU/100mL | 6 | 455 | 435 | 276 | 790 | 1,000 | No |
| | TSS | mg/L | 6 | 7.1 | 3.5 | 1.7 | 18.0 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.03 | 0.03 | 0.02 | 0.04 | 0.025 | 67% |
| | CBOD | mg/L | 5 | 0.86 | 1.00 | 0.29 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 16.75 | 14.00 | 7.10 | 37.50 | 20 | 17% |
| | Nitrate+Nitrite | mg/L | 6 | 0.21 | 0.21 | 0.09 | 0.34 | 10 | 0% |
| | SRP | mg/L | 6 | 0.01 | 0.01 | 0.01 | 0.02 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 1.13 | 1.12 | 0.96 | 1.39 | 1 | 83% |
| | Total Dissolved Nitrogen | mg/L | 6 | 1.15 | 1.00 | 0.84 | 1.89 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.02 | 0.01 | 0.00 | 0.07 | 0.1 | 0% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.01 | 0.01 | 0.01 | 0.03 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | 6 | 43 | 50 | 8 | 136 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 274 | 270 | 80 | 956 | 200 | Yes |
| | Total Coliform | CFU/100mL | 6 | 491 | 475 | 280 | 956 | 1,000 | No |
| | TSS | mg/L | 6 | 11.7 | 12.3 | 2.7 | 18.2 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.06 | 0.06 | 0.03 | 0.08 | 0.025 | 100% |
| | CBOD | mg/L | 6 | 1.47 | 1.00 | 1.00 | 3.80 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 7.35 | 6.70 | 5.30 | 10.70 | 20 | 0% |
| | Nitrate+Nitrite | mg/L | 6 | 0.34 | 0.20 | 0.01 | 1.35 | 10 | 0% |
| | SRP | mg/L | 6 | 0.02 | 0.01 | 0.01 | 0.06 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 0.93 | 0.88 | 0.72 | 1.29 | 1 | 33% |
| | Total Dissolved Nitrogen | mg/L | 6 | 0.83 | 0.90 | 0.37 | 1.07 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.02 | 0.02 | 0.02 | 0.03 | 0.1 | 0% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.01 | 0.01 | 0.01 | 0.01 | NA | NA |

**Table 4-56: Loma Alta Index Periods 1-4 Mass Emission Station Summary (continued)**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO[2] | Exceedance[3] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 6 | 212 | 216 | 136 | 296 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 740 | 640 | 470 | 2,150 | 200 | Yes |
| | Total Coliform | CFU/100mL | 6 | 1728 | 1,728 | 1,380 | 2,150 | 1,000 | Yes |
| | TSS | mg/L | 6 | 54.1 | 19.2 | 2.3 | 239.3 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.22 | 0.14 | 0.11 | 0.66 | 0.025 | 100% |
| | CBOD | mg/L | 6 | 1.32 | 1.0 | 1.0 | 2.90 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 31.70 | 6.65 | 3.60 | 120.60 | 20 | 33% |
| | Nitrate+Nitrite | mg/L | 6 | 1.07 | 0.60 | 0.38 | 3.22 | 10 | 0% |
| | SRP | mg/L | 6 | 0.16 | 0.03 | 0.02 | 0.74 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 2.39 | 1.60 | 1.21 | 6.20 | 1 | 100% |
| | Total Dissolved Nitrogen | mg/L | 6 | 2.45 | 1.82 | 1.05 | 5.69 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.05 | 0.05 | 0.01 | 0.10 | 0.1 | 17% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.19 | 0.07 | 0.03 | 0.81 | NA | NA |

(1) Enterococcus, fecal coliform, and total coliform were calculated as geometric means whereas all other constituents were calculated as arithmetic means.
(2) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.
(3) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.3.3.2 Lagoon Segment Site

Two composite samples were collected per day at the Loma Alta Slough Lagoon Segment Site. One sample was collected during slack low tide and one sample was collected during slack high tide. Composite samples were collected using automated sampling equipment programmed to collect aliquots every 15 minutes for a 30-minute period. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

Four index period events were sampled successfully at the lagoon segment site. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, chlorophyll *a*, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus. Sampling at the lagoon segment site followed the same schedule as the ocean inlet sites. Table 4-57 shows sampling schedule dates and tidal information.

Results from the four index period sampling events at the lagoon segment site are summarized statistically in Table 4-58. Detailed analytical results for all wet weather events are presented in Appendix C-3.

**Table 4-57: Loma Alta Lagoon Segment/Ocean Inlet Sites Index Period Sampling Schedule**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Index Period Event 1 | Day of the Week | Monday | Tuesday | Wednesday | Thursday | Friday | Monday |
| | Date | 1/14/2008 | 1/15/2008 | 1/16/2008 | 2/07/2008 | 2/08/2008 | 2/11/2008 |
| | 1st Composite | Low: 0712 | Low: 0849 | Low: 1027 | High: 0848 | High: 0924 | High: 1134 |
| | 2nd Composite | High: 1244 | High: 1425 | High: 1638 | Low: 1535 | Low: 1603 | Low: 1727 |
| Index Period Event 2 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Monday |
| | Date | 3/24/2008 | 3/25/2008 | 3/26/2008 | 3/31/2008 | 4/01/2008 | 4/07/2008 |
| | 1st Composite | High: 1130 | High: 1211 | High: 1304 | Low: 1246 | High: 0626 | High: 1059 |
| | 2nd Composite | Low: 1648 | Low: 1702 | Low: 1705 | High: 1940 | Low: 1318 | Low: 1618 |
| Index Period Event 3 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 7/07/2008 | 708/2008 | 7/09/2008 | 7/14/2008 | 7/15/2008 | 7/16/2008 |
| | 1st Composite | Low: 0712 | Low: 0751 | Low: 0831 | High: 0912 | High: 0938 | High: 1002 |
| | 2nd Composite | High: 1356 | High: 1444 | High: 1533 | Low: 1302 | Low: 1345 | Low: 1424 |
| Index Period Event 4 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 9/29/2008 | 9/30/2008 | 10/01/2008 | 10/07/2008 | 10/08/2008 | 10/09/2008 |
| | 1st Composite | High: 0939 | High: 1004 | High: 1029 | Low: 1002 | Low: 1136 | High: 0718 |
| | 2nd Composite | Low: 1556 | Low: 1633 | Low: 1711 | High: 1553 | High: 1715 | Low: 1224 |

**Table 4-58: Loma Alta Index Periods 1-4 Lagoon Segment Site Summary**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 12 | 45 | 54 | 2 | 320 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 12 | 120 | 186 | 2 | 922 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 265 | 276 | 48 | 856 | 1,000 | No |
| | TSS | mg/L | 12 | 13.7 | 9.0 | 3.5 | 39.7 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.02 | 0.02 | 0.01 | 0.05 | 0.025 | 45% |
| | CBOD | mg/L | 12 | 1.33 | 1.00 | 0.29 | 4.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 51.71 | 33.95 | 9.10 | 136.30 | 20 | 77% |
| | Nitrate+Nitrite | mg/L | 12 | 0.11 | 0.05 | 0.02 | 0.33 | 10 | 0% |
| | SRP | mg/L | 12 | 0.02 | 0.01 | 0.01 | 0.04 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 0.71 | 0.65 | 0.26 | 1.47 | 1 | 17% |
| | Total Dissolved Nitrogen | mg/L | 12 | 0.51 | 0.53 | 0.32 | 0.79 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.07 | 0.08 | 0.02 | 0.13 | 0.1 | 17% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.03 | 0.02 | 0.01 | 0.06 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 12 | 15 | 13 | 2 | 156 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 142 | 141 | 50 | 498 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 180 | 192 | 80 | 360 | 1,000 | No |
| | TSS | mg/L | 12 | 91.1 | 6.7 | 4.0 | 320.0 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.02 | 0.02 | 0.00 | 0.04 | 0.025 | 33% |
| | CBOD | mg/L | 12 | 2.36 | 1.40 | 0.29 | 4.80 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 73.95 | 37.05 | 6.40 | 253.70 | 20 | 67% |
| | Nitrate+Nitrite | mg/L | 12 | 0.02 | 0.01 | 0.00 | 0.08 | 10 | 0% |
| | SRP | mg/L | 12 | 0.01 | 0.01 | 0.00 | 0.01 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 0.84 | 0.83 | 0.26 | 1.51 | 1 | 33% |
| | Total Dissolved Nitrogen | mg/L | 12 | 0.52 | 0.51 | 0.37 | 0.72 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.06 | 0.04 | 0.02 | 0.19 | 0.1 | 17% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.01 | 0.01 | 0.01 | 0.04 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | 12 | 60 | 68 | 4 | 480 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 12 | 314 | 348 | 152 | 880 | 200 | Yes |
| | Total Coliform | CFU/100mL | 12 | 533 | 588 | 152 | 1540 | 1,000 | No |
| | TSS | mg/L | 12 | 4.9 | 4.0 | 1.3 | 11.7 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.07 | 0.07 | 0.02 | 0.11 | 0.025 | 92% |
| | CBOD | mg/L | 12 | 3.29 | 2.80 | 1.00 | 9.60 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 49.59 | 44.95 | 8.90 | 137.50 | 20 | 75% |
| | Nitrate+Nitrite | mg/L | 12 | 0.13 | 0.08 | 0.01 | 0.52 | 10 | 0% |
| | SRP | mg/L | 12 | 0.02 | 0.02 | 0.01 | 0.03 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 0.83 | 0.81 | 0.32 | 1.63 | 1 | 33% |
| | Total Dissolved Nitrogen | mg/L | 12 | 0.87 | 0.88 | 0.40 | 1.35 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.05 | 0.04 | 0.01 | 0.12 | 0.1 | 8% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.03 | 0.03 | 0.01 | 0.06 | NA | NA |

**Table 4-58: Loma Alta Index Period 1-4 Lagoon Segment Site Summary (continued)**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 12 | 229 | 236 | 52 | 1,020 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 12 | 327 | 307 | 124 | 880 | 200 | Yes |
| | Total Coliform | CFU/100mL | 12 | 1,155 | 1,310 | 480 | 2,480 | 1,000 | Yes |
| | TSS | mg/L | 12 | 5.9 | 5.3 | 2.0 | 14.8 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.12 | 0.10 | 0.01 | 0.25 | 0.025 | 92% |
| | CBOD | mg/L | 12 | 1.74 | 2.30 | 0.29 | 3.20 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 41.88 | 46.50 | 9.80 | 82.80 | 20 | 75% |
| | Nitrate+Nitrite | mg/L | 12 | 0.58 | 0.54 | 0.28 | 1.00 | 10 | 0% |
| | SRP | mg/L | 12 | 0.02 | 0.01 | 0.00 | 0.03 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 1.83 | 1.87 | 0.99 | 2.73 | 1 | 92% |
| | Total Dissolved Nitrogen | mg/L | 12 | 1.77 | 1.61 | 0.97 | 3.02 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.04 | 0.03 | 0.00 | 0.07 | 0.1 | 0% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.03 | 0.02 | 0.01 | 0.05 | NA | NA |

(1) Enterococcus, fecal coliform, and total coliform were calculated as geometric means whereas all other constituents were calculated as arithmetic means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.3.3.3 Ocean Inlet Site

Two composite samples were collected per day at Loma Alta Slough Ocean Inlet Site. One sample was collected during slack low tide and one sample was collected during slack high tide. Composite samples were collected using automated sampling equipment programmed to collect aliquots every 15 minutes for a 30-minute period. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

Four index period events were sampled successfully at the Ocean Inlet Site. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, chlorophyll *a*, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus. Sampling at the ocean inlet site followed the same schedule as the lagoon segment site. Table 4-57 shows sampling schedule dates and tidal information.

Results from the four index period sampling events at the two ocean inlet sites are summarized statistically in Tables 4-59. Detailed analytical results for all wet weather events are presented in Appendix C-3.

**Table 4-59: Loma Alta Index Period 1-4 Ocean Inlet 1 Site Summary**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 12 | 54 | 54 | 14 | 192 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 12 | 166 | 185 | 62 | 266 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 380 | 412 | 180 | 660 | 1,000 | No |
| | TSS | mg/L | 12 | 19.2 | 8.8 | 1.0 | 91.3 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.03 | 0.03 | 0.01 | 0.08 | 0.025 | 50% |
| | CBOD | mg/L | 12 | 1.44 | 1.00 | 0.29 | 9.10 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 22.76 | 16.35 | 5.90 | 72.40 | 20 | 33% |
| | Nitrate+Nitrite | mg/L | 12 | 0.22 | 0.18 | 0.01 | 0.64 | 10 | 0% |
| | SRP | mg/L | 12 | 0.02 | 0.02 | 0.01 | 0.05 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 0.68 | 0.51 | 0.27 | 1.52 | 1 | 25% |
| | Total Dissolved Nitrogen | mg/L | 12 | 0.59 | 0.44 | 0.28 | 1.19 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.05 | 0.04 | 0.01 | 0.11 | 0.1 | 8% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.04 | 0.03 | 0.01 | 0.08 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 12 | 18 | 16 | 2 | 86 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 119 | 119 | 32 | 460 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 149 | 152 | 30 | 400 | 1,000 | No |
| | TSS | mg/L | 12 | 75.1 | 50.0 | 8.0 | 274.0 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.03 | 0.02 | 0.01 | 0.09 | 0.025 | 50% |
| | CBOD | mg/L | 11 | 4.14 | 4.10 | 0.29 | 8.90 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 127.32 | 62.70 | 13.20 | 524.70 | 20 | 83% |
| | Nitrate+Nitrite | mg/L | 12 | 0.07 | 0.05 | 0.00 | 0.26 | 10 | 0% |
| | SRP | mg/L | 12 | 0.01 | 0.01 | 0.01 | 0.02 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 0.74 | 0.74 | 0.39 | 1.46 | 1 | 8% |
| | Total Dissolved Nitrogen | mg/L | 12 | 0.52 | 0.44 | 0.26 | 1.02 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.04 | 0.04 | 0.02 | 0.06 | 0.1 | 0% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.01 | 0.01 | 0.01 | 0.02 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | Lagoon mouth closed. No samples collected during Index Period Event 3. | | | | | | |
| | Fecal Coliform | CFU/100mL | | | | | | | |
| | Total Coliform | CFU/100mL | | | | | | | |
| | TSS | mg/L | | | | | | | |
| | Ammonia as N | mg/L | | | | | | | |
| | CBOD | mg/L | | | | | | | |
| | Chlorophyll *a* | ug/L | | | | | | | |
| | Nitrate+Nitrite | mg/L | | | | | | | |
| | SRP | mg/L | | | | | | | |
| | Total Nitrogen | mg/L | | | | | | | |
| | Total Dissolved Nitrogen | mg/L | | | | | | | |
| | Total Phosphorus | mg/L | | | | | | | |
| | Total Dissolved Phosphorus | mg/L | | | | | | | |

**Table 4-59: Loma Alta Index Period 1-4 Ocean Inlet 1 Site Summary (continued)**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 12 | 108 | 116 | 44 | 296 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 12 | 284 | 290 | 76 | 610 | 200 | Yes |
| | Total Coliform | CFU/100mL | 12 | 807 | 770 | 260 | 1,640 | 1,000 | No |
| | TSS | mg/L | 12 | 25.1 | 24.4 | 8.0 | 48.7 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.32 | 0.04 | 0.01 | 1.88 | 0.025 | 67% |
| | CBOD | mg/L | 12 | 6.23 | 6.55 | 3.10 | 8.40 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 123.70 | 131.65 | 18.20 | 215.30 | 20 | 92% |
| | Nitrate+Nitrite | mg/L | 12 | 0.09 | 0.03 | 0.00 | 0.42 | 10 | 0% |
| | SRP | mg/L | 12 | 0.02 | 0.00 | 0.00 | 0.13 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 1.74 | 1.71 | 0.60 | 2.70 | 1 | 83% |
| | Total Dissolved Nitrogen | mg/L | 12 | 1.41 | 1.26 | 0.64 | 2.74 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.09 | 0.07 | 0.01 | 0.23 | 0.1 | 92% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.04 | 0.02 | 0.01 | 0.16 | NA | NA |

(1) Enterococcus, fecal coliform, and total coliform were calculated as geometric means whereas all other constituents were calculated as arithmetic means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.3.3.4 Transect Sampling

Longitudinal transect sampling was conducted at eight designated locations along a salinity gradient within Loma Alta Slough. Sampling events occurred once during each index period event and included sampling once during the flood tide and once during the ebb tide on the same day. Specific conductivity, temperature, turbidity, DO, and pH water quality parameters were also measured concurrent to sample collection at each site and results are presented in Appendix C-3. Results from transect sampling events are summarized statistically in Table 4-60. Detailed analytical results for all wet weather events are presented in Appendix C-3.

**Table 4-60: Loma Alta Longitudinal Transect Data Summary for Index Period Events 1-4**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 10 | 129 | 138 | 32 | 2280 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 10 | 316 | 265 | 134 | 1736 | 200 | Yes |
| | Total Coliform | CFU/100mL | 10 | 463 | 433 | 254 | 2144 | 1,000 | No |
| | TSS | mg/L | 16 | 5.4 | 3.9 | 0.3 | 25.0 | NA | NA |
| | Ammonia as N | mg/L | 15 | 0.04 | 0.04 | 0.03 | 0.06 | 0.025 | 100% |
| | CBOD | mg/L | 16 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 16 | 11.98 | 5.30 | 2.70 | 62.60 | 20 | 13% |
| | Nitrate+Nitrite | mg/L | 15 | 1.01 | 1.06 | 0.47 | 1.32 | 10 | 0% |
| | SRP | mg/L | 15 | 0.05 | 0.04 | 0.03 | 0.07 | NA | NA |
| | Total Nitrogen | mg/L | 15 | 1.24 | 1.55 | 0.30 | 1.95 | 1 | 60% |
| | Total Dissolved Nitrogen | mg/L | 15 | 1.44 | 1.60 | 0.56 | 1.84 | NA | NA |
| | Total Phosphorus | mg/L | 15 | 0.07 | 0.07 | 0.03 | 0.14 | 0.1 | 20% |
| | Total Dissolved Phosphorus | mg/L | 15 | 0.08 | 0.08 | 0.04 | 0.12 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 10 | 38 | 43 | 6 | 162 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 10 | 200 | 174 | 142 | 348 | 200 | No |
| | Total Coliform | CFU/100mL | 10 | 366 | 346 | 124 | 668 | 1,000 | No |
| | TSS | mg/L | 16 | 15.3 | 14.5 | 1.3 | 62.4 | NA | NA |
| | Ammonia as N | mg/L | 16 | 0.03 | 0.03 | 0.01 | 0.05 | 0.025 | 69% |
| | CBOD | mg/L | 6 | 0.29 | 0.29 | 0.29 | 0.29 | NA | NA |
| | Chlorophyll *a* | ug/L | 16 | 19.50 | 11.55 | 4.30 | 86.80 | 20 | 25% |
| | Nitrate+Nitrite | mg/L | 16 | 0.47 | 0.50 | 0.11 | 0.81 | 10 | 0% |
| | SRP | mg/L | 16 | 0.01 | 0.01 | 0.01 | 0.02 | NA | NA |
| | Total Nitrogen | mg/L | 16 | 1.28 | 1.12 | 0.73 | 2.84 | 1 | 56% |
| | Total Dissolved Nitrogen | mg/L | 16 | 1.17 | 1.27 | 0.29 | 2.21 | NA | NA |
| | Total Phosphorus | mg/L | 16 | 0.02 | 0.02 | 0.00 | 0.03 | 0.1 | 0% |
| | Total Dissoled Phosphorus | mg/L | 16 | 0.01 | 0.01 | 0.00 | 0.03 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | 10 | 108 | 87 | 8 | 500 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 10 | 329 | 282 | 132 | 1240 | 200 | Yes |
| | Total Coliform | CFU/100mL | 10 | 509 | 480 | 132 | 1810 | 1,000 | No |
| | TSS | mg/L | 16 | 15.7 | 4.0 | 0.3 | 60.0 | NA | NA |
| | Ammonia as N | mg/L | 16 | 0.02 | 0.02 | 0.01 | 0.06 | 0.025 | 19% |
| | CBOD | mg/L | 6 | 2.48 | 1.60 | 1.00 | 6.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 16 | 66.69 | 22.95 | 3.50 | 312.90 | 20 | 63% |
| | Nitrate+Nitrite | mg/L | 16 | 0.12 | 0.07 | 0.00 | 0.44 | 10 | 0% |
| | SRP | mg/L | 16 | 0.01 | 0.00 | 0.00 | 0.01 | NA | NA |
| | Total Nitrogen | mg/L | 16 | 0.61 | 0.52 | 0.26 | 1.76 | 1 | 6% |
| | Total Dissolved Nitrogen | mg/L | 16 | 0.45 | 0.45 | 0.22 | 0.70 | NA | NA |
| | Total Phosphorus | mg/L | 16 | 0.03 | 0.01 | 0.00 | 0.18 | 0.1 | 6% |
| | Total Dissolved Phosphorus | mg/L | 16 | 0.01 | 0.01 | 0.00 | 0.02 | NA | NA |

**Table 4-60: Loma Alta Longitudinal Transect Data Summary for Index Period Events 1-4 (continued)**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 10 | 107 | 101 | 22 | 332 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 10 | 249 | 194 | 76 | 1040 | 200 | Yes |
| | Total Coliform | CFU/100mL | 10 | 585 | 505 | 350 | 1280 | 1,000 | No |
| | TSS | mg/L | 16 | 26.3 | 10.7 | 2.7 | 201.3 | NA | NA |
| | Ammonia as N | mg/L | 16 | 0.09 | 0.08 | 0.03 | 0.19 | 0.025 | 100% |
| | CBOD | mg/L | 6 | 3.32 | 2.50 | 1.00 | 9.10 | NA | NA |
| | Chlorophyll *a* | ug/L | 16 | 63.13 | 40.90 | 11.60 | 299.00 | 20 | 88% |
| | Nitrate+Nitrite | mg/L | 16 | 0.28 | 0.28 | 0.01 | 0.60 | 10 | 0% |
| | SRP | mg/L | 16 | 0.03 | 0.02 | 0.01 | 0.10 | NA | NA |
| | Total Nitrogen | mg/L | 16 | 1.47 | 1.43 | 0.56 | 2.22 | 1 | 94% |
| | Total Dissolved Nitrogen | mg/L | 16 | 1.49 | 1.43 | 1.20 | 1.91 | NA | NA |
| | Total Phosphorus | mg/L | 16 | 0.09 | 0.07 | 0.03 | 0.28 | 0.1 | 25% |
| | Total Dissolved Phosphorus | mg/L | 16 | 0.06 | 0.05 | 0.02 | 0.17 | NA | NA |

Note: Transects were sampled at high and low tides during each index period within Loma Alta Slough.
(1) Enterococcus, fecal coliform, and total coliform were calculated as geometric means whereas all other constituents were calculated as arithmetic means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.3.3.5 Specific Conductivity

Specific conductivity was continuously measured at all sample locations during the four index periods. Specific conductivity was lowest at the Loma Alta Mass Emission Station, which has a higher input of freshwater from the watershed. The Mass Emission Station consistently reported low specific conductivity values close to the typical freshwater range (less than 1.072 mS/cm) as the station is beyond the range of tidal influence. The other two sites reported specific conductivity values that approach the range of normal seawater (50 mS/cm to 56 mS/cm) with the exception of occasional wet weather events (United States Office of Naval Research).

Results for all parameters continuously monitored at all sites are summarized statistically in Tables 4-46 through 4-48. Results are summarized both monthly and by monitoring event. Detailed continuous monitoring results from the entire monitoring period are presented in Appendix B-3.

#### 4.3.3.6 Temperature

Temperature was continuously measured at all sample locations during the four index periods. Seasonal variation in temperature was reflected at all sample locations. Temperature averages and ranges were very similar at the three sample locations. Although the averages were roughly the same at the three locations, the Mass Emission Station recorded the lowest average temperature. Input from the watershed is a factor in the cooler water temperatures recorded at the Mass Emission Station.

Results for all parameters continuously monitored at all sites are summarized statistically in Tables 4-46 through 4-48. Results are summarized both monthly and by monitoring event. Detailed continuous monitoring results from the entire monitoring period are presented in Appendix B-3.

#### 4.3.3.7 Turbidity

Turbidity was measured at all sample locations during the four index periods. Turbidity was generally low during the Index Period Events. Turbidity was low during index period events at the Mass Emission Station and was generally low at the Lagoon Segment and Ocean Inlet Sites with the exception of occasional increases in turbidity. Turbidity spikes associated with storm events were most profound at the Mass Emission Station and dampened through the Lagoon Segment Sites.

Results for all parameters continuously monitored at all sites are summarized statistically in Tables 4-46 through 4-48. Results are summarized both monthly and by monitoring event. Detailed continuous monitoring results from the entire monitoring period are presented in Appendix B-3.

#### 4.3.3.8 Storm Drain and Tributary Sampling

Storm drain and tributary sampling occurred at the two designated locations once during each of the index sampling events. Flow conditions were noted at each location during each sampling event. Sample dates and analytical results are summarized in Table 4-61.

**Table 4-61: Loma Alta Index Period Storm Drain Sampling Results**

| Analyte Name | Units | Index Period Event 1 | | Index Period Event 2 | | Index Period Event 3 | | Index Period Event 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1/15/2008 | | 3/31/2008 | | 7/14-17/2008 | | 10/9/2008 | |
| | | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 |
| *Enterococcus* | CFU/100mL | 880 | 900 | 1,254 | 710 | 3,300 | 100 | 1,900 | 500 |
| Fecal Coliform | CFU/100mL | 590 | 1,850 | 1,068 | 378 | 7,600 | 8,400 | 7,500 | 8,800 |
| Total Coliform | CFU/100mL | 1,280 | 5,950 | 6,420 | 378 | 11,000 | 7,200 | 19,000 | 12,000 |
| TSS | mg/L | 8.8 | 8 | 5.6 | 30 | 2.4 | 17.2 | 1.2 | 25.6 |
| Ammonia as N | mg/L | 0.08 | 0.00 | 0.05 | 0.02 | 0.03 | 0.02 | 0.02 | 0.01 |
| CBOD | mg/L | 0.29 | 0.29 | 0.29 | 4.9 | 0.29 | 0.29 | 0.29 | 3.9 |
| Chlorophyll *a* | ug/L | 4.3 | 9.1 | 2.2 | 87.9 | 4.2 | 5.8 | 4.2 | 74.1 |
| Nitrate+Nitrite | mg/L | 2.4 | 0.9 | 7.76 | 1.43 | 4.85 | 0.57 | 6.40 | 0.52 |
| SRP | mg/L | 0.012 | 0.06 | 0.02 | 0.01 | 0.02 | 0.01 | 0.02 | 0.00 |
| TN | mg/L | 7.19 | 1.39 | 7.62 | 2.05 | 7.92 | 1.16 | 12.42 | 1.84 |
| TDN | mg/L | 5.88 | 4.85 | 6.68 | 1.16 | 7.56 | 0.61 | 9.65 | 2.39 |
| TP | mg/L | 0.04 | 0.05 | 0.02 | 0.03 | 0.01 | 0.00 | 0.01 | 0.01 |
| TDP | mg/L | 0.02 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.01 | 0.09 |
| Flow | cfs | 0.033 | 0.027 | 0.024 | 0.036 | 0.037 | 0.146 | 0.005 | 0.018 |

Note: During Index Period Event 3 bacteria samples were collected July 17, 2008 and the remaining samples were collected July 14, 2008.

### 4.3.4 Loma Alta Land Elevation Survey of Ocean Inlet Sites

Land elevation surveys were conducted at the Loma Alta Slough Ocean Inlet 1 Site prior to all index periods. Three cross-sections were surveyed each event. See Figure 4-11 for the locations of each cross-section. The surveys of the Ocean Inlet Site were conducted in January, March, July, and September 2008. Results from land elevation surveys are shown in Appendix J-2.

### 4.3.5 Loma Alta Open Ocean Inlet Days

The Loma Alta Ocean Inlet Site is the mouth of the lagoon that is open to the ocean. The mouth of the lagoon was open during most of the monitoring period associated with this program, but was closed for the following time frames:

- January 1 to January 3, 2008
- May 13 to May 21, 2008
- July 18 to October 8, 2008

**Figure 4-11: Loma Alta Ocean Inlet Land Elevation Survey Locations**

## 4.4 SAN ELIJO LAGOON MONITORING RESULTS

This section summarizes results from the continuous monitoring as well as wet weather and index period events. Detailed discussion of the results is presented in section 6.1.

### 4.4.1 San Elijo Continuous Monitoring

Continuous monitoring at San Elijo Lagoon included the following parameters:

- Rainfall (Mass Emission Station only)
- Flow (Mass Emission Station only)
- Specific conductivity
- Temperature
- Turbidity
- Dissolved Oxygen (DO)
- pH
- Water level (Lagoon Segment and Ocean Inlet Sites)

#### 4.4.1.1 Hydrology of the Lagoon

Table 4-62 summarizes results from the continuous water level monitoring statistically on a monthly basis as well as by event. Detailed continuous monitoring results for the entire monitoring period are presented in Appendix B-4.

In accordance with the QAPP, flow, rainfall, specific conductivity, and temperature monitoring was conducted from October 2007 to October 2008 at the San Elijo Mass Emission Station and monitoring of turbidity and DO was conducted from January 2008 to October 2008. Although monitoring of pH was required from January 2008 to October 2008, it was monitored from October 2007 to October 2008 at the Mass Emission Station. Monitoring of specific conductivity, temperature, turbidity, DO, pH, and water level at lagoon segment sites was required during a three-month wet weather period and a three to four-month dry weather period, covering all monitoring events. However, continuous monitoring of these parameters was conducted from January 2008 to October 2008 resulting in a greater time period than required by the QAPP.

Water level was not recorded with the data sonde at the Mass Emission Station as other instrumentation was installed to measure stage and to calculate real-time flows. Lagoon depth measurements from the data sondes were tied to North American Vertical Datum, 1988 (NAVD 88).

**Table 4-62: San Elijo Continuous Lagoon Depth Monitoring Monthly and Event Summary**

| Month (2008) | Lagoon Segment 1 Site | | | Lagoon Segment 2 Site | | | Ocean Inlet 1 Site | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lagoon Depth (m) | | | Lagoon Depth (m) | | | Lagoon Depth (m) | | |
| | Mean | Min | Max | Mean | Min | Max | Mean | Min | Max |
| January | 1.2 | 1.0 | 2.0 | 0.2 | -0.3 | 1.2 | 1.1 | 0.6 | 1.9 |
| February | 1.3 | 1.0 | 1.9 | 0.2 | -0.3 | 0.8 | 1.1 | 0.6 | 1.7 |
| March | 1.2 | 1.0 | 1.5 | 0.3 | -0.1 | 0.6 | 1.2 | 0.8 | 1.5 |
| April | 1.3 | 0.9 | 1.5 | 0.4 | -0.3 | 0.6 | 1.3 | 0.5 | 1.5 |
| May | 1.1 | 0.8 | 1.8 | 0.1 | -0.5 | 0.9 | 1.0 | 0.4 | 1.8 |
| June | 1.1 | 0.9 | 1.8 | 0.1 | -0.4 | 0.9 | 1.0 | 0.5 | 1.8 |
| July | 1.1 | 0.9 | 1.8 | 0.1 | -0.4 | 1.0 | 1.0 | 0.5 | 1.9 |
| August | 1.1 | 0.8 | 1.8 | 0.1 | -0.4 | 0.9 | 1.0 | 0.5 | 1.8 |
| September | 1.1 | 0.9 | 1.6 | 0.1 | -0.4 | 0.8 | 1.0 | 0.5 | 1.7 |
| October | 1.1 | 0.9 | 1.7 | 0.1 | -0.4 | 0.9 | 1.0 | 0.5 | 2.1 |
| Average | 1.2 | 0.9 | 1.7 | 0.2 | -0.3 | 0.8 | 1.1 | 0.5 | 1.8 |
| **Event** | **Lagoon Depth (m)** | | | **Lagoon Depth (m)** | | | **Lagoon Depth (m)** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 1.5 | 1.0 | 2.0 | 0.6 | -0.2 | 1.2 | 1.3 | 0.6 | 1.9 |
| Wet Weather 2 | 1.3 | 1.0 | 1.6 | 0.2 | -0.3 | 0.7 | 1.0 | 0.6 | 1.6 |
| Wet Weather 3 | 1.4 | 1.0 | 1.8 | 0.3 | -0.3 | 0.8 | 1.2 | 0.6 | 1.7 |
| Index Period 1 | 1.2 | 1.0 | 1.6 | 0.1 | -0.3 | 0.7 | 1.0 | 0.6 | 1.6 |
| Index Period 2 | 1.2 | 1.0 | 1.4 | 0.3 | 0.0 | 0.6 | 1.2 | 0.9 | 1.5 |
| Index Period 3 | 1.1 | 0.9 | 1.6 | 0.1 | -0.4 | 0.7 | 1.0 | 0.5 | 1.6 |
| Index Period 4 | 1.1 | 0.9 | 1.5 | 0.1 | -0.3 | 0.6 | 1.0 | 0.5 | 1.6 |

#### 4.4.1.2 Rainfall and Flow

Rainfall and flow were both continuously monitored at the San Elijo Lagoon Mass Emission Station throughout the monitoring period as required by the IO. Instrumentation installed at the Mass Emission Station measured and logged rainfall and flow beginning October 1, 2007 through October 31, 2008.

Daily and monthly precipitation totals are summarized in Table 4-63. The total rainfall for the entire monitoring year was 10.59 inches. January had the most rainfall in one month, totaling 3.54 inches. Detailed continuous rainfall results for the entire monitoring period are presented in Appendix A-4.

Daily and monthly discharge totals are summarized in Table 4-64. A total volume of 581,628,163 cubic feet was discharged into San Elijo Lagoon over the entire monitoring period. Although January had the highest rainfall total, February recorded the highest monthly discharge throughout the year with

179,927,675 cubic feet. Detailed continuous stage results and flow results for the entire monitoring period are presented in Appendix A-4.

**Table 4-63: San Elijo Mass Emission Station Daily and Monthly Precipitation Summary (inches)**

| Day | 2007 | | | 2008 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | October | November | December | January | February | March | April | May | June | July | August | September | October |
| 1 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.55 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5 | 0.00 | 0.00 | 0.00 | 1.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6 | 0.00 | 0.00 | 0.00 | 0.71 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7 | 0.00 | 0.00 | 0.39 | 0.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | 0.00 | 0.00 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 13 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 14 | 0.00 | 0.00 | 0.04 | 0.00 | 0.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 17 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 18 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 19 | 0.00 | 0.00 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 21 | 0.00 | 0.00 | 0.04 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 22 | 0.00 | 0.00 | 0.00 | 0.00 | 1.22 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 23 | 0.00 | 0.00 | 0.00 | 0.47 | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 24 | 0.00 | 0.00 | 0.00 | 0.04 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 26 | 0.00 | 0.00 | 0.00 | 0.31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 27 | 0.00 | 0.00 | 0.00 | 0.28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 28 | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 30 | 0.00 | 2.52 | 0.00 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 31 | 0.00 | | 0.00 | 0.00 | | 0.00 | | 0.00 | | 0.00 | 0.00 | | 0.00 |
| **Totals** | **0.16** | **2.52** | **1.06** | **3.54** | **3.11** | **0.00** | **0.04** | **0.16** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |

## Table 4-64: San Elijo Mass Emission Station Daily and Monthly Total Discharge Summary (cubic feet)

| Day | 2007 | | | 2008 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | October | November | December | January | February | March | April | May | June | July | August | September | October |
| 1 | 16,560 | 192,687 | 28,530,638 | 675,668 | 1,415,505 | 1,983,263 | 835,182 | 628,958 | 501,790 | 368,827 | 360,308 | 338,347 | 294,861 |
| 2 | 17,280 | 388,355 | 1,384,516 | 667,046 | 1,437,702 | 1,892,752 | 841,557 | 738,529 | 552,572 | 377,229 | 350,593 | 325,138 | 293,287 |
| 3 | 17,280 | 458,214 | 179,756 | 665,280 | 20,939,458 | 1,693,726 | 886,558 | 643,210 | 591,450 | 464,299 | 357,351 | 337,177 | 304,856 |
| 4 | 17,280 | 439,132 | 269,157 | 660,350 | 19,628,498 | 1,530,652 | 837,510 | 548,956 | 488,510 | 383,362 | 335,240 | 321,657 | 320,672 |
| 5 | 17,280 | 440,416 | 141,087 | 31,065,706 | 6,516,095 | 1,503,797 | 817,750 | 563,556 | 513,755 | 372,914 | 329,935 | 326,772 | 1,378,474 |
| 6 | 17,280 | 400,793 | 194,997 | 22,188,536 | 3,611,915 | 1,406,751 | 810,001 | 609,374 | 499,660 | 378,574 | 327,323 | 342,477 | 579,233 |
| 7 | 17,280 | 402,394 | 6,265,896 | 34,304,361 | 2,749,007 | 1,295,091 | 795,806 | 693,754 | 491,470 | 385,032 | 349,087 | 360,068 | 358,833 |
| 8 | 17,280 | 357,031 | 4,815,147 | 8,577,304 | 2,299,077 | 1,291,167 | 811,674 | 646,485 | 495,067 | 392,470 | 318,038 | 363,540 | 313,269 |
| 9 | 17,280 | 334,430 | 3,271,590 | 3,964,286 | 1,938,246 | 1,323,289 | 834,481 | 621,292 | 485,901 | 392,645 | 327,682 | 362,099 | 293,348 |
| 10 | 17,280 | 173,407 | 226,149 | 2,595,230 | 1,658,366 | 1,245,042 | 795,998 | 592,569 | 483,669 | 406,874 | 346,265 | 339,133 | 322,789 |
| 11 | 17,280 | 70,676 | 120,646 | 1,943,333 | 1,513,524 | 1,192,806 | 752,322 | 608,594 | 484,422 | 408,583 | 316,852 | 316,405 | 319,590 |
| 12 | 17,280 | 195,060 | 25,026 | 1,565,747 | 1,392,389 | 1,105,623 | 715,071 | 847,835 | 427,296 | 409,181 | 326,011 | 346,052 | 315,826 |
| 13 | 128,540 | 124,818 | 17,280 | 1,341,976 | 1,296,518 | 1,089,036 | 692,667 | 630,502 | 392,046 | 390,965 | 337,511 | 392,528 | 296,903 |
| 14 | 49,940 | 92,172 | 17,280 | 1,203,062 | 14,975,271 | 1,066,394 | 676,835 | 542,075 | 405,130 | 387,107 | 368,880 | 365,831 | 291,900 |
| 15 | 17,280 | 69,197 | 17,280 | 1,068,428 | 8,909,051 | 1,056,345 | 671,086 | 532,730 | 402,922 | 375,997 | 372,467 | 356,879 | 289,280 |
| 16 | 17,280 | 139,190 | 17,280 | 1,003,689 | 2,593,167 | 1,311,992 | 675,808 | 563,274 | 389,323 | 374,130 | 350,993 | 351,938 | 299,731 |
| 17 | 254,550 | 276,066 | 17,280 | 944,842 | 1,875,122 | 1,069,296 | 679,441 | 522,014 | 375,660 | 368,113 | 329,887 | 344,251 | 292,694 |
| 18 | 350,517 | 223,175 | 17,280 | 912,705 | 2,046,750 | 981,533 | 646,858 | 509,149 | 377,322 | 371,765 | 318,134 | 331,040 | 294,338 |
| 19 | 295,095 | 234,895 | 2,163,640 | 877,863 | 1,651,052 | 965,582 | 660,115 | 495,546 | 356,282 | 392,458 | 342,105 | 326,267 | 306,991 |
| 20 | 270,619 | 152,806 | 687,627 | 820,680 | 4,622,208 | 959,094 | 687,922 | 482,224 | 443,200 | 381,270 | 347,989 | 327,723 | 317,605 |
| 21 | 305,046 | 160,914 | 1,561,165 | 1,518,936 | 3,063,980 | 946,230 | 701,521 | 515,514 | 381,323 | 372,086 | 385,158 | 319,868 | 321,424 |
| 22 | 344,732 | 72,413 | 58,721 | 1,339,321 | 32,352,445 | 925,114 | 682,011 | 784,445 | 333,088 | 376,247 | 354,331 | 320,702 | 329,336 |
| 23 | 235,666 | 30,332 | 17,280 | 1,148,096 | 11,575,713 | 888,130 | 675,586 | 3,027,440 | 327,270 | 393,286 | 358,520 | 335,903 | 336,629 |
| 24 | 203,241 | 17,280 | 17,280 | 10,773,088 | 11,101,904 | 854,519 | 660,659 | 5,173,808 | 344,783 | 357,527 | 347,766 | 343,965 | 288,747 |
| 25 | 143,399 | 17,280 | 17,280 | 1,808,324 | 6,887,716 | 853,055 | 665,577 | 780,843 | 364,012 | 363,175 | 350,422 | 330,224 | 282,838 |
| 26 | 104,174 | 99,707 | 17,280 | 1,028,518 | 4,043,418 | 847,098 | 639,922 | 569,322 | 375,768 | 361,927 | 373,890 | 310,275 | 283,674 |
| 27 | 177,866 | 56,455 | 17,280 | 16,754,063 | 3,065,134 | 846,414 | 604,723 | 538,619 | 371,068 | 342,806 | 340,635 | 313,528 | 295,670 |
| 28 | 279,375 | 17,280 | 17,280 | 12,136,868 | 2,557,337 | 857,045 | 572,117 | 519,728 | 379,859 | 360,849 | 336,349 | 318,600 | 300,344 |
| 29 | 233,517 | 17,280 | 17,280 | 4,371,262 | 2,211,106 | 866,879 | 565,151 | 512,194 | 363,665 | 378,456 | 334,638 | 319,907 | 285,655 |
| 30 | 256,185 | 31,443,829 | 17,280 | 1,971,833 | | 874,812 | 602,522 | 533,753 | 354,319 | 406,771 | 361,420 | 305,152 | 282,663 |
| 31 | 219,838 | | 17,280 | 1,639,546 | | 904,873 | | 503,901 | | 361,390 | 371,436 | | 295,345 |
| **Total** | **4,093,501** | **37,097,685** | **50,154,957** | **171,535,944** | **179,927,675** | **35,627,399** | **21,494,431** | **25,480,192** | **12,752,603** | **11,856,314** | **10,727,216** | **10,093,443** | **10,786,803** |

#### 4.4.1.3 Continuous Monitoring of Water Quality Parameters

Results from the continuous monitoring are summarized statistically on a monthly basis, as well as by event, in Tables 4-65 through 4-68. Detailed continuous monitoring results for the entire monitoring period are presented in Appendix B-4.

Data gaps occurred as a result of fouling, tampering, unexpected decrease in water level, equipment malfunction, and other unforeseen events and are described in Section 3.1.1.2.

**Table 4-65: San Elijo Mass Emission Station Continuous Data Monthly and Event Summary**

| Month (2007/2008) | Specific Conductance (mS/cm) | | | Temperature (°C) | | | Turbidity (NTU)[1] | | | Dissolved Oxygen (mg/L)[1] | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| October | 2.5 | 1.9 | 2.9 | 16.5 | 13.3 | 19.5 | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | 8.0 | 7.7 | 8.1 |
| November | 2.7 | 0.3 | 3.4 | 14.7 | 10.3 | 17.5 | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | 8.0 | 7.5 | 8.1 |
| December | 1.9 | 0.4 | 2.9 | 10.7 | 6.8 | 16.5 | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | 7.9 | 7.5 | 8.0 |
| January | 1.8 | 0.3 | 2.8 | 11.0 | 7.1 | 14.9 | 7.1 | 0.0 | 153.2 | 9.4 | 8.0 | 11.1 | 7.9 | 7.6 | 8.3 |
| February | 1.7 | 0.4 | 2.8 | 12.1 | 8.1 | 15.5 | 30.2 | -0.1 | 751.2 | 9.3 | 8.1 | 10.6 | 7.9 | 7.5 | 8.1 |
| March | 2.3 | 2.0 | 2.5 | 14.7 | 11.2 | 18.1 | 2.0 | 0.0 | 7.8 | 8.7 | 7.3 | 10.4 | 8.0 | 7.8 | 8.2 |
| April | 2.4 | 2.3 | 2.6 | 16.5 | 13.0 | 20.0 | 3.3 | 0.0 | 9.5 | 8.0 | 6.7 | 9.6 | 7.9 | 7.7 | 8.0 |
| May | 2.3 | 0.9 | 2.6 | 17.9 | 14.7 | 22.8 | 4.8 | 0.0 | 43.4 | 7.6 | 5.9 | 8.9 | 7.8 | 7.3 | 8.0 |
| June | 2.5 | 2.0 | 2.7 | 20.6 | 17.2 | 24.1 | 4.6 | -0.4 | 244.5 | 7.2 | 6.0 | 8.4 | 7.7 | 7.6 | 8.0 |
| July | 2.5 | 2.4 | 2.6 | 22.0 | 19.5 | 23.7 | 2.8 | -0.2 | 9.8 | 7.1 | 6.3 | 8.2 | 7.7 | 7.3 | 7.7 |
| August | 2.6 | 2.4 | 2.8 | 22.4 | 20.4 | 24.5 | 2.5 | -0.1 | 13.0 | 7.0 | 5.9 | 8.2 | 7.7 | 6.8 | 7.8 |
| September | 2.6 | 2.5 | 2.7 | 20.9 | 18.0 | 23.7 | 2.9 | -0.1 | 8.7 | 7.3 | 6.4 | 8.5 | 7.7 | 6.7 | 7.8 |
| October | 2.5 | 1.9 | 2.8 | 17.7 | 12.4 | 21.4 | 3.6 | 0.3 | 28.8 | 7.2 | 4.6 | 9.4 | 7.7 | 7.2 | 7.9 |
| Average | 2.3 | 1.5 | 2.8 | 16.8 | 13.2 | 20.2 | 6.4 | -0.1 | 127.0 | 7.9 | 6.5 | 9.3 | 7.8 | 7.4 | 8.0 |
| **Event** | **Specific Conductance (mS/cm)** | | | **Temperature (°C)** | | | **Turbidity (NTU)** | | | **Dissolved Oxygen (mg/L)** | | | **pH** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1[2] | 1.2 | 0.3 | 2.8 | 12.5 | 10.7 | 13.8 | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | *No Data* | 7.7 | 7.6 | 8.0 |
| Wet Weather 2 | 1.2 | 0.5 | 2.6 | 11.9 | 9.4 | 14.9 | 16.6 | 0.1 | 153.2 | 9.0 | 8.0 | 10.0 | 7.8 | 7.6 | 8.0 |
| Wet Weather 3 | 1.3 | 0.4 | 2.5 | 10.9 | 8.6 | 12.6 | 161.2 | 1.4 | 751.2 | 9.6 | 8.6 | 10.5 | 7.8 | 7.6 | 8.0 |
| Index Period 1 | 2.2 | 1.9 | 2.5 | 10.9 | 8.7 | 13.4 | 1.7 | 0.0 | 5.6 | 9.6 | 8.8 | 10.5 | 8.1 | 7.9 | 8.2 |
| Index Period 2 | 2.4 | 2.4 | 2.5 | 15.7 | 13.3 | 17.8 | 3.1 | 0.6 | 7.7 | 8.3 | 7.4 | 9.7 | 7.9 | 7.8 | 8.0 |
| Index Period 3 | 2.6 | 2.5 | 2.6 | 22.3 | 21.1 | 23.7 | 2.9 | 0.4 | 7.5 | 7.0 | 6.3 | 7.8 | 7.6 | 7.6 | 7.7 |
| Index Period 4 | 2.6 | 2.6 | 2.7 | 19.7 | 18.0 | 21.4 | 3.4 | 0.9 | 7.0 | 7.5 | 6.9 | 8.5 | 7.7 | 6.7 | 7.8 |
| WQO | N/A | | | N/A | | | 20 NTU | | | < 5 mg/L | | | 6.5 – 8.5 | | |

(1) Per the QAPP, turbidity and DO was not required to be monitored prior to January 2008.
(2) Turbidity and DO probes were not installed prior to Wet Weather Event 1.

**Table 4-66: San Elijo Lagoon Segment 1 Continuous Data Monthly and Event Summary**

| Month (2008) | Specific Conductance (mS/cm) | | | Temperature (°C) | | | Turbidity (NTU) | | | Dissolved Oxygen (mg/L) | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| January | 4.4 | 0.9 | 48.1 | 11.2 | 7.6 | 14.0 | 5.9 | -0.1 | 30.2 | 8.3 | 4.7 | 12.9 | 7.7 | 7.3 | 8.2 |
| February | 2.0 | 1.0 | 21.3 | 12.1 | 8.4 | 15.8 | 6.9 | -0.3 | 95.7 | 8.5 | 4.8 | 12.2 | 7.7 | 7.4 | 8.1 |
| March | 3.1 | 2.2 | 3.9 | 15.7 | 11.9 | 19.5 | 5.4 | -0.7 | 30.0 | 8.3 | 4.9 | 11.3 | 7.8 | 7.6 | 8.0 |
| April | 3.9 | 3.4 | 13.2 | 17.7 | 13.5 | 22.0 | 6.5 | 0.0 | 41.3 | 8.8 | 5.1 | 25.9 | 7.8 | 7.6 | 8.5 |
| May | 9.9 | 3.3 | 50.5 | 20.1 | 14.6 | 29.2 | 7.6 | 0.0 | 56.2 | 5.8 | 1.8 | 14.1 | 7.7 | 7.3 | 8.3 |
| June | 13.7 | 3.5 | 51.1 | 23.4 | 17.7 | 30.7 | 6.7 | 0.0 | 52.2 | 4.9 | 0.8 | 18.2 | 7.7 | 7.3 | 8.4 |
| July | 19.1 | 4.0 | 51.2 | 24.6 | 20.0 | 30.8 | 5.1 | 0.0 | 52.1 | 3.9 | 0.2 | 17.4 | 7.7 | 7.3 | 8.4 |
| August | 22.5 | 5.3 | 50.7 | 25.2 | 21.9 | 31.2 | 5.9 | 0.1 | 385.4 | 3.6 | 0.4 | 12.4 | 7.7 | 7.4 | 8.2 |
| September | 19.8 | 5.5 | 49.9 | 23.4 | 19.0 | 29.2 | 5.2 | 0.0 | 30.5 | 3.9 | 0.4 | 13.7 | 7.7 | 7.4 | 8.2 |
| October | 14.8 | 4.0 | 50.1 | 19.0 | 12.1 | 24.2 | 5.2 | 0.0 | 32.2 | 4.8 | 0.8 | 10.4 | 7.7 | 7.4 | 8.0 |
| Average | 11.3 | 3.3 | 39.0 | 19.2 | 14.7 | 24.7 | 6.0 | -0.1 | 80.6 | 6.1 | 2.4 | 14.9 | 7.7 | 7.4 | 8.2 |
| **Event** | **Specific Conductance (mS/cm)** | | | **Temperature (°C)** | | | **Turbidity (NTU)** | | | **Dissolved Oxygen mg/L)** | | | **pH** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 3.0 | 0.9 | 40.1 | 12.5 | 10.7 | 14.0 | 16.7 | 5.4 | 30.2 | 5.8 | 4.7 | 10.0 | 7.5 | 7.3 | 8.1 |
| Wet Weather 2 | 3.2 | 1.6 | 29.2 | 11.8 | 9.7 | 14.0 | 3.9 | 0.7 | 26.0 | 7.8 | 5.0 | 11.7 | 7.7 | 7.4 | 8.0 |
| Wet Weather 3 | 1.6 | 1.1 | 2.5 | 11.1 | 8.7 | 13.1 | 11.5 | 0.8 | 21.6 | 7.7 | 5.7 | 10.0 | 7.6 | 7.4 | 7.9 |
| Index Period 1 | 2.4 | 1.5 | 3.0 | 11.0 | 8.7 | 13.3 | 3.8 | 0.0 | 14.1 | 9.1 | 7.3 | 12.0 | 7.8 | 7.6 | 8.2 |
| Index Period 2 | 3.7 | 3.5 | 3.9 | 16.8 | 13.5 | 19.5 | 6.6 | 1.8 | 30.0 | 7.5 | 5.2 | 9.7 | 7.7 | 7.6 | 7.8 |
| Index Period 3 | 15.1 | 4.7 | 49.9 | 25.3 | 22.4 | 30.8 | 5.4 | 0.6 | 48.1 | 3.5 | 0.3 | 17.4 | 7.7 | 7.5 | 8.4 |
| Index Period 4 | 19.0 | 6.9 | 44.8 | 22.0 | 19.0 | 27.7 | 4.3 | 0.0 | 26.6 | 4.7 | 1.4 | 13.3 | 7.7 | 7.5 | 8.2 |
| WQO | N/A | | | N/A | | | 20 NTU | | | < 5 mg/L | | | 6.5 – 8.5 | | |

**Table 4-67: San Elijo Lagoon Segment 2 Continuous Data Monthly and Event Summary**

| Month (2008) | Specific Conductance (mS/cm) | | | Temperature (°C) | | | Turbidity (NTU) | | | Dissolved Oxygen (mg/L) | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| January | 21.5 | 1.1 | 52.3 | 12.4 | 8.0 | 16.0 | 11.6 | -0.1 | 722.5 | 8.3 | 3.8 | 13.2 | 7.7 | 7.1 | 8.1 |
| February | 16.8 | 1.2 | 51.6 | 13.2 | 8.9 | 18.0 | 12.2 | -0.4 | 49.6 | 8.3 | 3.9 | 12.9 | 7.7 | 7.3 | 8.0 |
| March | 31.8 | 2.6 | 51.3 | 17.0 | 12.1 | 22.3 | 22.6 | -0.2 | 440.7 | 6.7 | 0.0 | 19.3 | 7.7 | 7.2 | 8.3 |
| April | 33.1 | 0.7 | 50.9 | 19.9 | 14.8 | 28.1 | 31.8 | 0.0 | 963.2 | 7.0 | 0.1 | 22.7 | 7.8 | 7.1 | 8.4 |
| May | 36.1 | 0.1 | 54.7 | 20.1 | 14.9 | 29.4 | 8.2 | 0.0 | 35.4 | 5.2 | 0.6 | 12.0 | 7.8 | 7.3 | 8.3 |
| June | 41.8 | 2.1 | 53.8 | 22.2 | 17.9 | 30.4 | 4.3 | 0.0 | 35.6 | 4.7 | 0.2 | 12.4 | 7.6 | 7.2 | 8.0 |
| July | 44.6 | 1.7 | 52.9 | 23.1 | 19.2 | 30.6 | 3.6 | 0.0 | 16.6 | 4.8 | 0.2 | 12.6 | 7.5 | 7.0 | 8.0 |
| August | 46.1 | 3.6 | 54.1 | 24.0 | 18.8 | 31.1 | 3.5 | -0.2 | 17.5 | 5.1 | 0.2 | 11.8 | 7.8 | 7.2 | 8.2 |
| September | 45.6 | 2.1 | 53.5 | 22.3 | 17.7 | 28.4 | 4.0 | -0.2 | 22.9 | 5.7 | 0.7 | 11.5 | 7.8 | 7.0 | 8.0 |
| October | 42.8 | 1.9 | 52.0 | 19.5 | 13.1 | 26.3 | 3.4 | 0.0 | 14.1 | 6.0 | 0.6 | 11.2 | 7.8 | 7.4 | 8.1 |
| Average | 36.0 | 1.7 | 52.7 | 19.4 | 14.5 | 26.0 | 10.5 | -0.1 | 231.8 | 6.2 | 1.0 | 13.9 | 7.7 | 7.2 | 8.1 |
| **Event** | **Specific Conductance (mS/cm)** | | | **Temperature (°C)** | | | **Turbidity (NTU)** | | | **Dissolved Oxygen (mg/L)** | | | **pH** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 19.3 | 1.1 | 51.7 | 13.1 | 10.6 | 14.6 | 18.1 | 0.7 | 55.6 | 6.6 | 4.7 | 8.9 | 7.6 | 7.2 | 8.1 |
| Wet Weather 2 | 18.2 | 1.8 | 51.9 | 12.6 | 9.6 | 16.0 | 14.5 | 0.9 | 722.5 | 8.1 | 5.7 | 11.3 | 7.7 | 7.1 | 8.0 |
| Wet Weather 3 | 15.7 | 1.3 | 51.6 | 12.1 | 9.0 | 13.8 | 16.0 | 0.9 | 34.8 | 8.0 | 5.8 | 10.7 | 7.6 | 7.3 | 7.9 |
| Index Period 1 | 19.4 | 1.9 | 51.5 | 12.3 | 8.9 | 16.4 | 8.4 | -0.4 | 20.0 | 8.8 | 4.3 | 12.8 | 7.7 | 7.3 | 8.0 |
| Index Period 2 | 33.6 | 7.4 | 51.0 | 18.6 | 15.4 | 22.3 | 133.0 | 0.0 | 963.2 | 6.5 | 0.0 | 17.2 | 7.7 | 7.3 | 8.1 |
| Index Period 3 | 43.8 | 5.7 | 52.6 | 22.9 | 19.8 | 28.6 | 4.0 | 0.7 | 12.3 | 4.9 | 0.9 | 9.3 | 7.5 | 7.1 | 7.9 |
| Index Period 4 | 46.3 | 17.2 | 53.1 | 21.0 | 17.7 | 26.3 | 3.4 | -0.1 | 11.8 | 6.2 | 1.5 | 11.5 | 7.8 | 7.4 | 8.0 |
| WQO | N/A | | | N/A | | | 20 NTU | | | < 5 mg/L | | | 6.5 – 8.5 | | |

**Table 4-68: San Elijo Ocean Inlet 1 Continuous Data Monthly and Event Summary**

| Month (2008) | Specific Conductance (mS/cm) | | | Temperature (°C) | | | Turbidity (NTU) | | | Dissolved Oxygen (mg/L) | | | pH | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| January | 29.1 | 1.5 | 52.2 | 12.8 | 8.3 | 16.7 | 9.5 | -0.3 | 97.4 | 8.4 | 5.0 | 12.9 | 7.8 | 7.2 | 8.2 |
| February | 23.6 | 1.4 | 51.9 | 13.5 | 9.3 | 18.5 | 11.5 | -0.3 | 74.6 | 8.5 | 4.2 | 12.4 | 7.8 | 7.3 | 8.1 |
| March | 39.3 | 3.9 | 51.8 | 16.6 | 12.6 | 20.9 | 5.2 | -0.1 | 42.2 | 8.1 | 2.0 | 21.2 | 7.9 | 7.4 | 8.5 |
| April | 37.4 | 0.0 | 52.2 | 19.0 | 13.8 | 26.2 | 6.5 | 0.0 | 161.5 | 6.7 | 0.1 | 19.8 | 8.0 | 7.4 | 8.6 |
| May | 44.6 | 1.0 | 53.5 | 19.6 | 15.2 | 27.1 | 4.7 | 0.3 | 21.2 | 5.7 | 0.6 | 11.5 | 7.8 | 7.3 | 8.3 |
| June | 47.3 | 2.4 | 53.1 | 21.3 | 17.8 | 28.2 | 3.7 | 0.5 | 21.0 | 5.5 | 0.6 | 7.9 | 7.7 | 7.2 | 8.0 |
| July | 48.2 | 2.0 | 52.1 | 22.0 | 18.1 | 27.5 | 3.8 | -4.1 | 11.9 | 5.2 | 0.5 | 9.2 | 7.7 | 7.0 | 10.0 |
| August | 48.7 | -1.7 | 52.0 | 23.2 | 18.2 | 30.2 | 3.0 | 0.0 | 11.8 | 5.5 | 0.2 | 11.0 | 7.9 | 7.0 | 8.2 |
| September | 49.3 | 5.2 | 52.9 | 21.8 | 17.4 | 28.1 | 3.8 | -0.3 | 27.5 | 6.3 | 0.4 | 11.5 | 7.9 | 7.1 | 8.1 |
| October | 47.6 | 8.8 | 51.8 | 19.8 | 14.3 | 26.2 | 9.2 | 0.0 | 40.6 | 6.7 | 1.6 | 10.6 | 8.0 | 7.7 | 8.2 |
| Average | 41.5 | 2.5 | 52.3 | 19.0 | 14.5 | 25.0 | 6.1 | -0.4 | 51.0 | 6.7 | 1.5 | 12.8 | 7.9 | 7.3 | 8.4 |
| **Event** | **Specific Conductance (mS/cm)** | | | **Temperature (°C)** | | | **Turbidity (NTU)** | | | **Dissolved Oxygen (mg/L)** | | | **pH** | | |
| | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** | **Mean** | **Min** | **Max** |
| Wet Weather 1 | 23.3 | 1.5 | 51.4 | 13.2 | 10.8 | 15.0 | 16.8 | 0.3 | 97.4 | 7.0 | 5.2 | 9.8 | 7.7 | 7.2 | 8.1 |
| Wet Weather 2 | 25.9 | 2.0 | 51.9 | 13.0 | 9.5 | 16.7 | 10.9 | 0.4 | 58.3 | 8.3 | 5.7 | 11.1 | 7.8 | 7.4 | 8.1 |
| Wet Weather 3 | 21.6 | 1.5 | 51.9 | 12.5 | 9.4 | 14.4 | 16.6 | 0.7 | 39.3 | 8.5 | 6.3 | 11.1 | 7.7 | 7.4 | 8.0 |
| Index Period 1 | 27.9 | 3.1 | 50.4 | 12.8 | 8.3 | 16.3 | 7.1 | -0.1 | 18.5 | 9.0 | 5.0 | 12.2 | 7.8 | 7.5 | 8.0 |
| Index Period 2 | 38.8 | 23.8 | 51.7 | 17.9 | 15.1 | 20.6 | 6.0 | 0.2 | 22.2 | 10.8 | 3.5 | 21.2 | 8.1 | 7.6 | 8.5 |
| Index Period 3 | 48.5 | 15.4 | 52.1 | 21.9 | 19.4 | 26.6 | 3.5 | 0.8 | 9.4 | 5.7 | 0.7 | 9.0 | 7.7 | 7.2 | 8.0 |
| Index Period 4 | 49.8 | 21.0 | 52.4 | 20.5 | 17.3 | 26.2 | 5.0 | 0.0 | 26.7 | 6.9 | 1.8 | 10.9 | 7.9 | 7.6 | 8.2 |
| WQO | N/A | | | N/A | | | 20 NTU | | | < 5 mg/L | | | 6.5 – 8.5 | | |

### 4.4.2 San Elijo Wet Weather Monitoring

The following three wet weather events were successfully monitored at San Elijo Lagoon:

- The first event occurred from January 5 to January 7, 2008. Rainfall began at 01:23 on January 5, 2008 and ended at 06:33 on January 7, 2008, totaling 2.20 inches.
- The second event occurred from January 23 to January 24, 2008. Rainfall began at 18:34 on January 23, 2008 and ended at 09:50 on January 24, 2008, totaling 0.51 inches.
- The third event occurred from February 3, 2008 to February 4, 2008. Rainfall began at 06:40 on February 3, 2008 and ended at 21:14 on February 3, 2008, totaling 0.55 inches of rainfall (0.51 inches as measured by agency performing sampling during this event).

All collected samples were placed on ice immediately after collection and stored at four degrees Celsius until delivery to the laboratory. Control of samples was maintained by Chain-of-Custody protocol from sample collection through sample analysis. All analytical methods performed on collected samples are outlined in Table 2-4 in Section 2.2.5. Quality Assurance/Quality Control samples were also collected per SWAMP requirements in accordance with the QAPP.

#### 4.4.2.1 Mass Emission Station

Two pollutagraph events and one flow-weighted composite sampling event were sampled successfully at the San Elijo Lagoon Mass Emission Station as required by the IO. Analytes monitored at this station were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus.

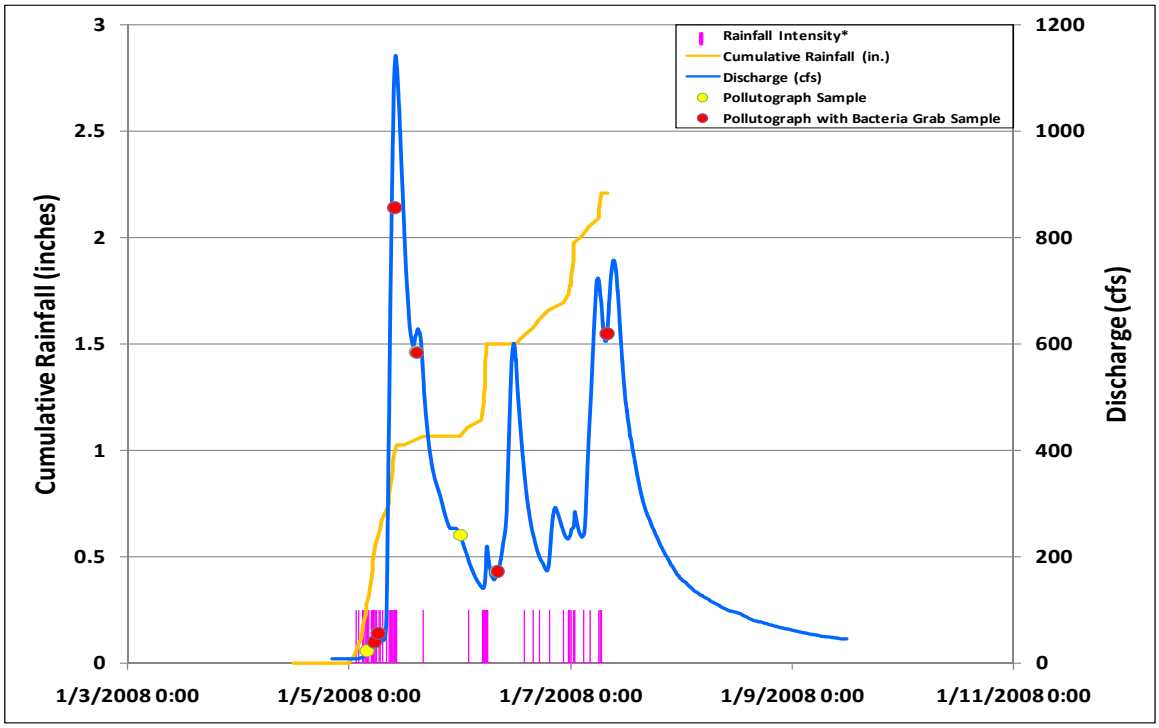
During the first monitored event, 12 pollutagraph samples were collected by the automated samplers. Eight of those 12 samples were submitted to the laboratory for analysis. Samples that represented the various flow regimes, specifically the rising limbs and peaks of the hydrograph, were selected. (Figure 4-12). Six microbiology grab samples were collected at targeted times during the storm event that corresponded to automated pollutagraph sample times. These samples were immediately submitted to the laboratory for analysis in order to meet the short hold time for bacteria analysis. Due to short holding times for microbiology samples, a sample collected earlier in the event had to be analyzed before notice was given of a sixth collected sample that was to be included in the analyzed suite. Results for the six samples are reported.

During the second monitored event, 12 pollutagraph samples were collected by the automated samplers. Eleven of those 12 samples were submitted to the laboratory for analysis. Samples that represented the

various flow regimes, specifically the rising limbs and peaks of the hydrograph, were selected (Figure 4-13). Six microbiology grab samples were collected at targeted times during the storm event that corresponded to automated pollutagraph sample times. These samples were immediately submitted to the laboratory for analysis in order to meet the short hold time for bacteria analysis. Due to short holding times for microbiology samples, a sample collected earlier in the event had to be analyzed before notice was given of a sixth collected sample that was to be included in the analyzed suite. Three pollutagraph samples were analyzed beyond the required eight. Results for any samples analyzed but not required are reported.

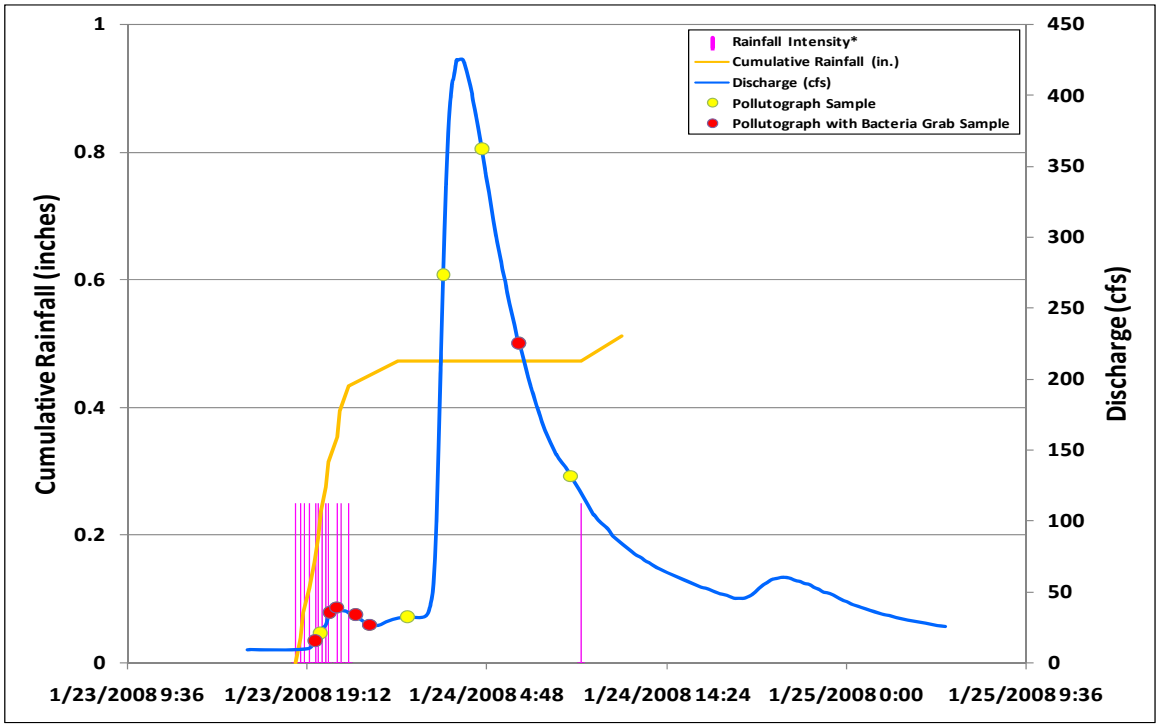
The third wet weather sampling event was not required to be a pollutagraph sample. Instead, a flow-weighted composite sample was successfully monitored from February 3 to February 4, 2008 under the San Diego County Regional Monitoring Program, Order No. 2007-01. See Figure 4-14 for the rainfall, flow, and sampling that occurred during this event.

**Figure 4-12: San Elijo Mass Emission Hydrograph and Hyetograph Wet Weather Event 1**



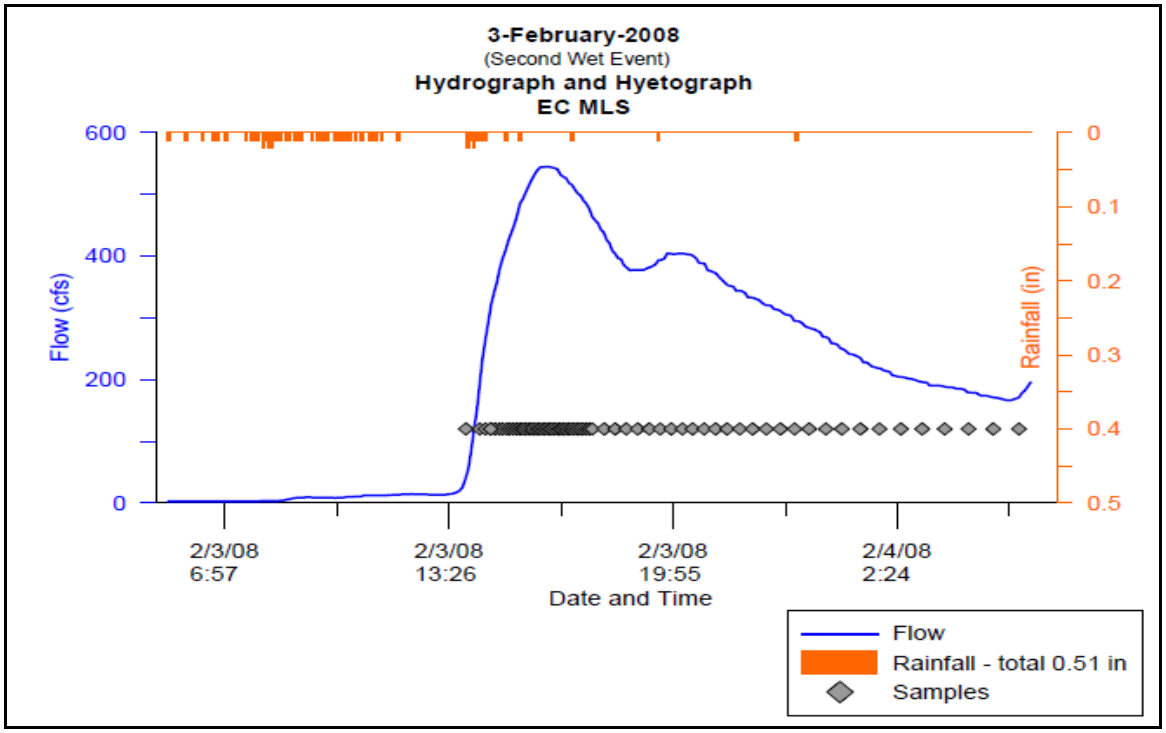

Note: Each vertical bar represents a one-millimeter rain gauge bucket tip.

**Figure 4-13: San Elijo Mass Emission Hydrograph and Hyetograph Wet Weather Event 2**




Note: Each vertical bar represents a one-millimeter rain gauge bucket tip.

**Figure 4-14: San Elijo Mass Emission Hydrograph and Hyetograph Wet Weather Event 3**




Note: Sampling for this event was conducted by an outside agency under the San Diego County Regional Monitoring Program, Order No. 2007-01.

Results from the two pollutagraph sampling events at the Mass Emission Station are summarized statistically in Table 4-69. The results from the third monitoring event are event mean concentrations (EMC) and those values are displayed in Table 4-70. Detailed analytical results for all wet weather events are presented in Appendix C-4.

**Table 4-69: San Elijo Wet Weather Events 1 and 2 Pollutagraph Summary**

| Event Category | Analyte | Units | Count | Mean | Median | Min | Max | WQO[1] | Percent Exceedance[2] (%) |
|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 January 5-7, 2008 | *Enterococcus* | CFU/100mL | 6 | 27,050 | 28,000 | 9,300 | 41,000 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 6 | 7,733 | 7,000 | 2,400 | 14,000 | 400 | 100 |
| | Total Coliform | MPN/100mL | 6 | 56,833 | 37,000 | 3,000 | 130,000 | 10,000 | 100 |
| | TSS | mg/L | 8 | 28.7 | 24.5 | 9.0 | 68.0 | NA | NA |
| | Ammonia as N | mg/L | 8 | 0.13 | 0.14 | 0.04 | 0.22 | 0.025 | 100 |
| | CBOD | mg/L | 8 | 2.21 | 1.00 | 1.00 | 7.10 | NA | NA |
| | Nitrate+Nitrite | mg/L | 8 | 1.38 | 1.35 | 0.24 | 3.40 | 10 | 0 |
| | SRP | mg/L | 8 | 0.19 | 0.19 | 0.01 | 0.45 | NA | NA |
| | Total Nitrogen | mg/L | 8 | 1.63 | 1.81 | 0.44 | 3.04 | 1 | 56 |
| | Total Dissolved Nitrogen | mg/L | 8 | 1.22 | 1.15 | 0.33 | 2.53 | NA | NA |
| | Total Phosphorus | mg/L | 8 | 0.24 | 0.25 | 0.02 | 0.64 | 0.1 | 67 |
| | Total Dissolved Phosphorus | mg/L | 8 | 0.16 | 0.17 | 0.002 | 0.31 | NA | NA |
| Wet Weather Event 2 January 23-25, 2008 | *Enterococcus* | CFU/100mL | 6 | 11,500 | 11,500 | 25,000 | 2,000 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 6 | 9,567 | 6,500 | 28,000 | 2,400 | 400 | 100 |
| | Total Coliform | MPN/100mL | 6 | 24,167 | 23,500 | 50,000 | 7,000 | 10,000 | 100 |
| | TSS | mg/L | 11 | 42.2 | 36.5 | 74.7 | 10.7 | NA | NA |
| | Ammonia as N | mg/L | 11 | 0.13 | 0.13 | 0.20 | 0.07 | 0.025 | 100 |
| | CBOD | mg/L | 11 | 1.68 | 1.00 | 3.90 | 1.00 | NA | NA |
| | Nitrate+Nitrite | mg/L | 11 | 2.70 | 3.04 | 4.51 | 0.42 | 10 | 0 |
| | SRP | mg/L | 11 | 0.13 | 0.13 | 0.22 | 0.03 | NA | NA |
| | Total Nitrogen | mg/L | 11 | 1.94 | 1.94 | 3.56 | 0.75 | 1 | 91 |
| | Total Dissolved Nitrogen | mg/L | 11 | 2.15 | 1.95 | 3.56 | 0.77 | NA | NA |
| | Total Phosphorus | mg/L | 11 | 0.17 | 0.17 | 0.27 | 0.07 | 0.1 | 82 |
| | Total Dissolved Phosphorus | mg/L | 11 | 0.14 | 0.14 | 0.24 | 0.03 | NA | NA |

(1) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.
(2) The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

**Table 4-70: San Elijo Wet Weather Event 3 EMC Summary**

| Analyte | Units | EMC | WQO[1] | Exceedance |
|---|---|---|---|---|
| *Enterococcus* | MPN/100mL | 3,000 | 276 | Yes |
| Fecal Coliform | MPN/100mL | 1,100 | 400 | Yes |
| Total Coliform | MPN/100mL | 22,000 | 10,000 | Yes |
| TSS | mg/L | 46 | NA | NA |
| Ammonia as N | mg/L | 0.1 | 0.025 | Yes |
| Nitrate+Nitrite as N | mg/L | 1.63 | 10 | No |
| TP | mg/L | 0.46 | 0.1 | Yes |
| TDP | mg/L | 0.33 | NA | NA |

(1) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.

#### 4.4.2.2 Lagoon Segment Sites

Three events were successfully monitored at the two San Elijo Lagoon Segment Sites required by the IO. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, chlorophyll *a*, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus. Wet weather event sampling within the lagoon was conducted simultaneously with pollutagraph sampling and ocean inlet sampling during wet weather events. The anticipated lag time (i.e., the amount of transit time after a storm's onset before the lagoon is affected) was accounted for when preparing to initialize a sampling program.

During the first event, the first composite sample was collected at the high tide that occurred at 06:41 on January 5, 2008 approximately six hours after rainfall began. The second composite sample was collected at the low tide that occurred at 14:01 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

During the second event, the first composite sample was collected at the high tide that occurred at 09:49 on January 24, 2008 approximately fifteen hours after rainfall began. Sampling was delayed for a longer period of time during this event for two reasons. Primarily, the rainfall was very light in intensity. This resulted in a slower transit time and therefore further delayed response within the lagoon. Secondly, the Health and Safety Plan for this project dictated that personnel cannot be out during non-daylight hours. Therefore the tide selected was the soonest possible time for sample collection to take place. The second composite sample was collected at the low tide that occurred at 16:35 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-

regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

During the third event, the first composite sample was collected at the high tide that occurred at 07:03 on February 4, 2008 approximately 13 hours after rainfall began. Sampling was delayed during this event due timing of the storm and the Health and Safety requirements of this project. Rainfall began just before dawn on February 3, 2008. Sampling that morning would not have allowed for transit time from the watershed to the lagoon. The ideal sample time for this event would have resulted in personnel sampling during non-daylight hours, which is prohibited by the Health and Safety Plan for this project. Therefore the tide selected was the soonest possible time for sample collection to take place. The second composite sample was collected at the low tide that occurred at 14:00 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

Results from the three wet weather sampling events at the two San Elijo Lagoon Segment Sites are summarized statistically in Table 4-71 and 4-72. Detailed analytical results for all wet weather events are presented in Appendix C-4.

**Table 4-71: San Elijo Wet Weather Events 1-3 Lagoon Segment 1 Summary**

| Event Category | Analyte | Units | Count | Mean | Median | Min | Max | WQO | Percent Exceedance[1] (%) |
|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 January 5-7, 2008 | *Enterococcus* | CFU/100mL | 2 | 4,645 | 4,645 | 890 | 8,400 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 1,500 | 1,500 | 700 | 2,300 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 13,000 | 13,000 | 9,000 | 17,000 | 10,000 | 100 |
| | TSS | mg/L | 2 | 44.0 | 44.0 | 42.0 | 46.0 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.06 | 0.06 | 0.01 | 0.11 | 0.025 | 50 |
| | CBOD | mg/L | 2 | 1.85 | 1.85 | 1.00 | 2.70 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 36.70 | 36.70 | 30.70 | 42.70 | 20 | 100 |
| | Nitrate+Nitrite | mg/L | 2 | 0.20 | 0.20 | 0.02 | 0.38 | 10 | 0 |
| | SRP | mg/L | 2 | 0.02 | 0.02 | 0.01 | 0.04 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 1.11 | 1.11 | 0.34 | 1.87 | 1 | 50 |
| | Total Dissolved Nitrogen | mg/L | 2 | 0.92 | 0.92 | 0.54 | 1.30 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.08 | 0.08 | 0.01 | 0.15 | 0.1 | 50 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.04 | 0.04 | 0.01 | 0.08 | NA | NA |
| Wet Weather Event 2 January 23-25, 2008 | *Enterococcus* | CFU/100mL | 2 | 135 | 135 | 210 | 60 | 276 | 50 |
| | Fecal Coliform | MPN/100mL | 2 | 735 | 735 | 1,300 | 170 | 400 | 50 |
| | Total Coliform | MPN/100mL | 2 | 9,750 | 9,750 | 16,000 | 3,500 | 10,000 | 50 |
| | TSS | mg/L | 2 | 8.3 | 8.3 | 10.5 | 6.0 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.04 | 0.04 | 0.05 | 0.04 | 0.025 | 100 |
| | CBOD | mg/L | 2 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 8.70 | 8.70 | 10.50 | 6.90 | 20 | 0 |
| | Nitrate+Nitrite | mg/L | 2 | 2.13 | 2.13 | 3.10 | 1.17 | 10 | 0 |
| | SRP | mg/L | 2 | 0.08 | 0.08 | 0.08 | 0.08 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 2.28 | 2.28 | 2.46 | 2.09 | 1 | 100 |
| | Total Dissolved Nitrogen | mg/L | 2 | 1.80 | 1.80 | 2.20 | 1.40 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.14 | 0.14 | 0.15 | 0.14 | 0.1 | 100 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.10 | 0.10 | 0.11 | 0.09 | NA | NA |
| Wet Weather Event 3 February 3-4, 2008 | *Enterococcus* | CFU/100mL | 2 | 4,250 | 4,250 | 3,200 | 5,300 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 2,150 | 2,150 | 1,300 | 3,000 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 19,500 | 19,500 | 11,000 | 28,000 | 10,000 | 100 |
| | TSS | mg/L | 2 | 18.9 | 18.9 | 14.7 | 23.0 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.02 | 0.02 | 0.02 | 0.02 | 0.025 | 0 |
| | CBOD | mg/L | 2 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 8.00 | 8.00 | 5.30 | 10.70 | 20 | 0 |
| | Nitrate+Nitrite | mg/L | 2 | 1.72 | 1.72 | 1.38 | 2.07 | 10 | 0 |
| | SRP | mg/L | 2 | 0.19 | 0.19 | 0.18 | 0.20 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 2.15 | 2.15 | 1.36 | 2.94 | 1 | 100 |
| | Total Dissolved Nitrogen | mg/L | 2 | 1.95 | 1.95 | 1.39 | 2.51 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.27 | 0.27 | 0.22 | 0.31 | 0.1 | 100 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.26 | 0.26 | 0.22 | 0.29 | NA | NA |

(1) The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

**Table 4-72: San Elijo Wet Weather Events 1-3 Lagoon Segment 2 Summary**

| Event Category | Analyte | Units | Count | Mean | Median | Min | Max | WQO | Percent Exceedance[1] (%) |
|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 January 5-7, 2008 | *Enterococcus* | CFU/100mL | 2 | 6,005 | 6,005 | 510 | 11,500 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 1,165 | 1,165 | 130 | 2,200 | 400 | 50 |
| | Total Coliform | MPN/100mL | 2 | 2,050 | 2,050 | 1,700 | 2,400 | 10,000 | 100 |
| | TSS | mg/L | 2 | 32.1 | 32.1 | 23.2 | 41.0 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.06 | 0.06 | 0.03 | 0.09 | 0.025 | 100 |
| | CBOD | mg/L | 2 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 12.25 | 12.25 | 9.80 | 14.70 | 20 | 0 |
| | Nitrate+Nitrite | mg/L | 2 | 0.28 | 0.28 | 0.09 | 0.47 | 10 | 0 |
| | SRP | mg/L | 2 | 0.03 | 0.03 | 0.01 | 0.04 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 0.52 | 0.52 | 0.27 | 0.76 | 1 | 0 |
| | Total Dissolved Nitrogen | mg/L | 2 | 0.76 | 0.76 | 0.42 | 1.10 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.06 | 0.06 | 0.02 | 0.09 | 0.1 | 0 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.06 | 0.06 | 0.03 | 0.08 | NA | NA |
| Wet Weather Event 2 January 23-25, 2008 | *Enterococcus* | CFU/100mL | 2 | 46 | 46 | 90 | 1 | 276 | 0 |
| | Fecal Coliform | MPN/100mL | 2 | 101 | 101 | 200 | 2 | 400 | 0 |
| | Total Coliform | MPN/100mL | 2 | 3,502 | 3,502 | 7,000 | 4 | 10,000 | 0 |
| | TSS | mg/L | 2 | 19.8 | 19.8 | 23.5 | 16.0 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.03 | 0.03 | 0.04 | 0.02 | 0.025 | 50 |
| | CBOD | mg/L | 2 | 1.90 | 1.90 | 2.80 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 15.85 | 15.85 | 20.30 | 11.40 | 20 | 50 |
| | Nitrate+Nitrite | mg/L | 2 | 0.60 | 0.60 | 1.19 | 0.01 | 10 | 0 |
| | SRP | mg/L | 2 | 0.03 | 0.03 | 0.05 | 0.01 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 0.61 | 0.61 | 1.01 | 0.22 | 1 | 50 |
| | Total Dissolved Nitrogen | mg/L | 2 | 0.54 | 0.54 | 0.98 | 0.10 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.04 | 0.04 | 0.06 | 0.02 | 0.1 | 0 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.02 | 0.02 | 0.03 | 0.01 | NA | NA |
| Wet Weather Event 3 February 3-4, 2008 | *Enterococcus* | CFU/100mL | 2 | 1,948 | 1,948 | 196 | 3,700 | 276 | 50 |
| | Fecal Coliform | MPN/100mL | 2 | 715 | 715 | 330 | 1,100 | 400 | 50 |
| | Total Coliform | MPN/100mL | 2 | 45,650 | 45,650 | 1300 | 90,000 | 10,000 | 50 |
| | TSS | mg/L | 2 | 31.7 | 31.7 | 25.7 | 37.7 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.03 | 0.03 | 0.02 | 0.04 | 0.025 | 50 |
| | CBOD | mg/L | 2 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 12.90 | 12.90 | 8.00 | 17.80 | 20 | 0 |
| | Nitrate+Nitrite | mg/L | 2 | 0.55 | 0.55 | 0.03 | 1.07 | 10 | 0 |
| | SRP | mg/L | 2 | 0.11 | 0.11 | 0.02 | 0.20 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 0.90 | 0.90 | 0.34 | 1.45 | 1 | 50 |
| | Total Dissolved Nitrogen | mg/L | 2 | 1.08 | 1.08 | 0.26 | 1.89 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.15 | 0.15 | 0.03 | 0.27 | 0.1 | 50 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.12 | 0.12 | 0.01 | 0.24 | NA | NA |

(1) The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

4.4.2.4 Ocean Inlet Site

Three events were successfully monitored at the San Elijo Lagoon Ocean Inlet Site as required by the IO. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, chlorophyll *a*, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus. As with the lagoon segment sampling, expected lag time was considered and the same protocol was followed for sampling program initiation.

During the first event, the first composite samples were collected at the high tide that occurred at 06:41 on January 5, 2008 approximately six hours after rainfall began. The second composite samples were collected at the low tide that occurred at 14:01 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

During the second event, the first composite samples were collected at the high tide that occurred at 09:49 on January 24, 2008 approximately 15 hours after rainfall began. Sampling was delayed for a longer period of time during this event for two reasons. Primarily, the rainfall was very light in intensity. This resulted in a slower transit time and therefore further delayed response within the lagoon. Secondly, the Health and Safety Plan for this project dictated that personnel could not be out during non-daylight hours. Therefore the tide selected was the soonest possible time for sample collection to take place. The second composite samples were collected at the low tide that occurred at 16:35 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

During the third event, the first composite samples were collected at the high tide that occurred at 07:03 on February 4, 2008 approximately 13 hours after rainfall began. Sampling was delayed during this event due timing of the storm and the Health and Safety requirements of this project. Rainfall began just before dawn on February 3, 2008. Sampling that morning would not have allowed for transit time from the watershed to the lagoon. The ideal sample time for this event would have resulted in personnel sampling during non-daylight hours which was prohibited by the Health and Safety Plan for this project. Therefore the tide selected was the soonest possible time for sample collection to take place. The second composite samples were collected at the low tide that occurred at 14:00 the same day. Sample aliquots were collected every 15 minutes for a three-hour period around the high tide and again around the low tide. During the two tidally-

regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

Results from the three wet weather sampling events at the San Elijo Lagoon Ocean Inlet Site are summarized statistically in Tables 4-73. Detailed analytical results for all wet weather events are presented in Appendix C-4.

**Table 4-73: San Elijo Wet Weather Events 1-3 Ocean Inlet 1 Summary**

| Event Category | Analyte | Units | Count | Mean | Median | Min | Max | WQO | Percent Exceedance[1] (%) |
|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 January 5-7, 2008 | *Enterococcus* | CFU/100mL | 2 | 1,355 | 1,355 | 1,010 | 1,700 | 276 | 100 |
| | Fecal Coliform | MPN/100mL | 2 | 1,100 | 1,100 | 500 | 1,700 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 3,900 | 3,900 | 2,800 | 5,000 | 10,000 | 100 |
| | TSS | mg/L | 2 | 25.5 | 25.5 | 24.0 | 27.0 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.07 | 0.07 | 0.03 | 0.11 | 0.025 | 100 |
| | CBOD | mg/L | 2 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 6.25 | 6.25 | 4.50 | 8.00 | 20 | 0 |
| | Nitrate+Nitrite | mg/L | 2 | 0.36 | 0.36 | 0.03 | 0.69 | 10 | 0 |
| | SRP | mg/L | 2 | 0.03 | 0.03 | 0.01 | 0.05 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 0.72 | 0.72 | 0.34 | 1.11 | 1 | 50 |
| | Total Dissolved Nitrogen | mg/L | 2 | 0.91 | 0.91 | 0.22 | 1.61 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.09 | 0.09 | 0.02 | 0.16 | 0.1 | 50 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.06 | 0.06 | 0.01 | 0.12 | NA | NA |
| Wet Weather Event 2 January 23-25, 2008 | *Enterococcus* | CFU/100mL | 2 | 26 | 26 | 50 | 1 | 276 | 0 |
| | Fecal Coliform | MPN/100mL | 2 | 60 | 60 | 80 | 40 | 400 | 0 |
| | Total Coliform | MPN/100mL | 2 | 322 | 322 | 344 | 300 | 10,000 | 0 |
| | TSS | mg/L | 2 | 13.9 | 13.9 | 16.5 | 11.3 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.02 | 0.02 | 0.04 | 0.01 | 0.025 | 50 |
| | CBOD | mg/L | 2 | 1.55 | 1.55 | 2.10 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 15.50 | 15.50 | 16.60 | 14.40 | 20 | 0 |
| | Nitrate+Nitrite | mg/L | 2 | 0.21 | 0.21 | 0.42 | 0.00 | 10 | 0 |
| | SRP | mg/L | 2 | 0.02 | 0.02 | 0.03 | 0.01 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 0.38 | 0.38 | 0.63 | 0.13 | 1 | 0 |
| | Total Dissolved Nitrogen | mg/L | 2 | 0.38 | 0.38 | 0.62 | 0.14 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.03 | 0.03 | 0.04 | 0.02 | 0.1 | 0 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.02 | 0.02 | 0.03 | 0.01 | NA | NA |
| Wet Weather Event 3 February 3-4, 2008 | *Enterococcus* | CFU/100mL | 2 | 1,635 | 1,635 | 70 | 3,200 | 276 | 50 |
| | Fecal Coliform | MPN/100mL | 2 | 2,050 | 2,050 | 1,700 | 2,400 | 400 | 100 |
| | Total Coliform | MPN/100mL | 2 | 25,850 | 25,850 | 1,700 | 50,000 | 10,000 | 50 |
| | TSS | mg/L | 2 | 42.5 | 42.5 | 31.0 | 54.0 | NA | NA |
| | Ammonia as N | mg/L | 2 | 0.03 | 0.03 | 0.02 | 0.04 | 0.025 | 50 |
| | CBOD | mg/L | 2 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 2 | 11.80 | 11.80 | 8.50 | 15.10 | 20 | 0 |
| | Nitrate+Nitrite | mg/L | 2 | 0.83 | 0.83 | 0.04 | 1.62 | 10 | 0 |
| | SRP | mg/L | 2 | 0.09 | 0.09 | 0.02 | 0.15 | NA | NA |
| | Total Nitrogen | mg/L | 2 | 1.00 | 1.00 | 0.23 | 1.77 | 1 | 50 |
| | Total Dissolved Nitrogen | mg/L | 2 | 1.25 | 1.25 | 0.29 | 2.21 | NA | NA |
| | Total Phosphorus | mg/L | 2 | 0.12 | 0.12 | 0.02 | 0.22 | 0.1 | 50 |
| | Total Dissolved Phosphorus | mg/L | 2 | 0.11 | 0.11 | 0.01 | 0.21 | NA | NA |

(1) The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.4.2.5 Wet Weather Aqueous Sediment Grain Size at San Elijo Mass Emission Station

In addition to the chemical constituents required for a given impairment, all lagoons were monitored for grain size distribution of aqueous sediment (i.e., suspended sediment) at the mass emission stations during both required pollutagraph monitoring events of the season. The samples submitted to the laboratory consisted of one composite sample per lagoon. Each sample was composited from the pollutagraph samples, based on event, collected over the course of the storm. The samples were analyzed for grain size distribution among the following size categories: clay < 0.0039 millimeters, silt 0.0039 to <0.0625 millimeters, sand 0.0625 to < 2.0 millimeters, and granule 2.0 to < 4.0 millimeters. Results of the aqueous grain size distribution during both wet weather events are summarized in Table 4-74.

**Table 4-74: San Elijo Wet Weather Events 1-2 Aqueous Grain Size Distribution**

| Grain Size Classes | Units | Wet Weather Event 1 1/5-7/08 | Wet Weather Event 2 1/23-24/08 |
|---|---|---|---|
| Clay < 0.0039 mm | % | 15.1 | 26.2 |
| Silt 0.0039 to < 0.0625 mm | % | 81.9 | 71.0 |
| Sand 0.0625 to < 2.0 mm | % | 3.0 | 2.8 |
| Granule 2.0 to < 4.0 mm | % | 0.0 | 0.0 |

Note: Analysis was run on a composite of all pollutagraph samples collected for each storm.

#### 4.4.2.6 Post-Storm Sediment

Post-storm event sediment sampling at San Elijo Lagoon occurred on January 15, 2008, eight days after the end of the first sampled storm event. Sampling took place at the Lagoon Segment Site and both Ocean Inlet Sites. These samples were analyzed for percentage of organic carbon, percentage of sand, percentage of total nitrogen, and percentage of total phosphorus. The analytical results are summarized statistically in Table 4-75. These data along with the associated sample locations will be used in a special study by SCCWRP to determine the characteristics of sediments and where they settle in the lagoon. Detailed analytical results for all wet weather events are presented in Appendix C-4.

**Table 4-75: San Elijo Post-Storm Sediment Results (January 15, 2008)**

| Monitoring Location | % Analyte | Number of Samples | Mean | SD | CV | Median | Min | Max |
|---|---|---|---|---|---|---|---|---|
| San Elijo Lagoon Segment 1 | % Organic Carbon | 12 | 1.04 | 0.58 | 0.555 | 0.9 | 0.3 | 2.1 |
| | % Sand | 12 | 59.26 | 34.81 | 0.587 | 79.7 | 5.0 | 97.6 |
| | % Total Nitrogen | 10 | 0.15 | 0.07 | 0.452 | 0.1 | 0.1 | 0.3 |
| | % Total Phosphorus | 12 | 0.03 | 0.01 | 0.407 | 0.0 | 0.0 | 0.1 |
| San Elijo Lagoon Segment 2 | % Organic Carbon | 18 | 1.09 | 0.80 | 0.736 | 0.8 | 0.2 | 2.7 |
| | % Sand | 18 | 76.01 | 20.82 | 0.274 | 82.6 | 29.8 | 98.0 |
| | % Total Nitrogen | 14 | 0.14 | 0.09 | 0.622 | 0.1 | 0.1 | 0.3 |
| | % Total Phosphorus | 18 | 0.04 | 0.02 | 0.467 | 0.0 | 0.0 | 0.1 |
| San Elijo Ocean Inlet 1 | % Organic Carbon | 5 | 0.26 | 0.22 | 0.837 | 0.1 | 0.1 | 0.6 |
| | % Sand | 5 | 95.16 | 2.98 | 0.031 | 96.7 | 91.1 | 97.7 |
| | % Total Nitrogen | 1 | 0.06 | NA | NA | 0.1 | 0.1 | 0.1 |
| | % Total Phosphorus | 5 | 0.03 | 0.01 | 0.334 | 0.0 | 0.0 | 0.0 |

### 4.4.3 San Elijo Index Period Monitoring

Four index period events were successfully monitored at the sample locations associated with San Elijo Lagoon. Each index period event spanned six days and generally took place over two weeks. Index periods at San Elijo Lagoon occurred in late January to early February 2008, late March to early April 2008, July 2008, and late September to early October 2008.

All samples collected were placed on ice immediately after collection and stored at four degrees Celsius until delivery to the laboratory. Control of samples was maintained by Chain-of-Custody protocol from sample collection through sample analysis. All analytical methods performed on collected samples are outlined in Table 2-4 in Section 2.2.5. Quality Assurance/Quality Control samples were also collected per SWAMP requirements in accordance with the QAPP.

#### 4.4.3.1 Mass Emission Station

Mass emission station sampling was conducted once daily during the same index periods as the lagoon segment and ocean inlet sampling. Sampling at this station occurred between the tidally-regulated sample times at the Lagoon Segment and Ocean Inlet Sites. Daily time-weighted composite samples were collected. Automated sampling equipment programmed to collect aliquots every 15 minutes for a 30-minute period. Microbiology grab samples were collected concurrently with the composite samples.

All four events were sampled successfully at the San Elijo Lagoon Mass Emission Station. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, chlorophyll *a*, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus. Table 4-76 shows sampling schedule dates.

**Table 4-76: San Elijo Mass Emission Station Index Period Event Sampling Schedule**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Index Period Event 1 | Day of the Week | Monday | Tuesday | Wednesday | Thursday | Friday | Monday |
| | Date | 1/14/2008 | 1/15/2008 | 1/16/2008 | 2/07/2008 | 2/08/2008 | 2/11/2008 |
| Index Period Event 2 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Monday |
| | Date | 3/24/2008 | 3/25/2008 | 3/26/2008 | 3/31/2008 | 4/01/2008 | 4/07/2008 |
| Index Period Event 3 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 7/07/2008 | 708/2008 | 7/09/2008 | 7/14/2008 | 7/15/2008 | 7/16/2008 |
| Index Period Event 4 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 10/7/2008 | 10/8/2008 | 10/9/2008 | 10/13/2008 | 10/14/2008 | 10/15/2008 |

Sampling during Index Period Event1 was spread out over three different weeks as two unanticipated storms caused a delay in the proposed schedule. Per the requirements of the QAPP, dry weather sampling cannot occur less than 72 hours after a rain event. Index Period Event 2 was spread out over three weeks as rain was predicted during the last week but never occurred. This delayed the last day of sampling. On September 29, 2008, during Index Period Event 4, 0.04 inches of rain was recorded by the Loma Alta rain gauge. Although the rain gauge at San Elijo did not record this rainfall, sampling was postponed a week per the request of the RPs. All other index period events were sampled according to the general two-week approach.

Results from the four index period sampling events at the San Elijo Lagoon Mass Emission Station are summarized statistically in Table 4-77. Detailed analytical results for all wet weather events are presented in Appendix C-4.

**Table 4-77: San Elijo Index Period Events 1-4 Mass Emission Station Summary**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO[2] | Exceedance[3] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 6 | 108 | 98 | 40 | 258 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 118 | 129 | 50 | 222 | 200 | No |
| | Total Coliform | CFU/100mL | 6 | 334 | 338 | 240 | 456 | 1,000 | No |
| | TSS | mg/L | 6 | 1.6 | 1.5 | 0.3 | 3.7 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.09 | 0.11 | 0.04 | 0.14 | 0.025 | 100% |
| | CBOD | mg/L | 6 | 0.76 | 1.00 | 0.29 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 3.92 | 2.40 | 0.50 | 14.40 | 20 | 0% |
| | Nitrate+Nitrite | mg/L | 6 | 2.52 | 0.57 | 0.14 | 6.86 | 10 | 0% |
| | SRP | mg/L | 6 | 0.05 | 0.02 | 0.02 | 0.11 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 3.13 | 1.31 | 0.87 | 7.36 | 1 | 83% |
| | Total Dissolved Nitrogen | mg/L | 6 | 2.45 | 1.18 | 0.53 | 6.45 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.08 | 0.08 | 0.03 | 0.13 | 0.1 | 33% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.06 | 0.04 | 0.02 | 0.14 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 6 | 22 | 28 | 2 | 102 | 35 | No |
| | Fecal Coliform | CFU/100mL | 6 | 54 | 66 | 20 | 120 | 200 | No |
| | Total Coliform | CFU/100mL | 6 | 169 | 169 | 60 | 360 | 1,000 | No |
| | TSS | mg/L | 6 | 74.4 | 73.5 | 3.7 | 133.7 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.10 | 0.10 | 0.08 | 0.11 | 0.025 | 100% |
| | CBOD | mg/L | 6 | 0.76 | 1.00 | 0.29 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 3.65 | 3.80 | 0.50 | 6.70 | 20 | 0% |
| | Nitrate+Nitrite | mg/L | 6 | 0.15 | 0.09 | 0.04 | 0.46 | 10 | 0% |
| | SRP | mg/L | 6 | 0.02 | 0.02 | 0.02 | 0.03 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 0.54 | 0.47 | 0.31 | 0.98 | 1 | 0% |
| | Total Dissolved Nitrogen | mg/L | 6 | 0.76 | 0.56 | 0.43 | 1.91 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.03 | 0.03 | 0.01 | 0.05 | 0.1 | 0% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.05 | 0.05 | 0.01 | 0.07 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | 6 | 167 | 156 | 124 | 348 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 251 | 272 | 116 | 524 | 200 | Yes |
| | Total Coliform | CFU/100mL | 6 | 337 | 370 | 160 | 560 | 1,000 | No |
| | TSS | mg/L | 6 | 7.6 | 7.2 | 5.2 | 11.3 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.04 | 0.04 | 0.03 | 0.05 | 0.025 | 100% |
| | CBOD | mg/L | 6 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 1.65 | 1.30 | 0.50 | 3.60 | 20 | 0% |
| | Nitrate+Nitrite | mg/L | 6 | 1.22 | 1.55 | 0.21 | 1.74 | 10 | 0% |
| | SRP | mg/L | 6 | 0.04 | 0.05 | 0.01 | 0.06 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 1.60 | 1.70 | 0.78 | 2.31 | 1 | 83% |
| | Total Dissolved Nitrogen | mg/L | 6 | 1.76 | 1.69 | 1.30 | 2.32 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.05 | 0.05 | 0.04 | 0.07 | 0.1 | 0% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.06 | 0.06 | 0.05 | 0.09 | NA | NA |

**Table 4-77: San Elijo Index Period Events 1-4 Mass Emission Station Summary (continued)**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO[2] | Exceedance[3] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 6 | 113 | 120 | 84 | 144 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 6 | 306 | 325 | 190 | 480 | 200 | Yes |
| | Total Coliform | CFU/100mL | 6 | 708 | 690 | 540 | 1,120 | 1,000 | No |
| | TSS | mg/L | 6 | 6.6 | 6.9 | 4.3 | 9.0 | NA | NA |
| | Ammonia as N | mg/L | 6 | 0.03 | 0.03 | 0.02 | 0.04 | 0.025 | 83% |
| | CBOD | mg/L | 6 | 1.27 | 1.00 | 1.00 | 2.60 | NA | NA |
| | Chlorophyll *a* | ug/L | 6 | 1.50 | 1.30 | 0.50 | 2.70 | 20 | 0% |
| | Nitrate+Nitrite | mg/L | 6 | 1.40 | 1.32 | 0.97 | 1.93 | 10 | 0% |
| | SRP | mg/L | 6 | 0.07 | 0.07 | 0.06 | 0.08 | NA | NA |
| | Total Nitrogen | mg/L | 6 | 2.29 | 2.14 | 1.99 | 3.07 | 1 | 100% |
| | Total Dissolved Nitrogen | mg/L | 6 | 2.43 | 2.35 | 1.79 | 3.04 | NA | NA |
| | Total Phosphorus | mg/L | 6 | 0.10 | 0.10 | 0.08 | 0.13 | 0.1 | 33% |
| | Total Dissolved Phosphorus | mg/L | 6 | 0.10 | 0.11 | 0.07 | 0.14 | NA | NA |

(1) Enterococcus, fecal coliform, and total coliform were calculated as geometric means whereas all other constituents were calculated as arithmetic means.
(2) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.
(3) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.4.3.2 Lagoon Segment Site

Two composite samples were collected per day at the two San Elijo Lagoon Segment Sites. One sample was collected during slack low tide and one sample was collected during slack high tide. Composite samples were collected using automated sampling equipment programmed to collect aliquots every 15 minutes for a 30-minute period. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

Four index period events were sampled successfully at the Lagoon Segment Sites. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, chlorophyll *a*, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus. Sampling at the Lagoon Segment Sites followed the same schedule as the Ocean Inlet Site. Table 4-78 shows sampling schedule dates and tidal information.

Results from the four index period sampling events at the two San Elijo Lagoon Segment Sites are summarized statistically in Table 4-79 and 4-80. Detailed analytical results for all wet weather events are presented in Appendix C-4.

**Table 4-78: San Elijo Lagoon Segment/Ocean Inlet Sites Index Period Sampling Schedule**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Index Period Event 1 | Day of the Week | Monday | Tuesday | Wednesday | Thursday | Friday | Monday |
| | Date | 1/14/2008 | 1/15/2008 | 1/16/2008 | 2/07/2008 | 2/08/2008 | 2/11/2008 |
| | 1st Composite | Low: 0712 | Low: 0849 | Low: 1027 | High: 0848 | High: 0924 | High: 1134 |
| | 2nd Composite | High: 1244 | High: 1425 | High: 1638 | Low: 1535 | Low: 1603 | Low: 1727 |
| Index Period Event 2 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Monday |
| | Date | 3/24/2008 | 3/25/2008 | 3/26/2008 | 3/31/2008 | 4/01/2008 | 4/07/2008 |
| | 1st Composite | High: 1130 | High: 1211 | High: 1304 | Low: 1246 | High: 0626 | High: 1059 |
| | 2nd Composite | Low: 1648 | Low: 1702 | Low: 1705 | High: 1940 | Low: 1318 | Low: 1618 |
| Index Period Event 3 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 7/07/2008 | 708/2008 | 7/09/2008 | 7/14/2008 | 7/15/2008 | 7/16/2008 |
| | 1st Composite | Low: 0712 | Low: 0751 | Low: 0831 | High: 0912 | High: 0938 | High: 1002 |
| | 2nd Composite | High: 1356 | High: 1444 | High: 1533 | Low: 1302 | Low: 1345 | Low: 1424 |
| Index Period Event 4 | Day of the Week | Monday | Tuesday | Wednesday | Monday | Tuesday | Wednesday |
| | Date | 10/7/2008 | 10/8/2008 | 10/9/2008 | 10/13/2008 | 10/14/2008 | 10/15/2008 |
| | 1st Composite | Low: 0858 | Low: 1106 | High: 0729 | High: 0939 | High: 1004 | High: 1029 |
| | 2nd Composite | High: 1540 | High: 1712 | Low: 1221 | Low: 1556 | Low: 1633 | Low: 1711 |

**Table 4-79: San Elijo Index Period Events 1-4 Lagoon Segment 1 Site Summary**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 12 | 70 | 93 | 6 | 198 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 12 | 77 | 76 | 14 | 192 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 212 | 252 | 40 | 472 | 1,000 | No |
| | TSS | mg/L | 12 | 18.3 | 8.0 | 2.0 | 132.0 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.06 | 0.06 | 0.03 | 0.09 | 0.025 | 100% |
| | CBOD | mg/L | 12 | 0.76 | 1.00 | 0.29 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 23.24 | 7.50 | 4.10 | 139.70 | 20 | 17% |
| | Nitrate+Nitrite | mg/L | 12 | 3.25 | 3.42 | 2.23 | 3.87 | 10 | 0% |
| | SRP | mg/L | 12 | 0.15 | 0.14 | 0.11 | 0.19 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 4.08 | 4.03 | 2.66 | 6.09 | 1 | 100% |
| | Total Dissolved Nitrogen | mg/L | 12 | 4.09 | 3.89 | 2.52 | 6.12 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.23 | 0.24 | 0.13 | 0.28 | 0.1 | 100% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.21 | 0.21 | 0.14 | 0.27 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 12 | 35 | 37 | 6 | 148 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 194 | 163 | 84 | 630 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 333 | 316 | 184 | 670 | 1,000 | No |
| | TSS | mg/L | 12 | 168.7 | 82.0 | 8.0 | 576.0 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.12 | 0.11 | 0.08 | 0.19 | 0.025 | 100% |
| | CBOD | mg/L | 12 | 1.05 | 1.00 | 0.29 | 2.90 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 20.39 | 18.70 | 4.70 | 49.30 | 20 | 42% |
| | Nitrate+Nitrite | mg/L | 12 | 1.07 | 1.14 | 0.65 | 1.29 | 10 | 0% |
| | SRP | mg/L | 12 | 0.12 | 0.13 | 0.07 | 0.15 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 1.51 | 1.28 | 0.62 | 2.40 | 1 | 83% |
| | Total Dissolved Nitrogen | mg/L | 12 | 1.64 | 1.71 | 0.64 | 2.52 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.17 | 0.17 | 0.05 | 0.26 | 0.1 | 75% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.14 | 0.16 | 0.04 | 0.24 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | 12 | 18 | 16 | 8 | 44 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 84 | 86 | 24 | 264 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 133 | 150 | 16 | 450 | 1,000 | No |
| | TSS | mg/L | 12 | 36.5 | 18.5 | 4.0 | 105.8 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.14 | 0.09 | 0.02 | 0.53 | 0.025 | 92% |
| | CBOD | mg/L | 12 | 1.66 | 1.00 | 1.00 | 3.10 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 16.01 | 11.25 | 1.20 | 41.50 | 20 | 25% |
| | Nitrate+Nitrite | mg/L | 12 | 0.06 | 0.03 | 0.01 | 0.32 | 10 | 0% |
| | SRP | mg/L | 12 | 0.11 | 0.10 | 0.01 | 0.26 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 0.77 | 0.69 | 0.39 | 1.30 | 1 | 25% |
| | Total Dissolved Nitrogen | mg/L | 12 | 0.71 | 0.67 | 0.24 | 1.10 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.22 | 0.23 | 0.13 | 0.34 | 0.1 | 100% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.20 | 0.22 | 0.09 | 0.35 | NA | NA |

**Table 4-79: San Elijo Index Period Events 1-4 Lagoon Segment 1 Site Summary (continued)**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 12 | 22 | 24 | 4 | 62 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 113 | 122 | 48 | 176 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 241 | 245 | 160 | 400 | 1,000 | No |
| | TSS | mg/L | 12 | 15.8 | 15.2 | 5.2 | 33.0 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.17 | 0.14 | 0.09 | 0.38 | 0.025 | 100% |
| | CBOD | mg/L | 12 | 1.20 | 1.00 | 1.00 | 2.20 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 7.95 | 6.40 | 4.30 | 13.70 | 20 | 0% |
| | Nitrate+Nitrite | mg/L | 12 | 0.09 | 0.08 | 0.04 | 0.17 | 10 | 0% |
| | SRP | mg/L | 12 | 0.11 | 0.10 | 0.08 | 0.15 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 0.78 | 0.88 | 0.18 | 1.40 | 1 | 25% |
| | Total Dissolved Nitrogen | mg/L | 12 | 0.89 | 0.89 | 0.18 | 1.25 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.17 | 0.18 | 0.09 | 0.24 | 0.1 | 92% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.17 | 0.17 | 0.11 | 0.22 | NA | NA |

(1) Enterococcus, fecal coliform, and total coliform were calculated as geometric means whereas all other constituents were calculated as arithmetic means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

**Table 4-80: San Elijo Index Period Events 1-4 Lagoon Segment 2 Site Summary**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 12 | 44 | 56 | 2 | 316 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 12 | 74 | 78 | 8 | 256 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 153 | 208 | 28 | 620 | 1,000 | No |
| | TSS | mg/L | 12 | 17.5 | 17.4 | 5.7 | 33.7 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.06 | 0.07 | 0.01 | 0.10 | 0.025 | 83% |
| | CBOD | mg/L | 12 | 0.76 | 1.00 | 0.29 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 8.93 | 9.00 | 3.70 | 17.60 | 20 | 0% |
| | Nitrate+Nitrite | mg/L | 12 | 2.10 | 2.21 | 0.01 | 3.43 | 10 | 0% |
| | SRP | mg/L | 12 | 0.10 | 0.12 | 0.01 | 0.15 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 2.79 | 2.53 | 0.19 | 6.83 | 1 | 83% |
| | Total Dissolved Nitrogen | mg/L | 12 | 2.39 | 1.92 | 0.19 | 6.10 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.18 | 0.17 | 0.02 | 0.40 | 0.1 | 75% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.14 | 0.16 | 0.01 | 0.30 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 12 | 9 | 8 | 2 | 50 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 68 | 83 | 10 | 170 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 79 | 157 | 10 | 348 | 1,000 | No |
| | TSS | mg/L | 12 | 22.8 | 19.8 | 15.0 | 39.6 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.03 | 0.02 | 0.01 | 0.10 | 0.025 | 33% |
| | CBOD | mg/L | 12 | 5.49 | 5.55 | 0.29 | 22.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 112.05 | 83.00 | 10.80 | 534.00 | 20 | 67% |
| | Nitrate+Nitrite | mg/L | 12 | 0.16 | 0.10 | 0.00 | 0.57 | 10 | 0% |
| | SRP | mg/L | 12 | 0.03 | 0.02 | 0.00 | 0.08 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 0.95 | 0.87 | 0.42 | 2.54 | 1 | 25% |
| | Total Dissolved Nitrogen | mg/L | 12 | 0.67 | 0.65 | 0.27 | 1.34 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.12 | 0.10 | 0.04 | 0.32 | 0.1 | 50% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.05 | 0.04 | 0.03 | 0.10 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | 12 | 3 | 2 | 2 | 26 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 13 | 14 | 4 | 72 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 20 | 20 | 4 | 120 | 1,000 | No |
| | TSS | mg/L | 12 | 11.2 | 11.4 | 2.8 | 20.0 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.06 | 0.04 | 0.02 | 0.12 | 0.025 | 92% |
| | CBOD | mg/L | 12 | 1.11 | 1.00 | 1.00 | 2.30 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 3.15 | 2.70 | 0.50 | 7.10 | 20 | 0% |
| | Nitrate+Nitrite | mg/L | 12 | 0.03 | 0.01 | 0.01 | 0.24 | 10 | 0% |
| | SRP | mg/L | 12 | 0.06 | 0.04 | 0.01 | 0.17 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 0.38 | 0.34 | 0.12 | 0.83 | 1 | 0% |
| | Total Dissolved Nitrogen | mg/L | 12 | 0.38 | 0.34 | 0.08 | 0.79 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.08 | 0.08 | 0.01 | 0.16 | 0.1 | 50% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.08 | 0.07 | 0.01 | 0.20 | NA | NA |

**Table 4-80: San Elijo Index Period Events 1-4 Lagoon Segment 2 Site Summary (continued)**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 12 | 4 | 2 | 2 | 18 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 25 | 26 | 4 | 180 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 49 | 60 | 10 | 140 | 1,000 | No |
| | TSS | mg/L | 12 | 12.7 | 11.0 | 5.0 | 24.3 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.06 | 0.05 | 0.01 | 0.18 | 0.025 | 75% |
| | CBOD | mg/L | 12 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 1.98 | 2.20 | 0.50 | 3.30 | 20 | 0% |
| | Nitrate+Nitrite | mg/L | 12 | 0.02 | 0.02 | 0.01 | 0.03 | 10 | 0% |
| | SRP | mg/L | 12 | 0.04 | 0.04 | 0.01 | 0.09 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 0.40 | 0.36 | 0.14 | 0.82 | 1 | 0% |
| | Total Dissolved Nitrogen | mg/L | 12 | 0.35 | 0.31 | 0.13 | 0.67 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.07 | 0.07 | 0.02 | 0.13 | 0.1 | 42% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.06 | 0.05 | 0.02 | 0.11 | NA | NA |

(1) Enterococcus, fecal coliform, and total coliform were calculated as geometric means whereas all other constituents were calculated as arithmetic means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.4.3.3 Ocean Inlet Site

Two composite samples were collected per day during each index period event at the San Elijo Lagoon Ocean Inlet Site. One sample was collected during slack low tide and one sample was collected during slack high tide. Composite samples were collected using automated sampling equipment programmed to collect aliquots every 15 minutes for a 30-minute period. During the two tidally-regulated sampling events, microbiology grab samples were collected concurrently with the composite samples.

Four index period events were sampled successfully at the Ocean Inlet Site. Analytes monitored at this site were *Enterococcus* bacteria, total and fecal coliform bacteria, TSS, ammonia as N, CBOD, chlorophyll *a*, nitrate + nitrite, SRP, total and dissolved nitrogen, and total and dissolved phosphorus. Sampling at the ocean inlet site followed the same schedule as the lagoon segment site. Table 4-78 shows sampling schedule dates and tidal information.

Results from the four index period events at the San Elijo Lagoon Ocean Inlet Site are summarized statistically in Table 4-81. Detailed analytical results for all wet weather events are presented in Appendix C-4.

**Table 4-81: San Elijo Index Period Events 1-4 Ocean Inlet 1 Site Summary**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 12 | 23 | 34 | 2 | 159 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 35 | 53 | 2 | 140 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 101 | 140 | 4 | 420 | 1,000 | No |
| | TSS | mg/L | 12 | 12.7 | 11.2 | 6.8 | 20.7 | NA | NA |
| | Ammonia as N | mg/L | 11 | 0.05 | 0.04 | 0.01 | 0.12 | 0.025 | 55% |
| | CBOD | mg/L | 12 | 0.90 | 1.00 | 0.29 | 2.60 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 12.00 | 9.00 | 4.30 | 24.00 | 20 | 17% |
| | Nitrate+Nitrite | mg/L | 11 | 0.91 | 0.79 | 0.01 | 1.95 | 10 | 0% |
| | SRP | mg/L | 11 | 0.06 | 0.08 | 0.01 | 0.12 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 1.10 | 0.71 | 0.17 | 2.64 | 1 | 38% |
| | Total Dissolved Nitrogen | mg/L | 12 | 1.06 | 0.53 | 0.15 | 2.92 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.08 | 0.08 | 0.01 | 0.17 | 0.1 | 46% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.07 | 0.06 | 0.01 | 0.17 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 12 | 16 | 9 | 2 | 896 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 51 | 88 | 2 | 280 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 112 | 142 | 20 | 280 | 1,000 | No |
| | TSS | mg/L | 12 | 21.1 | 13.8 | 0.3 | 69.3 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.03 | 0.02 | 0.00 | 0.06 | 0.025 | 50% |
| | CBOD | mg/L | 12 | 4.08 | 2.80 | 0.29 | 15.50 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 24.28 | 19.60 | 0.50 | 50.70 | 20 | 50% |
| | Nitrate+Nitrite | mg/L | 12 | 0.15 | 0.06 | 0.01 | 0.47 | 10 | 0% |
| | SRP | mg/L | 12 | 0.04 | 0.03 | 0.01 | 0.11 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 0.72 | 0.66 | 0.44 | 1.31 | 1 | 8% |
| | Total Dissolved Nitrogen | mg/L | 12 | 0.48 | 0.55 | 0.14 | 0.88 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.10 | 0.09 | 0.04 | 0.20 | 0.1 | 42% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.06 | 0.05 | 0.01 | 0.15 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | 12 | 4 | 2 | 2 | 24 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 14 | 14 | 4 | 56 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 22 | 20 | 4 | 200 | 1,000 | No |
| | TSS | mg/L | 12 | 13.6 | 6.4 | 3.0 | 70.7 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.07 | 0.06 | 0.01 | 0.19 | 0.025 | 67% |
| | CBOD | mg/L | 12 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 2.33 | 2.20 | 0.50 | 5.80 | 20 | 0% |
| | Nitrate+Nitrite | mg/L | 12 | 0.04 | 0.02 | 0.00 | 0.17 | 10 | 0% |
| | SRP | mg/L | 12 | 0.04 | 0.02 | 0.01 | 0.16 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 0.28 | 0.21 | 0.07 | 0.64 | 1 | 0% |
| | Total Dissolved Nitrogen | mg/L | 12 | 0.24 | 0.19 | 0.06 | 0.62 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.03 | 0.02 | 0.01 | 0.12 | 0.1 | 17% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.03 | 0.02 | 0.00 | 0.12 | NA | NA |

**Table 4-81: San Elijo Index Period Events 1-4 Ocean Inlet 1 Site Summary (continued)**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 12 | 7 | 5 | 2 | 80 | 35 | No |
| | Fecal Coliform | CFU/100mL | 12 | 16 | 16 | 4 | 72 | 200 | No |
| | Total Coliform | CFU/100mL | 12 | 33 | 35 | 10 | 190 | 1,000 | No |
| | TSS | mg/L | 12 | 15.4 | 10.5 | 2.8 | 42.0 | NA | NA |
| | Ammonia as N | mg/L | 12 | 0.04 | 0.02 | 0.00 | 0.12 | 0.025 | 50% |
| | CBOD | mg/L | 12 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 12 | 1.99 | 2.15 | 0.50 | 3.10 | 20 | 0% |
| | Nitrate+Nitrite | mg/L | 12 | 0.02 | 0.01 | 0.01 | 0.07 | 10 | 0% |
| | SRP | mg/L | 12 | 0.02 | 0.01 | 0.00 | 0.05 | NA | NA |
| | Total Nitrogen | mg/L | 12 | 0.23 | 0.18 | 0.13 | 0.50 | 1 | 0% |
| | Total Dissolved Nitrogen | mg/L | 12 | 0.22 | 0.18 | 0.12 | 0.43 | NA | NA |
| | Total Phosphorus | mg/L | 12 | 0.04 | 0.03 | 0.02 | 0.09 | 0.1 | 0% |
| | Total Dissolved Phosphorus | mg/L | 12 | 0.03 | 0.02 | 0.01 | 0.07 | NA | NA |

(1) Enterococcus, fecal coliform, and total coliform were calculated as geometric means whereas all other constituents were calculated as arithmetic means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.4.3.4 Transect Sampling

Longitudinal transect sampling was conducted at three designated locations along a salinity gradient within the eastern-most basin in San Elijo Lagoon. Sampling events occurred once during each index period event and included sampling once during the flood tide and once during the ebb tide on the same day. Specific conductivity, temperature, turbidity, DO, and pH water quality parameters were also measured concurrent to sample collection at each site and results are presented in Appendix C-4. Results from transect sampling events are summarized statistically in Table 4-82. Detailed analytical results for all wet weather events are presented in Appendix C-4.

**Table 4-82: San Elijo Longitudinal Transect Data Summary for Index Period Events 1-4**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 1 | *Enterococcus* | CFU/100mL | 10 | 52 | 70 | 32 | 92 | 35 | Yes |
| | Fecal Coliform | CFU/100mL | 10 | 95 | 106 | 46 | 168 | 200 | No |
| | Total Coliform | CFU/100mL | 10 | 259 | 258 | 184 | 376 | 1000 | No |
| | TSS | mg/L | 36 | 15.5 | 13.9 | 6.0 | 34.0 | NA | NA |
| | Ammonia as N | mg/L | 36 | 0.08 | 0.06 | 0.05 | 0.25 | 0.025 | 100% |
| | CBOD | mg/L | 6 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 36 | 8.77 | 8.60 | 3.60 | 22.00 | 20 | 3% |
| | Nitrate+Nitrite | mg/L | 36 | 3.25 | 3.39 | 1.51 | 5.98 | 10 | 0% |
| | SRP | mg/L | 36 | 0.14 | 0.14 | 0.12 | 0.16 | NA | NA |
| | Total Nitrogen | mg/L | 36 | 5.30 | 5.09 | 1.50 | 8.77 | 1.0 | 100% |
| | Total Dissolved Nitrogen | mg/L | 36 | 5.23 | 4.74 | 2.14 | 9.32 | NA | NA |
| | Total Phosphorus | mg/L | 36 | 0.26 | 0.25 | 0.11 | 0.44 | 0.1 | 100% |
| | Total Dissolved Phosphorus | mg/L | 36 | 0.24 | 0.22 | 0.10 | 0.35 | NA | NA |
| Index Period Event 2 | *Enterococcus* | CFU/100mL | 10 | 7 | 5 | 2 | 36 | 35 | No |
| | Fecal Coliform | CFU/100mL | 10 | 101 | 101 | 72 | 142 | 200 | No |
| | Total Coliform | CFU/100mL | 10 | 265 | 265 | 150 | 450 | 1000 | No |
| | TSS | mg/L | 36 | 30.4 | 28.2 | 14.8 | 99.2 | NA | NA |
| | Ammonia as N | mg/L | 36 | 0.08 | 0.09 | 0.01 | 0.15 | 0.025 | 83% |
| | CBOD | mg/L | 6 | 1.50 | 1.00 | 1.00 | 2.90 | NA | NA |
| | Chlorophyll *a* | ug/L | 36 | 46.99 | 18.25 | 1.80 | 456.60 | 20 | 44% |
| | Nitrate+Nitrite | mg/L | 36 | 0.66 | 0.59 | 0.01 | 1.43 | 10 | 0% |
| | SRP | mg/L | 36 | 0.09 | 0.09 | 0.03 | 0.15 | NA | NA |
| | Total Nitrogen | mg/L | 36 | 1.72 | 1.73 | 0.61 | 3.12 | 1.0 | 89% |
| | Total Dissolved Nitrogen | mg/L | 36 | 1.44 | 1.27 | 0.40 | 2.69 | NA | NA |
| | Total Phosphorus | mg/L | 36 | 0.19 | 0.18 | 0.07 | 0.35 | 0.1 | 94% |
| | Total Dissolved Phosphorus | mg/L | 36 | 0.14 | 0.13 | 0.04 | 0.24 | NA | NA |
| Index Period Event 3 | *Enterococcus* | CFU/100mL | 10 | 9 | 13 | 2 | 68 | 35 | No |
| | Fecal Coliform | CFU/100mL | 10 | 19 | 32 | 4 | 136 | 200 | No |
| | Total Coliform | CFU/100mL | 10 | 24 | 48 | 4 | 136 | 1000 | No |
| | TSS | mg/L | 36 | 16.5 | 10.5 | 3.7 | 95.3 | NA | NA |
| | Ammonia as N | mg/L | 36 | 0.05 | 0.05 | 0.01 | 0.10 | 0.025 | 75% |
| | CBOD | mg/L | 6 | 1.00 | 1.00 | 1.00 | 1.00 | NA | NA |
| | Chlorophyll *a* | ug/L | 36 | 9.71 | 5.35 | 0.50 | 41.50 | 20 | 14% |
| | Nitrate+Nitrite | mg/L | 36 | 0.02 | 0.02 | 0.01 | 0.05 | 10 | 0% |
| | SRP | mg/L | 36 | 0.07 | 0.07 | 0.01 | 0.14 | NA | NA |
| | Total Nitrogen | mg/L | 36 | 0.25 | 0.23 | 0.01 | 0.53 | 1.0 | 0% |
| | Total Dissolved Nitrogen | mg/L | 36 | 0.23 | 0.21 | 0.02 | 0.51 | NA | NA |
| | Total Phosphorus | mg/L | 36 | 0.08 | 0.09 | 0.01 | 0.19 | 0.1 | 42% |
| | Total Dissolved Phosphorus | mg/L | 36 | 0.07 | 0.08 | 0.00 | 0.18 | NA | NA |

**Table 4-82: San Elijo Longitudinal Transect Data Summary for Index Period Events 1-4 (continued)**

| Event Category | Analyte | Units | Count | Mean[1] | Median | Min | Max | WQO | Exceedance[2] |
|---|---|---|---|---|---|---|---|---|---|
| Index Period Event 4 | *Enterococcus* | CFU/100mL | 10 | 2 | 2 | 2 | 8 | 35 | No |
| | Fecal Coliform | CFU/100mL | 10 | 30 | 36 | 4 | 140 | 200 | No |
| | Total Coliform | CFU/100mL | 10 | 60 | 50 | 10 | 450 | 1000 | No |
| | TSS | mg/L | 36 | 28.5 | 9.4 | 2.0 | 320.0 | NA | NA |
| | Ammonia as N | mg/L | 36 | 0.09 | 0.08 | 0.03 | 0.20 | 0.025 | 100% |
| | CBOD | mg/L | 6 | 1.28 | 1.00 | 1.00 | 2.70 | NA | NA |
| | Chlorophyll *a* | ug/L | 36 | 7.40 | 2.95 | 1.10 | 56.10 | 20 | 6% |
| | Nitrate+Nitrite | mg/L | 36 | 0.04 | 0.02 | 0.01 | 0.41 | 10 | 0% |
| | SRP | mg/L | 36 | 0.07 | 0.09 | 0.02 | 0.14 | NA | NA |
| | Total Nitrogen | mg/L | 36 | 0.53 | 0.58 | 0.13 | 0.95 | 1.0 | 0% |
| | Total Dissolved Nitrogen | mg/L | 36 | 0.46 | 0.49 | 0.15 | 0.86 | NA | NA |
| | Total Phosphorus | mg/L | 36 | 0.11 | 0.13 | 0.02 | 0.19 | 0.1 | 67% |
| | Total Dissolved Phosphorus | mg/L | 36 | 0.10 | 0.11 | 0.02 | 0.19 | NA | NA |

Note: Transects were sampled at high and low tides during each index period within San Elijo Lagoon.
(1) Enterococcus, fecal coliform, and total coliform were calculated as geometric means whereas all other constituents were calculated as arithmetic means.
(2) Exceedance result is based on WQO used for specific constituent groups. Geometric means, used to compare dry weather bacteria results to WQOs, result in a single number, therefore a Yes/No result is presented. All other constituents are compared on a single-sample basis and, therefore, a percent exceedance can be calculated. The percent exceedance is based on the number of samples that exceeded the WQO divided by the total number of samples collected.

#### 4.4.3.5 Specific Conductivity

Specific conductivity was continuously measured at all sample locations during the four index periods. Specific conductivity was lowest at all stations during Index Period 1, which occurred in the wet season and experienced a higher input of freshwater from the watershed. The Mass Emission Station consistently reported low specific conductivity values close to the typical freshwater range (less than 1.072 mS/cm) as the station is beyond the range of tidal influence. All other sites reported specific conductivity values that generally fell near the range of normal seawater (50 mS/cm to 56 mS/cm) with the exception of occasional wet weather events (United States Office of Naval Research).

Results for all parameters continuously monitored at all sites are summarized statistically in Tables 4-65 through 4-68. Results are summarized both monthly and by monitoring event. Detailed continuous monitoring results from the entire monitoring period are presented in Appendix B-4.

#### 4.4.3.6 Temperature

Temperature was continuously measured at all sample locations during the four index periods. Seasonal variation in temperature was reflected at all sample locations. Temperature averages and ranges were similar at all sites.

Results for all parameters continuously monitored at all sites are summarized statistically in Tables 4-65 through 4-68. Results are summarized both monthly and by monitoring event. Detailed continuous monitoring results from the entire monitoring period are presented in Appendix B-4.

#### 4.4.3.7 Turbidity

Turbidity was measured at all sample locations during the four index periods. Turbidity was generally low during the Index Period sampling events. Turbidity spikes associated with storm events were most profound at the mass emission station and dampened through the lagoon and ocean inlet sites.

Results for all parameters continuously monitored at all sites are summarized statistically in Tables 4-65 through 4-68. Results are summarized both monthly and by monitoring event. Detailed continuous monitoring results from the entire monitoring period are presented in Appendix B-4.

#### 4.4.3.8 Storm Drain and Tributary Sampling

Storm drain and tributary sampling occurred at the two designated locations once during each of the index sampling events. Flow conditions were noted at each location during each sampling event. Sample dates and analytical results are summarized in Table 4-83.

**Table 4-83: San Elijo Index Period Storm Drain Sampling Results**

| Analyte Name | Units | Index Period Event 1 | | Index Period Event 2 | | Index Period Event 3 | | Index Period Event 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1/16/2008 | | 4/1/2008 | | 7/7/2008 | | 10/1/2008 | |
| | | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 |
| *Enterococcus* | CFU/100mL | 180 | 100 | 570 | 74 | 440 | 60 | 600 | 200 |
| Fecal Coliform | CFU/100mL | 180 | 188 | 450 | 650 | 300 | 700 | 1,400 | 1,600 |
| Total Coliform | CFU/100mL | 820 | 2,950 | 330 | 1,350 | 400 | 1,200 | 1,400 | 2,600 |
| TSS | mg/L | 16.8 | 7.6 | 8 | 28.8 | 8.8 | 29.6 | 6.5 | 7.5 |
| Ammonia as N | mg/L | 0.02 | 0.02 | 0.29 | 0.02 | 0.02 | 0.01 | 0.01 | 0.03 |
| CBOD | mg/L | 1 | 2.7 | 0.29 | 0.29 | 2.8 | 3.1 | 2.5 | 0.29 |
| Chlorophyll *a* | ug/L | 89.9 | 8.9 | 15.05 | 2.1 | 19.2 | 81.3 | 34.1 | 4.9 |
| Nitrate + Nitrite | mg/L | 9.9 | 0.44 | 4.62 | 0.13 | 0.03 | 0.01 | 0.51 | 0.01 |
| SRP | mg/L | 0.01 | 0.03 | 0.01 | 0.04 | 0.01 | 0.07 | 0.01 | 0.06 |
| TN | mg/L | 17.04 | 1.87 | 3.85 | 0.35 | 0.39 | 0.56 | 2.74 | 0.67 |
| TDN | mg/L | 19.20 | 1.23 | 4.51 | 0.95 | 0.83 | 0.50 | 1.97 | 1.10 |
| TP | mg/L | 0.02 | 0.07 | 0.02 | 0.03 | 0.01 | 0.08 | 0.01 | 0.11 |
| TDP | mg/L | 0.01 | 0.07 | 0.00 | 0.04 | 0.01 | 0.05 | 0.01 | 0.10 |
| Flow | cfs | Not Reported | Not Reported | 0.001 | Not Reported | 0.004 | Ponded | 0.004 | Not Reported |

### 4.4.4 San Elijo Land Elevation Survey of Ocean Inlet Site

Land elevation surveys were conducted at the San Elijo Lagoon Ocean Inlet Site prior to all index periods. See Figure 4-15 for the locations of the two cross-sections. One survey of either of the two potential locations was conducted in January, March, July, and September 2008. Results from land elevation surveys are shown on Appendix J-3.

### 4.4.5 San Elijo Open Ocean Inlet Days

The San Elijo Lagoon Ocean Inlet Site is the mouth of the lagoon that is open to the ocean. The mouth of the lagoon was open for the majority of the monitoring period associated with this program. However there were two short time frames where the mouth was closed:

- March 28 to April 4, 2008
- April 15 to April 28, 2008

**Figure 4-15: San Elijo Ocean Inlet Land Elevation Survey Locations**

# 5.0. LOAD ANALYSIS

## 5.1 AGUA HEDIONDA LAGOON LOAD ANALYSIS

Annual and daily dry and wet weather load estimates were calculated for the Agua Hedionda Lagoon for the following 303(d) listed categories and individual constituents:

- Bacteria
  - *Enterococcus*
  - Fecal Coliform
  - Total Coliform
- Sediment
  - TSS
- Total Dissolved Solids
  - TDS

### 5.1.1 Agua Hedionda Wet Weather Load Estimate

The daily and annual wet weather loads for each constituent were calculated based on flows measured during wet weather conditions and calculated EMCs.

#### 5.1.1.1 Flow Calculations

Table 5-1 presents the average daily, median daily, minimum daily, maximum daily, and total annual wet weather flows calculated from flow measurements obtained every 15 minutes at the Agua Hedionda Mass Emission Station. The dry weather flows are also shown for comparison purposes.

Table 4-3 presents the flows by day. The total annual wet weather flow volume was 156 million cubic feet, or 79 percent of the total (wet and dry weather) annual flow volume.

**Table 5-1: Agua Hedionda Flow Calculations**

| Flow Calculation | Units | Wet Weather | Dry Weather |
|---|---|---|---|
| Average Daily | cf per day | 3,316,690 | 132,442 |
| Median Daily | cf per day | 1,326,392 | 79,728 |
| Minimum Daily | cf per day | 181,946 | 12,742 |
| Maximum Daily | cf per day | 40,212,470 | 850,000 |
| Total Annual[1] | cf | 155,884,426 | 42,249,139 |

(1) Annual flow measurements were taken from November 1, 2007 to October 31, 2008.

5.1.1.2 Calculation of Event Mean Concentrations

Table 5-2 presents the EMCs calculated from the results of the individual pollutagraph samples collected during Wet Weather Events 1 (January 7, 2008) and 2 (January 24, 2008) and the EMCs measured from the flow-weighted composite samples collected during Wet Weather Event 3 (February 3, 2008). Sampling for Wet Weather Event 3 was conducted by an outside agency under the San Diego County Regional Monitoring Program, Order No. 2007-01, which did not sample for TDS. As a result the wet weather average EMC was used for the Wet Weather Event 3 TDS loading calculation.

**Table 5-2: Agua Hedionda Event Mean Concentrations**

| Constituent | Units | Wet Weather Event | Date | EMC |
|---|---|---|---|---|
| *Enterococcus* | CFU/100mL | 1 | 1/7/2008 | 13,720 |
| | CFU/100mL | 2 | 1/24/2008 | 10,103 |
| | CFU/100mL | 3 | 2/3/2008 | 3,000 |
| | Average =8,941 CFU/100mL | | | |
| Fecal Coliform | MPN/100mL | 1 | 1/7/2008 | 6,565 |
| | MPN/100mL | 2 | 1/24/2008 | 4,634 |
| | MPN/100mL | 3 | 2/3/2008 | 5,000 |
| | Average = 5,400 MPN/100mL | | | |
| Total Coliform | MPN/100mL | 1 | 1/7/2008 | 44,498 |
| | MPN/100mL | 2 | 1/24/2008 | 14,814 |
| | MPN/100mL | 3 | 2/3/2008 | 30,000 |
| | Average = 29,771 MPN/100mL | | | |
| TDS | mg/L | 1 | 1/7/2008 | 470 |
| | mg/L | 2 | 1/24/2008 | 477 |
| | mg/L | 3 | 2/3/2008 | 580 |
| | Average = 509 mg/L | | | |
| TSS | mg/L | 1 | 1/7/2008 | 89 |
| | mg/L | 2 | 1/24/2008 | 267 |
| | mg/L | 3 | 2/3/2008 | 215 |
| | Average = 190 mg/L | | | |

5.1.1.3 Daily and Annual Wet Weather Load Estimate

Table 5-3 presents the average, minimum, and maximum daily wet weather load estimates for each constituent. The daily dry weather load estimates are also shown for comparison purposes. Appendix D-1 lists the loads by day (wet weather loads are highlighted).

**Table 5-3: Agua Hedionda Daily Load Estimates**

| Constituent | Wet Weather Daily Load | | | Dry Weather Daily Load | | |
|---|---|---|---|---|---|---|
| | Average | Minimum | Maximum | Average | Minimum | Maximum |
| *Enterococcus* (G-org) | 9,884 | 461 | 109,275 | 5.38 | 0.77 | 29.9 |
| Fecal Coliform (G-org) | 5,417 | 278 | 61,485 | 10.5 | 2.09 | 59.6 |
| Total Coliform (G-org) | 29,582 | 1,534 | 338,996 | 21.6 | 4.06 | 144 |
| TDS (lbs) | 106,575 | 5,781 | 1,277,785 | 15,485 | 1,608 | 96,041 |
| TSS (lbs) | 36,924 | 2,162 | 477,810 | 38.0 | 1.40 | 307 |

Table 5-4 presents the annual wet weather loads for each constituent. This table also shows the annual dry weather loads and total (dry and wet weather) annual loads for comparison purposes.

**Table 5-4: Agua Hedionda Annual Load Estimates**

| Constituent | Wet Weather Annual Load | Dry Weather Annual Load | Total Annual Load |
|---|---|---|---|
| *Enterococcus* (G-org) | 464,560 | 1,716 | 466,277 |
| Fecal Coliform (G-org) | 254,583 | 3,359 | 257,942 |
| Total Coliform (G-org) | 1,390,367 | 6,882 | 1,397,249 |
| TDS (lbs) | 5,009,003 | 4,939,611 | 9,948,614 |
| TSS (lbs) | 1,735,416 | 12,131 | 1,747,547 |

### 5.1.2 Agua Hedionda Dry Weather Load Estimate

The daily and annual dry weather loads for each constituent were calculated based on flows measured during dry weather conditions at the Mass Emission Station and the analytical results of samples collected during index periods. For storm drains, the daily dry weather loads for each constituent were calculated based on instantaneous flow measurements and the analytical results of samples collected during index periods.

#### 5.1.2.1 Flow Calculations

Table 5-1 presents the average daily, median daily, minimum daily, maximum daily, and total annual dry weather flows calculated from flow measurements obtained every 15 minutes at the Agua Hedionda mass emission station. Table 4-3 presents the flows by day. The total annual dry weather flow volume was 42 million cubic feet, or 21 percent of the total (dry and wet weather) annual flow volume.

5.1.2.2 Concentrations

Table 5-5 presents the average concentrations calculated from the results of samples collected from the Agua Hedionda Mass Emission Station during each of the four index periods.

**Table 5-5: Agua Hedionda Average Index Period Concentrations**

| Constituent | Units | Average Concentrations by Index Period | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| *Enterococcus* | CFU/100mL | 124 | 125 | 310 | 212 |
| Fecal Coliform | CFU/100mL | 116 | 280 | 1,190 | 760 |
| Total Coliform | CFU/100mL | 219 | 677 | 2,240 | 1,537 |
| TDS | mg/L | 1,740 | 2,047 | 2,021 | 2,199 |
| TSS | mg/L | 5.52 | 1.23 | 6.67 | 5.73 |

5.1.2.3 Calculation of Daily and Annual Dry Weather Loads

The average Index Period sample results in Table 5-5 were used to calculate loads for days occurring during the corresponding three-month period. More specifically, average Index Period 1, 2, 3, and 4 sample results were used to calculate daily loads for days occurring between December 4, 2007 and March 31, 2008, April 1, 2008 and July 2, 2008, July 3, 2008 and September 28, 2008, and September 29, 2008 and October 31, 2008, respectively. Additionally, Index Period 4 was used to calculate loads at the beginning of the monitoring season from November 1, 2007 to November 29, 2007. A four-day gap between Index Period 4 and Index Period 1 was due to a storm event from November 30, 2007 to December 3, 2007.

Table 5-3 presents the average, minimum, and maximum daily dry weather loads for each constituent. Table 5-4 presents the annual dry weather loads. Table 5-6 presents the average daily load estimates by index period event. Appendix D-1 lists the dry weather loads by day for each constituent. Table 5-7 presents the daily load estimates for storm drains by index period event.

**Table 5-6: Agua Hedionda Average Index Period Daily Loading Estimates**

| Constituent | Units | Average Daily Loading by Index Period | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| *Enterococcus* | G-org | 11.9 | 3.75 | 2.34 | 4.19 |
| Fecal Coliform | G-org | 11.1 | 8.41 | 8.95 | 15.3 |
| Total Coliform | G-org | 20.9 | 20.4 | 16.9 | 30.8 |
| TDS | lbs | 36,691 | 13,544 | 3,368 | 9,599 |
| TSS | lbs | 117 | 8.10 | 11.1 | 24.8 |

**Table 5-7: Agua Hedionda Storm Drain Daily Load Estimates**

| Analyte | Units | Index Period Event 1 | | Index Period Event 2 | | Index Period Event 3 | | Index Period Event 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2/7/2008 | 2/8/2008 | 4/8/2008 | | 7/21-23/2008[1] | | 10/8/2008 | |
| | | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 |
| *Enterococcus* | G-org/day | 0.17 | 0.15 | 13.90 | 0.22 | 2.52 | 0.57 | 1.36 | 0.37 |
| Fecal Coliform | G-org/day | 0.78 | 0.33 | 9.27 | 0.28 | 4.96 | 1.31 | 23.2 | 1.90 |
| Total Coliform | G-org/day | 1.74 | 3.62 | 105 | 4.26 | 19.5 | 6.54 | 34.9 | 20.4 |
| TSS | lbs/day | 0.19 | 0.50 | 2.40 | 0.65 | 0.81 | 0.22 | 0.18 | 0.51 |

[1] TSS samples were collected July 21, 2008, and bacteria samples were collected July 23, 2008.

## 5.2 BUENA VISTA LAGOON LOAD ANALYSIS

Annual and daily dry and wet weather load estimates were calculated for the Buena Vista Lagoon for the following 303(d) listed categories and individual constituents:

- Bacteria
  - *Enterococcus*
  - Fecal Coliform
  - Total Coliform
- Nutrients/Eutrophication
  - Ammonia as N
  - CBOD
  - Chlorophyll *a*
  - Nitrate + Nitrite as N
  - SRP
  - TN
  - TDN
  - TP
  - TDP
- Sediment
  - TSS

### 5.2.1 Buena Vista Wet Weather Load Estimate

The daily and annual wet weather loads for each constituent were calculated based on flows measured during wet weather conditions and calculated EMCs.

#### 5.2.1.1 Flow Calculations

Table 5-8 presents the average daily, median daily, minimum daily, maximum daily, and total annual wet weather flows calculated from flow measurements obtained every 15 minutes at the Buena Vista Lagoon Mass Emission Station. The dry weather flows are also shown for comparison purposes.

Table 4-27 presents the flows by day. The total annual wet weather flow volume was 512 million cubic feet, or 81 percent of the total (wet and dry weather) annual flow volume.

**Table 5-8: Buena Vista Flow Calculations**

| Flow Calculation | Units | Wet Weather | Dry Weather |
|---|---|---|---|
| Average Daily | cf per day | 11,385,178 | 374,427 |
| Median Daily | cf per day | 2,209,842 | 236,341 |
| Minimum Daily | cf per day | 193,313 | 111,509 |
| Maximum Daily | cf per day | 95,502,393 | 1,522,977 |
| Total Annual[1] | cf | 512,333,020 | 120,190,992 |

(1) Annual flow measurements were taken from November 1, 2007 to October 31, 2008.

5.2.1.2 Calculation of Event Mean Concentrations

Table 5-9 presents the EMCs calculated from the results of the individual pollutagraph samples collected during Wet Weather Events 1 (January 7, 2008) and 2 (January 24, 2008) and the EMCs measured from the flow-weighted composite samples collected during Wet Weather Event 3 (February 3, 2008). Sampling for Wet Weather Event 3 was conducted by an outside agency under the San Diego County Regional Monitoring Program, Order No. 2007-01, which did not sample for total nitrogen, total dissolved nitrogen, or soluble reactive phosphorus. As a result the wet weather average EMC for these constituents was used for their respective Wet Weather Event 3 loading calculations.

**Table 5-9: Buena Vista Event Mean Concentrations**

| Constituent | Units | Wet Weather Event | Date | EMC |
|---|---|---|---|---|
| *Enterococcus* | CFU/100mL | 1 | 1/7/2008 | 23,007 |
| | CFU/100mL | 2 | 1/24/2008 | 13,151 |
| | CFU/100mL | 3 | 2/3/2008 | 17,000 |
| | Average = 17,719 CFU/100mL | | | |
| Fecal Coliform | MPN/100mL | 1 | 1/7/2008 | 8,608 |
| | MPN/100mL | 2 | 1/24/2008 | 46,348 |
| | MPN/100mL | 3 | 2/3/2008 | 5,000 |
| | Average = 19,985 MPN/100mL | | | |
| Total Coliform | MPN/100mL | 1 | 1/7/2008 | 87,751 |
| | MPN/100mL | 2 | 1/24/2008 | 55,625 |
| | MPN/100mL | 3 | 2/3/2008 | 80,000 |
| | Average = 74,459 MPN/100mL | | | |
| TSS | mg/L | 1 | 1/7/2008 | 141 |
| | mg/L | 2 | 1/24/2008 | 300 |
| | mg/L | 3 | 2/3/2008 | 290 |
| | Average = 244 mg/L | | | |
| Ammonia as N | mg/L | 1 | 1/7/2008 | 0.13 |
| | mg/L | 2 | 1/24/2008 | 0.21 |
| | mg/L | 3 | 2/3/2008 | 0.13 |
| | Average = 0.16 mg/L | | | |
| CBOD | mg/L | 1 | 1/7/2008 | 4.15 |
| | mg/L | 2 | 1/24/2008 | 3.89 |
| | mg/L | 3 | 2/3/2008 | 5.30 |
| | Average = 4.45 mg/L | | | |
| Nitrate + Nitrite as N | mg/L | 1 | 1/7/2008 | 1.33 |
| | mg/L | 2 | 1/24/2008 | 1.53 |
| | mg/L | 3 | 2/3/2008 | 1.09 |
| | Average = 1.32 mg/L | | | |
| SRP | mg/L | 1 | 1/7/2008 | 0.22 |
| | mg/L | 2 | 1/24/2008 | 0.14 |
| | mg/L | 3 | 2/3/2008 | No Data |
| | Average = 0.18 mg/L | | | |
| Total Nitrogen | mg/L | 1 | 1/7/2008 | 2.02 |
| | mg/L | 2 | 1/24/2008 | 1.64 |
| | mg/L | 3 | 2/3/2008 | No Data |
| | Average = 1.22 mg/L | | | |

**Table 5-9: Buena Vista Event Mean Concentrations (continued)**

| Constituent | Units | Wet Weather Event | Date | EMC |
|---|---|---|---|---|
| Total Dissolved Nitrogen | mg/L | 1 | 1/7/2008 | 1.59 |
| | mg/L | 2 | 1/24/2008 | 1.53 |
| | mg/L | 3 | 2/3/2008 | No Data |
| | Average = 1.56 mg/L | | | |
| Total Phosphorus | mg/L | 1 | 1/7/2008 | 0.32 |
| | mg/L | 2 | 1/24/2008 | 0.16 |
| | mg/L | 3 | 2/3/2008 | 0.43 |
| | Average = 0.30 mg/L | | | |
| Total Dissolved Phosphorus | mg/L | 1 | 1/7/2008 | 0.21 |
| | mg/L | 2 | 1/24/2008 | 0.14 |
| | mg/L | 3 | 2/3/2008 | 0.18 |
| | Average = 0.18 mg/L | | | |

No Data – This constituent was not analyzed as part of the San Diego County Regional Monitoring Program that provided EMCs for Wet Weather Event 3 per the Work Plan.

#### 5.2.1.3 Daily and Annual Wet Weather Load Estimate

Table 5-10 presents the average, minimum, and maximum daily wet weather load estimates for each constituent. The daily dry weather load estimates are also shown for comparison purposes. Appendix D-2 lists the loads by day (wet weather loads are highlighted).

**Table 5-10: Buena Vista Daily Load Estimates**

| Constituent | Wet Weather Daily Load | | | Dry Weather Daily Load | | |
|---|---|---|---|---|---|---|
| | Average | Minimum | Maximum | Average | Minimum | Maximum |
| *Enterococcus* (G-org) | 63,577 | 970 | 667,997 | 16.2 | 1.47 | 68.4 |
| Fecal Coliform (G-org) | 53,082 | 318 | 540,469 | 33.6 | 3.85 | 171 |
| Total Coliform (G-org) | 231,435 | 4,076 | 2,013,605 | 82.4 | 24.5 | 342 |
| TSS | 157,567 | 2,941 | 1,452,944 | 435 | 37.5 | 3,493 |
| Ammonia as N (lbs) | 103 | 1.89 | 932 | 0.77 | 0.22 | 3.04 |
| CBOD (lbs) | 3,073 | 53.7 | 26,517 | 21.2 | 5.31 | 75.6 |
| Chlorophyll *a* (lbs) | No Data | No Data | No Data | 0.37 | 0.02 | 3.42 |
| Nitrate + Nitrite as N (lbs) | 954 | 15.9 | 7,846 | 32.9 | 0.19 | 178 |
| SRP (lbs) | 137 | 2.17 | 1,318 | 1.34 | 0.39 | 6.68 |
| Total Nitrogen (lbs) | 1,035 | 14.7 | 10,344 | 41.9 | 11.0 | 190 |
| Total Dissolved Nitrogen (lbs) | 1,043 | 18.8 | 9,310 | 48.9 | 10.5 | 247 |
| Total Phosphorus (lbs) | 228 | 3.68 | 1,816 | 2.05 | 0.16 | 15.1 |
| Total Dissolved Phosphorus (lbs) | 121 | 2.11 | 1,043 | 1.90 | 0.27 | 9.60 |

No Data – Wet weather samples collected at the Mass Emission Station were not required to be analyzed for Chlorophyll *a*. per the QAPP.

Table 5-11 presents the annual wet weather loads for each constituent. This table also shows the annual dry weather loads and total (dry and wet weather) annual loads for comparison purposes.

**Table 5-11: Buena Vista Annual Load Estimates**

| Constituent | Wet Weather Annual Load | Dry Weather Annual Load | Total Annual Load |
|---|---|---|---|
| *Enterococcus* (G-org) | 2,860,945 | 5,187 | 2,866,132 |
| Fecal Coliform (G-org) | 2,388,702 | 10,801 | 2,399,504 |
| Total Coliform (G-org) | 10,414,577 | 26,458 | 10,441,036 |
| TSS (lbs) | 7,090,501 | 139,522 | 7,230,024 |
| Ammonia as N (lbs) | 4,630 | 247 | 4,877 |
| CBOD (lbs) | 138,283 | 6,801 | 145,084 |
| Chlorophyll *a* (lbs) | No Data | 120 | No Data |
| Nitrate + Nitrite as N (lbs) | 42,925 | 10,552 | 53,477 |
| SRP (lbs) | 6,149 | 429 | 6,578 |
| Total Nitrogen (lbs) | 46,581 | 13,448 | 60,029 |
| Total Dissolved Nitrogen (lbs) | 46,933 | 15,712 | 62,645 |
| Total Phosphorus (lbs) | 10,259 | 659 | 10,918 |
| Total Dissolved Phosphorus (lbs) | 5,428 | 608 | 6,037 |

No Data – Wet weather samples collected at the Mass Emission Station were not required to be analyzed for Chlorophyll *a*. per the QAPP.

### 5.2.2 Buena Vista Dry Weather Load Estimate

The daily and annual dry weather loads for each constituent were calculated based on flows measured during dry weather conditions at the Mass Emission Station and the analytical results of samples collected during index periods. For storm drains, the daily dry weather loads for each constituent were calculated based on instantaneous flow measurements and the analytical results of samples collected during index periods.

#### 5.2.2.1 Flow Calculations

Table 5-8 presents the average daily, median daily, minimum daily, maximum daily, and total annual dry weather flows calculated from flow measurements obtained every 15 minutes at the Buena Vista Lagoon Mass Emission Station. Table 4-27 presents the flows by day. The total annual dry weather flow volume was 120 million cubic feet, or 19 percent of the total (dry and wet weather) annual flow volume.

#### 5.2.2.2 Concentrations

Table 5-12 presents the average concentrations calculated from the results of samples collected from the Buena Vista Mass Emission Station during each of the four index periods.

**Table 5-12: Buena Vista Average Index Period Concentrations**

| Constituent | Units | Average Concentrations by Index Period | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| *Enterococcus* | CFU/100mL | 159 | 59.3 | 225 | 170 |
| Fecal Coliform | CFU/100mL | 216 | 173 | 678 | 410 |
| Total Coliform | CFU/100mL | 792 | 472 | 947 | 910 |
| TSS | mg/L | 5.38 | 46.4 | 35.7 | 10.5 |
| Ammonia as N | mg/L | 0.03 | 0.03 | 0.04 | 0.03 |
| CBOD | mg/L | 0.76 | 0.88 | 1.27 | 1.00 |
| Chlorophyll *a* | mg/m3 | 6.78 | 45.4 | 16.1 | 10.4 |
| Nitrate + Nitrite as N | mg/L | 1.80 | 1.87 | 0.58 | 0.63 |
| SRP | mg/L | 0.07 | 0.05 | 0.04 | 0.05 |
| TN | mg/L | 1.90 | 2.53 | 0.90 | 1.49 |
| TDN | mg/L | 2.60 | 2.63 | 1.02 | 1.18 |
| TP | mg/L | 0.07 | 0.20 | 0.03 | 0.08 |
| TDP | mg/L | 0.10 | 0.08 | 0.03 | 0.07 |

5.2.2.3 Calculation of Daily and Annual Dry Weather Loads

The average index period sample results in Table 5-12 were used to calculate loads for days occurring during the corresponding 3-month period. More specifically, average Index Period 1, 2, 3, and 4 sample results were used to calculate daily loads for days occurring between December 4, 2007 and March 28, 2008, March 29, 2008 and June 28, 2008, June 29, 2008 and September 7, 2008, and September 8, 2008 and October 31, 2008, respectively. Additionally, Index Period 4 was used to calculate loads at the beginning of the monitoring season from November 1, 2007 to November 29, 2007. A four-day gap between Index Period 4 and Index Period 1 was due to a storm event from November 30, 2007 to December 3, 2007.

Table 5-10 presents the average, minimum, and maximum daily dry weather loads for each constituent. Table 5-11 presents the annual dry weather loads. Table 5-13 presents the average daily load estimates by index period event. Table 5-14 presents the daily load estimates for storm drains by index period event. Appendix D-2 lists the dry weather loads by day for each constituent.

**Table 5-13: Buena Vista Average Index Period Daily Loading Estimates**

| Constituent | Units | Average Daily Loading by Index Period | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| *Enterococcus* | G-org | 33.9 | 4.06 | 16.8 | 13.0 |
| Fecal Coliform | G-org | 46.6 | 11.9 | 50.6 | 31.4 |
| Total Coliform | G-org | 169 | 32.5 | 70.4 | 69.8 |
| TSS | lbs | 252 | 699 | 586 | 178 |
| Ammonia as N | lbs | 1.51 | 0.47 | 0.59 | 0.59 |
| CBOD | lbs | 36.0 | 13.3 | 20.8 | 16.9 |
| Chlorophyll *a* | lbs | 0.32 | 0.68 | 0.26 | 0.17 |
| Nitrate + Nitrite as N | lbs | 85.4 | 28.2 | 9.51 | 10.6 |
| SRP | lbs | 3.33 | 0.75 | 0.62 | 0.80 |
| TN | lbs | 90.5 | 38.2 | 14.8 | 25.3 |
| TDN | lbs | 123 | 39.8 | 16.8 | 19.9 |
| TP | lbs | 3.19 | 3.02 | 0.50 | 1.28 |
| TDP | lbs | 4.76 | 1.19 | 0.54 | 1.25 |

(1) Annual flow measurements were taken from November 1, 2007 to October 31, 2008.

**Table 5-14: Buena Vista Storm Drain Daily Load Estimates**

| Analyte | Units | Index Period Event 1 | | Index Period Event 2 | | Index Period Event 3 | | Index Period Event 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1/15/2008 | | 3/31/2008 | | 7/14-17/20081 | | 9/23/2008 | |
| | | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 |
| *Enterococcus* | G-org/day | 0.34 | 0.06 | 0.36 | 0.27 | 6.87 | 0.05 | 3.22 | 0.02 |
| Fecal Coliform | G-org/day | 0.28 | 0.22 | 0.24 | 0.42 | 12.5 | 0.37 | 4.89 | 0.13 |
| Total Coliform | G-org/day | 0.85 | 2.59 | 0.61 | 0.30 | 20.3 | 0.45 | 6.00 | 0.12 |
| TSS | lbs/day | 0.45 | 1.77 | 0.35 | 2.02 | 2.84 | 0.35 | 1.59 | 0.49 |
| Ammonia as N | lbs/day | 0.002 | 0.001 | 0.003 | 0.002 | 0.015 | 0.002 | 0.007 | 0.005 |
| CBOD | lbs/day | 0.02 | 0.34 | 0.01 | 0.07 | 0.11 | 0.07 | 0.04 | 0.01 |
| Chlorophyll *a* | lbs/day | 0.0002 | 0.01 | 0.0001 | 0.0002 | 0.0002 | 0.001 | 0.0023 | 0.0008 |
| Nitrate+Nitrite as N | lbs/day | 0.27 | 0.001 | 0.285 | 0.0005 | 3.330 | 0.001 | 1.606 | 0.0004 |
| SRP | lbs/day | 0.002 | 0.001 | 0.001 | 0.0005 | 0.01 | 0.000 | 0.005 | 0.0[2] |
| TN | lbs/day | 1.87 | 0.04 | 0.19 | 0.03 | 2.77 | 0.02 | 1.80 | 0.02 |
| TDN | lbs/day | 1.32 | 0.08 | 0.20 | 0.03 | 2.98 | 0.02 | 1.88 | 0.02 |
| TP | lbs/day | 0.004 | 0.001 | 0.001 | 0.001 | 0.007 | 0.001 | 0.005 | 0.001 |
| TDP | lbs/day | 0.007 | 0.004 | 0.0004 | 0.0005 | 0.011 | 0.0[2] | 0.007 | 0.0002 |

(1) Bacteria samples were collected on July 23, 2008 and the remaining samples were collected on July 21, 2008.
(2) Analytical result was non-detect, therefore daily load was zero.

The daily and annual dry weather loads for each constituent were calculated based on flows measured during dry weather conditions at the Mass Emission Station and the analytical results of samples collected during index periods. For storm drains, the daily dry weather loads for each constituent were calculated based on instantaneous flow measurements and the analytical results of samples collected during index periods.

## 5.3 LOMA ALTA SLOUGH LOAD ANALYSIS

Annual and daily dry and wet weather load estimates were calculated for Loma Alta Slough for the following 303(d) listed categories and individual constituents:

- Bacteria
  - *Enterococcus*
  - Fecal Coliform
  - Total Coliform
- Nutrients/Eutrophication
  - Ammonia as N
  - CBOD
  - Chlorophyll *a*
  - Nitrate + Nitrite as N
  - SRP
  - TN
  - TDN
  - TP
  - TDP
- Sediment
  - TSS

### 5.3.1 Loma Alta Wet Weather Load Estimate

The daily and annual wet weather loads for each constituent were calculated based on flows measured during wet weather conditions and calculated EMCs.

#### 5.3.1.1 Flow Calculations

Table 5-15 presents the average daily, median daily, minimum daily, maximum daily, and total annual wet weather flows calculated from flow measurements obtained every 15 minutes at the Loma Alta Slough Mass Emission Station. The dry weather flows are also shown for comparison purposes.

Table 4-45 presents the flows by day. The total annual wet weather flow volume was 111 million cubic feet, or 62 percent of the total (wet and dry weather) annual flow volume.

**Table 5-15: Loma Alta Flow Calculations**

| Flow Calculation | Units | Wet Weather | Dry Weather |
|---|---|---|---|
| Average Daily | cf per day | 2,260,343 | 168,313 |
| Median Daily | cf per day | 634,106 | 8,744 |
| Minimum Daily | cf per day | 98,847 | 2,034 |
| Maximum Daily | cf per day | 18,787,253 | 2,221,613 |
| Total Annual[1] | cf | 110,756,831 | 66,820,071 |

(1) Annual flow measurements were taken from November 1, 2007 to October 31, 2008.

5.3.1.2 Calculation of Event Mean Concentrations

Table 5-16 presents the EMCs calculated from the results of the individual pollutagraph samples collected during Wet Weather Events 1 (January 7, 2008) and 2 (January 24, 2008) and the EMCs measured from the flow-weighted composite samples collected during Wet Weather Event 3 (February 3, 2008). Sampling for Wet Weather Event 3 was conducted by an outside agency under the San Diego County Regional Monitoring Program, Order No. 2007-01, which did not sample for total nitrogen, total dissolved nitrogen, or soluble reactive phosphorus. As a result, the wet weather average EMC for these constituents was used for their respective Wet Weather Event 3 loading calculations.

**Table 5-16: Loma Alta Event Mean Concentrations**

| Constituent | Units | Wet Weather Event | Date | EMC |
|---|---|---|---|---|
| *Enterococcus* | CFU/100mL | 1 | 1/7/2008 | 21,712 |
| | CFU/100mL | 2 | 1/24/2008 | 11,862 |
| | CFU/100mL | 3 | 2/3/2008 | 13,000 |
| | Average = 15,525 CFU/100mL | | | |
| Fecal Coliform | MPN/100mL | 1 | 1/7/2008 | 9,273 |
| | MPN/100mL | 2 | 1/24/2008 | 29,658 |
| | MPN/100mL | 3 | 2/3/2008 | 1,700 |
| | Average = 13,544 MPN/100mL | | | |
| Total Coliform | MPN/100mL | 1 | 1/7/2008 | 55,021 |
| | MPN/100mL | 2 | 1/24/2008 | 86,468 |
| | MPN/100mL | 3 | 2/3/2008 | 35,000 |
| | Average = 58,830 MPN/100mL | | | |
| TSS | mg/L | 1 | 1/7/2008 | 167 |
| | mg/L | 2 | 1/24/2008 | 142 |
| | mg/L | 3 | 2/3/2008 | 101 |
| | Average = 136 mg/L | | | |
| Ammonia as N | mg/L | 1 | 1/7/2008 | 0.10 |
| | mg/L | 2 | 1/24/2008 | 0.12 |
| | mg/L | 3 | 2/3/2008 | 0.45 |
| | Average = 0.23 mg/L | | | |
| CBOD | mg/L | 1 | 1/7/2008 | 4.18 |
| | mg/L | 2 | 1/24/2008 | 6.74 |
| | mg/L | 3 | 2/3/2008 | 1.00 |
| | Average = 3.97 mg/L | | | |
| Nitrate + Nitrite as N | mg/L | 1 | 1/7/2008 | 0.61 |
| | mg/L | 2 | 1/24/2008 | 0.48 |
| | mg/L | 3 | 2/3/2008 | 0.27 |
| | Average = 0.45 mg/L | | | |
| SRP | mg/L | 1 | 1/7/2008 | 0.29 |
| | mg/L | 2 | 1/24/2008 | 0.14 |
| | mg/L | 3 | 2/3/2008 | No Data |
| | Average = 0.21 mg/L | | | |
| Total Nitrogen | mg/L | 1 | 1/7/2008 | 1.40 |
| | mg/L | 2 | 1/24/2008 | 1.28 |
| | mg/L | 3 | 2/3/2008 | No Data |
| | Average = 1.34 mg/L | | | |

**Table 5-16: Loma Alta Event Mean Concentrations (continued)**

| Constituent | Units | Wet Weather Event | Date | EMC |
|---|---|---|---|---|
| Total Dissolved Nitrogen | mg/L | 1 | 1/7/2008 | 1.11 |
| | mg/L | 2 | 1/24/2008 | 0.93 |
| | mg/L | 3 | 2/3/2008 | No Data |
| | Average = 1.02 mg/L | | | |
| Total Phosphorus | mg/L | 1 | 1/7/2008 | 0.38 |
| | mg/L | 2 | 1/24/2008 | 0.23 |
| | mg/L | 3 | 2/3/2008 | 0.30 |
| | Average = 0.30 mg/L | | | |
| Total Dissolved Phosphorus | mg/L | 1 | 1/7/2008 | 0.29 |
| | mg/L | 2 | 1/24/2008 | 0.17 |
| | mg/L | 3 | 2/3/2008 | 0.19 |
| | Average = 0.22 mg/L | | | |

No Data – This constituent was not analyzed as part of the San Diego County Regional Monitoring Program that provided EMCs for Wet Weather Event 3 per the Work Plan.

#### 5.3.1.3 Daily and Annual Wet Weather Load Estimate

Table 5-17 presents the average, minimum, and maximum daily wet weather load estimates for each constituent. The daily dry weather load estimates are also shown for comparison purposes. Appendix D-3 lists the loads by day (wet weather loads are highlighted).

**Table 5-17: Loma Alta Daily Load Estimates**

| Constituent | Wet Weather Daily Load | | | Dry Weather Daily Load | | |
|---|---|---|---|---|---|---|
| | Average | Minimum | Maximum | Average | Minimum | Maximum |
| *Enterococcus* (G-org) | 10,988 | 435 | 107,097 | 6.08 | 0.02 | 54.3 |
| Fecal Coliform (G-org) | 7,794 | 379 | 72,052 | 14.9 | 0.18 | 140 |
| Total Coliform (G-org) | 35,215 | 1,647 | 312,971 | 33.0 | 0.59 | 312 |
| TSS (lbs) | 20,332 | 842 | 175,113 | 100 | 0.46 | 989 |
| Ammonia as N (lbs) | 28.0 | 1.40 | 265 | 0.42 | 0.01 | 3.82 |
| CBOD (lbs) | 528 | 24.5 | 4,661 | 10.3 | 0.13 | 106 |
| Chlorophyll *a* (lbs) | No Data | No Data | No Data | 0.19 | 0.001 | 2.32 |
| Nitrate + Nitrite as N (lbs) | 72.8 | 2.78 | 787 | 4.08 | 0.005 | 29.5 |
| SRP (lbs) | 33.5 | 1.30 | 346 | 0.28 | 0.003 | 2.48 |
| Total Nitrogen (lbs) | 200 | 8.27 | 1,748 | 15.3 | 0.18 | 157 |
| Total Dissolved Nitrogen (lbs) | 137 | 6.28 | 1,195 | 15.7 | 0.19 | 159 |
| Total Phosphorus (lbs) | 48.0 | 1.87 | 478 | 0.44 | 0.001 | 4.50 |
| Total Dissolved Phosphorus (lbs) | 30.6 | 1.33 | 253 | 0.37 | 0.003 | 3.31 |

No Data – Wet weather samples collected at the Mass Emission Station were not required to be analyzed for Chlorophyll *a* per the QAPP.

Table 5-18 presents the annual wet weather loads for each constituent. This table also shows the annual dry weather loads and total (dry and wet weather) annual loads for comparison purposes.

**Table 5-18: Loma Alta Annual Load Estimates**

| Constituent | Wet Weather Annual Load | Dry Weather Annual Load | Total Annual Load |
|---|---|---|---|
| *Enterococcus* (G-org) | 538,399 | 1,928 | 540,327 |
| Fecal Coliform (G-org) | 381,892 | 4,721 | 386,613 |
| Total Coliform (G-org) | 1,725,532 | 10,454 | 1,735,987 |
| TSS (lbs) | 996,287 | 31,795 | 1,028,082 |
| Ammonia as N (lbs) | 1,370 | 133 | 1,503 |
| CBOD (lbs) | 25,853 | 3,260 | 29,112 |
| Chlorophyll *a* (lbs) | No Data | 61.5 | No Data |
| Nitrate + Nitrite as N (lbs) | 3,568 | 1,293 | 4,861 |
| SRP (lbs) | 1,643 | 89.2 | 1,732 |
| Total Nitrogen (lbs) | 9,788 | 4,855 | 14,643 |
| Total Dissolved Nitrogen (lbs) | 6,728 | 4,964 | 11,693 |
| Total Phosphorus (lbs) | 2,354 | 140 | 2,493 |
| Total Dissolved Phosphorus (lbs) | 1,501 | 117 | 1,618 |

No Data – Wet weather samples collected at the Mass Emission Station were not required to be analyzed for Chlorophyll *a* per the QAPP.

### 5.3.2 Loma Alta Dry Weather Load Estimate

The daily and annual dry weather loads for each constituent were calculated based on flows measured during dry weather conditions at the Mass Emission Station and the analytical results of samples collected during index periods. For storm drains, the daily dry weather loads for each constituent were calculated based on instantaneous flow measurements and the analytical results of samples collected during index periods.

#### 5.3.2.1 Flow Calculations

Table 5-15 presents the average daily, median daily, minimum daily, maximum daily, and total annual dry weather flows calculated from flow measurements obtained every 15 minutes at the Loma Alta Slough Mass Emission Station. Flow results used for loading calculations are presented in Appendix A-3.

Table 4-45 presents the flows by day. The total annual dry weather flow volume was 67 million cubic feet, or 38 percent of the total (dry and wet weather) annual flow volume.

5.3.2.2 Concentrations

Table 5-19 presents the average concentrations calculated from the results of samples collected from the Loma Alta Slough Mass Emission Station during each of the four index periods.

**Table 5-19: Loma Alta Average Index Period Concentrations**

| Constituent | Units | Average Concentrations by Index Period | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| *Enterococcus* | CFU/100mL | 170 | 86.3 | 58.0 | 221 |
| Fecal Coliform | CFU/100mL | 276 | 222 | 355 | 867 |
| Total Coliform | CFU/100mL | 662 | 496 | 530 | 1,745 |
| TSS | mg/L | 2.74 | 7.13 | 11.7 | 54.1 |
| Ammonia as N | mg/L | 0.02 | 0.03 | 0.06 | 0.22 |
| CBOD | mg/L | 0.76 | 0.76 | 1.47 | 1.32 |
| Chlorophyll *a* | mg/m3 | 2.87 | 16.8 | 7.35 | 31.7 |
| Nitrate + Nitrite as N | mg/L | 0.71 | 0.21 | 0.34 | 1.07 |
| SRP | mg/L | 0.06 | 0.01 | 0.02 | 0.16 |
| TN | mg/L | 1.21 | 1.13 | 0.93 | 2.39 |
| TDN | mg/L | 1.31 | 1.15 | 0.83 | 2.45 |
| TP | mg/L | 0.07 | 0.02 | 0.02 | 0.05 |
| TDP | mg/L | 0.09 | 0.01 | 0.01 | 0.19 |

5.3.2.3 Calculation of Daily and Annual Dry Weather Loads

The average index period sample results in Table 5-19 were used to calculate loads for days occurring during the corresponding three-month period. More specifically, average Index Period 1, 2, 3, and 4 sample results were used to calculate daily loads for days occurring between December 4, 2007 and March 11, 2008, March 12, 2008 and June 21, 2008, June 22, 2008 and September 14, 2008, and September 15, 2008 and October 31, 2008, respectively. Additionally, Index Period 4 was used to calculate loads at the beginning of the monitoring season from November 1, 2007 to November 29, 2007. A four-day gap between Index Period 4 and Index Period 1 was due to a storm event from November 30, 2007 to December 3, 2007.

Table 5-17 presents the average, minimum, and maximum daily dry weather loads for each constituent. Table 5-18 presents the annual dry weather loads. Table 5-20 presents the average daily load estimates by index period event. Table 5-21 presents the daily load estimates for storm drains by index period event. Appendix D-3 lists the dry weather loads by day for each constituent.

**Table 5-20: Loma Alta Average Index Period Daily Loading Estimates**

| Constituent | Units | Average Daily Loading by Index Period | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| *Enterococcus* | G-org | 8.63 | 13.4 | 0.11 | 1.38 |
| Fecal Coliform | G-org | 14.4 | 34.9 | 0.65 | 5.40 |
| Total Coliform | G-org | 33.7 | 77.5 | 0.98 | 10.9 |
| TSS | lbs | 30.9 | 244 | 4.74 | 74.3 |
| Ammonia as N | lbs | 0.27 | 0.94 | 0.02 | 0.31 |
| CBOD | lbs | 8.54 | 26.3 | 0.59 | 1.81 |
| Chlorophyll *a* | lbs | 0.03 | 0.57 | 0.003 | 0.04 |
| Nitrate + Nitrite as N | lbs | 7.92 | 7.24 | 0.14 | 1.47 |
| SRP | lbs | 0.71 | 0.32 | 0.01 | 0.22 |
| TN | lbs | 13.5 | 38.7 | 0.38 | 3.29 |
| TDN | lbs | 14.7 | 39.1 | 0.34 | 3.36 |
| TP | lbs | 0.84 | 0.87 | 0.01 | 0.07 |
| TDP | lbs | 1.03 | 0.38 | 0.004 | 0.26 |

**Table 5-21: Loma Alta Storm Drain Daily Load Estimates**

| Analyte Name | Units | Index Period Event 1 | | Index Period Event 2 | | Index Period Event 3 | | Index Period Event 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1/15/2008 | | 3/31/2008 | | 7/14-17/20081 | | 10/9/2008 | |
| | | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 |
| *Enterococcus* | G-org/day | 0.72 | 0.59 | 0.75 | 0.62 | 3.02 | 0.36 | 0.23 | 0.22 |
| Fecal Coliform | G-org/day | 0.48 | 1.21 | 0.64 | 0.33 | 6.96 | 30.0 | 0.90 | 3.79 |
| Total Coliform | G-org/day | 1.05 | 3.89 | 3.85 | 0.33 | 10.1 | 25.7 | 2.28 | 5.17 |
| TSS | lbs/day | 1.59 | 1.15 | 0.74 | 5.77 | 0.48 | 13.5 | 0.03 | 2.43 |
| Ammonia as N | lbs/day | 0.01 | 0.0[2] | 0.01 | 0.00 | 0.01 | 0.02 | 0.001 | 0.00 |
| CBOD | lbs/day | 0.05 | 0.04 | 0.04 | 0.94 | 0.06 | 0.23 | 0.01 | 0.37 |
| Chlorophyll *a* | lbs/day | 0.0008 | 0.001 | 0.0003 | 0.02 | 0.0008 | 0.005 | 0.0001 | 0.007 |
| Nitrate+Nitrite as N | lbs/day | 0.43 | 0.13 | 1.03 | 0.27 | 0.98 | 0.45 | 0.17 | 0.05 |
| SRP | lbs/day | 0.002 | 0.01 | 0.003 | 0.002 | 0.004 | 0.01 | 0.00 | 0.0[2] |
| TN | lbs/day | 1.30 | 0.20 | 1.01 | 0.39 | 1.60 | 0.91 | 0.33 | 0.17 |
| TDN | lbs/day | 1.06 | 0.70 | 0.88 | 0.22 | 1.53 | 0.48 | 0.26 | 0.23 |
| TP | lbs/day | 0.01 | 0.01 | 0.003 | 0.01 | 0.002 | 0.0[2] | 0.0003 | 0.0009 |
| TDP | lbs/day | 0.004 | 0.0[2] | 0.0[2] | 0.0[2] | 0.004 | 0.0[2] | 0.0003 | 0.01 |

(1) Bacteria samples were collected on July 23, 2008 and the remaining samples were collected on July 21, 2008.
(2) Analytical result was non-detect, therefore daily load was zero.

## 5.4 SAN ELIJO LAGOON LOAD ANALYSIS

Annual and daily dry and wet weather load estimates were calculated for San Elijo Lagoon for the following 303(d) listed categories and individual constituents:

- Bacteria
  - *Enterococcus*
  - Fecal Coliform
  - Total Coliform
- Nutrients/Eutrophication
  - Ammonia as N
  - CBOD
  - Chlorophyll *a*
  - Nitrate + Nitrite as N
  - SRP
  - TN
  - TDN
  - TP
  - TDP
- Sediment
  - TSS

### 5.4.1 San Elijo Wet Weather Load Estimate

The daily and annual wet weather loads for each constituent were calculated based on flows measured during wet weather conditions and calculated EMCs.

#### 5.4.1.1 Flow Calculations

Table 5-22 presents the average daily, median daily, minimum daily, maximum daily, and total annual wet weather flows calculated from flow measurements obtained every 15 minutes at the San Elijo Lagoon Mass Emission Station. The dry weather flows are also shown for comparison purposes.

Table 4-64 presents the flows by day. The total annual wet weather flow volume was 403 million cubic feet, or 70 percent of the total (wet and dry weather) annual flow volume.

**Table 5-22: San Elijo Flow Calculations**

| Flow Calculation | Units | Wet Weather | Dry Weather |
|---|---|---|---|
| Average Daily | cf per day | 7,906,360 | 553,366 |
| Median Daily | cf per day | 3,611,915 | 379,859 |
| Minimum Daily | cf per day | 17,280 | 17,280 |
| Maximum Daily | cf per day | 34,304,361 | 2,749,007 |
| Total Annual[1] | cf | 403,224,383 | 174,310,279 |

(1) Annual flow measurements were taken from November 1, 2007 to October 31, 2008.

5.4.1.2 Calculation of Event Mean Concentrations

Table 5-23 presents the EMCs calculated from the results of the individual pollutagraph samples collected during Wet Weather Events 1 (January 7, 2008) and 2 (January 24, 2008) and the EMCs measured from the flow-weighted composite samples collected during Wet Weather Event 3 (February 3, 2008). Sampling for Wet Weather Event 3 was conducted by an outside organization under the San Diego County Regional Monitoring Program, Order No. 2007-01, which did not sample for total nitrogen, total dissolved nitrogen, or soluble reactive phosphorus. As a result the wet weather average EMC for these constituents was used for their respective Wet Weather Event 3 loading calculations.

**Table 5-23: San Elijo Event Mean Concentrations**

| Constituent | Units | Wet Weather Event | Date | EMC |
|---|---|---|---|---|
| *Enterococcus* | CFU/100mL | 1 | 1/7/2008 | 31,951 |
| | CFU/100mL | 2 | 1/24/2008 | 18,579 |
| | CFU/100mL | 3 | 2/3/2008 | 3,000 |
| | Average = 17,843 CFU/100mL | | | |
| Fecal Coliform | MPN/100mL | 1 | 1/7/2008 | 8,204 |
| | MPN/100mL | 2 | 1/24/2008 | 6,526 |
| | MPN/100mL | 3 | 2/3/2008 | 1,100 |
| | Average = 5,277 MPN/100mL | | | |
| Total Coliform | MPN/100mL | 1 | 1/7/2008 | 88,230 |
| | MPN/100mL | 2 | 1/24/2008 | 27,916 |
| | MPN/100mL | 3 | 2/3/2008 | 22,000 |
| | Average = 46,049 MPN/100mL | | | |
| TSS | mg/L | 1 | 1/7/2008 | 37.0 |
| | mg/L | 2 | 1/24/2008 | 52.5 |
| | mg/L | 3 | 2/3/2008 | 46.0 |
| | Average = 45.3 mg/L | | | |
| Ammonia as N | mg/L | 1 | 1/7/2008 | 0.08 |
| | mg/L | 2 | 1/24/2008 | 0.11 |
| | mg/L | 3 | 2/3/2008 | 0.10 |
| | Average = 0.10 mg/L | | | |
| CBOD | mg/L | 1 | 1/7/2008 | 3.66 |
| | mg/L | 2 | 1/24/2008 | 2.30 |
| | mg/L | 3 | 2/3/2008 | 5.50 |
| | Average = 3.82 mg/L | | | |
| Nitrate + Nitrite as N | mg/L | 1 | 1/7/2008 | 1.29 |
| | mg/L | 2 | 1/24/2008 | 3.24 |
| | mg/L | 3 | 2/3/2008 | 1.63 |
| | Average = 2.05 mg/L | | | |
| SRP | mg/L | 1 | 1/7/2008 | 0.25 |
| | mg/L | 2 | 1/24/2008 | 0.16 |
| | mg/L | 3 | 2/3/2008 | No Data |
| | Average = 0.21 mg/L | | | |
| Total Nitrogen | mg/L | 1 | 1/7/2008 | 2.19 |
| | mg/L | 2 | 1/24/2008 | 2.24 |
| | mg/L | 3 | 2/3/2008 | No Data |
| | Average = 2.21 mg/L | | | |

**Table 5-23: San Elijo Event Mean Concentrations (continued)**

| Constituent | Units | Wet Weather Event | Date | EMC |
|---|---|---|---|---|
| Total Dissolved Nitrogen | mg/L | 1 | 1/7/2008 | 1.66 |
| | mg/L | 2 | 1/24/2008 | 2.37 |
| | mg/L | 3 | 2/3/2008 | No Data |
| | Average = 2.01 mg/L | | | |
| Total Phosphorus | mg/L | 1 | 1/7/2008 | 0.41 |
| | mg/L | 2 | 1/24/2008 | 0.20 |
| | mg/L | 3 | 2/3/2008 | 0.46 |
| | Average = 0.36 mg/L | | | |
| Total Dissolved Phosphorus | mg/L | 1 | 1/7/2008 | 0.20 |
| | mg/L | 2 | 1/24/2008 | 0.18 |
| | mg/L | 3 | 2/3/2008 | 0.33 |
| | Average = 0.24 mg/L | | | |

No Data – This constituent was not analyzed as part of the San Diego County Regional Monitoring Program that provided EMCs for Wet Weather Event 3 per the Work Plan.

#### 5.4.1.3 Daily and Annual Wet Weather Load Estimate

Table 5-24 presents the average, minimum, and maximum daily wet weather load estimates for each constituent. The daily dry weather load estimates are also shown for comparison purposes. Appendix D-4 lists the loads by day (wet weather loads are highlighted).

**Table 5-24: San Elijo Daily Load Estimates**

| Constituent | Wet Weather Daily Load | | | Dry Weather Daily Load | | |
|---|---|---|---|---|---|---|
| | Average | Minimum | Maximum | Average | Minimum | Maximum |
| *Enterococcus* (G-org) | 42,464 | 87 | 323,267 | 17.3 | 0.45 | 201 |
| Fecal Coliform (G-org) | 12,808 | 26 | 135,995 | 25.6 | 0.64 | 131 |
| Total Coliform (G-org) | 116,246 | 225 | 1,262,809 | 55.6 | 1.68 | 355 |
| TSS (lbs) | 20,593 | 49 | 99,425 | 926 | 1.71 | 7,553 |
| Ammonia as N (lbs) | 46.1 | 0.10 | 210 | 2.60 | 0.03 | 15.0 |
| CBOD (lbs) | 1,783 | 4.12 | 9,904 | 30.2 | 0.82 | 172 |
| Chlorophyll *a* (lbs) | No Data | No Data | No Data | 0.11 | 0.002 | 0.96 |
| Nitrate + Nitrite as N (lbs) | 940 | 2.22 | 4,148 | 49.3 | 1.51 | 1,111 |
| SRP (lbs) | 105 | 0.22 | 621 | 1.45 | 0.05 | 18.6 |
| Total Nitrogen (lbs) | 1,069 | 2.39 | 4,744 | 67.7 | 2.47 | 1,176 |
| Total Dissolved Nitrogen (lbs) | 926 | 2.17 | 4,067 | 62.8 | 2.62 | 926 |
| Total Phosphorus (lbs) | 179 | 0.38 | 950 | 2.16 | 0.08 | 23.1 |
| Total Dissolved Phosphorus (lbs) | 111 | 0.26 | 478 | 2.23 | 0.07 | 21.0 |

No Data – Wet weather samples collected at the Mass Emission Station were not required to be analyzed for Chlorophyll *a* per the QAPP.

Table 5-25 presents the annual wet weather loads for each constituent. This table also shows the annual dry weather loads and total (dry and wet weather) annual loads for comparison purposes.

**Table 5-25: San Elijo Annual Load Estimates**

| Constituent | Wet Weather Annual Load | Dry Weather Annual Load | Total Annual Load |
|---|---|---|---|
| *Enterococcus* (G-org) | 2,165,664 | 5,442 | 2,171,106 |
| Fecal Coliform (G-org) | 653,194 | 8,072 | 661,266 |
| Total Coliform (G-org) | 5,928,542 | 17,516 | 5,946,058 |
| TSS (lbs) | 1,050,231 | 291,602 | 1,341,833 |
| Ammonia as N (lbs) | 2,350 | 819 | 3,169 |
| CBOD (lbs) | 90,948 | 9,520 | 100,468 |
| Chlorophyll *a* (lbs) | No Data | 33.3 | No Data |
| Nitrate + Nitrite as N (lbs) | 47,916 | 15,543 | 63,459 |
| SRP (lbs) | 5,338 | 456 | 5,794 |
| Total Nitrogen (lbs) | 54,499 | 21,311 | 75,811 |
| Total Dissolved Nitrogen (lbs) | 47,220 | 19,784 | 67,004 |
| Total Phosphorus (lbs) | 9,134 | 682 | 9,816 |
| Total Dissolved Phosphorus (lbs) | 5,673 | 703 | 6,376 |

No Data – Wet weather samples collected at the Mass Emission Station were not required to be analyzed for Chlorophyll *a* per the QAPP.

### 5.4.2 San Elijo Dry Weather Load Estimate

The daily and annual dry weather loads for each constituent were calculated based on flows measured during dry weather conditions and the analytical results of samples collected during index periods.

#### 5.4.2.1 Flow Calculations

Table 5-22 presents the average daily, median daily, minimum daily, maximum daily, and total annual dry weather flows calculated from flow measurements obtained every 15 minutes at the San Elijo Lagoon Mass Emission Station.

Table 4-64 presents the flows by day. The total annual dry weather flow volume was 174 million cubic feet, or 30 percent of the total (dry and wet weather) annual flow volume.

#### 5.4.2.2 Concentrations

Table 5-26 presents the average concentrations calculated from the results of samples collected from the San Elijo Lagoon Mass Emission Station during each of the four index periods.

**Table 5-26: San Elijo Average Index Period Concentrations**

| Constituent | Units | Average Concentrations by Index Period | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| *Enterococcus* | CFU/100mL | 129 | 43.3 | 179 | 115 |
| Fecal Coliform | CFU/100mL | 131 | 63.7 | 282 | 323 |
| Total Coliform | CFU/100mL | 344 | 195 | 371 | 733 |
| TSS | mg/L | 1.67 | 74.40 | 7.62 | 6.57 |
| Ammonia as N | mg/L | 0.09 | 0.10 | 0.04 | 0.03 |
| CBOD | mg/L | 0.76 | 0.76 | 1.00 | 1.27 |
| Chlorophyll *a* | mg/m3 | 4.08 | 3.73 | 1.82 | 1.75 |
| Nitrate + Nitrite as N | mg/L | 2.52 | 0.15 | 1.22 | 1.40 |
| SRP | mg/L | 0.05 | 0.019 | 0.04 | 0.07 |
| TN | mg/L | 3.13 | 0.54 | 1.60 | 2.29 |
| TDN | mg/L | 2.45 | 0.76 | 1.76 | 2.43 |
| TP | mg/L | 0.08 | 0.03 | 0.05 | 0.10 |
| TDP | mg/L | 0.06 | 0.05 | 0.06 | 0.10 |

5.4.2.3 Calculation of San Elijo Lagoon Daily and Annual Dry Weather Loads

The average index period sample results in Table 5-26 were used to calculate loads for days occurring during the corresponding three-month period. More specifically, average Index Period 1, 2, 3, and 4 sample results were used to calculate daily loads for days occurring between December 4, 2007 and March 17, 2008, March 18, 2008 and June 12, 2008, June 13, 2008 and September 9, 2008, and September 10, 2008 and October 31, 2008, respectively. Additionally, Index Period 4 was used to calculate loads at the beginning of the monitoring season from November 1, 2007 to November 29, 2007. A four-day gap between Index Period 4 and Index Period 1 was due to a storm event from November 30, 2007 to December 3, 2007. Index period specific loading results are presented in Table 5-24.

Table 5-24 presents the average, minimum, and maximum daily dry weather loads for each constituent. Table 5-25 presents the annual dry weather loads. Table 5-27 presents average daily load estimates by index period. Table 5-28 presents daily load estimates for storm drains by index period. Appendix D-4 lists the dry weather loads by day for each constituent.

**Table 5-27: San Elijo Average Index Period Daily Loading**

| Constituent | Units | Average Daily Loading by Index Period | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| *Enterococcus* | G-org | 37.9 | 8.28 | 18.5 | 9.41 |
| Fecal Coliform | G-org | 37.5 | 12.2 | 29.1 | 26.5 |
| Total Coliform | G-org | 99.1 | 37.3 | 38.3 | 60.2 |
| TSS | lbs | 99.4 | 3,138 | 173 | 119 |
| Ammonia as N | lbs | 5.78 | 4.07 | 0.87 | 0.56 |
| CBOD | lbs | 48.0 | 32.1 | 22.7 | 22.9 |
| Chlorophyll *a* | lbs | 0.24 | 0.15 | 0.04 | 0.03 |
| Nitrate + Nitrite as N | lbs | 169 | 6.18 | 27.8 | 25.3 |
| SRP | lbs | 3.20 | 0.80 | 1.01 | 1.25 |
| TN | lbs | 207 | 22.7 | 36.4 | 41.4 |
| TDN | lbs | 162 | 32.1 | 40.0 | 43.8 |
| TP | lbs | 5.04 | 1.33 | 1.23 | 1.84 |
| TDP | lbs | 4.21 | 2.05 | 1.36 | 1.87 |

**Table 5-28: San Elijo Storm Drain Daily Load Estimates**

| Analyte Name | Units | Index Period Event 1 | | Index Period Event 2 | | Index Period Event 3 | | Index Period Event 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1/16/2008 | | 4/1/2008 | | 7/7/2008 | | 10/1/2008 | |
| | | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 | Storm Drain 1 | Storm Drain 2 |
| *Enterococcus* | G-org/day | No Data | No Data | 0.01 | No Data | 0.05 | No Data | 0.07 | No Data |
| Fecal Coliform | G-org/day | No Data | No Data | 0.01 | No Data | 0.03 | No Data | 0.15 | No Data |
| Total Coliform | G-org/day | No Data | No Data | 0.005 | No Data | 0.04 | No Data | 0.15 | No Data |
| TSS | lbs/day | No Data | No Data | 0.03 | No Data | 0.21 | No Data | 0.16 | No Data |
| Ammonia as N | lbs/day | No Data | No Data | 0.001 | No Data | 0.0005 | No Data | 0.0002 | No Data |
| CBOD | lbs/day | No Data | No Data | 0.001 | No Data | 0.067 | No Data | 0.060 | No Data |
| Chlorophyll *a* | lbs/day | No Data | No Data | 0.00005 | No Data | 0.0005 | No Data | 0.0008 | No Data |
| Nitrate + Nitrite as N | lbs/day | No Data | No Data | 0.015 | No Data | 0.001 | No Data | 0.012 | No Data |
| SRP | lbs/day | No Data | No Data | 0.0000 | No Data | 0.0002 | No Data | 0.0002 | No Data |
| TN | lbs/day | No Data | No Data | 0.012 | No Data | 0.009 | No Data | 0.066 | No Data |
| TDN | lbs/day | No Data | No Data | 0.015 | No Data | 0.020 | No Data | 0.047 | No Data |
| TP | lbs/day | No Data | No Data | 0.0001 | No Data | 0.0002 | No Data | 0.0002 | No Data |
| TDP | lbs/day | No Data | No Data | 0.00 | No Data | 0.0002 | No Data | 0.0002 | No Data |

No Data – Load estimates were not calculated because no flow data was reported. Flow was either ponded or not measurable at the time of sampling..

# 6.0 DISCUSSION

This section provides a preliminary analysis and discussion of the results presented in Sections 4 and 5 for each lagoon. The preliminary analysis and discussion of the results addresses daily and annual rainfall and flows, seasonal and within-event variations in concentrations and loadings, tidal variations, first flush effects, comparisons to WQOs and loading capacities, and site-to-site comparisons. Table 6-1 lists the specific management questions from the Work Plan and the locations in this section where they are addressed for each lagoon.

**Table 6-1: Management Questions Addressed**

| Question | Section(s) |
|---|---|
| What are the Concentrations of Targeted Constituents at the mouth of the Creek before entering the Lagoon? | 6.1.2 (Agua Hedionda)<br>6.2.2 (Buena Vista)<br>6.3.2 (Loma Alta)<br>6.4.2 (San Elijo) |
| What is the Daily Rainfall? | 6.1.1 (Agua Hedionda)<br>6.2.1 (Buena Vista)<br>6.3.1 (Loma Alta)<br>6.4.1 (San Elijo) |
| What is the Total Daily and Annual Flow and Mass Loads of Targeted Constituents from the creek into the Lagoon? What is the volume of sediment from the creeks to the lagoons for lagoons impaired with respect to sediment/turbidity? | 6.1.6 (Agua Hedionda)<br>6.2.6 (Buena Vista)<br>6.3.6 (Loma Alta)<br>6.4.6 (San Elijo) |
| What are the Concentrations of Constituents in Lagoon? Do they exceed Water Quality Objectives and / or Beneficial Use Criteria? | 6.1.3 (Agua Hedionda)<br>6.2.3 (Buena Vista)<br>6.3.3 (Loma Alta)<br>6.4.3 (San Elijo) |
| What are the Concentrations of Constituents at the Ocean Inlet Before it enters Lagoon? | 6.1.4 (Agua Hedionda)<br>6.2.4 (Buena Vista)<br>6.3.4 (Loma Alta)<br>6.4.4 (San Elijo) |
| What are the Dissolved Oxygen Concentrations in Lagoon? | 6.2.7 (Buena Vista)<br>6.3.7 (Loma Alta)<br>6.4.7 (San Elijo) |

It should be noted that the preliminary analysis and discussion of results are based on the WQOs presented in Section 1, as well as other assumptions stated in the relevant sections. Although the analyses were conducting using WQOs and assumptions reflective of those that may occur during the TMDL process, these could change. The use of different WQOs, for example, could significantly alter the outcome of many of the preliminary analyses conducted and conclusions reached.

## 6.1 AGUA HEDIONDA LAGOON DISCUSSION

### 6.1.1 Agua Hedionda Daily, Monthly, and Annual Rainfall

Based on measurements at the Mass Emission Station, Agua Hedionda Lagoon received 11.29 inches of rain between October 1, 2007 and October 31, 2008. Daily and monthly rainfall totals are summarized in Table 4-2. January had the most rainfall, 3.62 inches, followed by February, which had 3.27 inches. The majority of the rainfall, 98 percent, occurred during the winter months of November through February.

Isopluvial maps from the San Diego County Hydrology Manual indicate that the mean annual rainfall for the Agua Hedionda Watershed area is about 13 inches, ranging between approximately 12 to 14 inches (Chang, 2009). Based on this data, the total rainfall at the mass emission station (located near the 12-inch isopluvial) during the monitoring period was slightly (about 5 percent) less than average for the area.

#### 6.1.1.1 Agua Hedionda Watershed Response to Rainfall

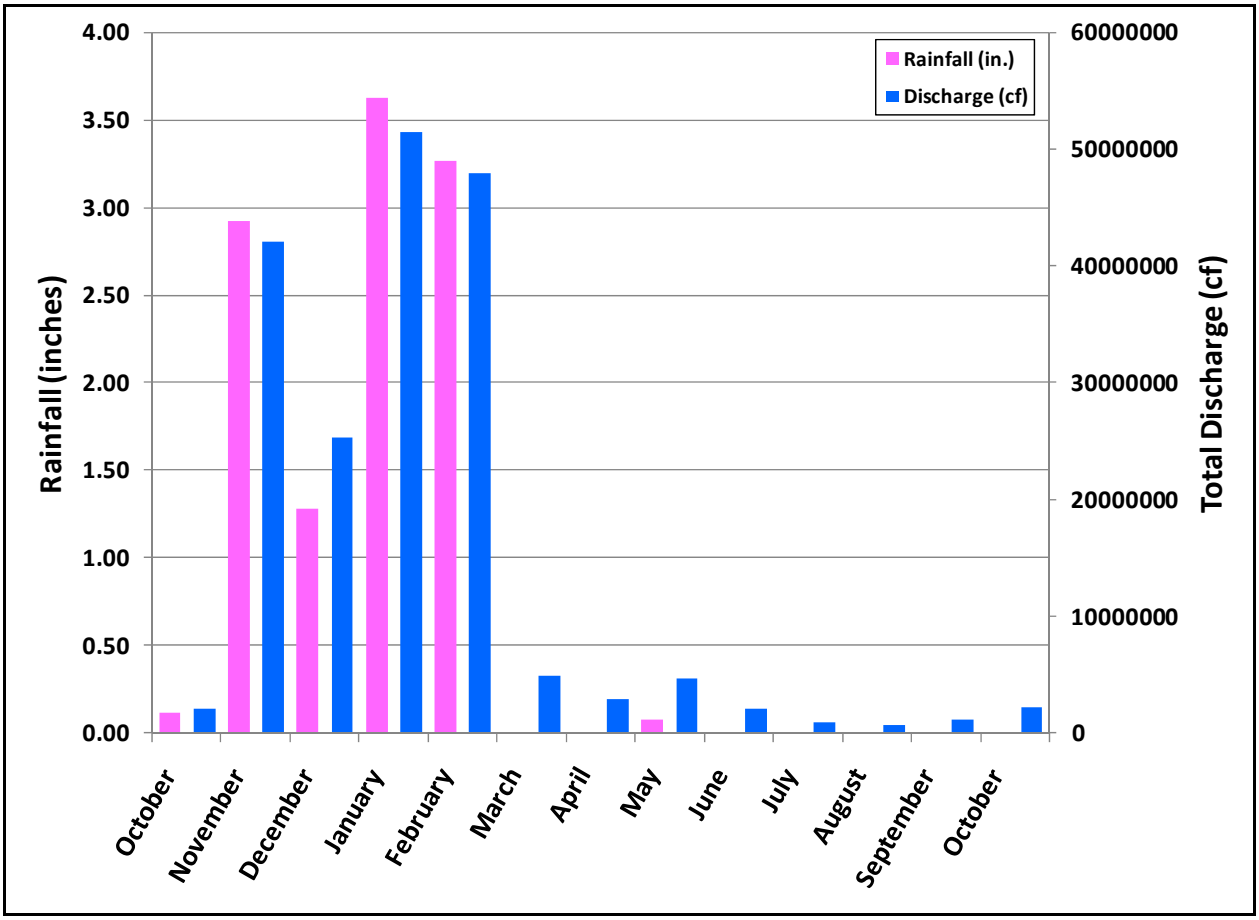
The Agua Hedionda Watershed covers an area of approximately 18,837 acres and extends about 10.62 miles inland from the coast. It represents about 14 percent of the CHU. The Agua Hedionda Watershed includes portions of the Cities of Carlsbad, Oceanside, Vista, and San Marcos, as well as unincorporated areas of the County of San Diego. Land use within the watershed is dominated by urban development. Natural habitats are scattered and occur in a matrix of agricultural and urban development; however, several large patches of native vegetation occur in the eastern portion of the watershed and in the central area on the eastern boundary of Agua Hedionda Lagoon. Impervious surface in the Agua Hedionda Watershed is estimated at 20 percent. (Carlsbad Watershed Management Plan, 2002). The Agua Hedionda Creek Watershed is a subset of the overall Agua Hedionda Lagoon watershed and comprises an area of 11,072 acres (Chang, 2009), or about 59 percent of the total watershed area.

Watershed response to rainfall is characterized by the discharge volumes and peak flows of Agua Hedionda Creek at the Agua Hedionda Mass Emission Station. Watershed response varies throughout the season based on factors such as antecedent soil moisture conditions, impervious area, rainfall amount, and rainfall intensity. Antecedent soil moisture condition throughout the watershed is the saturation levels of the soil from previous storm events. Earlier in the season, when the watershed soil conditions are drier, the ground can soak up more water and, therefore, discharge less. Later in the season after a few storm events, the ground is more saturated, resulting in greater discharge volumes and higher peak flows (UCANR, 2002). Impervious area is directly related to urban development and includes paved surfaces, structures, and other land uses where soil is not exposed and is unable to absorb rainfall. This facilitates

direct storm water runoff resulting in higher discharge volumes and higher peak flows as the response to rainfall is immediate.

Daily and monthly discharge totals are summarized in Table 4-3. A total of 188,510,669 cubic feet was discharged into the Agua Hedionda Lagoon via Agua Hedionda Creek between October 1, 2007 and October 31, 2008. The three largest events occurred on November 30, 2007, January 5 to 7, 2008, and February 22, 2008; produced approximately 48 million, 30 million, and 21 million cubic feet of discharge, respectively; and had peak discharge rates of approximately 1,114 cubic feet-per-second (cfs), 560 cfs, and 775 cfs, respectively. Based on the peak discharge rates and rainfall totals for these events, the runoff coefficients (the fraction of precipitation that appears to runoff) were 0.03, 0.04, and 0.04, respectively. These coefficients are typical of sandy loam soil with a two-percent slope (Hill, 2002) and correspond to the relatively low percentage of impervious area in the watershed. The low runoff coefficients calculated from the two largest events indicate that most of the runoff throughout the watershed is infiltrating into the soils. The response to rainfall is depicted by the highest discharge totals corresponding to the months with the highest rainfall totals. The relationship between monthly rainfall and discharge totals is shown graphically on Figure 6-1.

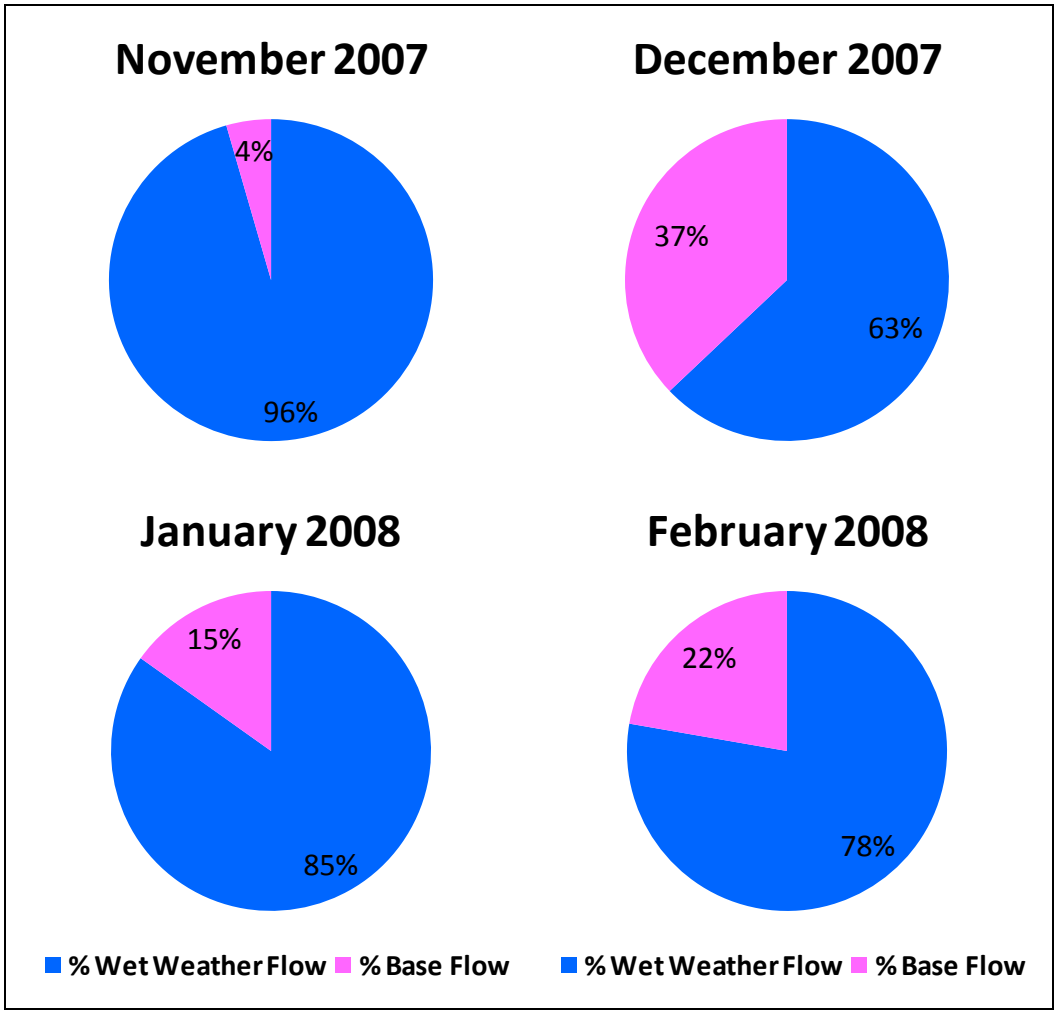
**Figure 6-1: Agua Hedionda Mass Emission Station Monthly Rainfall and Discharge Totals**




Rainfall intensity and amount affect the relationship between rainfall and watershed discharge. Although the overall relationship between rainfall and discharge was relatively stable, the amount of discharge due to wet weather events can vary based on the intensity, timing, and amount of rainfall associated with a given storm event. Figure 6-2 shows the percentage of discharge attributed to direct runoff during wet weather events compared to base flow conditions. Base flows represent stream flows resulting from precipitation that infiltrates into the soil and, over time, moves through the soil into the stream channel, as well as dry weather urban runoff such as irrigation. Discharge due to wet weather events includes water directly running off the surface from rainfall and does not include ground water discharge or seepage from saturated soils. November experienced the highest percentage of wet weather-related discharge due to direct runoff at 96 percent of the total discharge that month. This was primarily due to low base flows early in the season along with a relatively large storm event of 2.92 inches on the last day of the month, resulting in high discharge rates recorded throughout the day. December base flows were high due to the large event at the end of November. This resulted in the lowest wet weather-related discharge percentage

due to a relatively high percentage of base flow discharge. January and February were more similar in discharge percentages attributable to wet weather events with 85 percent and 78 percent, respectively. The impact of the large event in November had decreased at this point and subsequent storm events that occurred were more moderate in both frequency and amount. Throughout the entire year approximately 168 million cubic feet of discharge was due to wet weather, accounting for 85 percent of the total amount discharged into Agua Hedionda Lagoon.

**Figure 6-2: Agua Hedionda Monthly Percentage of Watershed Discharge Due to Wet Weather Events Compared to Base Flow**



### 6.1.2 Agua Hedionda Constituent Concentrations – Mass Emission Station

Constituent concentrations for the range of events monitored provide a snapshot of the variation in watershed input and the lagoon's response to different flow and seasonal conditions. A comparison of constituent concentrations to the associated WQOs provided in Table 1-4 in Section 1.2 helps assess the overall water quality of the lagoon during wet and dry weather conditions. The Agua Hedionda Mass Emission Station characterizes the watershed contribution during wet and dry weather conditions. Although the mass emission station is key input to the lagoon, the lagoon is subject to other inputs and processes that influence water quality as presented in Figures 1-1 to 1-4 of Section 1.4. A summary of concentrations for the Agua Hedionda Mass Emission Station, including geometric means, arithmetic means, and ranges and exceedances compared to WQOs, is provided in Tables 4-10 and 4-11 for wet weather events and in Table 4-18 for index period events.

#### 6.1.2.1 Comparison to Water Quality Objectives

A comparison of concentrations to the WQOs established in the Basin Plan was conducted for the following constituents:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- TDS

<u>Bacteria</u>

Saltwater WQOs were applied to mass emission station as the receiving water is a saltwater body. Wet weather standard for indicator bacteria are based on a single-sample maximum allowable concentration presented as the wet weather WQO in Table 1-4. For Wet Weather Events 1 and 2, at least five bacteria samples were collected and each concentration was compared to the wet weather WQO to determine the percent exceedance. The EMC for Wet Weather Event 3 was compared directly to the wet weather WQO. A 22 percent exceedance allowance was applied to the wet weather water quality objectives for indicator bacteria, for preliminary comparison purposes, based on a SDRWQCB Beachs and Creeks TMDL (2007) and a natual loading study by SCCWRP (2007). The development of this preliminary exceedance allowance is described in Section 1.3.

- *Enterococcus*: For all wet weather events, 100 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 22 percent.

- Fecal Coliform: For Wet Weather Events 1 and 2, 91 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 22 percent. The Wet Weather Event 3 EMC at 5,000 MPN/100mL also exceeded the WQO.
- Total Coliform: For Wet Weather Events 1 and 2, 73 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 22 percent. The Wet Weather Event 3 EMC at 30,000 MPN/100mL also exceeded the WQO.

Dry weather standards for indicator bacteria require the application of two criteria; the geometric mean concentration and the single-sample maximum requirement. Per the Basin Plan, the geometric means must be derived from a minimum of five samples in a 30-day period and must not exceed the dry weather geometric mean WQOs. *Enterococcus* and total coliform samples may not exceed the single-sample maximum allowable concentrations that are presented as the wet weather WQOs in Table 1-4. However, fecal coliform samples have a ten percent allowable exceedance rate over a 30-day period when compared to the single-sample maximum allowable concentrations. The geometric means and single-sample exceedance frequencies for the index period events were compared to both dry weather WQO criteria. For each index period event, the geometric mean was calculated from the six samples collected. The breakdown of bacteria exceedance for index period events is as follows:

- *Enterococcus*: The geometric mean concentrations exceeded the dry weather geometric mean-based WQO of 35 CFU/100mL for all four index period events. For the entire monitoring period, 13 percent (3 of 24 samples) had concentrations that exceeded the single-sample maximum allowable concentration of 276 CFU/100mL. These exceedances occurred during Index Period Events 3 and 4.
- Fecal Coliform: The geometric mean concentrations exceeded the dry weather geometric mean-based WQO of 200 MPN/100mL for Index Period Events 2, 3, and 4. For the entire monitoring period, 50 percent (12 of 24 samples) had concentrations that exceeded the single-sample maximum allowable concentration of 400 MPN/100mL. These exceedances, listed by index period event, are as follows:
  - Index Period Events 2, 3, and 4 had concentrations greater than 400 MPN/100mL at a frequency of 17 percent (1 of 6 samples), 100 percent (6 of 6 samples), and 83 percent (5 of 6 samples), respectively, which exceeded the ten percent allowable frequency (per 30-day period).
- Total Coliform: The geometric mean concentrations exceeded the dry weather geometric mean-based WQO of 1,000 MPN/100mL for Index Period Events 3 and 4. For the entire monitoring period, 0 percent (0 of 24 samples) had concentrations that exceeded the single-sample maximum allowable concentration of 10,000 MPN/100mL.

TDS

For Wet Weather Events 1 and 2, eight pollutagraphs were collected and each concentration was compared to the WQO to determine the percent exceedance. The EMC for Wet Weather Event 3 was compared directly to the wet weather WQO.

- For Wet Weather Events 1 and 2 the mean concentration was 727 mg/L which exceeded the WQO of 500 mg/L. In total 56 percent of Mass Emission Station samples for Wet Weather Events 1 and 2 exceeded the WQO, versus an allowable exceedance of ten percent. The Wet Weather Event 3 EMC was 580 mg/L which also exceeded the WQO.

For each Index Period Event, six samples were collected and each concentration was compared to the WQO to determine the percent exceedance.

- For all index period results the mean concentration was 2,002 mg/L which exceeded the WQO of 500 mg/L. In total, 100 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of ten percent.

6.1.2.2 Event and Seasonal Variations

Variations in constituent concentrations between events and during events throughout the season are discussed for both wet and dry weather conditions. Both within-event and seasonal patterns can help better understand possible sources, processes, and mechanisms that affect runoff and associated bacteria concentrations.

Wet Weather – Seasonal Variations

For bacteria, Wet Weather Event 1 had higher concentrations than Wet Weather Events 2 and 3 (Tables 4-10 and 4-11). The following factors may have influenced the higher concentrations during Wet Weather Event 1: longer event duration, higher rainfall intensity, higher peak discharge, and a longer length of antecedent dry period and, therefore, potential for greater pollutant build-up prior to the event. In fact, SCCWRP found that antecedent dry period was strongly correlated with bacteria concentrations from mass emission sites in an exponential manner (Tiefenthaler, Stein and Shiff, 2008). For that study, early season storms generally had higher bacteria concentrations than late season storms both within and between watersheds, even when rainfall quantities were similar. SCCWRP attributed this to likely bacteria buildup during dry periods that flushes to rivers during early season storms. SCCWRP found that storm size may be a less reliable predictor of the magnitude of bacterial concentrations and loading.

For TDS, Wet Weather Events 1 and 2 had similar ranges in concentrations and EMCs. The TDS EMC for Wet Weather Event 3 was lower than the other two events (Table 5-2). For TSS, Wet Weather Events 2 and 3 EMCs exceeded the Wet Weather Event 1 EMC (Table 5-2).

Wet Weather – Within-Event Variations

Within-event variations were evaluated by assessing the concentrations graphs in Appendix E. For Wet Weather Event 1, bacteria concentrations appeared to remain fairly consistent throughout the event, with no apparent trends. However, for Wet Weather Event 2, bacteria concentrations increased slightly from the beginning of the event to the time of peak discharge. The highest concentrations appeared during the latter part of the event as the creek was returning to base flow conditions, as illustrated by samples collected 8 to 24 hours after the first peak of the storm event.

For both Wet Weather Events 1 and 2, the highest TDS concentrations occurred during the first six hours of each event prior to peak flow conditions. TDS concentrations then decreased and remained relatively stable throughout the remainder of the event (with some slight increases towards the end of each event). For Wet Weather Events 1 and 2, TSS concentrations appeared to correlate with the flow rate where higher concentrations occurred during higher flow rates and lower concentrations occurred during lower flow rates.

Another method to evaluate the variability of concentrations within events is to assess the magnitude of first-flush concentrations relative to the rest of the event. First-flush effects describe the effect of the early flows of a storm carrying a higher level of contaminants relative to the latter flows. First-flush ratios were calculated for the first two wet weather events where pollutagraph sampling occurred. First-flush ratios are the result of a partial event mean concentration (PEMC) divided by the entire event mean concentration (EMC) at distinct intervals during a storm event. First-flush effects are indicated by a ratio of greater than 1.0, with the effect being stronger with higher ratios. Table 6-2 presents the first-flush ratios for the first six hours of discharge for each wet weather event. Appendix F graphically present how the first-flush ratios changed throughout each wet weather event.

**Table 6-2: Agua Hedionda Concentration First-Flush Effects**

| Constituent | First-Flush Ratio[1] | | First-Flush Effect[2] |
|---|---|---|---|
| | Wet Weather Event 1 | Wet Weather Event 2 | |
| *Enterococcus* | 0.65 | 0.05 | None |
| Total Coliform | 0.99 | 0.11 | None |
| Fecal Coliform | 0.97 | 0.11 | None |
| TSS | 1.37 | 0.27 | Moderate to None |
| TDS | 1.35 | 3.25 | Moderate to Strong |

(1) The first-flush ratio presented is based on the ratio for the first two samples collected within the first 6 hours of discharge just prior to peak flows.
(2) Ratios > 2.0 were considered to have strong first-flush effects, ratios between 1.5 and 2.0 were considered to have moderate first-flush effects, ratios between 1.0 and 1.5 were considered to have minor first-flush effects, and ratios ≤ 1.0 were considered to have no first-flush effects.

As shown in Table 6-2, bacteria constituents did not show any first-flush effects during the wet weather events, as their first-flush ratios were, generally, less than one. Of the bacteria constituents, total coliform had a significantly higher ratio (0.99) than the other bacteria constituents. It should be noted that the lack of a first-flush effect for bacteria is contrary to findings by SCCWRP (Tiefenthaler, et al., 2008). This study found that the greatest concentrations of bacteria occurred at or just before the first peak in discharge of the storm event for most of the 20 events sampled. Generally, more pronounced first-flush effects are found in highly urbanized and impervious watersheds. All but two of the watersheds studied were urban, densely populated watersheds ranging from 49 to 94 percent developed (two relatively undeveloped, non-urban watersheds less than 5 percent developed were also monitored). By contrast, the Agua Hedionda watershed is listed as 80 percent developed, but only 20 percent impervious in the Carlsbad Watershed Management Plan. The SCCWRP study found that for the two undeveloped, non-urban watersheds, peak concentrations tended to occur later in the storm and persist for a longer duration (although bacteria concentrations steadily decreased following the early peak in storm), which is similar to what occurred at the Agua Hedionda Mass Emission Station.

Generally, both TDS and TSS showed moderate first-flush effects during the first wet weather event. Both constituents had ratios of approximately 1.4 after the first three hours of the storm and then dropped below 1.0 thereafter. These results were generally consistent with the results of the study by SCCWRP (Tiefenthaler, et al., 2008), where higher concentrations of suspended sediment were observed in the early part of the storm events. The second wet weather event results were notably different from the first. For this event, TDS showed a strong first-flush effect with a value of 3.25 and remained above 1.0 for the first four hours of the storm. TSS ratios were generally opposite to those of TDS with very low initial ratios indicating no first-flush effect. TSS ratios did rise above 1.0 approximately two to three hours into the wet weather event and decreased toward 1.0 throughout the remainder of the event.

Dry Weather – Seasonal Variations

Seasonal variations in dry weather concentrations can be significant and have both positive and inverse relationships with flow, temperature, and other factors. These variations and relationships with flow are shown on Table 6-2. Variations in constituent concentrations within and between each season are discussed below.

**Table 6-3: Agua Hedionda Mass Emission Station Concentrations by Season and Flow Regime**

| Constituent | Season[3] | Flow Regime[1] | | | | | Season Mean[2] |
|---|---|---|---|---|---|---|---|
| | | High Flows | Moist Conditions | Mid-Range Flows | Dry Conditions | Low Flows | |
| *Enterococcus* (CFU/100mL) | Winter | 8,050 | 159 | | | | 124 |
| | Spring | | | 124 | 130 | | 125 |
| | Summer | | | | 265 | 536 | 310 |
| | Fall | | | 155 | 241 | | 212 |
| | Flow Regime Average | 8,050 | 159 | 133 | 242 | 536 | 193 |
| Fecal Coliform (MPN/100mL) | Winter | 4,843 | 141 | | | | 116 |
| | Spring | | | 304 | 156 | | 280 |
| | Summer | | | | 640 | 3,940 | 1,190 |
| | Fall | | | 1,205 | 538 | | 760 |
| | Flow Regime Average | 4,843 | 141 | 562 | 551 | 3,940 | 586 |
| Total Coliform (MPN/100mL) | Winter | 28,141 | 247 | | | | 219 |
| | Spring | | | 781 | 160 | | 677 |
| | Summer | | | | 1,896 | 3,960 | 2,240 |
| | Fall | | | 2,070 | 1,270 | | 1,537 |
| | Flow Regime Average | 28,141 | 247 | 1,149 | 1,472 | 3,960 | 1,168 |
| TDS (mg/L) | Winter | 923 | 1,800 | | | | 1,740 |
| | Spring | | | 2,056 | 2,004 | | 2,047 |
| | Summer | | | | 2,034 | 1,960 | 2,021 |
| | Fall | | | 1,949 | 2,324 | | 2,199 |
| | Flow Regime Average | 923 | 1,800 | 2,025 | 2,147 | 1,960 | 2,002 |
| TSS (mg/L) | Winter | 107.7 | 5.4 | | | | 5.5 |
| | Spring | | | 1.4 | 0.3 | | 1.2 |
| | Summer | | | | 7.8 | 1.2 | 6.7 |
| | Fall | | | 3.6 | 6.8 | | 5.7 |
| | Flow Regime Average | 107.7 | 5.4 | 2.0 | 6.6 | 1.2 | 4.8 |

(1) Flow regimes are based on percent days exceeded and broken down into the following categories: high flows are classified as < 10% days exceeded; moist conditions are classified as > 10% and < 40% days exceeded; mid-range flows are classified as > 40% and < 60% days exceeded; dry conditions are classified as > 60% and < 90% days exceeded; low flows are classified as > 90% days exceeded.
(2) Season average does not include wet weather high flow events.
(3) Index Period 1 represents winter, Index Period 2 represents spring, Index Period 3 represents summer, Index Period 4 represents fall.

Winter

Index Period Event 1 was representative of dry weather conditions during the winter season. Samples were collected between February 7, 2008 and February 19, 2008. The water temperature at the Mass Emission Station ranged from 8.4 to 18 degrees Celsius. During this period, daily total discharges ranged from 389,909 to 563,696 cubic feet (Table 4-3), which exceeded the average daily dry weather discharge of 132,442 cubic feet (Table 5-1). As shown in Table 6-3, these discharges fell within the high flow and moist condition flow regimes.

Spring

Index Period Event 2 was representative of dry weather conditions during the spring season. Samples were collected between April 7, 2008 and April 16, 2008. The water temperature at the Mass Emission Station ranged from 12.1 to 26.6 degrees Celsius. During this event, daily total discharges ranged from 89,706 to 112,299 cubic feet (Table 4-3), which was below the average daily dry weather discharge of 132,442 cubic feet (Table 5-1), but above the median daily dry weather discharge of 79,728 cubic feet (Table 5-1). As shown in Table 6-2, these discharges fell within the mid-range flows and dry conditions flow regimes.

Summer

Index Period Event 3 was representative of dry weather conditions during the summer season. Samples were collected between July 21, 2008 and July 30, 2008. The water temperature at the Mass Emission Station ranged from 17.4 to 32 degrees Celsius. During this period, daily total discharge ranged from 22,215 to 30,500 cubic feet (Table 4-3), which was below the average and median daily discharges (Table 5-1). As shown in Table 6-2, these discharges fell within the dry conditions and low flow regimes.

Fall

Index Period Event 4 was representative of baseline conditions during the fall season. Samples were collected between October 7, 2008 and October 15, 2008. The water temperature at the Mass Emission Station ranged from 11.6 to 25.7 degrees Celsius. During this event, daily total discharge ranged from 22,215 to 30,500 cubic feet (Table 4-3), which was below the average and median daily discharges (Table 5-1).

Overall, as shown in Table 6-3, the highest bacteria concentrations occurred during high flow, wet weather events. Dry weather concentrations were orders of magnitude lower than the wet weather concentrations. During dry weather conditions, higher bacteria concentrations tend to occur during the

hotter, drier months of summer and fall generally characterized by slower moving, low flows within the creek. The summer mean concentrations for *Enterococcus*, fecal coliform, and total coliform were the highest compared to the mean concentrations for the other seasons. In contrast, the fall mean concentrations for *Enterococcus*, fecal coliform, and total coliform were the lowest compared to the means for the other seasons. For bacteria, higher temperatures and lower flows (and, therefore, slower velocities and potentially stagnant conditions) can provide an environment conducive to higher bacteria concentrations. Additionally, nuisance flows from urban land use activities, such as car washing, sidewalk washing, and lawn over-irrigation, tend to occur more frequently during the summer and fall. These nuisance flows can pick up and transport bacteria, potentially leading to higher bacteria concentrations in the creek.

The spring mean TDS concentration was relatively consistent with the mean TDS concentrations for the other seasons. The summer mean TDS concentration was slightly greater than the mean concentrations for the winter and fall. The winter TSS mean concentration was relatively consistent with the mean TSS concentrations for the summer and fall, although above the mean concentration for the spring. The spring mean TSS concentration (1.2 mg/L), however, was significantly lower than the mean TSS concentrations for the other index periods.

### 6.1.3 Agua Hedionda Constituent Concentrations – Lagoon Segment Site

The lagoon segment sampling characterized both seasonal and spatial variations, and helped establish baseline conditions to evaluate the lagoon's response during wet weather events.

#### 6.1.3.1 Comparison to Water Quality Objectives

A summary of concentrations for the Agua Hedionda Lagoon Segment, including geometric and arithmetic mean concentrations, ranges, and exceedances as compared to WQOs are provided in Tables 4-12 for wet weather events and in Table 4-20 for index period events. A comparison of concentrations to WQOs established in the San Diego Basin Plan was conducted for the following constituents:

- *Enterococcus*
- Fecal Coliform
- Total Coliform

Water quality at the Lagoon Segment varied for indicator bacteria during wet weather events. For Wet Weather Events 1, 2 and 3, two bacteria samples were collected and each concentration was compared to

the wet weather WQOs to determine the percent exceedance. A 22 percent exceedance allowance was applied to the wet weather water quality objectives for indicator bacteria, for preliminary comparison purposes, based on a SDRWQCB Beachs and Creeks TMDL (2007) and a natual loading study by SCCWRP (2007). The development of this preliminary exceedance allowance is described in Section 1.3.

- *Enterococcus*: For all wet weather events 67 percent of Lagoon Segment samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Fecal Coliform: For all wet weather events 50 percent of Lagoon Segment samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Total Coliform: For all wet weather events 17 percent of Lagoon Segment samples exceeded the WQO, versus an allowable exceedance of 22 percent.

Dry weather standards for indicator bacteria require the application of two criteria; the geometric mean concentration and the single-sample maximum requirement. Per the Basin Plan, the geometric means must be derived from a minimum of five samples in a 30-day period and must not exceed the dry weather geometric mean WQOs. *Enterococcus* and total coliform samples may not exceed the single-sample maximum allowable concentrations that are presented as the wet weather WQOs in Table 1-4. However, fecal coliform samples have a ten percent allowable exceedance rate over a 30-day period when compared to the single-sample maximum allowable concentrations. The geometric means and single-sample exceedance frequencies for the index period events were compared to both dry weather WQO criteria. For each index period event, the geometric mean was calculated from the twelve samples collected. The breakdown of bacteria exceedance for index period events is as follows:

- *Enterococcus*: The geometric mean concentrations for the Lagoon Segment and transects were below the dry weather geometric mean-based WQO of 35 CFU/100mL for all four index period events. For the entire monitoring period, 1 percent of Lagoon Segment and transect concentrations exceeded the single-sample maximum allowable concentration of 276 CFU/100mL. These exceedances, listed by sample site, are as follows:
  - Lagoon Segment: Two percent (1 of 48 samples) had concentrations greater than 276 CFU/100mL, which occurred during Index Period Event 4.
  - Transects: Zero percent (0 of 24 samples) had concentrations greater than 276 CFU/100mL.
- Fecal Coliform: The geometric mean concentrations for the Lagoon Segment and transects were below the dry weather geometric mean-based WQO of 200 MPN/100mL for all four index period events. For the entire monitoring period, 1 percent of Lagoon Segment and transect concentrations exceeded the single-sample maximum allowable concentration of 400 MPN/100mL. These exceedances, listed by sample site and index period, are as follows:

  - Lagoon Segment: Index Period Event 4 had concentrations greater than 400 MPN/100mL at a frequency of 8 percent (1 of 12 samples), which did not exceed the ten percent allowable frequency (per 30-day period).
  - Transects: Zero percent (0 of 24 samples) had concentrations greater than 400 MPN/100mL.

- Total Coliform: The geometric mean concentrations for the Lagoon Segment and transects were below the dry weather geometric mean-based WQO of 1,000 MPN/100mL for all four index period events. For the entire monitoring period, 0 percent of Lagoon Segment and Transect concentrations exceeded the single-sample maximum allowable concentration of 10,000 MPN/100mL.

6.1.3.2 Event and Seasonal Variations

Wet Weather – Seasonal Variations

As shown in Table 4-12, Wet Weather Event 1 had higher *Enterococcus* and fecal coliform concentrations while Wet Weather Event 2 had higher total coliform concentrations. Wet Weather Event 1 had the lowest TSS concentrations and Wet Weather Event 2 had the highest single-sample TSS concentration.

Wet Weather – Within-Event Variations

Within-event variations at the Lagoon Segment Site were related to tidal conditions. During Wet Weather Events 1 and 3, higher concentrations of all bacteria (Enterococcus, fecal coliform, and total coliform) were associated with slack low tide conditions. During Wet Weather Event 2 Enterococcus and total coliform had higher concentrations associated with slack low tide conditions. However, for this event the higher concentration of fecal coliform was associated with slack high tide conditions.

During all wet weather events, higher TSS concentrations were associated with slack low tides.

For all events, slack high tide samples were collected 6.5 to 7.5 hours prior to the collection of low tide samples. During Wet Weather Event 1, the high tide sample was collected six hours after rainfall began and the low tide sample was collected 13.5 hours after rainfall began. The timing of sample collection was similar for Wet Weather Events 2 and 3, high tide samples were collected 15 and 13 hours after rainfall began, respectively, and low tide samples were collected 21.5 and 20 hours after rainfall began, respectively.

Dry Weather – Seasonal Variations

As shown in Table 4-20, concentrations of indicator bacteria were generally low at the Lagoon Segment Site during dry weather conditions, with the exception of samples collected during the fall (Index Period Event 4). These samples had relatively higher concentrations for all indicator bacteria (Enterococcus, fecal coliform, and total coliform). Samples collected during the spring (Index Period Event 2) had lower ranges of bacteria concentrations than samples collected during the other seasons. Samples collected during the winter (Index Period Event 1) and summer (Index Period Event 3) had similar mean concentrations and ranges, although Enterococcus and total coliform had higher concentrations in the winter, whereas fecal coliform had slightly higher concentrations during the summer.

At the Lagoon Segment Site, TSS concentrations were lower during the winter, while the highest concentrations occurred during the fall. During the fall, water temperature ranged from 17.3 to 22.4 degrees Celsius and TSS concentrations ranged from 10 to 425 mg/L. However, samples collected during the summer had a higher range of values based on a median value of 40.5 mg/L, as compared median values of 29.0 mg/L and 25.8 mg/L for Index Period Events 2 and 4, respectively.

### 6.1.4 Agua Hedionda Constituent Concentrations – Ocean Inlet Sites

The ocean inlet sampling characterized the exchange between the lagoon and ocean during wet weather and index period events.

#### 6.1.4.1 Comparisons to Water Quality Objectives

A summary of concentrations for the Agua Hedionda Lagoon Ocean Inlet Sites, including geometric and arithmetic mean concentrations, ranges, and exceedances as compared to the WQO, are provided in Tables 4-13 and 4-14 for wet weather events and in Tables 4-21 and 4-22 for index period events. A comparison of concentrations to WQOs established in the San Diego Basin Plan was conducted for the following constituents:

- *Enterococcus*
- Fecal Coliform
- Total Coliform

For all wet weather events, two bacteria samples were collected at the Ocean Inlets and each concentration was compared to the wet weather WQO to determine the percent exceedance. A 22 percent exceedance allowance was applied to the wet weather water quality objectives for indicator bacteria, for

preliminary comparison purposes, based on a SDRWQCB Beachs and Creeks TMDL (2007) and a natual loading study by SCCWRP (2007). The development of this preliminary exceedance allowance is described in Section 1.3. A breakdown of water quality at the Ocean Inlet during all wet weather events is as follows:

- *Enterococcus*: For all wet weather events at Ocean Inlet 1 and 2, 0 percent of samples and 50 percent of samples, respectively, exceeded the WQO. In total, 23 percent of ocean inlet samples exceeded the WQO, versus an allowable 22 percent.
- Fecal Coliform: For all wet weather events at Ocean Inlet 1 and 2, 0 percent of samples and 40 percent of samples, respectively, exceeded the WQO. In total, 18 percent of ocean inlet samples exceeded the WQO, versus an allowable 22 percent.
- Total Coliform: For all wet weather events at Ocean Inlet 1 and 2, 0 percent of samples and 10 percent of samples, respectively, exceeded the WQO. In total, 5 percent of ocean inlet samples exceeded the WQO, versus an allowable 22 percent.

Dry weather standards for indicator bacteria require the application of two criteria; the geometric mean concentration and the single-sample maximum requirement. Per the Basin Plan, the geometric means must be derived from a minimum of five samples in a 30-day period and must not exceed the dry weather geometric mean WQOs. *Enterococcus* and total coliform samples may not exceed the single-sample maximum allowable concentrations that are presented as the wet weather WQOs in Table 1-4. However, fecal coliform samples have a ten percent allowable exceedance rate over a 30-day period when compared to the single-sample maximum allowable concentrations. The geometric means and single-sample exceedance frequencies for the index period events were compared to both dry weather WQO criteria. For each index period event, the geometric mean was calculated from the six samples collected. The breakdown of bacteria exceedance for index period events is as follows:

- *Enterococcus*: The geometric mean concentrations for Ocean Inlets 1 and 2 were below the dry weather geometric mean-based WQO of 35 CFU/100mL for all four index period events. For the entire monitoring period, 0 percent of samples had concentrations that exceeded the single-sample maximum allowable concentration of 276 CFU/100mL.
- Fecal Coliform: The geometric mean concentrations for Ocean Inlets 1 and 2 were below the dry weather geometric mean-based WQO of 200 MPN/100mL for all four index period events. For the entire monitoring period, 0 percent of samples had concentrations that exceeded the single-sample maximum allowable concentration of 400 MPN/100mL. There were no exceedances that were greater than the ten percent allowable frequency (per 30-day period).
- Total Coliform: The geometric mean concentrations for Ocean Inlets 1 and 2 were below the dry weather geometric mean-based WQO of 1,000 MPN/100mL for all four index period

events. For the entire monitoring period 0 percent of samples had concentrations that exceeded the single-sample maximum allowable concentration of 10,000 MPN/100mL.

6.1.4.2 Event and Seasonal Variations

Wet Weather – Seasonal Variations

As shown in Table 4-13, at Ocean Inlet 1, Wet Weather Event 1 had higher Enterococcus and fecal coliform concentrations while Wet Weather Event 2 had higher total coliform concentrations. At Ocean Inlet 2, Wet Weather Event 1 had higher Enterococcus concentrations while Wet Weather Event 2 had higher fecal coliform and total coliform concentrations. Wet Weather Event 3 had the lowest overall bacteria concentrations for Ocean Inlets 1 and 2. At Ocean Inlet 1, Wet Weather Event 2 TSS concentrations exceeded Wet Weather Event 1 TSS concentrations. Wet Weather Event 3 had the highest concentrations at this site. In contrast, TSS concentrations were higher during Wet Weather Event 2 at Ocean Inlet 2. Wet Weather Event 3 had the lowest TSS concentrations at this site.

Wet Weather – Within-Event Variations

Within-event variations were related to site and tidal conditions. For all events, slack high tide samples were collected 6.5 to 7.5 hours prior to the collection of low tide samples. During Wet Weather Event 1, the high tide sample was collected six hours after rainfall began and the low tide sample was collected 13.5 hours after rainfall began. The timing of sample collection was similar for Wet Weather Events 2 and 3, high tide samples were collected 15 and 13 hours after rainfall began, respectively, and low tide samples were collected 21.5 and 20 hours after rainfall began, respectively.

At Ocean Inlet 1, Wet Weather Event 1 had higher concentrations of all bacteria (Enterococcus, fecal coliform, and total coliform) associated with slack high tide conditions. However, Wet Weather Events 2 and 3 bacteria concentrations at this site were not associated with a particular tidal condition. At Ocean Inlet 2 during Wet Weather Events 1 and 3, higher concentrations of all bacteria (Enterococcus, fecal coliform, and total coliform) were associated with slack low tide conditions. During Wet Weather Event 2, the higher concentration of Enterococcus was associated with slack high tide conditions although fecal coliform and total coliform concentrations were not associated with a particular tidal condition.

The highest TSS concentrations were from samples collected during the slack low tides. During all wet weather events at Ocean Inlet 1, the maximum TSS concentrations were generally associated with slack high tides. In contrast, TSS concentrations at Ocean Inlet 2 were higher during Wet Weather Event 2 and during all events the maximum concentrations were generally associated with slack low tides.

Dry Weather – Seasonal Variations

As shown in Tables 4-21 and 4-22, concentrations of indicator bacteria were generally low at the ocean inlets during dry weather conditions. At Ocean Inlet 1, Enterococcus concentrations were consistent throughout each season based on similar ranges. At Ocean Inlet 2, Enterococcus concentrations were consistent throughout each season based on similar ranges, with the exception of summer (Index Period Event 3), which had relatively higher concentrations. For both Ocean Inlets, fecal coliform concentrations were similar during the winter and fall (Index Period Events 1 and 4, respectively). Fecal coliform concentrations were also similar for the spring and summer (Index Periods 2 and 3, respectively), although higher relative to the winter and fall concentrations. At Ocean Inlet 1, total coliform concentrations were similar for all seasons, except for the summer, which had relatively higher concentrations. At Ocean Inlet 2, total coliform concentrations were similar throughout all seasons.

At both ocean inlets, TSS concentrations were the highest during the spring. At Ocean Inlet 1, the winter and summer had similar TSS concentrations. TSS concentrations in the fall were slightly higher, although still below spring concentrations. At Ocean Inlet 2, TSS concentrations during the fall were lower than concentrations during the other seasons.

### 6.1.5 Agua Hedionda Site-to-Site Comparisons

For each site, wet weather and dry weather results were compared to the single-sample maximum allowable concentration then divided by the corresponding total number of wet weather or dry weather samples to determine the seasonal percent exceedance. Table 6-4 compares the WQO exceedance frequency at each site for wet and dry weather conditions.

**Table 6-4: Agua Hedionda Comparison of WQO Exceedance Frequency**

| Constituent | WQO | Units | Wet Weather | | | | WQO | Units | Dry Weather | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mass Emission[1] | Lagoon Segment | Ocean Inlet 1 | Ocean Inlet 2 | | | Mass Emission[1] | Lagoon Segment | Ocean Inlet 1 | Ocean Inlet 2 |
| *Enterococcus* | 276 | CFU/ 100mL | 100% | 66.7% | 0.0% | 50.0% | 276 | CFU/ 100mL | 12.5% | 2.1% | 0.0% | 0.0% |
| Fecal Coliform | 400 | MPN/ 100mL | 90.9% | 50.0% | 0.0% | 40.0% | 400 | MPN/ 100mL | 50.0% | 2.1% | 0.0% | 0.0% |
| Total Coliform | 10,000 | MPN/ 100mL | 72.7% | 16.7% | 0.0% | 10.0% | 10,000 | MPN/ 100mL | 0.0% | 0.0% | 0.0% | 0.0% |
| TDS | 500 | mg/L | 56.3% | NA | NA | NA | 500 | mg/L | 100% | NA | NA | NA |

(1) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.

Based on Table 6-4, during wet weather events, all sites had bacteria exceedances. However, exceedances were less frequent at the Lagoon Segment and Ocean Inlet Sites, and varied by constituent, event, and tide. The Mass Emission Station samples exceeded the WQO for bacteria throughout the dry season while, Lagoon Segment and Ocean Inlet 1 and 2 samples were below the WQOs.

Table 6-5 compares the mean concentrations at each site for wet and dry weather conditions.

**Table 6-5: Agua Hedionda Comparison of Mean Concentrations**

| Constituent | WQO | Units | Wet Weather | | | | WQO | Units | Dry Weather[1] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mass Emission[2] | Lagoon Segment | Ocean Inlet 1 | Ocean Inlet 2 | | | Mass Emission[2] | Lagoon Segment | Ocean Inlet 1 | Ocean Inlet 2 |
| *Enterococcus* | 276 | CFU/ 100mL | 9,517 | 829 | 110 | 403 | 35 | CFU/ 100mL | 166 | 5.51 | 2.24 | 4.24 |
| Fecal Coliform | 400 | MPN/ 100mL | 4,866 | 880 | 95.0 | 612 | 200 | CFU/ 100mL | 346 | 6.88 | 4.91 | 5.81 |
| Total Coliform | 10,000 | MPN/ 100mL | 36,409 | 5,293 | 645 | 5,347 | 1,000 | CFU/ 100mL | 756 | 12.7 | 9.37 | 11.5 |
| TDS | 500 | mg/L | 727 | NA | NA | NA | 500 | mg/L | 2,002 | NA | NA | NA |
| TSS | NA | mg/L | 131 | 89.6 | 38.5 | 51.1 | NA | mg/L | 4.79 | 49.4 | 21.7 | 50.6 |

(1) Enterococcus, fecal coliform, and total coliform were calculated as geometric means for dry weather events, whereas all other constituents were calculated as arithmetic means.
(2) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.

During wet weather events, the Mass Emission Station, Lagoon Segment, and Ocean Inlet 2 had bacteria exceedances based on mean concentrations. The Mass Emission Station had the highest mean bacteria and TSS concentrations while the Ocean Inlet 1 had the lowest mean bacteria and TSS concentrations. Lagoon Segment and Ocean Inlets 1 and 2 had total coliform mean concentrations below the associated WQOs during wet weather events. The Mass Emission Station bacteria mean concentrations exceeded the WQO for bacteria throughout the dry season while, Lagoon Segment and Ocean Inlet mean concentrations were below the dry weather WQOs. Mean TSS concentrations were lowest at the Mass Emission Station than the Lagoon Segment and Ocean Inlets.

### 6.1.6 Agua Hedionda Mass Emission Station Constituent Loading

Constituent loading is an important factor when considering point and nonpoint source contaminant input to a receiving water body. While constituent concentrations provide information on specific contaminant levels at a given point in time, load estimations consider discharge amounts along with constituent concentrations to provide insight into the overall amount of targeted constituents introduced into a water body. For example, equal concentrations of a given constituent measured under different flow regimes

will result in different load values, which contribute to a better understanding of the impacts of that given constituent.

Although, the watershed may contribute to the constituent loading, the lagoon is subject to other inputs and processes that influence water quality as presented in Figures 1-1 to 1-4 of Section 1.4. As part of the load assessment, load estimates were developed for the watershed associated with the Mass Emission Station only. It should be noted that the watershed for the Mass Emission Station represents approximately 59 percent of the entire watershed for the Agua Hedionda Lagoon. The other 41 percent of the watershed comprises the area discharging into the lagoon (or the creek) from adjacent lands downstream from the Mass Emission Station. Runoff from this area generally sheet flows into the lagoon from pervious surfaces or discharges into storm drains that then discharge directly into the lagoon. The total load entering the lagoon (and the lagoon's loading capacity) would, therefore, include loads from the watershed for the Mass Emission Station and the loads for the watershed(s) downstream from the Mass Emission Station. Although the load assessments in this section do not account for this additional area downstream from the Mass Emission Station, the assessments still provide snapshots of the potential impacts of loading from the Mass Emission Station's watershed on the lagoon.

#### 6.1.6.1 Daily and Annual Loading

Total daily and annual flows for the Agua Hedionda Lagoon Mass Emission Station are reported in Section 4.1.1.2. Detailed continuous stage and flow data results for the entire monitoring period are presented in Appendix A-1. Section 4.1.2.1 contains hydrographs and hyetographs depicting total rainfall, rainfall intensity, and discharge for monitored wet weather events (Figures 4-1 through 4-3).

Total daily and annual loads for the Agua Hedionda Lagoon Mass Emission Station are reported in Section 5.1.1.3. Daily load estimates are provided for both wet weather and dry weather periods in Table 5-3. Total annual load estimates are provided in Table 5-4. Detailed daily and annual load calculations are provided in Appendix D-1.

As shown in Table 5-3 in Section 5, the average daily wet weather loads greatly exceed the daily average dry weather loads due to higher constituent concentrations for all constituents (except TDS) and significantly greater flows during wet weather conditions.

Also, as shown in Table 5-4, the total annual wet weather load for every constituent, except TDS, represents approximately 99 percent of the total annual dry and wet weather load. This is typical for

Southern California watersheds. For example, for the bacteria TMDLs developed for beaches and creeks by SDRWQCB (2007), wet weather loads constituted approximately 99 percent of the total annual loads for bacteria.

For TDS, the total annual wet weather load is nearly identical to the total annual dry weather load. Although the total annual wet weather flows significantly exceeded the total dry weather flows, TDS concentrations during dry weather conditions averaged approximately 2,000 mg/L, whereas concentrations during wet weather conditions averaged 178 mg/L.

#### 6.1.6.2 Event and Seasonal Variations

Variations in constituent loading between events throughout the season and during events are discussed for both wet and dry weather conditions. Both within-event and seasonal patterns can help provide a better understanding of possible sources, processes, and mechanisms that affect runoff and associated bacteria concentrations.

<u>Wet Weather - Seasonal Variations</u>

Seasonal wet weather variations in bacteria loading were assessed by reviewing the load duration curves in Appendix H-1 and comparing the total constituent loads for each event.

Overall, Wet Weather Event 1 peak flows and bacteria loading rates were higher than the peak flows and loading rates that occurred during Wet Weather Event 2. Peak loading rates during Wet Weather Event 1were approximately four times the loading rates during Wet Weather Event 2.

For bacteria, the three bacteria constituents exceeded their associated wet weather loading capacities for all three wet weather events. These exceedances occurred under high flow regimes, which also indicated these exceedances were likely resulting from non-point source inputs. These non-point source inputs include urban runoff resulting in the flushing of the storm water drainage and the washing of streets and yards in areas with significant domestic and wildlife populations.

Table 6-6 shows the total loads for bacteria during the three monitored wet weather events. Total loads for all three bacteria constituents were highest during Wet Weather Event 1. This is primarily due to the significantly higher total discharge volume associated with Wet Weather Event 1. Wet Weather Events 2 and 3 had discharge volumes that were more similar and this is reflected in the relative similarity in bacteria total loads calculated for those events.

**Table 6-6: Agua Hedionda Wet Weather Event Total Load Estimates**

| Event | *Enterococcus* | Fecal Coliform | Total Coliform | TDS | TSS |
|---|---|---|---|---|---|
| Wet Weather Event 1 | 159,910 | 69,036 | 346,938 | 1,124,341 | 268,408 |
| Wet Weather Event 2 | 16,026 | 8,103 | 67,236 | 144,025 | 63,819 |
| Wet Weather Event 3 | 12,164 | 11,546 | 70,100 | 190,642 | 89,607 |

TDS exceeded the wet weather loading capacity during all three wet weather events for all but two samples, where one sample during each of Wet Weather Event 1 and 2 fell just below the loading capacity. One notable point is that the daily load results from wet weather events that exceeded the loading capacities set by the WQO exceeded that capacity by a relatively small margin when compared to index period event results.

Table 6-6 shows the total loads for TDS and TSS during the three monitored wet weather events. Total load for TDS and TSS was highest during Wet Weather Event 1. This is primarily due to the significantly higher total discharge volume associated with Wet Weather Event 1. Wet Weather Events 2 and 3 had discharge volumes that were more similar and this is reflected by the similarity in TDS and TSS total loads calculated for those events.

Wet Weather - Within-Event Variations

Pollutagraph sampling provided information on varying contaminant levels throughout Wet Weather Events 1 and 2. As flows varied throughout these wet weather events, contaminant loads varied as well. Results from pollutagraph sampling were used to calculate changing loading rates throughout both pollutagraph sampling events. These load pollutagraphs show loading rates along with discharge throughout each wet weather event. Based on the length of each monitored wet weather event, different time intervals were selected to calculate loading rates. A three-hour interval was selected for Wet Weather Event 1, which lasted approximately 53 hours. A one-hour interval was selected for Wet Weather Event 2, which lasted approximately 24 hours. Appendix G-1 contains the load pollutagraphs for all monitored constituents during the first two wet weather events for the following constituents:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- TDS
- TSS

Wet Weather Event 1 had two discharge peaks, which affected loading rates during the event. Relative to discharge throughout the event, *Enterococcus* and fecal coliform both had higher loading rates during the second peak compared to the first peak. Total coliform, however, showed a higher loading rate during the first peak compared to the second peak. The loading rates for TDS and TSS appeared to correlate well with the flow rates throughout the event. Because only five bacteria samples were collected throughout the event (as compared to eight samples for TDS and TSS), the first loading rate interval with TDS and TSS results does not have corresponding bacteria loading rates. With the exception of this interval, the loading rates for *Enterococcus* and fecal coliform appear to correlate closely to the loading rates for TDS and TSS (particularly as compared to the loading rates for total coliform). Generally, these constituents show a lower loading rate relative to the first peak in the storm event and a higher loading rate relative to the second peak in the storm event. Total coliform appeared to correlate well with the first peak in discharge.

Wet Weather Event 2 was a shorter event and had a single peak in discharge. The five monitored constituents generally showed higher loading rates at the initial peak of the hydrograph. One notable exception was total coliform, where loading rates continued to persist at a relatively high rate after the peak discharge when compared to both discharges and to other bacteria loading rates.

Another method to evaluate the variability of loads within events is to assess the magnitude of the first-flush loads relative to the rest of the event. Mass first-flush is similar to the concentration first-flush discussed earlier; however, mass first-flush is based on a loading approach for an entire event. Mass first-flush describes the percent mass of monitored analytes that have been observed in the first 20 to 40 percent of storm discharge volume. Higher percent mass, those greater than 80 percent, for a given analyte has been suggested as an indicator that an analyte demonstrates a strong mass first-flush effect (Kayhanian and Stenstrom, 2008).

Table 6-7 presents the percent mass values along with the associated percent of storm discharge for both wet weather events.

**Table 6-7: Agua Hedionda First-Flush Percent Mass**

| Analyte | Wet Weather Event 1 (at 28% of Storm Discharge) | | Wet Weather Event 2 (at 36% of Storm Discharge) | |
|---|---|---|---|---|
| | Mass First-Flush % | First-Flush Effect[1] | Mass First-Flush % | First-Flush Effect[1] |
| *Enterococcus* | 14 | None | 26 | None |
| Fecal Coliform | 12 | None | 25 | None |
| Total Coliform | 51 | Minor | 7 | None |
| TDS | 23 | None | 33 | None |
| TSS | 16 | None | 48 | Minor |

(1) For discussion purposes first-flush categories are defined as follows: strong = > 80%, moderate = < 80% and > 60%, minor = < 60% and > 35%, none = < 35%.

None of the constituents monitored at the Agua Hedionda Mass Emission Station demonstrated a strong mass first-flush effect. The strongest mass first-flush effect throughout both events was demonstrated by TSS during Wet Weather Event 2. This result is in contrast to the concentration-based first-flush analysis of TSS, where TSS did not show first-flush effects during Wet Weather Event 2, but showed a moderate effect during Wet Weather Event 1. TDS was similar in that the mass first-flush results were opposite those from the concentration first-flush results. However, in the case of TDS, during Wet Weather Event 2, the concentration-based first-flush ratio demonstrated a strong first-flush effect and the mass-based first-flush ratio did not indicate a first-flush effect.

During Wet Weather Event 1 both TSS and TDS showed moderate first-flush effects based on concentration first-flush ratios between 1.0 and 1.5. However, the mass-based first-flush ratios did not indicate a first-flush effect. These results highlight the importance of a loading versus concentration analyses, as the mass-based and concentration-based first-flush results for TSS and TDS show opposite results. Total discharge influences the overall amount of a constituent being input into a water body and is important when consider in the next step of the TMDL process.

Seasonal Variations – Dry Weather

Seasonal dry weather variations in bacteria loading were assessed by comparing the average constituent loads for each event in Table 5-6 and reviewing the load duration curves in Appendix H-1.

Average total load for *Enterococcus* was the highest during the winter months, but did not vary much through the remaining seasons. This may be attributed to the higher flows experienced during those months as the mean concentration for that period was the lowest of the four index period events. *Enterococcus* average load was the lowest during the summer months despite reporting the highest

average concentration. Low discharge during this period resulted in the low average load. Spring and fall average loads were close due to discharge during those periods as the corresponding average concentrations were higher in the fall than the spring.

Average total load for fecal coliform was highest during the fall months. Fall reported the second highest average concentration, behind summer, however higher discharge was reported for fall compared to summer resulting in contrasting load and concentration values. Average fecal coliform during the winter months was the lowest of all four seasonal periods; however, average load was the second highest due to high discharge during that period. Average spring load was very similar to summer despite reporting a much lower average concentration. Higher discharge during spring compared to summer resulted in relatively equal load values.

Average total coliform loads during winter and spring were similar due to higher flows during the winter months but lower average concentration when compared to spring. Fall months had the highest load as a result of a combination of the high average concentration and moderate discharge. Summer recorded the highest average concentration however when combined with low discharge the average load was the lowest of all four seasonal periods.

Average TDS and TSS loads followed similar patterns through the four seasonal periods. Average concentrations for both constituents were fairly consistent throughout the monitoring period resulting in loads correlating strongly to discharges associated with those periods. There was one exception with TSS during the spring period where average concentration was relatively low compared to the other three index period events. This resulted average load for that period being the lowest for all seasonal periods and not following discharge trends.

Exceedances of the loading capacities varied throughout each season. *Enterococcus* exceeded the dry weather water loading capacity during each of the four seasons. These exceedances occurred under all flow regimes suggesting that *Enterococcus* exceedances are a result of both point and non-point sources. Influences from non-point sources appear to have occurred during the first index period which took place in winter with residual effects from wet weather events. Dry weather fecal coliform samples collected during high flows and moist conditions in the winter did not exceed loading capacities. Most fecal coliform samples collected during the spring and summer and all of the samples collected during the fall exceeded the loading capacities. These exceedances occurred during the mid-range flow, dry conditions, and low flow regimes. Total coliform followed the same pattern as fecal coliform, with the exception that

all summer samples and most samples collected during the fall exceeding the loading capacities. These results suggest that dry weather total and fecal coliform loading capacity exceedances may be driven primarily by point source inputs, such as dry weather discharge from storm drains. Dry weather discharges may be associated activities such as car washing, yard irrigation and other urban activities as well as agricultural runoff.

The TDS loading capacity was exceeded during all seasons under all flow regimes. A possible source can be agricultural runoff.

### 6.1.7 Agua Hedionda Summary of Key Findings

For the 2008-2009 monitoring year, precipitation totaled 11.29 inches, which was slightly below the mean annual rainfall of approximately 13 inches. Approximately 189 million cubic feet of water discharged into the lagoon from Agua Hedionda Creek. Of that amount, approximately 68 percent was discharged during wet weather events during the winter. For the two largest precipitation events, the runoff coefficients averaged 0.04, indicating that the majority of the precipitation infiltrated into the soil, ponded, or was diverted or retained before reaching the lagoon. Based on the sampling results and data assessment, a summary of the key findings for each constituent category are presented below.

<u>Bacteria</u>

Comparison to WQOs:

- WQOs and loading capacities were exceeded during wet weather conditions at almost all locations, indicating that beneficial uses of the lagoon may have been impacted during wet weather conditions.
- Although WQOs and loading capacities were exceeded at the Mass Emission Station, no exceedances occurred within the lagoon or at the ocean inlets during dry weather conditions. This suggests that the beneficial uses of the lagoon were not impacted during dry weather conditions.

Seasonal Variations:

- Seasonal variations were observed at the Mass Emission Station for both wet and dry weather conditions for all bacteria indicators. Wet weather concentrations were greater than dry weather concentrations by approximately 1,100 percent (for fecal coliform) and 5,200 percent (for *Enterococcus*). During wet weather conditions, Wet Weather Event 1 concentrations and loadings were greater than Wet Weather Events 2 and 3 concentrations suggesting the presence of a seasonal first-flush.
- During dry weather conditions, higher bacteria concentrations occurred during the summer months, characterized by lower flows and hotter temperatures. The lowest concentrations

occurred during the winter and spring seasons, particularly during relatively higher flow conditions.

- Within the lagoon, the highest concentrations occurred during wet weather conditions, with lower concentrations during dry weather conditions. For dry weather conditions, the fall had the highest concentrations (although still below WQOs) and the spring had the lowest concentrations.

Within-Event Variations:

- Generally, bacteria concentrations were similar throughout wet weather events. As a result, no concentration or mass-based first-flush effects were found. This lack of a first-flush effect is generally characteristic of watersheds that are less urbanized and not highly impervious.
- Within-event variations in the lagoons correlated with the tides, with higher bacteria concentrations generally occurring during slack low tides. However, at the ocean inlets, tidal variations in concentrations varied by event and ocean inlet sites.

Total Dissolved Solids and Sediment

Comparison to WQOs:

- WQOs and loading capacities for TDS were exceeded during wet and dry weather conditions at the Mass Emission Station. TDS samples were not required for collection within the lagoon or at the ocean inlet.

Seasonal Variations:

- TDS concentrations at the Mass Emission Station were similar for Wet Weather Events 1 and 2 and slightly lower for Wet Weather Event 3.
- During dry weather conditions, TDS concentrations were similar throughout the different seasons and flow regimes, with the lowest concentrations associated with the relatively higher flow regimes during the winter.
- TSS concentrations at the Mass Emission Station during Wet Weather Events 2 and 3 were greater than Wet Weather Event 1 concentrations.
- During dry weather conditions, TSS concentrations were the highest for the high flow regime during the winter. TSS concentrations were relatively consistent throughout the rest of the year, with the lowest concentrations occurring during the spring.
- The Mass Emission Station had bacteria concentrations significantly greater than all the other sites for all wet weather events and dry weather events. During dry weather events, the Segment and Ocean Inlet 2 had TSS concentrations greater than the Mass Emission Station.

Within-Event Variations:

- For TDS, the highest concentrations tended to occur within the first six hours of each event prior to peak flow conditions.

- For TSS, concentrations generally correlated with the flow rate, i.e., higher concentrations during higher flows and lower concentrations during lower flows.
- Generally inconsistent first-flush effects were found. TDS had moderate to strong concentration-based first-flush effects. However, TDS did not have a mass-based first-flush effect. This was due to relatively high concentrations during the first six hours of discharge, but only on the early part of the rising limb of the hydrograph. As these concentrations occurred during a relatively low flow period, only minor loading occurred. Concentrations remained fairly consistent throughout the rest of the event.
- TDS had a moderate concentration-based first-flush effect during Wet Weather Event 1, but no concentration-based first-flush effect during Wet Weather Event 2. Little to no mass-based, first-flush effects were found.

## 6.2 BUENA VISTA LAGOON DISCUSSION

### 6.2.1 Buena Vista Daily, Monthly, and Annual Rainfall

Based on measurements at the Mass Emission Station, Buena Vista Lagoon received 11.58 inches of rain between October 1, 2007 and October 31, 2008. Daily and monthly rainfall totals are summarized in Table 4-26. January had the most rainfall, 4.09 inches, followed by February, which had 3.35 inches. The majority of the rainfall, 98 percent, occurred during the winter months of November through February.

Isopluvial maps from the San Diego County Hydrology Manual indicate that the mean annual rainfall for the Buena Vista Watershed area is about 13 inches, ranging between approximately 12 to 14 inches (Chang, 2009). Based on this data, the total rainfall at the Buena Vista Mass Emission Station (located near the 12-inch isopluvial) during the monitoring period was slightly (about 4 percent) less than average for the area.

#### 6.2.1.1 Buena Vista Watershed Response to Rainfall

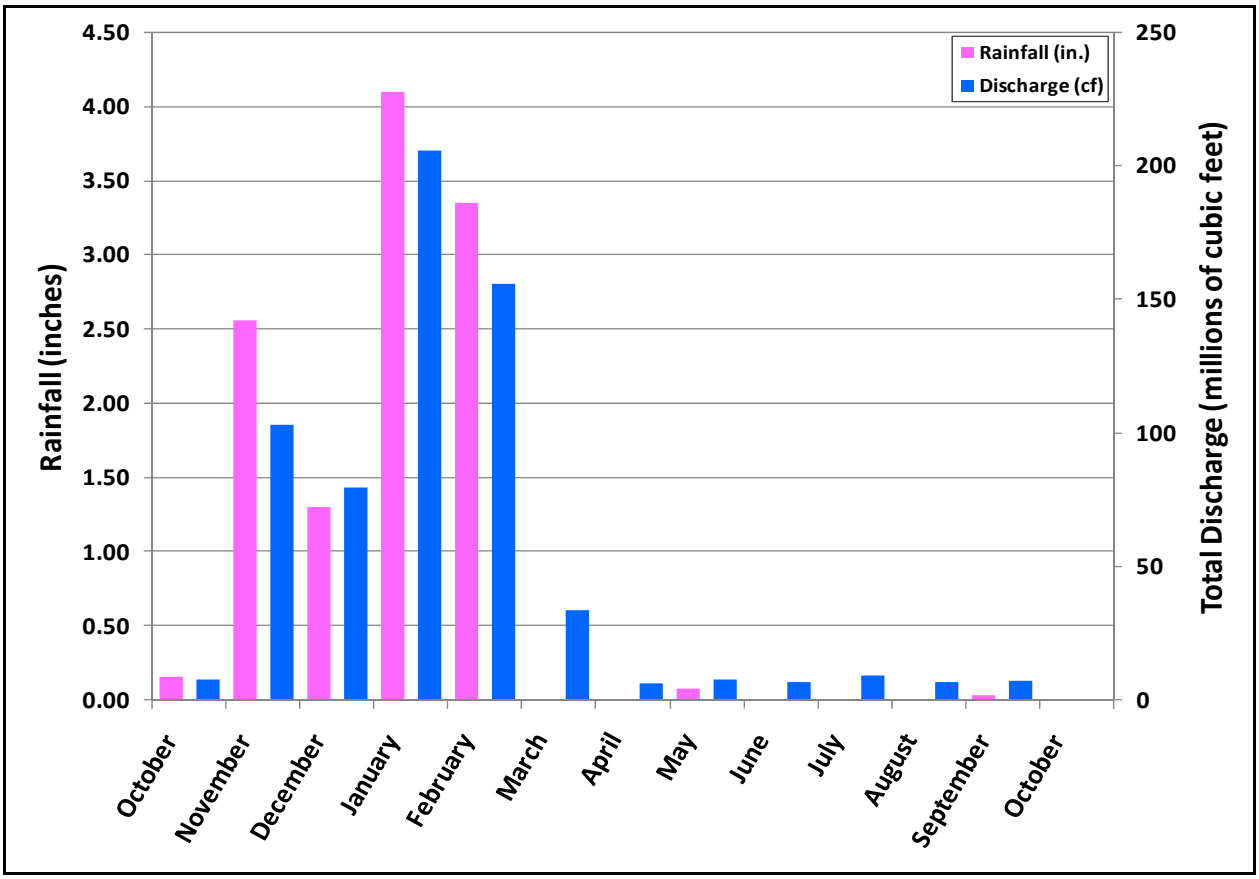
The Buena Vista Watershed covers an area of approximately 14,437 acres and extends about 10.60 miles inland from the coast, representing 11 percent of the CHU. The Buena Vista Watershed includes portions of the Cities of Carlsbad, Oceanside, Vista, and unincorporated County of San Diego land. Approximately 80 percent of the watershed is developed. Generally riparian vegetation is fragmented into isolated patches within the watershed. The vast majority of the watershed consists of an urban landscape, including developed parks and residential areas as well as a major regional shopping center and adjacent freeway / highway system. Impervious surface in the Buena Vista Watershed is estimated at 31 percent, which is among the highest in the CHU (Carlsbad Watershed Management Plan, 2002).

Watershed response to rainfall is characterized by the discharge volumes and peak flows of Buena Vista Creek at the Mass Emission Station. Watershed response varies throughout the season based on factors such as antecedent soil moisture conditions, impervious area, rainfall amount, and rainfall intensity. Antecedent soil moisture condition throughout the watershed is the saturation levels of the soil from previous storm events. Earlier in the season, when the watershed soil conditions are drier, the ground can soak up more water and therefore discharge less. Later in the season after a few storm events, the ground is more saturated, resulting in greater discharge volumes and higher peak flows (UCANR, 2002). Impervious area is directly related to urban development and includes paved surfaces, structures, and other land uses where soil is not exposed and able to absorb rainfall. This facilitates direct storm water

runoff resulting in higher discharge volumes and higher peak flows as the response to rainfall is immediate.

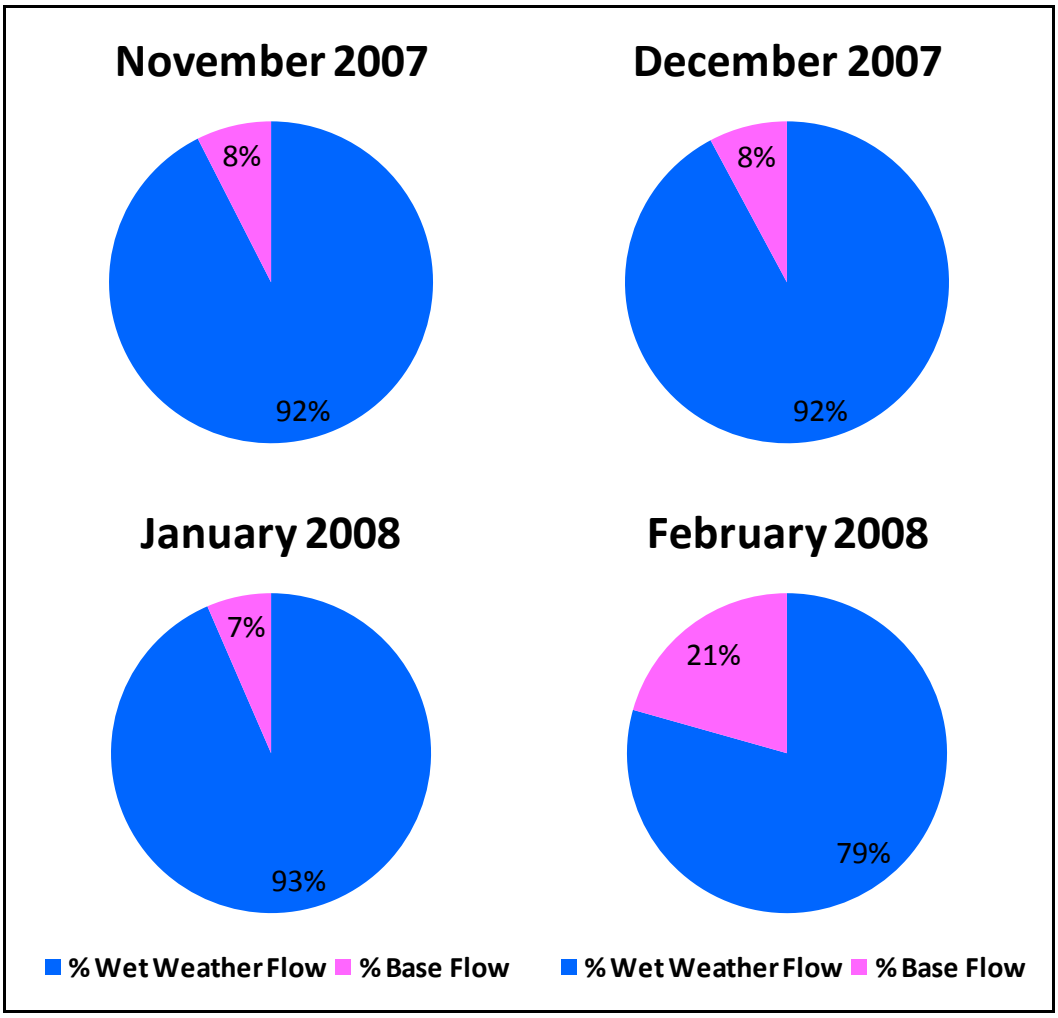
Daily and monthly discharge totals are summarized in Table 4-27. A total of 640,319,759 cubic feet was discharged into the Buena Vista Lagoon via Buena Vista Creek between October 1, 2007 and October 31, 2008. The three largest events occurred on November 30, 2007, January 5 to 7, 2008 and February 22, 2008 and produced approximately 130 million, 113 million, and 60 million cubic feet of discharge, respectively, and had peak discharge rates of approximately 2640 cfs, 1252 cfs, and 2065 cfs, respectively. The response to rainfall is depicted by the highest discharge totals corresponding to the months with the highest rainfall totals. The relationship between monthly rainfall and discharge totals are shown graphically on Figure 6-3.

**Figure 6-3: Buena Vista Mass Emission Station Monthly Rainfall and Discharge Totals**



Rainfall intensity and amount affect the relationship between rainfall and watershed discharge. Although the overall relationship between rainfall and discharge was relatively stable, the amount of discharge due to wet weather events can vary based on the intensity, timing, and amount of rainfall associated with a given storm event. Figure 6-4 shows the percentage of discharge attributed to direct runoff during wet weather events as compared to base flow conditions. Base flows represent stream flow resulting from precipitation that infiltrates into the soil that eventually moves through the soil to the stream channel, as well as dry weather urban runoff such as irrigation. Discharge due to wet weather events includes water directly running off the surface from rainfall and does not include ground water discharge or seepage from saturated soils. November, December, and January report very similar percentages of runoff due to wet weather related discharge at 92 to 93 percent. February experienced the lowest percentage of wet weather related runoff at 79 percent. The consistent nature of wet weather runoff compared to base flow in the Buena Vista Watershed may be attributable to the relatively high percentage of impervious surface, which is among the highest in the CHU, along with the fact that 80 percent of the watershed is developed. Although February reported a relatively high percentage of wet weather related runoff, it was not as consistent as the other three months. This may be due to increased base flow late in the season after the watershed had become saturated and an increased contribution of flow in stream channels from soil drainage. Throughout the entire year approximately 535 million cubic feet of discharge was due to wet weather, accounting for 84 percent of the total amount discharged into Buena Vista Lagoon.

**Figure 6-4: Buena Vista Monthly Percentage of Watershed Discharge Due to Wet Weather Events Compared to Base Flow**




### 6.2.2 Buena Vista Constituent Concentrations – Mass Emission Station

Constituent concentrations for the range of events monitored provide a snapshot of the variation in watershed input and the lagoon's response to different flow and seasonal conditions. A comparison of constituent concentrations to the associated WQOs provided in Table 1-4 in Section 1.3 helps assess the overall water quality of the lagoon during wet and dry weather conditions. The Mass Emission Station characterizes the watershed contribution during wet and dry weather conditions. Although, the mass emission station is key contributor the lagoon is subject to other inputs and processes that influence water quality as presented in Figures 1-1 to 1-4 of Section 1.4.

A summary of concentrations for the Mass Emission Station at Buena Vista Lagoon, including geometric means, arithmetic means, ranges and exceedances compared to WQOs, are provided in Tables 4-31 and 4-32 for wet weather events and in Table 4-38 for index period events.

#### 6.2.2.1 Comparison to Water Quality Objectives

A comparison of concentrations to the WQOs was conducted for the following constituents with WQOs established in the Basin Plan:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- Ammonia as nitrogen
- Chlorophyll *a*
- Nitrate+Nitrite (N+N)
- Total Nitrogen (TN)
- Total Phosphorus (TP)

<u>Bacteria</u>

For Wet Weather Events 1 and 2, at least five bacteria samples were collected at the Mass Emission Station and each concentration was compared to the wet weather WQO to determine the percent exceedance. The EMCs for Wet Weather Event 3 were compared directly to the wet weather WQOs. A 22 percent exceedance allowance was applied to the wet weather water quality objectives for indicator bacteria, for preliminary comparison purposes, based on a SDRWQCB Beachs and Creeks TMDL (2007) and a natual loading study by SCCWRP (2007). The development of this preliminary exceedance allowance is described in Section 1.3. The breakdown of bacteria exceedances for wet weather events is as follows:

- *Enterococcus:* For all wet weather events, 100 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Fecal Coliform: For Wet Weather Events 1 and 2, 83 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 22 percent. The Wet Weather Event 3 EMC at 5,000 MPN/100mL also exceeded the WQO.
- Total Coliform: For Wet Weather Events 1 and 2, 75 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 22 percent. The Wet Weather Event 3 EMC at 80,000 MPN/100mL also exceeded the WQO.

Dry weather standards for indicator bacteria require the application of two criteria; the geometric mean concentration and the single-sample maximum requirement. Per the Basin Plan, the geometric means

must be derived from a minimum of five samples in a 30-day period and must not exceed the dry weather geometric mean WQOs. *Enterococcus* and total coliform samples may not exceed the single-sample maximum allowable concentrations that are presented as the wet weather WQOs in Table 1-4. However, fecal coliform samples have a ten percent allowable exceedance rate over a 30-day period when compared to the single-sample maximum allowable concentrations. The geometric means and single-sample exceedance frequencies for the index period events were compared to both dry weather WQO criteria. For each index period event, the geometric mean was calculated from the six samples collected. The breakdown of bacteria exceedance for index period events is as follows:

- *Enterococcus*: The geometric mean concentrations exceeded the dry weather geometric mean-based WQO of 33 CFU/100mL for all four index period events. For the entire monitoring period, 58 percent (14 of 24 samples) had concentrations that exceeded the single-sample maximum allowable concentration of 108 CFU/100mL. These exceedances occurred during Index Period Events 1, 3, and 4.
- Fecal Coliform: The geometric mean concentrations exceeded the dry weather mean-based WQO of 200 MPN/100mL for Index Period Events 3 and 4. For the entire monitoring period, 42 percent (10 of 24 samples) had concentrations that exceeded the single-sample maximum allowable concentration of 400 MPN/100mL. These exceedances, listed by index period event, are as follows:
  - Index Period Events 1, 3, and 4 had concentrations greater than 400 MPN/100mL at a frequency of 17 percent (1 of 6 samples), 83 percent (5 of 6 samples), and 67 percent (4 of 6 samples), respectively, which exceeded the ten percent allowable frequency (per 30-day period).
- Total Coliform: The geometric mean concentrations did not exceed the dry weather geometric mean-based WQO of 1,000 MPN/100mL. For the entire monitoring period, 0 percent (0 of 24 samples) had concentrations that exceeded the single-sample maximum allowable concentration of 10,000 MPN/100mL.

Nutrients

Based on the limited availability of site-specific criteria the following WQOs were used for preliminary analysis purposes. SCCWRP in collaboration with SWRCB, USEPA, and other agencies are working to develop nutrient numeric endpoints for coastal water bodies (SCCWRP, 2009).

Wet and dry weather standards for nutrients vary by constituent; WQOs are based on an allowable exceedance that consider background levels or numerical limits that represent the maximum levels of constituents. N+N, TN, and TP have a ten percent allowable annual exceedance frequency. For N+N, TN, and TP each concentration was compared to the wet weather WQO to determine the percent exceedance. Ammonia and chlorophyll *a* are based on a numerical objective. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were

above the WQO. In addition, a percent exceedance was calculated for ammonia to provide a relative comparison with the other nutrients. For Wet Weather Events 1 and 2, at least eight pollutagraphs were collected at the Mass Emission Station and each concentration was compared to the WQO. The EMC for Wet Weather Event 3 was compared directly to the wet weather WQOs. The breakdown of nutrient exceedances for wet weather events is as follows:

- Ammonia: For Wet Weather Events 1 and 2, the mean concentration was 0.15 mg/L, which did exceed the WQO of 0.025 mg/L. In total, 88 percent of Mass Emission Station samples exceeded the WQO. The Wet Weather 3 EMC at 0.13 mg/L also exceeded the WQO.
- Chlorophyll *a*: Wet weather samples collected at the Mass Emission Station were not required to be analyzed for Chlorophyll per the QAPP and Work Plan.
- N+N: For all wet weather events, no Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 10 percent.
- TN: For Wet Weather Events 1 and 2, 94 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 10 percent. No Wet Weather Event 3 sample was analyzed for TN.
- TP: For Wet Weather Events 1 and 2, 88 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 10 percent. The Wet Weather Event 3 EMC was 0.43 mg/L, which also exceeded the WQO.

A total of 24 samples were collected during four index period events, and each concentration was compared to the dry weather WQO to determine the percent exceedance. N+N, TN, and TP percent exceedances were compared to the 10 percent allowable annual exceedance frequency. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were above the WQO. The breakdown of nutrient exceedances for index period events is as follows:

- Ammonia: For all index period events, the mean concentration was 0.03 mg/L, which did exceed the WQO of 0.025 mg/L. In total, 79 percent of Mass Emission Station samples exceeded the WQO.
- Chlorophyll *a*: For all index period events, the mean concentration was 19.7 ug/L, which did not exceed the WQO of 20 ug/L. In total, 25 percent of Mass Emission Station samples exceeded the WQO.
- N+N: For all index period events, 0 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 10 percent.
- TN: For all index period events, 79 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 10 percent.
- TP: For all index period events, 17 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 10 percent.

#### 6.2.2.2 Event and Seasonal Variations

Both within-event and seasonal patterns can help better understand possible sources, processes, and mechanisms that affect runoff and associated concentrations.

Variations in constituent concentrations between events throughout the season and during events are discussed for both wet and dry weather conditions for the following constituents:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- TSS
- Ammonia
- CBOD
- Chlorophyll *a*
- N+N
- TN
- TP

The total fraction of nitrogen and phosphorus will be the primary focus of the nutrient discussion, considering the dissolved fractions comprised a consistent amount of the total throughout the seasons.

<u>Wet Weather – Seasonal Variations</u>

For bacteria, Wet Weather Event 1 had higher concentrations at the Mass Emission Station than Wet Weather Events 2 and 3 (Tables 4-31 and 4-32). The following factors may have influenced the higher concentrations during Wet Weather Event 1: longer event duration, higher rainfall intensity, higher peak discharge, and a longer length of antecedent dry period and, therefore, potential for greater pollutant build-up prior to the event. In fact, SCCWRP found that antecedent dry period was strongly correlated with bacteria concentrations from mass emission sites in an exponential manner (Tiefenthaler, Stein and Shiff, 2008). Early season storms generally had higher bacteria concentrations than late season storms both within and between watersheds, even when rainfall quantities were similar. SCCWRP attributed this to likely bacteria buildup during dry periods that flushes to rivers during early season storms. SCCWRP found that storm size may be a less reliable predictor of the magnitude of bacterial concentrations and loading.

For TSS, Wet Weather Events 2 and 3 EMCs exceeded the Wet Weather Event 1 EMC (Table 5-9).

For nutrients, a majority of the constituents had higher concentrations in Wet Weather Event 1 with the exception of ammonia and N+N. During both wet weather events, nitrogen and phosphorus were mostly present in the dissolved state based on the comparison between the total and dissolved mean values presented in Table 4-31.

Wet Weather – Within-Event Variations

Within-event variations were evaluated by assessing the concentrations graphs in Appendix E-2. For Wet Weather Event 1, bacteria concentrations appeared to remain fairly consistent throughout the event, with no apparent trends. However, for Wet Weather Event 2, bacteria concentrations increased slightly from the beginning of the event to the time of peak discharge. The highest Enterococcus and fecal coliform concentrations occurred during the last part of the event as the creek was returning to baseflow conditions; this was illustrated by samples collected 8 to 24 hours after the first peak of the storm event.
For Wet Weather Events 1 and 2, TSS concentrations appeared to correlate with the flow rate; i.e., higher concentrations occurred during higher flow rates and lower concentrations occurred during lower flow rates.

During wet weather events, nutrient concentrations remained relatively consistent with no apparent trends. However, during Wet Weather Event 1, N+N concentrations were generally higher than the TN concentrations until the time of peak discharge then the N+N concentrations decreased and were within the range of TN concentrations.

Another method to evaluate the variability of concentrations within events is to assess the magnitude of first-flush concentrations relative to the rest of the event. First-flush effects describe the effect of the early flows of a storm carrying a higher level of contaminants relative to the latter flows. First-flush ratios were calculated for the first two wet weather events where pollutograph sampling occurred. First-flush ratios are the result of a partial event mean concentration (PEMC) divided by the entire event mean concentration (EMC) at distinct intervals during a storm event. First-flush effects are indicated by a ratio of one and greater, with the effect being stronger with higher ratios. Table 6-8 presents the first-flush ratios for the first six hours of discharge for each wet weather event. Figures provided in Appendix F-2 graphically present how the first-flush ratios changed throughout each wet weather event.

**Table 6-8: Buena Vista Concentration First-Flush Effects**

| Constituent | First-Flush Ratio[1] | | First-Flush Effect[2] |
|---|---|---|---|
| | Wet Weather Event 1 | Wet Weather Event 2 | |
| *Enterococcus* | 0.87 | 0.17 | None |
| Fecal Coliform | 1.00 | 0.12 | Minor to None |
| Total Coliform | 1.82 | 0.17 | Moderate to None |
| TSS | 0.52 | 0.29 | None |
| Ammonia | 1.28 | 0.75 | Minor to None |
| CBOD | 1.14 | 1.25 | Minor |
| N+N | 0.70 | 1.84 | None to Moderate |
| TN | 0.49 | 1.03 | None to Minor |
| TP | 0.51 | 0.29 | None |

(1) The first-flush ratio presented is based on the ratio for the first two samples collected within the first 6 hours of discharge just prior to peak flows.
(2) Ratios > 2.0 were considered to have strong first-flush effects, ratios between 1.5 to 2.0 were considered to have moderate first-flush effects, ratios between 1.0 and 1.5 were considered to have minor first-flush effects, and ratios < 1.0 were considered to have no first-flush effects.

As shown in Table 6-8, during Wet Weather Event 1, fecal and total coliform had a moderate first-flush ratios although Enterococcus had a ratio below 1.0 it showed a greater first-flush effect than during the other event. Bacteria constituents did not show any first-flush effects during the Wet Weather Event 2, as their first-flush ratios were, generally, significantly less than one. It should be noted that the lack of a first-flush effect for bacteria is contrary to findings by SCCWRP (Tiefenthaler, et al., 2008). This study found that the greatest concentrations of bacteria occurred at or just before the first peak in discharge of the storm event for most of the 20 events sampled. Generally, more pronounced first-flush effects are found in highly urbanized and impervious watersheds. All but two of the watersheds studied were urban, densely populated watersheds ranging from 49 to 94 percent developed (two relatively undeveloped, non-urban watersheds less than five percent developed were also monitored). By contrast, the Buena Vista watershed is listed as 80 percent developed, but only 20 percent impervious in the Carlsbad Watershed Management Plan. The SCCWRP study found that for the two undeveloped, non-urban watersheds, peak concentrations tended to occur later in the storm and persist for a longer duration (although bacteria concentrations steadily decreased following the early peak in storm), which is similar to what occurred at the Buena Vista Mass Emission Station.

TSS concentrations did not show first-flush effects during either wet weather events. These results were generally inconsistent with the results of the study by SCCWRP (Tiefenthaler et al., 2008), where higher concentrations of suspended sediment were observed in the early part of the storm events.

Majority of nutrients did not show first-flush effects with a few exceptions. Wet Weather Event 1, ammonia and CBOD had moderate first-flush ratios slightly above 1.0. Wet Weather Event 2, N+N and TN had moderate first-flush ratios although the other nutrient constituents did not. SRP and TP did not show any first-flush effects during either wet weather event, as their first-flush ratios were, generally, significantly less than 1.0.

Dry Weather – Seasonal Variations

Seasonal variations in dry weather concentrations can be significant and have both positive and inverse relationships with flow, temperature, and other factors. In order to assess these variations and possible relationships with flow, Table 6-9 was developed.

**Table 6-9: Buena Vista Mass Emission Station Concentrations by Season and Flow Regime**

| Constituent | Season[3] | Flow Regime[1] | | | | | Season Mean[2] |
|---|---|---|---|---|---|---|---|
| | | High Flows | Moist Conditions | Mid-Range Flows | Dry Conditions | Low Flows | |
| *Enterococcus* (CFU/100 mL) | Winter | 18,165 | 159 | | | | 159 |
| | Spring | | 52 | 61 | | | 59 |
| | Summer | | 230 | 200 | | | 225 |
| | Fall | | | 103 | 237 | | 170 |
| | Flow Regime Average | 18,165 | 179 | 90 | 237 | | 153 |
| Fecal Coliform (MPN/100 mL) | Winter | 12,159 | 216 | | | | 216 |
| | Spring | | 340 | 139 | | | 173 |
| | Summer | | 762 | 260 | | | 678 |
| | Fall | | | 307 | 513 | | 410 |
| | Flow Regime Average | 12,159 | 454 | 208 | 513 | | 369 |
| Total Coliform (MPN/100 mL) | Winter | 55,511 | 792 | | | | 792 |
| | Spring | | 650 | 436 | | | 472 |
| | Summer | | 952 | 920 | | | 947 |
| | Fall | | | 753 | 1,067 | | 910 |
| | Flow Regime Average | 55,511 | 847 | 596 | 1,067 | | 780 |
| TSS (mg/L) | Winter | 199 | 5 | | | | 5 |
| | Spring | | 18 | 52 | | | 46 |
| | Summer | | 40 | 15 | | | 36 |
| | Fall | | | 6 | 15 | | 11 |
| | Flow Regime Average | 199 | 21 | 33 | 15 | | 25 |
| Ammonia (mg/L) | Winter | 0.14 | 0.03 | | | | 0.03 |
| | Spring | | 0.04 | 0.03 | | | 0.03 |
| | Summer | | 0.04 | 0.02 | | | 0.04 |
| | Fall | | | 0.03 | 0.04 | | 0.03 |
| | Flow Regime Average | 0.14 | 0.04 | 0.03 | 0.04 | | 0.03 |

**Table 6-9: Buena Vista Mass Emission Station Concentrations by Season and Flow Regime (continued)**

| Constituent | Season[3] | Flow Regime[1] | | | | | Season Mean |
|---|---|---|---|---|---|---|---|
| | | High Flows | Moist Conditions | Mid-Range Flows | Dry Conditions | Low Flows | |
| Chlorophyll *a* (ug/L) | Winter | | 6.78 | | | | 6.78 |
| | Spring | | 9.80 | 52.54 | | | 45.42 |
| | Summer | | 18.42 | 4.60 | | | 16.12 |
| | Fall | | | 3.10 | 17.63 | | 10.37 |
| | Flow Regime Average | | 11.88 | 30.73 | 17.63 | | 19.67 |
| N+N (mg/L) | Winter | 1.29 | 1.80 | | | | 1.80 |
| | Spring | | 2.30 | 1.78 | | | 1.87 |
| | Summer | | 0.62 | 0.36 | | | 0.58 |
| | Fall | | | 0.50 | 0.75 | | 0.63 |
| | Flow Regime Average | 1.29 | 1.35 | 1.20 | 0.75 | | 1.22 |
| TN (mg/L) | Winter | 1.88 | 1.90 | | | | 1.90 |
| | Spring | | 2.65 | 2.50 | | | 2.53 |
| | Summer | | 0.89 | 0.94 | | | 0.90 |
| | Fall | | | 1.46 | 1.52 | | 1.49 |
| | Flow Regime Average | 1.88 | 1.55 | 1.98 | 1.52 | | 1.71 |
| TP (mg/L) | Winter | 0.28 | 0.07 | | | | 0.07 |
| | Spring | | 0.10 | 0.22 | | | 0.20 |
| | Summer | | 0.03 | 0.04 | | | 0.03 |
| | Fall | | | 0.06 | 0.09 | | 0.08 |
| | Flow Regime Average | 0.28 | 0.05 | 0.15 | 0.09 | | 0.09 |

(1) Flow regimes are based on percent days exceeded and broken down into the following categories: high flows are classified as < 10% days exceeded; moist conditions are classified as > 10% and < 40% days exceeded; mid-range flows are classified as > 40% and < 60% days exceeded; dry conditions are classified as > 60% and < 90% days exceeded; low flows are classified as > 90% days exceeded.
(2) Season average does not include wet weather high flow events.
(3) Index Period 1 represents winter, Index Period 2 represents spring, Index Period 3 represents summer, Index Period 4 represents fall.

Based on Table 6-9, variations in constituent concentrations within and between each season are discussed below:

Winter

Index Period Event 1 was representative of dry weather conditions during the winter season. Samples were collected between January 14, 2008 and February 11, 2008. The water temperature at the Mass Emission Station ranged from 9.7 to 15.3 degrees Celsius. During this sampling event, daily total discharges ranged from 577,812 to 931,647 cubic feet (Table 4-27), which exceeded the average daily dry

weather discharge of 374,427 cubic feet (Table 5-8). As shown in Table 6-9, these discharges fell within the moist condition flow regime.

Spring

Index Period Event 2 was representative of dry weather conditions during the spring season. Samples were collected between March 31, 2008 and April 10, 2008. The water temperature at the Mass Emission Station ranged from 13.1 to 19.7 degrees Celsius. During this event, daily total discharges ranged from 226,317 to 418,438 cubic feet (Table 4-27), which contain the average daily dry weather discharge of 374,427 cubic feet (Table 5-8). As shown in Table 6-9, these discharges fell within the moist conditions and mid-range flow regimes.

Summer

Index Period Event 3 was representative of dry weather conditions during the summer season. Samples were collected between July 14, 2008 and July 23, 2008. The water temperature at the Mass Emission Station ranged from 18.7 to 24.9 degrees Celsius. During this period, daily total discharge ranged from 226,370 to 370,520 cubic feet (Table 4-27), which was below the average daily discharge (Table 5-8). As shown in Table 6-9, these discharges fell within the moist conditions and mid-range flow regimes.

Fall

Index Period Event 4 was representative of baseline conditions during the fall season. Samples were collected between September 15, 2008 and September 24, 2008. The water temperature at the Mass Emission Station ranged from 18.2 to 23.3 degrees Celsius. During this event, daily total discharge ranged from 194,998 to 264,408 cubic feet (Table 4-27), which was below the average and median daily discharges (Table 5-8). As shown in Table 6-9, these discharges fell within mid-range flows and dry conditions flow regimes.

*Enterococcus*, fecal coliform, and total coliform had the highest mean concentrations during the high flow conditions which reflect the wet weather concentrations. Dry weather concentrations were orders of magnitude lower than the wet weather concentrations. *Enterococcus*, fecal coliform, and total coliform concentrations were higher during the summer and fall seasons which were generally characterized by lower flows and warmer temperatures.

TSS mean concentrations were highest during the high flow conditions which reflect the wet weather concentrations, however, during winter dry weather conditions, the mean concentrations were the lowest.

In contrast, the spring TSS mean concentration was higher than the TSS mean concentrations for the other seasons.

Although not shown in Table 6-9, DO and pH had similar seasonal trends based on Table 4-28; higher DO concentrations (and lower pH readings) during the winter season (characterized by higher flow regimes and lower temperatures) and lower DO concentrations (and lower pH readings) during the fall season (characterized by mid-range to dry condition flow regimes). DO concentrations and pH readings were the highest during the winter (Index Period Event 1) with DO concentrations ranging from 8.3 to 12 mg/L and pH readings between 8 to 8.1 pH units, as shown in Table 4-28. Higher DO concentrations during the winter season can typically be attributed to elevated DO saturation resulting from the higher flow conditions (Nezlin, 2009). Fall DO concentrations were lower than the other seasons, with concentrations ranging from 5.6 to 11.1 mg/L and pH readings were ranging from 6 to 8.1 pH units.

The spring N+N, TN, and TP mean concentrations were higher than the other seasonal mean concentrations, however, the magnitude of variance between seasons differed by constituent. The summer mean CBOD concentration was higher than the other seasons and the mean ammonia concentration was slightly higher than the other seasons. Ammonia also had a wider range of concentrations between 0.02 to 0.09 mg/L, as shown in Table 4-38. It should be noted that an algal bloom was observed during the fall index period sampling. During this time the lowest DO concentrations were recorded (ranging between 5.6 to 11.1 mg/L) at the Mass Emission Station and nutrients had elevated concentrations at the Mass Emission Station in comparison to the other seasons.

### 6.2.3 Buena Vista Constituent Concentrations – Lagoon Segment Site

The lagoon segment sampling characterized both seasonal and spatial variations, and helped establish baseline conditions to evaluate the lagoon's response during wet weather events.

#### 6.2.3.1 Comparison to Water Quality Objectives

A summary of concentrations for the Buena Vista Lagoon Segment, including geometric and arithmetic mean concentrations, ranges, and exceedances as compared to WQOs are provided in Tables 4-33 and 4-34 for wet weather events and in Tables 4-39 and 4-40 for index period events.

A comparison of concentrations to WQOs was conducted for the following constituents with WQOs established in the San Diego Basin Plan:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- Ammonia
- Chlorophyll *a*
- N+N
- TN
- TP

Bacteria

For all wet weather events, two bacteria samples were collected at both lagoon segments and each concentration was compared to the wet weather WQO to determine the percent exceedance. A 22 percent exceedance allowance was applied to the wet weather water quality objectives for indicator bacteria, for preliminary comparison purposes, based on a SDRWQCB Beachs and Creeks TMDL (2007) and a natual loading study by SCCWRP (2007). The development of this preliminary exceedance allowance is described in Section 1.3. A breakdown of water quality for both lagoons during all wet weather events is as follows:

- *Enterococcus*: For all wet weather events at Lagoon Segments 1 and 2, 100 percent and 67 percent of samples, respectively, exceeded the WQO. In total 83 percent of lagoon segment samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Fecal Coliform: For all wet weather events at Lagoon Segments 1 and 2, 83 percent and 67 percent of samples, respectively, exceeded the WQO. Int total 83 percent of lagoon segment samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Total Coliform: For all wet weather events at Lagoon Segments 1 and 2, 83 percent and 17 percent of samples, respectively, exceeded the WQO. In total 50 percent of lagoon segment samples exceeded the WQO, versus an allowable exceedance of 22 percent.

Dry weather standards for indicator bacteria require the application of two criteria; the geometric mean concentration and the single-sample maximum requirement. Per the Basin Plan, the geometric means must be derived from a minimum of five samples in a 30-day period and must not exceed the dry weather geometric mean WQOs. *Enterococcus* and total coliform samples may not exceed the single-sample maximum allowable concentrations that are presented as the wet weather WQOs in Table 1-4. However, fecal coliform samples have a ten percent allowable exceedance rate over a 30-day period when compared to the single-sample maximum allowable concentrations. The geometric means and single-sample

exceedance frequencies for the index period events were compared to both dry weather WQO criteria. For each index period event, the geometric mean was calculated from the six samples collected. The breakdown of bacteria exceedance for index period events is as follows:

- *Enterococcus*: The geometric mean concentrations for the lagoon segments and transects exceeded the dry weather geometric mean-based WQO of 33 CFU/100mL for Index Period Events 1 and 3 at Lagoon Segment 1. For the entire monitoring period, 3 percent of lagoon segment and transect concentrations exceeded the single-sample maximum allowable concentration of 108 CFU/100mL. The exceedances, by samples site, are as follows:
  - Lagoon Segment 1: 13 percent (3 of 24 samples) had concentrations greater than 108 CFU/100mL, which occurred during Index Period Events 1 and 3.
  - Lagoon Segment 2: 0 percent (0 of 24 samples) had concentrations greater than 108 CFU/100mL.
  - Transects: 0 percent (0 of 40 samples) had concentrations greater than 108 CFU/100mL.
- Fecal Coliform: The geometric mean concentrations for the lagoon segments and transects did not exceed the dry weather geometric mean-based WQO of 200 MPN/100mL for all four index period events. For the entire monitoring period, eight percent of lagoon segment and transect concentrations exceeded the single-sample maximum allowable concentration of 400 MPN/100mL. These exceedances, listed by sample site and index period, are as follows:
  - Lagoon Segment 1: Index Period Event 3 had concentrations greater than 400 MPN/100mL at a frequency of 17 percent (1 of 6 samples), which exceeded the ten percent allowable frequency (per 30-day period).
  - Lagoon Segment 2: Zero percent (0 of 24 samples) had concentrations greater than 400 MPN/100mL.
  - Transects: Index Period Events 2 and 3 had concentrations greater than 400 MPN/100mL at a frequency of 20 percent (2 of 10 samples), and 30 percent (3 of 10 samples), respectively, which exceeded the ten percent allowable frequency (per 30-day period).
- Total Coliform: The geometric mean concentrations for the lagoon segments and transects did not exceed the dry weather geometric mean-based WQO of 1,000 MPN/100mL for all four index period events. For the entire monitoring period, zero percent of lagoon segment and transect concentrations exceeded the single-sample maximum allowable concentration of 10,000 MPN/100mL.

Nutrients

Based on the limited availability of site-specific criteria the following WQOs were used for preliminary analysis purposes. SCCWRP in collaboration with SWRCB, USEPA, and other agencies are working to develop nutrient numeric endpoints for coastal water bodies (SCCWRP, 2009).

Wet and dry weather standards for nutrients vary by constituent; WQOs are based on an allowable exceedance that consider background levels or numerical limits that represent the maximum levels of constituents. N+N, TN, and TP have a ten percent allowable annual exceedance frequency. For N+N, TN, and TP each concentration was compared to the wet weather WQO to determine the percent exceedance.

Ammonia and chlorophyll *a* are based on a numerical objective. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were above the WQO. For Wet Weather Events 1, 2 and 3, two samples were collected and each concentration was compared to the wet weather WQOs to determine the percent exceedance. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were above the WQO. In addition, a percent exceedance was calculated for ammonia and chlorophyll *a* to provide a relative comparison with the other nutrients. The breakdown of nutrient exceedances for wet weather events is as follows:

- Ammonia: For all wet weather events at Lagoon Segments 1, the mean concentration was 0.11 mg/L, which did exceed the WQO of 0.025 mg/L for 100 percent of samples. For all wet weather events at Lagoon Segment 2, the mean concentration was 0.07 mg/L, which did exceed the WQO of 0.025 mg/L for 67 percent of samples. In total, 83 percent of lagoon segment samples exceeded the WQO.
- Chlorophyll *a*: For all wet weather events at Lagoon Segment 1, the mean concentration was 11.2 ug /L, which did not exceed the WQO of 20 ug/L for 100 percent of samples. For all wet weather events at Lagoon Segment 2, the mean concentration was 25.8 ug /L, which did exceed the WQO of 20 ug/L for 67 percent of samples. In total, 33 percent of all lagoon segement samples exceeded the WQO.
- N+N: For all wet weather events at Lagoon Segments 1 and 2, 0 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent.
- TN: For all wet weather events at Lagoon Segment 1, 100 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent. At Lagoon Segment 2, 67 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent.
- TP: For all wet weather events at Lagoon Segment 1, 100 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent. At Lagoon Segment 2, 100 percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.

A total of 24 samples were collected during four index period events, and each concentration was compared to the dry weather WQO to determine the percent exceedance. For each Index Period Event, two samples were collected at each of the ten transect locations and each concentration was compared to the WQO to determine the percent exceedance. N+N, TN, and TP percent exceedances were compared to the 10 percent allowable annual exceedance frequency. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were above the WQO. The breakdown of nutrient exceedances for index period events is as follows:

- Ammonia: For all index period events at Lagoon Segment 1, the mean concentration was 0.05 mg/L, which did exceed the WQO of 0.025 mg/L. In total, 46 percent of samples exceeded the WQO. At Lagoon Segment 2, the mean concentration was 0.03 mg/L, which

did exceed the WQO of 0.025 mg/L. In total, 29 percent of samples exceeded the WQO. For all transects, 19 percent of samples exceeded the WQO.

- Chlorophyll *a*: For all index period events at Lagoon Segment 1, the mean concentration was 142 ug /L, which did exceed the WQO of 20 ug/L. In total, 71 percent of samples exceeded the WQO. At Lagoon Segment 2, the mean concentration was 46.6 ug /L, which did exceed the WQO of 20 ug/L. In total, 63 percent of samples exceeded the WQO. For all transects, 81 percent of samples exceeded the WQO.
- N+N: For all index period events at Lagoon Segments 1 and 2 and transects, zero percent of samples exceeded the WQO.
- TN: For all index period events at Lagoon Segment 1, 63 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent. At Lagoon Segment 2, 67 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent. For all transects, 56 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent.
- TP: For all index period events at Lagoon Segment 1, 58 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent. At Lagoon Segment 2, 50 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent. For all transects, 37 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent.

#### 6.2.3.2 Event and Seasonal Variations

Variations in constituent concentrations between events throughout the season and during events are discussed for both wet and dry weather conditions for the following constituents. Both within-event and seasonal patterns can help better understand possible sources, processes, and mechanisms that affect runoff and associated concentrations.

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- TSS
- Ammonia
- CBOD
- Chlorophyll *a*
- N+N
- TN
- TP

<u>Wet Weather – Seasonal Variations</u>

As shown in Tables 4-33 and 4-34, Lagoon Segment 1 samples had higher bacteria concentrations during Wet Weather Event 1 while Lagoon Segment 2 samples had higher bacteria concentrations during Wet Weather Event 3. Wet Weather Event 1 had the highest TSS concentrations for both lagoon segments.

Wet Weather – Within-Event Variations

For all events, the initial samples were collected 6.5 to 7.5 hours prior to the collection of the second set of samples. During Wet Weather Event 1, the initial samples were collected six hours after rainfall began and the second set of samples was collected 13.5 hours after rainfall began. The timing of sample collection was similar for Wet Weather Events 2 and 3, initial sample were collected 15 and 13 hours after rainfall and second samples were collected 21.5 and 20 hours after rainfall, respectively.

During Wet Weather Event 1 and 3, higher bacteria concentrations (*Enterococcus*, fecal coliform, and total coliform) generally occurred in the initial set of samples collected as compared to the subsequent set of samples collected later in the storm. However, Wet Weather Event 2 elevated bacteria concentrations did not correspond to a particular sample time.

TSS concentrations were greater in the initial sample collected as compared to the subsequent sample.
During Wet Weather Event 1 at both lagoon segments, nutrient samples had lower constituent concentrations than in samples collected for other wet weather events with the exception of CBOD collected at Lagoon Segment 1. Generally, most of the nutrient concentrations were greater during Wet Weather Event 3 at both lagoon segments than the other events. However, CBOD and chlorophyll *a* had higher concentrations during Wet Weather Event 2 than the other events, in addition to ammonia and N+N collected at Lagoon Segment 1. Generally, the initial samples collected at the lagoon segments had higher nutrient concentrations relative to the subsequent samples collected later in the storm.

Dry Weather – Seasonal Variations

As shown in Tables 4-39 and 4-40, concentrations of indicator bacteria were generally low at the lagoon segments during dry weather conditions, with the exception of samples collected at Lagoon Segment 1during the winter (Index Period Event 1). These samples had relatively higher concentrations for all indicator bacteria (*Enterococcus*, fecal coliform, and total coliform). Seasonal low bacteria concentrations varied by constituent, however, were mostly associated with the spring and fall (Index Period Events 1 and 4).

TSS concentrations were higher during the winter (Index Period Event 1) at Lagoon Segment 1 and during spring (Index Period Event 2) at Lagoon Segment 2, while the lowest concentrations occurred during the summer (Index Period Event 3) for both lagoon segments.

Although not shown in Table 6-9, DO and pH are important factors when evaluating nutrient concentrations and possible eutrophic conditions in a water body. The DO WQO (5 mg/L) was established as the minimum allowable DO concentrations in inland surface waters to maintain levels protective of aquatic organisms and habitats. Low DO levels can be harmful or lethal to aquatic organisms. Furthermore, low DO concentrations can be a symptom of eutrophic conditions within a water body. Eutrophication produces excess organic matter that fuels the development of hypoxia (i.e., low surface water DO concentrations) as organic matter is respired (McLaughlin, 2007). The acceptable pH levels established as the WQO (ranging 6.5 to 8.5) are required to be supportive of aquatic life. A change in pH can impact the bioavailability of nutrients.

DO concentrations and pH levels had different seasonal trends at Lagoon Segments 1 and 2. At Lagoon Segment 1, relatively higher DO concentrations and pH readings, ranging from 8.6 to 26.3 mg/L for DO and 7.8 to 8.4 pH units for pH during the spring (Index Period 2). The lowest concentrations occurred during the summer (5.8 mg/L average and 2.8 mg/L to 9.9 mg/L range). At Segment 2, DO concentrations (and pH readings) followed a pattern of higher concentrations during the winter (characterized by higher flows from the creek and lower temperatures) and lower during fall (characterized by mid-range to dry condition flow regimes). At Lagoon Segment 2, the lowest DO concentrations occurred during the fall (4.6 mg/L average and 1.0 mg/L to 9.0 mg/L range) which coincided with an observed algal bloom. Low DO concentrations are a commonly observed symptom in DO eutrophic estuaries and can result from one or more of three environmental factors: low solar radiation (resulting in reduced oxygen production via photosynthesis), increased freshwater discharge (resulting in enhanced haline stratification which prevents ventilation of bottom waters), and sluggish bottom water ventilation due to stratification often occurring during neap tidal phase (Nezlin, 2009).

Overall, nutrient concentrations at the lagoon segments were greater during the dry season than the wet season, with the exception of TP and a couple of dissolved nutrients. Nutrient concentrations were higher at the lagoon segments during the winter and spring (Index Period Events 1 and 2); although no algal blooms or other visual signs or symptoms of eutrophication were observed. During the winter, DO concentrations never fell below 5 mg/L, with minimum concentrations of 6.9 mg/L at Lagoon Segment 1 and 6.9 mg/L at Lagoon Segment 2. During the fall when an algal bloom was observed, DO concentrations were mostly above 5 mg/L, with minimum concentrations of 8.6 mg/L at Lagoon Segment 1 and minimum and mean concentrations of 4.6 and 9.2 mg/L, respectively at Lagoon Segment 2. During the dry season, higher concentrations of chlorophyll *a* corresponded with higher temperatures that may have increased levels of photosynthesis within the lagoon. During this period, chlorophyll *a* was elevated,

with a mean concentration of 82.10 ug/L (the highest concentrations occurred in the spring, with a mean concentration of 409.23 mg/L). A nutrient study conducted by SCCWRP further supports the relationship of high concentrations of chlorophyll *a* to the overproduction of algae (McLaughlin, 2007). Mean nitrogen and phosphorus concentrations, however, were relatively low, with mean concentrations of 0.87 and 0.04 mg/L, respectively (both below the WQO). Although the highest nutrient concentrations did not coincide directly with the algal bloom, it should be noted that ambient conditions in a water body can reflect biological processing and nutrient loading that has already occurred (McLaughlin, 2007). For historical comparison purposes, the mean concentrations for TN and TP for each season were below historical mean concentrations within the lagoon of 2.2 mg/L for TN and 0.24 mg/L for TP (RWQCB, 1985). This may be due to seasonal or spatial variations, or due to possible overall improvements in water quality.

### 6.2.4 Buena Vista Site-to-Site Comparisons

Table 6-10 compares the WQO exceedance frequency at each site for wet and dry weather conditions based on single-sample maximum concentration allowable. Based on Table 6-10, during wet weather events, all sites had bacteria exceedances. However, exceedances were less frequent at Lagoon Segment 2.

Table 6-11 compares the mean concentrations at each site for wet and dry weather conditions. Based on Table 6-11, during wet weather events, the mean concentrations for bacteria samples collected at the Mass Emission Station and Lagoon Segment exceedances geometric mean-based WQOs. Lagoon Segment 1 samples had relatively greater bacteria concentrations than samples collected from Lagoon Segment 2 during all wet weather events.

For all wet weather events, TSS concentrations were greater at Lagoon Segment 1 compared to Lagoon Segment 2, although the variance was relatively smaller during Wet Weather Event 3. Throughout the dry season, TSS concentrations were greater at Lagoon Segment 1 as compared to Lagoon Segment 2.

The Mass Emission Station *Enterococcus*, total coliform, and fecal coliform mean concentrations exceeded the geometric mean-based WQOs for dry weather conditions. Mean TSS concentrations were highest at the Lagoon Segment 1 compared to the other sites. Generally, the lagoon segments had higher nutrient mean concentrations than the Mass Emission Station.

**Table 6-10: Buena Vista Comparison of WQO Exceedance Frequency**

| Constituent | WQO | Units | Wet Weather | | | WQO | Units | Dry Weather | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mass Emission | Lagoon Segment 1 | Lagoon Segment 2 | | | Mass Emission | Lagoon Segment 1 | Lagoon Segment 2 |
| *Enterococcus* | 108 | CFU/100mL | 100% | 100% | 66.7% | 108 | CFU/100mL | 58.3% | 12.5% | 0.0% |
| Fecal Coliform | 400 | MPN/100mL | 83.3% | 100% | 66.7% | 400 | MPN/100mL | 41.7% | 4.2% | 0.0% |
| Total Coliform | 10,000 | MPN/100mL | 75.0% | 83.3% | 16.7% | 10,000 | MPN/100mL | 0.0% | 0.0% | 0.0% |
| Ammonia | 0.025 | mg/L | 88.2% | 100% | 66.7% | 0.025 | mg/L | 79.2% | 45.8% | 29.2% |
| Chlorophyll *a* | 20 | ug/L | NA | 0.0% | 66.7% | 20 | ug/L | 25.0% | 70.8% | 62.5% |
| Nitrate+Nitrite | 10 | mg/L | 0.0% | 0.0% | 0.0% | 10 | mg/L | 0.0% | 0.0% | 0.0% |
| Total Nitrogen | 1.0 | mg/L | 94.1% | 100% | 66.7% | 1.0 | mg/L | 79.2% | 62.5% | 66.7% |
| Total Phosphorus | 0.1 | mg/L | 88.2% | 100% | 100% | 0.1 | mg/L | 16.7% | 58.3% | 50.0% |

**Table 6-11: Buena Vista Comparison of Mean Concentrations**

| Constituent | WQO | Units | Wet Weather[1] | | | WQO | Units | Dry Weather[2] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mass Emission[3] | Lagoon Segment 1 | Lagoon Segment 2 | | | Mass Emission | Lagoon Segment 1 | Lagoon Segment 2 |
| *Enterococcus* | 108 | CFU/100mL | 13,478 | 8,807 | 1,320 | 33 | CFU/100mL | 125 | 25.6 | 13.8 |
| Fecal Coliform | 400 | MPN/100mL | 13,631 | 6,950 | 590 | 200 | CFU/100mL | 257 | 113 | 80.0 |
| Total Coliform | 10,000 | MPN/100mL | 55,160 | 90,833 | 5,867 | 1,000 | CFU/100mL | 712 | 304 | 153 |
| TSS | 500 | mg/L | 138 | 53.2 | 12.5 | 500 | mg/L | 24.5 | 40.3 | 13.2 |
| Ammonia | 0.025 | mg/L | 0.15 | 0.11 | 0.07 | 0.025 | mg/L | 0.03 | 0.05 | 0.03 |
| CBOD | NA | mg/L | 3.65 | 2.57 | 2.73 | NA | mg/L | 0.98 | 5.02 | 2.75 |
| Chlorophyll *a* | 20 | ug/L | NA | 11.2 | 25.8 | 20 | ug/L | 19.7 | 142 | 46.6 |
| Nitrate+Nitrite | 10 | mg/L | 1.33 | 0.98 | 0.29 | 10 | mg/L | 1.22 | 0.46 | 0.11 |
| SRP | NA | mg/L | 0.15 | 0.16 | 0.11 | NA | mg/L | 0.05 | 0.05 | 0.06 |
| Total Nitrogen | 1.0 | mg/L | 1.71 | 1.85 | 1.27 | 1.0 | mg/L | 1.71 | 1.64 | 1.20 |
| Total Dissolved Nitrogen | NA | mg/L | 1.49 | 1.76 | 0.97 | NA | mg/L | 1.86 | 0.99 | 0.94 |
| Total Phosphorus | 0.1 | mg/L | 0.19 | 0.23 | 0.19 | 0.1 | mg/L | 0.09 | 0.15 | 0.15 |
| Total Dissolved Phosphorus | NA | mg/L | 0.16 | 0.23 | 0.14 | NA | mg/L | 0.07 | 0.06 | 0.09 |

(1) Wet weather Mass Emission Station data omits Wet Weather Event 3 because pollutagraph samples were not collected.
(2) For general chemistry, means were calculated as arithmetic means. For bacteria (Enterococcus, fecal coliform, and total coliform), means were calculated as geometric means.
(3) Chlorphyll *a* was not sampled for wet weather pollutagraphs.

### 6.2.5 Buena Vista Mass Emission Station Constituent Loading

Constituent loading is an important factor when considering point and non-point source contaminant input to a receiving water body. While constituent concentrations provide information on specific contaminant levels at a given point in time, load estimations consider discharge amounts along with constituent concentrations to provide insight into the overall amount of targeted constituents introduced into a water body. For example, equal concentrations of a given constituent measured under different flow regimes will result in different load values, which contribute to a better understanding of the impacts of that given constituent.

As part of the load assessment, load estimates were developed for the watershed associated with the Mass Emission Station only. It should be noted that the Mass Emission Station represents a majority of the watershed for the Buena Vista Lagoon. The remaining portion of the watershed comprises the area discharging into the lagoon (or the creek) from adjacent lands downstream from the Mass Emission Station. Runoff from this area generally sheet flows into the lagoon from pervious surfaces or discharges into storm drains that then discharge directly into the lagoon. The total load entering the lagoon (and the lagoon's loading capacity) would, therefore, include loads from the watershed for the Mass Emission Station and the loads for the watershed(s) downstream from the Mass Emission Station. Although the load assessments in this section do not account for this additional area downstream from the Mass Emission Station, the assessments still provide snapshots of the potential impacts of loading from the Mass Emission Station's watershed on the lagoon.

#### 6.2.5.1 Daily and Annual Loading

Total daily and annual flows for the Buena Vista Lagoon Mass Emission Station are reported in Section 4.2.1.2. Detailed continuous stage and flow data results for the entire monitoring period is presented in Appendix B-2. Section 4.2.2.1 contains hydrographs and hyetographs depicting total rainfall, rainfall intensity, and discharge for monitored wet weather events (Figures 4-5 through 4-7).

Total daily and annual loads for the Buena Vista Lagoon Mass Emission Station are reported in Section 5.2.1. Daily load estimates are provided for both wet weather and dry weather periods in Table 5-10. Total annual load estimates are provided in Table 5-11. Detailed daily and annual load calculations are provided in Appendix D-2.

As shown in Table 5-10 in Section 5, the average daily wet weather loads greatly exceed the daily average dry weather loads due to higher constituent concentrations for all constituents (not including chlorophyll *a* as it was not sampled during wet weather events) and significantly greater flows during wet weather conditions.

Also, as shown in Table 5-11, the total annual wet weather load for most constituents represents approximately 90 to 99 percent of the total annual dry and wet weather load. This is typical for Southern California watersheds. For example, for the bacteria TMDLs developed for beaches and creeks by SDRWQCB (2007), wet weather loads constituted approximately 99 percent of the total annual loads for bacteria.

For some of the constituents such as TN, TDN, N+N, the relative percentage of total annual load represented by wet weather loads was between 73 and 80 percent. Although the relative percentage was lower, the majority of total annual load for these constituents is due to wet weather load. Although the wet weather and dry weather concentration were similar, total annual wet weather flows significantly exceeded the total dry weather flows resulting in a greater portion of annual load for these constituents due the wet weather events.

#### 6.2.5.2 Seasonal and Event Variations

Variations in constituent loading between events throughout the season and during events are discussed for both wet and dry weather conditions. Both within-event and seasonal patterns can help provide a better understanding of possible sources, processes, and mechanisms that affect runoff and associated bacteria concentrations.

<u>Wet Weather - Seasonal Variations</u>

Seasonal wet weather variations in bacteria loading were assessed by reviewing the load duration curves in Appendix H-2 and comparing the total constituent loads for each event. Load duration curves were generated for constituents with a corresponding WQO, which include the following:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- Ammonia
- Chlorophyll *a*
- N+N

- TN
- TP

Overall, Wet Weather Event 1 peak flows and bacteria loading rates were higher than the peak flows and loading rates that occurred during Wet Weather Event 2. Peak loading rates during Wet Weather Event 1were approximately four times the loading rates during Wet Weather Event 2.

For bacteria, the three bacteria constituents exceeded their associated wet weather loading capacities for all three wet weather events with the exception of one day during Wet Weather Event 2 when both fecal and total coliform fell just below the loading capacity. These exceedances occurred under high flow regimes, which also indicated these exceedances were likely resulting from non-point source inputs. These non-point source inputs include urban runoff resulting in the flushing of the storm water drainage and the washing of streets and yards in areas with significant domestic and wildlife populations.

Table 6-12 shows the total loads for bacteria during the three monitored wet weather events. Total loads for all three bacteria constituents were highest during Wet Weather Event 1. This is primarily due to the significantly higher total discharge volume associated with Wet Weather Event 1. Wet Weather Events 2 and 3 had discharge volumes that were more similar and this is reflected in the relative similarity in bacteria total loads calculated for those events. Differences in event total loads for Wet Weather Events 2 and 3 are primarily due to varied concentrations between constituents and events.

For nutrients examined, TN, TP, and ammonia exceeded the wet weather loading capacity during all three wet weather events (TN data not available for Wet Weather Event 3) for all but one ammonia sample during Wet Weather Event 3 which fell just below the loading capacity. Nitrate+nitrite did not exceed the loading capacity during all three wet weather events.

Table 6-12 shows the total loads for nutrients and other monitored constituents during the three monitored wet weather events. Total loads for all constituents were highest during Wet Weather Event 1. This is primarily due to the significantly higher total discharge volume associated with Wet Weather Event 1. Wet Weather Events 2 and 3 had discharge volumes that were more similar and this is reflected by the relative similarity in nutrient total loads calculated for those events. The effect of discharge is apparent when comparing concentrations with loads as the concentrations between events are relatively similar yet when combined with total discharge for the event, the loads reflect greater differences.

**Table 6-12: Buena Vista Wet Weather Event Total Load Estimates**

| Event | *Enterococcus* | Fecal Coliform | Total Coliform | TSS | Ammonia (as N) | CBOD | Nitrate + Nitrite (as N) | SRP | Total Nitrogen | Total Dissolved Nitrogen | Total Phosphorus | Total Dissolved Phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 | 887,884 | 219,403 | 2,148,580 | 970,043 | 759 | 27,440 | 10,575 | 1815 | 16,103 | 9,253 | 2,649 | 1,117 |
| Wet Weather Event 2 | 52,845 | 83,209 | 120,060 | 214,765 | 160 | 3,060 | 1,142 | 108 | 1253 | 1,137 | 131 | 108 |
| Wet Weather Event 3 | 155,792 | 63,925 | 668,557 | 544,458 | 270 | 9967[1] | 2,285 | 264[1] | 2463[1] | 2,117[1] | 791 | 346 |

(1) Constituents were not analyzed for Wet Weather Event 3; therefore, the values presented are calculated values.

Wet Weather - Within-Event Variations

Pollutagraph sampling provided information on varying contaminant levels throughout Wet Weather Events 1 and 2. As flows varied throughout these wet weather events, contaminant loads varied as well. Results from pollutagraph sampling were used to calculate changing loading rates throughout both pollutagraph sampling events. These load pollutagraphs show loading rates along with discharge throughout each wet weather event. Based on the length of each monitored wet weather event, different time intervals were selected to calculate loading rates. A three-hour interval was selected for Wet Weather Event 1, which lasted approximately 53 hours. A one-hour interval was selected for Wet Weather Event 2, which lasted approximately 24 hours. Appendix G-2 contains the load pollutagraphs for all monitored constituents during the first two wet weather events for the following constituents:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- TSS
- Ammonia
- CBOD
- Chlorophyll *a*
- N+N
- SRP
- TN
- TDN
- TP
- TDP

Wet Weather Event 1 had two discharge peaks, which affected loading rates during the event. Relative to discharge throughout the event, fecal and total coliform both had higher loading rates during the first peak compared to the second peak. *Enterococcus*, however, showed relatively similar responses to both peaks. The loading rates for TSS appeared to correlate well with the response shown by fecal and total coliform with a relatively high loading rate during the first peak and a relatively lower response during the second. CBOD and ammonia also followed this trend. N+N, SRP, TN, TDN, TP, and TDP all followed a pattern similar to *Enterococcus* with relatively similar responses to both peaks.

Wet Weather Event 2 was a shorter event and had a single peak in discharge. All monitored constituents followed a similar pattern, correlating well with discharge throughout the event.

Another method to evaluate the variability of loads within events is to assess the magnitude of the first-flush loads relative to the rest of the event. Mass first-flush is similar to concentration first-flush discussed

earlier, however, mass first-flush is based on a loading approach for an entire event. Mass first-flush describes the percent mass of monitored analytes that have been observed in the first 20 to 40 percent of storm discharge volume. Higher percent mass, those greater than 80 percent, for a given analyte has been suggested as an indicator that an analyte demonstrates a strong mass first-flush effect (Kayhanian and Stenstrom, 2008).

Table 6-13 presents the percent mass values along with the associated percent of storm discharge for both wet weather events.

**Table 6-13: Buena Vista First-Flush Percent Mass**

| Analyte | Wet Weather Event 1 (at 30% of Storm Flow) | | Wet Weather Event 2 (at 31% Storm Flow) | |
|---|---|---|---|---|
| | Mass First-Flush % | First-Flush Effect[1] | Mass First-Flush % | First-Flush Effect[1] |
| *Enterococcus* | 13 | None | 27 | None |
| Fecal Coliform | 38 | Minor | 68 | Moderate |
| Total Coliform | 25 | None | 61 | Moderate |
| TSS | 29 | None | 40 | Minor |
| Ammonia (as N) | 32 | None | 31 | None |
| CBOD | 33 | None | 22 | None |
| N+ N | 14 | None | 35 | None |
| SRP | 21 | None | 29 | None |
| TN | 22 | None | 28 | None |
| TDN | 33 | None | 30 | None |
| TP | 22 | None | 29 | None |
| TDP | 38 | Minor | 29 | None |

(1) For discussion purposes first-flush categories are defined as follows: strong = > 80%, moderate = < 80% and > 60%, minor = < 60% and > 35%, none = < 35%.

None of the constituents monitored at the Buena Vista Mass Emission Station demonstrated a strong mass first-flush effect. The strongest mass first-flush effect throughout both events was demonstrated by fecal and total coliform showing a moderate first-flush effect during Wet Weather Event 2. Nearly all of the remaining constituents did not show a mass first-flush effect with the exception of some minor effects shown by fecal coliform and TP during Wet Weather Event 1 and TSS during Wet Weather Event 2.

Wet Weather Event 1 mass first-flush results for some constituents contrast to the concentration first-flush results. The first-flush ratios for fecal coliform, TSS, and ammonia were slightly above 1.0, demonstrating a minor first-flush effect and total coliform showed a moderate concentration first-flush

effect. However, of those four constituents, fecal coliform showed a corresponding minor first-flush effect while total coliform, TSS, and ammonia did not show a mass first-flush effect. Although TDP showed a minor mass first-flush effect, concentration first-flush ratios reported a ratio below 1.0, demonstrating no first-flush effect. The other mass first-flush results correspond to the concentration first-flush results in that neither showed first-flush effects.

Wet Weather Event 2 mass and concentration first-flush results for fecal and total coliform reflect different results. Both constituents demonstrated moderate mass first-flush effects; however, the concentration first-flush ratios did not demonstrate first-flush effects. Conversely, N+N demonstrated a moderate concentration first-flush effect but no mass first-flush effect. CBOD shows the same relationship as N+N, but the concentration first-flush is not as evident as N+N. These results highlight the importance volume when assessing first-flush effects, as total discharge influences the overall amount of a constituent being input into a water body.

Seasonal Variations – Dry Weather

Seasonal dry weather variations in constituent loading were assessed by comparing the average constituent loads for each event in Table 5-12 and reviewing the load duration curves in Appendix H-2.

Average total load for bacteria constituents were highest during the winter months with the exception of fecal coliform which reported a slightly higher load during the summer months. High winter loads may be attributed to the higher flows experienced during those months as the mean concentration for that period were among the lowest of the four index period events. The slightly higher fecal coliform load in the summer is due to that period reporting the highest average concentration throughout all seasons at approximately three times the average concentration observed in winter. All three bacteria average constituent loads were the lowest during the spring months. Relatively low discharge during this period along with the lowest average concentration for all three constituents resulted in the low average load. Summer and fall average loads were close due to similar discharge total during those periods and relatively similar concentrations between the two seasons.

TSS and chlorophyll *a* both reported the highest loads during the spring. This may be attributed to increased primary productivity during the spring months with increased algal growth and corresponding suspended material in the water column. Despite high discharge rates, TSS loads were among the lowest during winter months which corresponds to concentration results which were also very low. This may be attributed to large TSS loads being transported during wet weather events removing material that

otherwise may be suspended in the water column. With the exception of spring, chlorophyll *a* loads generally decreased from winter to fall, which corresponds both to discharge patterns and concentration patterns.

Nutrient loads generally corresponded to flow patterns with the highest loads experienced in the winter months when discharge rates were highest. This pattern reflects the influence of discharge when analyzing load versus concentration. Concentrations for nutrients during spring were generally close or greater than those during winter. The relatively high concentrations correspond to the increased level of chlorophyll *a* reported during the spring months. Although nutrient loads were similar in summer and fall, loads were higher in fall primarily due to slightly higher average concentrations during the fall months.

Exceedances of the loading capacities varied throughout each season. *Enterococcus* exceeded the dry weather loading capacity during each of the four seasons with the exception of one day during Index Period Event 2. These exceedances occurred under all flow regimes suggesting that *Enterococcus* exceedances are a result of both point and non-point sources. Influences from non-point sources appear to have occurred during the first index period which took place in winter with residual effects from wet weather events. Dry weather fecal coliform samples collected during moist conditions and mid-range flows in the summer exceeded loading capacities. However, fecal coliform samples collected during other seasons did not consistently exceed the loading capacities. These exceedances occurred during moist conditions, mid-range flow, and dry condition flow regimes. Total coliform exceeded loading capacities on some occasions but generally did not exceed loading capacities. The samples were collected under moist conditions, mid-range flows, and dry condition flow regimes.

Total nitrogen and ammonia were the primary nutrients to exceed loading capacities consistently through the seasons which represented moist conditions, mid-range flows, and dry condition flow regimes. TP did exceed loading capacities on some occasions, particularly during Index Period Event 2 in the spring which corresponds to elevated concentrations and loads during those months. Chlorophyll *a* and N+N did not exceed loading capacities during any season or under any flow regimes.

### 6.2.6 Buena Vista Dissolved Oxygen Concentrations

Dissolved Oxygen (DO) concentration can be an important indicator of eutrophic conditions within a water body. Eutrophic conditions caused by excessive nutrient input (such as nitrogen and phosphorus) result in excessive plant growth, or algal blooms. When algae begin to die and decompose, oxygen is consumed in the process by microorganisms feeding on the dead algae, leading to low DO concentrations.

The eutrophication process can impair aquatic life and fisheries by causing depressed levels of oxygen which result in a change to the benthic community structure from aerobic to anaerobic organisms and stress or eliminate desirable aquatic life (USEPA, 1999). The DO WQO was established as a minimum concentration to maintain DO levels above 5 mg/L and average annual concentration of 7mg/L to be protective of aquatic life and habitats.

Fluctuations in DO can result from various environmental factors such as temperature, plant respiration, decomposition of organic matter, and stratification of the water column. Low DO concentrations are caused from one or more of three environmental factors: low solar radiation (resulting in reduced oxygen production via photosynthesis), increased freshwater discharge (resulting in enhanced haline stratification which prevents ventilation of bottom waters), and sluggish bottom water ventilation due to stratification often occurring during neap tidal phase (Nezlin, 2009). In the study conducted by SCCWRP, hypoxic events were defined as periods when either the DO daily average was below 3 mg/L or any observation during the 24-hr period was less than 1.0 mg/L (Nezlin, 2009).

#### 6.2.6.1 Comparison to WQO

DO data for the lagoon segment sites is summarized in Table 4-29 and 4-30 in Section 4.2.1. Complete continuous DO data is reported in Appendix B-2. Detecting hypoxia is difficult because DO is exceptionally variable over short time scales, i.e., less than a day, due to variable rates of oxygen production and consumption, which fluctuate in response to different environmental factors (Nezlin, 2009). In general, DO data indicated potential eutrophic conditions at both Lagoon Segment sites with wide ranges of DO concentrations and low minimum concentrations. Nearly all monthly mean concentrations at both sites were above the WQO of 5 mg/L with the exception of September, where the mean concentration at Lagoon Segment 2 was 3.4 mg/L. This appeared to be the result of an observed algal bloom. The low DO concentrations were associated with a rise in turbidity, which is also a common aspect to algal bloom events resulting from increased particulate matter.

#### 6.2.6.2 Comparison to DO WQOs

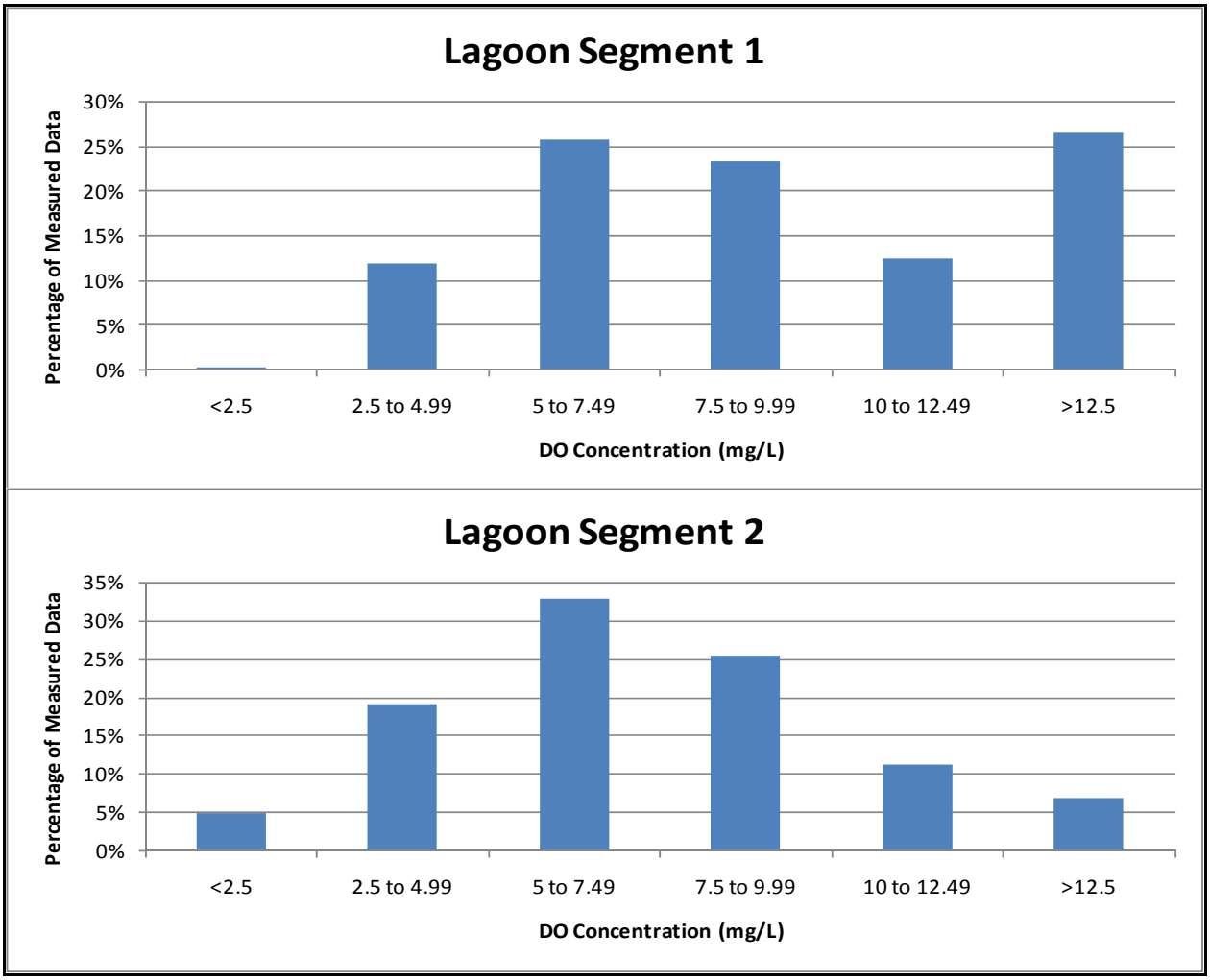
The WQO for DO requires that no single measurement fall below a concentration of 5 mg/L along with an annual mean objective of 7 mg/L as described in Table 1-4 in Section 1.3. Figure 6-5 is a frequency distribution of all measured DO concentrations throughout the entire monitoring period. The distribution is broken down into 2.5 mg/L bins. There are six bins with the last bin containing the percentage of

measured concentrations of 12.5 mg/L and greater. The percentage of measured concentrations in the first two bins represents the percentage of concentrations not meeting the WQO.

Lagoon Segment 1 shows approximately 12 to 13 percent of all measured concentrations falling below the single-sample minimum WQO. Approximately 50 percent of the concentrations occur between 5 and 10 mg/L, which surrounds the annual mean objective of 7 mg/L. The mean for the entire monitoring period at Lagoon Segment 1 is 10.0 mg/L. A high percentage of DO values above 12.5 mg/L was observed at Lagoon Segment 1 and may be attributable to one or more of four environmental factors causing wide ranging DO concentrations: temperature, plant respiration, decomposition of organic matter, or stratification of the water column.

Lagoon Segment 2 shows approximately 25 percent of measured concentrations below the single-sample minimum WQO along with approximately 58 percent within the range of 5 to 10 mg/L. The higher percentage of low DO concentrations at Lagoon Segment 2 may be attributed to an algal bloom event in September which resulted in sustained low DO concentrations. A greater number of low DO concentrations may be a factor in the lower percentage of DO concentration above 12.5 mg/L compared to Lagoon Segment 1.

**Figure 6-5: Buena Vista Frequency Distribution of Measured DO Concentrations**




6.2.6.3 Seasonal Variations in DO Concentrations

Index period events are intended to represent seasonal variations within the lagoon. Both Lagoon Segment sites reflected similar patterns, with higher DO concentrations in the winter and spring and lower concentrations in the summer and fall. Water temperature is an important factor when considering DO, as water with lower water temperatures can hold higher concentrations of DO. Although the DO concentrations appeared to correspond to temperature values, a wide ranges of DO concentrations as well as mean concentrations higher and lower than non-eutrophic water bodies. The lowest concentrations at the Lagoon Segment 2 were observed in the Fall during Index Period Event 4 which was affected by an algal bloom that occurred in September and coincides with the sampling event. Mean concentration for Index Period Event 4 was 4.6 mg/L with a minimum value of 1.0 mg/L. The lowest concentrations at the

Lagoon Segment 1 were observed in the summer during Index Period Event 3. Mean concentration for this event was 5.8 mg/L with a minimum of 2.8 mg/L. As was common throughout most of the year at both sites, this event at the Lagoon Segment 2 reported an average above the WQO but minimum concentrations fell below. Instantaneous DO collected throughout the monitoring period are plotted for all sites and can be found in Appendix I-1.

### 6.2.7 Buena Vista Summary of Key Findings

For the 2008-2009 monitoring year, precipitation totaled 11.58 inches, which was slightly below the mean annual rainfall of approximately 12 inches. Approximately 640 million cubic feet of water discharged into the lagoon from Buena Vista Creek. Of that amount, approximately 84 percent was discharged during wet weather events during the winter. Based on the sampling results and data assessment, a summary of the key findings for each constituent category is presented below.

<u>Bacteria</u>

Comparison to WQOs:

- During wet weather conditions, WQOs and loading capacities were exceeded at almost all locations, indicating that beneficial uses of the lagoon may have been impacted during wet weather conditions.
- During dry weather conditions, WQOs and loading capacities were exceeded at the Mass Emission Station and the lagoon's east basin (Lagoon Segment 1). This suggests that the beneficial uses of the lagoon's east basin were impacted during dry weather conditions.

Seasonal Variations:

- Seasonal variations were observed at the Buena Vista Mass Emission Station for both wet and dry weather conditions for all bacteria indicators. Wet weather concentrations were greater than dry weather concentrations by approximately x percent (for fecal coliform) and x percent (for *Enterococcus*). During wet weather conditions, Wet Weather Event 1 concentrations and loadings were greater than concentrations and loadings for Wet Weather Events 2 and 3, possibly due to a longer antecedent dry period and/or higher rainfall intensities and peak flows.
- During dry weather conditions, higher bacteria concentrations occurred during the summer months, characterized by lower flows and hotter temperatures. The lowest concentrations occurred during the winter and spring seasons.
- Within the lagoon, the highest concentrations occurred during wet weather conditions, with lower concentrations during dry weather conditions. For dry weather conditions, the winter had the highest concentrations (although still below WQOs) and the spring and fall had the lowest concentrations.

Within-Event Variations:

- Generally, bacteria concentrations at the Mass Emission Station were similar throughout wet weather events, although during Wet Weather Event 2, the highest *Enterococcus* and fecal coliform concentrations occurred towards the end of the storm. With the exception of a moderate concentration first-flush effect for total coliform for Wet Weather Event 1, no concentration first-flush effects were seen at the Mass Emission Station. Moderate mass first-flush effects were seen, however, for total and fecal coliform for Wet Weather Event 2.
- Bacteria concentrations within the lagoons were generally higher during the first part of each storm.

Site Differences:

- Differences in concentrations between sites were found, with Mass Emission Station mean concentrations of *Enterococcus* and total coliform generally greater than lagoon mean concentrations during wet and dry weather conditions.

<u>Sediment</u>

Seasonal Variations:

- During wet weather conditions, TSS concentrations and loadings were greater during Wet Weather Event 1 than concentrations and loadings for Wet Weather Events 2 and 3, possibly due to a longer antecedent dry period and/or higher rainfall intensities and peak flows
- During dry weather conditions, TSS concentrations were the highest during spring under moist conditions and mid-range flows. TSS concentrations were lowest during winter under moist condition flow regimes.
- Within the lagoon, TSS concentrations were relatively similar between wet weather and dry weather conditions. The TSS concentrations of Lagoon Segment 1 during wet weather conditions were approximately 30 percent higher than concentrations during dry weather. The TSS mean concentrations for Lagoon Segment 2 were slightly higher during dry weather compared to wet weather conditions.

Within-Event Variations:

- For TSS, concentrations generally correlated with the flow rate, with higher concentrations during higher flows and lower concentrations during lower flows.
- Generally, TSS did not show first-flush effects. TSS had no concentration-based first-flush effects during Wet Weather Events 1 and 2. Little to no mass-based first-flush effects were found.

Nutrients

Comparison to WQOs:

- WQOs and loading capacities for most nutrient constituents were exceeded during wet weather conditions at almost all locations, indicating that beneficial uses of the lagoon may have been impacted during wet weather conditions.
- During dry weather conditions, WQOs and loading capacities were exceeded at locations for most nutrient constituents. This suggests that the beneficial uses of the lagoon were impacted during dry weather conditions.

Seasonal Variations:

- Seasonal variations were observed at the Mass Emission Station for both wet and dry weather conditions for most nutrient constituents. However, wet weather concentrations were not always greater than dry weather concentrations as spring showed higher concentrations for N+N and TN. During wet weather conditions, Wet Weather Event 1 concentrations and loadings were greater than concentrations and loadings for Wet Weather Events 2 and 3, possibly due to a longer antecedent dry period and/or higher rainfall intensities and peak flows.
- During dry weather conditions, higher nutrient concentrations occurred during the spring months, characterized by moist conditions and mid-range flow regimes, potentially contributing to high chlorophyll *a* concentrations during that period. The lowest concentrations occurred during spring and fall.
- Within the lagoon, the highest concentrations occurred during winter and spring, with lower concentrations during summer and fall. For dry weather conditions, spring had the highest concentrations (although still below WQOs) and summer and fall generally had the lowest concentrations.

Within-Event Variations:

- Generally, nutrient concentrations at the Mass Emission Station were similar throughout wet weather events, although some constituents did show occasional minor or moderate concentration first-flush effects. However no mass-based first-flush effects were found. This lack of a first-flush effect is generally characteristic of watersheds less urbanized and not highly impervious.

Site Differences:

- During dry weather conditions, concentrations of chlorophyll *a* and CBOD at Lagoon Segment 1 were higher than the Mass Emission Station.

## 6.3 LOMA ALTA SLOUGH DISCUSSION

### 6.3.1 Loma Alta Daily, Monthly, and Annual Rainfall

Based on measurements at the Mass Emission Station, Loma Alta Slough received 12.41 inches of rain between October 1, 2007 and October 31, 2008. Daily and monthly rainfall totals are summarized in Table 4-44. January had the most rainfall, 4.49 inches, followed by February, which had 3.98 inches. The majority of the rainfall, 97 percent, occurred during the winter months of November through February.

Isopluvial maps from the San Diego County Hydrology Manual indicate that the mean annual rainfall for the Loma Alta Watershed area is about 13 inches, ranging between approximately 12 to 14 inches (Chang, 2009). Based on this data, the total rainfall at the Mass Emission Station (located near the 12-inch isopluvial) during the monitoring period was slightly (about 3 percent) above average for the area.

#### 6.3.1.1 Loma Alta Watershed Response to Rainfall

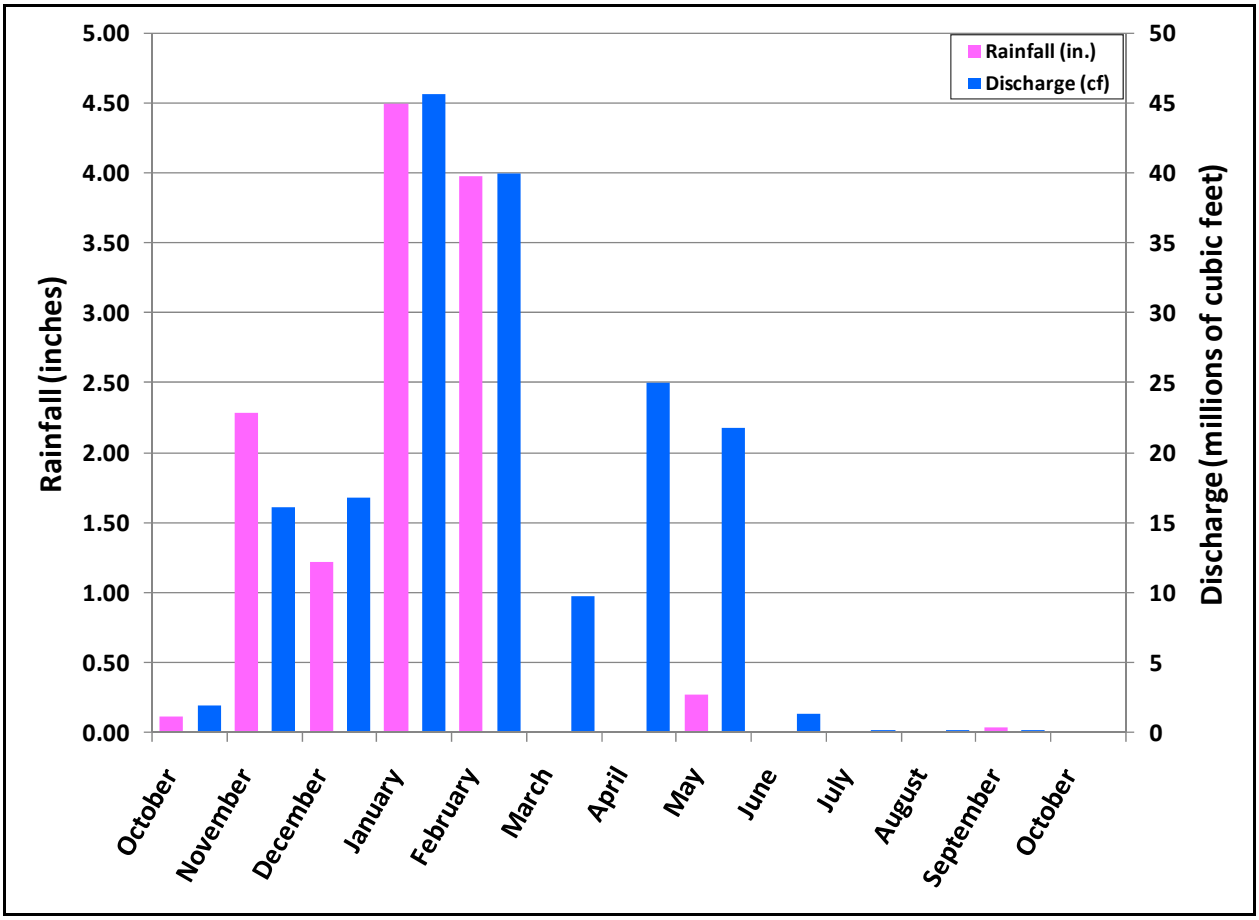
The Loma Alta Watershed covers an area of approximately 6,277 acres and extends about 7.29 miles inland from the coast, representing four percent of the CHU. The Loma Alta Watershed makes up the northern border of the CHU and is almost entirely in the jurisdictional area of the City of Oceanside with a very small percentage in the city of Vista and in unincorporated areas of the County of San Diego. Land use within the watershed is dominated by residential and other urban development, including industrial andlight industrial business parks. In addition, Sprinter light rail services began in March 2008 and runs along a historical railway corridor adjacent to Loma Alta Creek. Industrial development of the upper watershed has occurred. The drainage also includes a relatively new commuter railroad development running through the entire watershed with many rail segments and stations located within close proximity to the creek. Impervious surface in the Loma Alta Watershed is estimated at 29 percent, which is among the highest in the CHU (Carlsbad Watershed Management Plan, 2002).

Watershed response to rainfall is characterized by the discharge volumes and peak flows of Loma Alta Creek at the Mass Emission Station. Watershed response varies throughout the season based on factors such as antecedent soil moisture conditions, impervious area, rainfall amount, and rainfall intensity. Antecedent soil moisture condition throughout the watershed is the saturation level of the soil from previous storm events. Earlier in the season, when the watershed soil conditions are drier, the ground can soak up more water and therefore discharge less. Later in the season after a few storm events, the ground is more saturated, resulting in greater discharge volumes and higher peak flows (UCANR, 2002). Impervious area is directly related to urban development and includes paved surfaces, structures, and

other land uses where soil is not exposed and unable to absorb rainfall. This facilitates direct storm water runoff resulting in higher discharge volumes and higher peak flows as the response to rainfall is immediate.

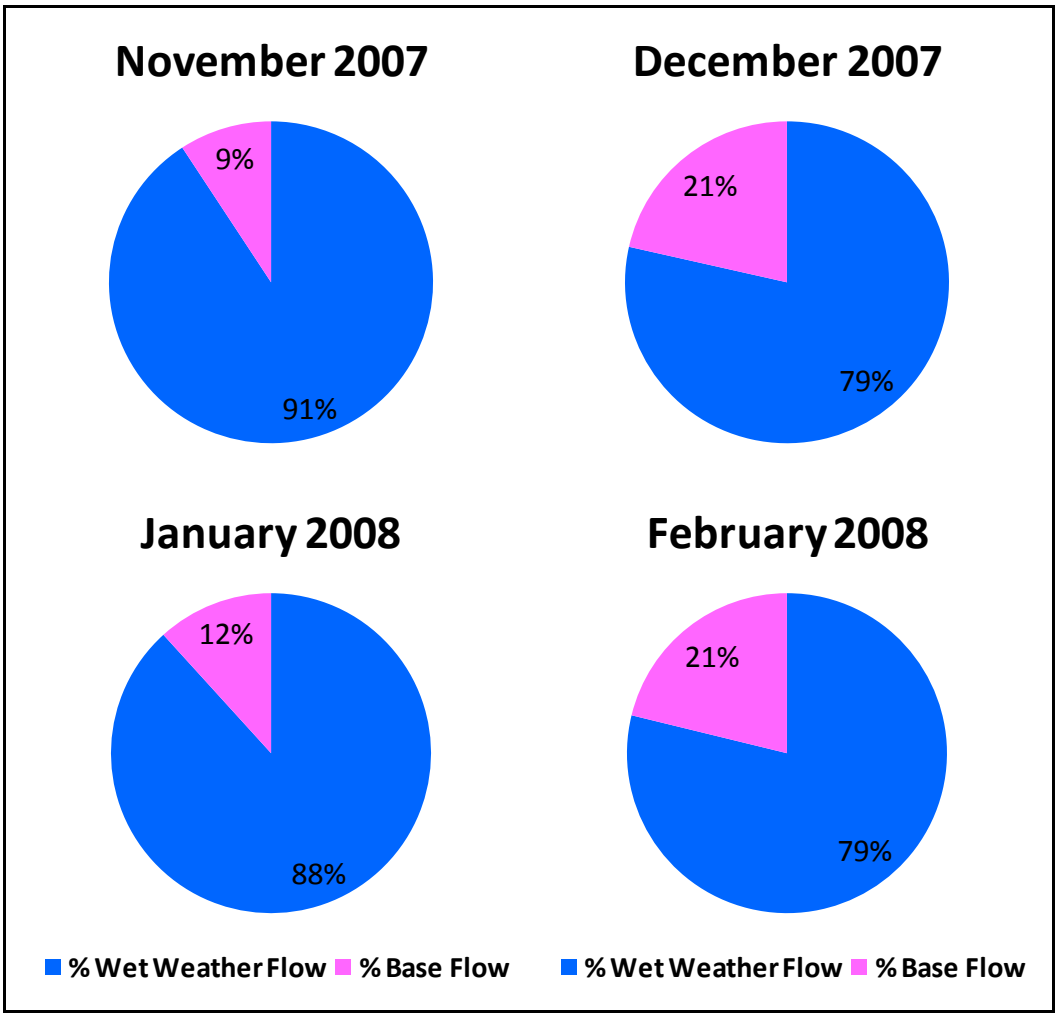
Daily and monthly discharge totals are summarized in Table 4-45. A total of 179,167,679 cubic feet was discharged into the Loma Alta Slough via Loma Alta Creek between October 1, 2007 and October 31, 2008. The three largest events occurred on November 30, 2007, January 5 to 7, 2008 and February 22, 2008 and produced approximately 20 million, 24 million, and 20 million cubic feet of discharge, respectively, and had peak discharge rates of approximately 482 cfs, 519 cfs, and 692 cfs, respectively. The response to rainfall is depicted by the highest discharge totals corresponding to the months with the highest rainfall totals. The relationship between monthly rainfall and discharge totals are shown graphically on Figure 6-6.

**Figure 6-6: Loma Alta Mass Emission Station Monthly Rainfall and Discharge Totals**



Rainfall intensity and amount affect the relationship between rainfall and watershed discharge. Although the overall relationship between rainfall and discharge was relatively stable, the amount of discharge due to wet weather events can vary based on the intensity, timing, and amount of rainfall associated with a given storm event. Figure 6-7 shows the percentage of discharge attributed to direct runoff during wet weather events as compared to base flow conditions. Base flows represent stream flow resulting from precipitation that infiltrates into the soil and eventually moves through the soil to the stream channel, as well as dry weather urban runoff such as irrigation. Discharge due to wet weather events includes water directly running off the surface from rainfall and does not include ground water discharge or seepage from saturated soils. November experienced the highest percentage of wet weather-related discharge due to direct runoff at 91 percent of the total discharge that month. This was primarily due to low base flows early in the season along with a relatively large storm event of 2.28 inches on the last day of the month, resulting in high discharge rates recorded throughout the day. December base flows were high due to the large event at the end of November. This resulted in December being one of the months with the lowest wet weather-related discharge percentage due to a relatively high percentage of base flow discharge. January and February 2009 followed a similar pattern as November and December 2008 with a higher percentage of wet weather flow occurring in January compared to February. January recorded higher base flow than November due to occurring later in the season when the watershed is more saturated. January was also the month with the most rainfall, contributing to high base flow recorded in February decreasing the percent of flow attributed to wet weather that month. Throughout the entire year approximately 176 million cubic feet of discharge was due to wet weather, accounting for 98 percent of the total amount discharged into Loma Alta Slough.

**Figure 6-7: Loma Alta Monthly Percentage of Watershed Discharge Due to Wet Weather Events Compared to Base Flow**




### 6.3.2 Loma Alta Constituent Concentrations – Mass Emission Station

Constituent concentrations for the range of monitored events provide a snapshot of the variation in watershed input and the lagoon's response to different flow and seasonal conditions. A comparison of constituent concentrations to the associated WQOs provided on Table 1-4 in Section 1.3 helps assess the overall water quality of the lagoon during wet and dry weather conditions. The Loma Alta Mass Emission Station characterizes the watershed contribution during wet and dry weather conditions. Although, the mass emission station is key contributor the lagoon is subject to other inputs and processes that influence water quality as presented in Figures 1-1 to 1-4 of Section 1.4.

A summary of concentrations for the Mass Emission Station, including geometric means, arithmetic means, ranges and exceedances compared to WQOs, are provided on Tables 4-49 and 4-50 for wet weather events and on Table 4-56 for index period events.

6.3.2.1 Comparison to Water Quality Objectives

A comparison of concentrations to the WQOs was conducted for the following constituents with WQOs established in the Basin Plan:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- Ammonia as nitrogen
- Chlorophyll *a*
- Nitrate+Nitrite (N+N)
- Total Nitrogen (TN)
- Total Phosphorus (TP)

<u>Bacteria</u>

Saltwater WQOs were applied to mass emission station as the receiving water is a saltwater body. For Wet Weather Events 1 and 2, at least five bacteria samples were collected at the Mass Emission Station and each for concentration was compared to the wet weather WQO to determine the percent exceedance. The EMCs for Wet Weather Event 3 were compared directly to the wet weather WQOs. A 22 percent exceedance allowance was applied to the wet weather water quality objectives for indicator bacteria, for preliminary comparison purposes, based on a SDRWQCB Beachs and Creeks TMDL (2007) and a natual loading study by SCCWRP (2007). The development of this preliminary exceedance allowance is described in Section 1.3. The breakdown of bacteria exceedances for wet weather events is as follows:

- *Enterococcus:* For all wet weather events, 100 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Fecal Coliform: For all wet weather events, 100 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Total Coliform: For Wet Weather Events 1 and 2, 91 of Mass Emission Station samples exceeded the WQO, versus an allowable exxceedance of 22 percent. For Wet Weather Event 3, the EMC of 35,000MPN/100mL also exceeded the WQO.

Dry weather standards for indicator bacteria require the application of two criteria; the geometric mean concentration and the single-sample maximum requirement. Per the Basin Plan, the geometric means

must be derived from a minimum of five samples in a 30-day period and must not exceed the dry weather geometric mean WQOs. *Enterococcus* and total coliform samples may not exceed the single-sample maximum allowable concentrations that are presented as the wet weather WQOs in Table 1-4. However, fecal coliform samples have a ten percent allowable exceedance rate over a 30-day period when compared to the single-sample maximum allowable concentrations. The geometric means and single-sample exceedance frequencies for the index period events were compared to both dry weather WQO criteria. For each index period event, the geometric mean was calculated from the six samples collected. The breakdown of bacteria exceedance for index period events is as follows:

- *Enterococcus*: The geometric mean concentrations exceeded the dry weather geometric mean-based WQO of 35 CFU/100mL for all four index period events. For the entire monitoring period, eight percent (2 of 24 samples) had concentrations that exceeded the single-sample maximum allowable concentration of 276 CFU/100mL. These exceedances occurred during Index Period Event 4.
- Fecal Coliform: The geometric mean concentrations exceeded the dry weather geometric mean-based WQO of 200MPN/100mL for Index Period Events 1, 3, and 4. For the entire monitoring period, 42 percent (10 of 24 samples) had concentrations that exceeded the single-sample maximum allowable concentration of 400 MPN/100mL. These exceedances, listed by index period event, are as follows:
  - Index Period Events 1, 2, 3, and 4 had concentrations greater than 400 MPN/100mL at a frequency of 33 percent (2 of 6 samples), 17 percent (1 of 6 samples), 17 percent (1 of 6 samples), and 100 percent (6 of 6 samples), respectively, which exceeded the ten percent allowable frequency (per 30-day).
- Total Coliform: The geometric mean concentrations exceeded the dry weather geometric mean-based WQO of 1,000MPN/100mL for Index Period Event 4. For the entire monitoring period, zero percent (0 of 24 samples) had concentrations that exceeded the single-sample maximum allowable concentration of 10,000 MPN/100mL.

Nutrients

Based on the limited availability of site-specific criteria the following WQOs were used for preliminary analysis purposes. SCCWRP in collaboration with SWRCB, USEPA, and other agencies are working to develop nutrient numeric endpoints for coastal water bodies (SCCWRP, 2009).

Wet and dry weather standards for nutrients vary by constituent; WQOs are based on an allowable exceedance that considers background levels or numerical limits representing the maximum levels of constituents. Nitrate+nitrite, TN, and TP have a ten percent allowable annual exceedance frequency. Each N+N, TN, and TP concentration was compared to the wet weather WQO to determine the percent exceedance. Ammonia and chlorophyll *a* are based on a numerical objective. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations

were above or below the WQO. In addition, a percent exceedance was calculated for ammonia and chlorophyll *a* to provide a relative comparison with the other nutrients. For Wet Weather Events 1 and 2, at least eight pollutagraphs were collected at the Mass Emission Station and each concentration was compared to the WQO. The EMC for Wet Weather Event 3 was compared directly to the wet weather WQOs. The breakdown of nutrient exceedances for wet weather events is as follows:

- Ammonia: For Wet Weather Events 1 and 2, the mean concentration was 0.13 mg/L, which exceeded the WQO of 0.025 mg/L. In total, 88 percent of Mass Emission Station samples exceeded the WQO. The EMC for Wet Weather Event 3 was 0.45 mg/L which also exceeded the WQO.
- Chlorophyll *a*: Wet weather samples collected at the Mass Emission Station were not required to be analyzed for chlorophyll *a* per the QAPP and Work Plan.
- Nitrate+nitrite: For all wet weather events no Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TN: For Wet Weather Events 1 and 2, 88 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of ten percent. TN was not analyzed during Wet Weather Event 3.
- TP: For all wet weather events, 100 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of ten percent.

A total of 24 samples were collected during four index period events. Each concentration was compared to the dry weather WQO to determine the percent exceedance. Nitrate+nitrite, TN, and TP percent exceedances were compared to the ten percent allowable annual exceedance frequency. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were above the WQO. In addition, a percent exceedance was calculated for ammonia and chlorophyll *a* to provide a relative comparison with the other nutrients. The breakdown of nutrient exceedances for index period events is as follows:

- Ammonia: For all index period events, the mean concentration was 0.08 mg/L, which exceeded the WQO of 0.025 mg/L. In total, 75 percent of Mass Emission Station samples exceeded the WQO.
- Chlorophyll *a*: For all index period events, the mean concentration was 14.7 ug/L, which did not exceed the WQO of 20 ug/L. In total, 13 percent of Mass Emission Station samples exceeded the WQO.
- Nitrate+nitrite: For all index period events, no Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TN: For all index period events, 75 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of ten percent.

- TP: For all index period events, 13 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of ten percent.

6.3.2.2 Event and Seasonal Variations

Variations in constituent concentrations between events throughout the season and during events are discussed for both wet and dry weather conditions for the following constituents. Both within-event and seasonal patterns can help better understand possible sources, processes, and mechanisms that affect runoff and associated concentrations.

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- TSS
- Ammonia
- CBOD
- Chlorophyll *a*
- N+N
- TN
- TP

The total fraction of nitrogen and phosphorus will be the primary focus of the nutrient discussion, considering the dissolved fractions comprised a consistent amount of the total throughout the seasons.

<u>Wet Weather – Seasonal Variations</u>

For bacteria, Wet Weather Event 1 had higher concentrations of *Enterococcus* at the Mass Emission Station than Wet Weather Events 2 and 3 (Tables 4-49 and 4-50). Fecal and total coliform concentrations were highest during Wet Weather Event 2. The following factors may have influenced the higher concentrations of *Enterococcus* during Wet Weather Event 1: longer event duration, higher rainfall intensity, higher peak discharge, and a longer length of antecedent dry period and, therefore, potential for greater pollutant build-up prior to the event. In fact, SCCWRP found that antecedent dry period was strongly correlated with bacteria concentrations from mass emission sites in an exponential manner (Tiefenthaler, Stein and Shiff, 2008). Early season storms generally had higher bacteria concentrations than late season storms both within and between watersheds, even when rainfall quantities were similar. SCCWRP attributed this to likely bacteria buildup during dry periods that flushes to rivers during early season storms. SCCWRP found that storm size may be a less reliable predictor of the magnitude of bacterial concentrations and loading. Although *Enterococcus* results are in accord with trends found by SCCWRP, the results are inconsistent to fecal and total coliform results from this monitoring program.

For TSS, Wet Weather Event 1 EMCs exceeded the EMCs of Wet Weather Events 2 and 3, although Wet Weather Event 2 was only slightly exceeded by Wet Weather Event 1 (Table 5-16).

For nutrients, a majority of the constituents had higher concentrations in Wet Weather Event 1 with the exception of ammonia and N+N. During both wet weather events, nitrogen and phosphorus were mostly present in the dissolved state based on the comparison between the total and dissolved mean values presented in Table 4-49.

Wet Weather – Within-Event Variations

Within-event variations were evaluated by assessing the concentration graphs in Appendix E. For Wet Weather Events 1 and 2, bacteria concentrations appeared to remain fairly consistent throughout the events, with no apparent trends. The highest total and fecal coliform concentrations during Wet Weather Event 1occurred after the first peak of the storm as the creek returned to lower flows prior to the onset of the second peak. Bacteria concentrations during Wet Weather Event 2 were relatively consistent and reached their highest point prior to the peak in discharge.

For Wet Weather Events 1 and 2, TSS concentrations appeared to correlate with the flow rate, with higher concentrations occurring during higher flow rates and lower concentrations occurring during lower flow rates. However, TSS concentrations during Wet Weather Event 2 were relatively high prior to the peak in discharge.

During wet weather events, nutrient concentrations remained relatively consistent with no apparent trends. However, during Wet Weather Event 1, ammonia concentrations decreased with the onset of the storm and remained very low throughout the remainder of the event.

Another method to evaluate the variability of concentrations within events is to assess the magnitude of first-flush concentrations relative to the rest of the event. First-flush effects describe the effect of the early flows of a storm carrying a higher level of contaminants relative to the latter flows. First-flush ratios were calculated for the first two wet weather events where pollutagraph sampling occurred. First-flush ratios are the result of a partial event mean concentration (PEMC) divided by the entire event mean concentration (EMC) at distinct intervals during a storm event. First-flush effects are indicated by a ratio of 1.0 and greater, with the effect being stronger with higher ratios. Table 6-14 presents the first-flush ratios for the first six hours of discharge for each wet weather event. Figures in Appendix F graphically present how the first-flush ratios changed throughout each wet weather event.

**Table 6-14: Loma Alta Concentration First-Flush Effects**

| Constituent | First-Flush Ratio[1] | | First-Flush Effect[2] |
|---|---|---|---|
| | Wet Weather Event 1 | Wet Weather Event 2 | |
| *Enterococcus* | 0.90 | 0.64 | None |
| Fecal Coliform | 0.73 | 0.74 | None |
| Total Coliform | 0.93 | 0.26 | None |
| TSS | 0.85 | 0.57 | None |
| Ammonia | 2.19 | 2.28 | Strong |
| CBOD | 1.91 | 1.49 | Moderate to Minor |
| N+N | 0.41 | 1.36 | None to Minor |
| TN | 1.20 | 1.25 | Minor |
| TP | 0.88 | 0.77 | None |

(1) The first-flush ratio presented is based on the ratio for the first two samples collected within the first six hours of discharge just prior to peak flows.
(2) Ratios > 2.0 were considered to have strong first-flush effects, ratios between 1.5 to 2.0 were considered to have moderate first-flush effects, ratios between 1.0 and 1.5 were considered to have minor first-flush effects, and ratios ≤ 1.0 were considered to have no first-flush effects.

As shown on Table 6-14, during Wet Weather Events 1 and 2, none of the bacteria constituents showed first-flush effects. Although *Enterococcus* and total coliform had ratios below 1.0, both showed a greater first-flush effect than during Wet Weather Event 3. It should be noted that the lack of a first-flush effect for bacteria is contrary to findings by SCCWRP (Tiefenthaler, et al., 2008). This study found that the greatest concentrations of bacteria occurred at or just before the first peak in discharge of the storm event for most of the 20 events sampled. Generally, more pronounced first-flush effects are found in highly urbanized and impervious watersheds. All but two of the watersheds studied were urban, densely populated watersheds ranging from 49 to 94 percent developed (two relatively undeveloped, non-urban watersheds less than five percent developed were also monitored). By contrast, Loma Alta Watershed is listed as only 29 percent impervious in the Carlsbad Watershed Management Plan. The SCCWRP study found that for the two undeveloped, non-urban watersheds, peak concentrations tended to occur later in the storm and persist for a longer duration (although bacteria concentrations steadily decreased following the early peak in storm), which is similar to what occurred at the Loma Alta Mass Emission Station.

TSS concentrations did not show first-flush effects during either wet weather events. These results were generally inconsistent with the results of the study by SCCWRP (Tiefenthaler et al., 2008), where higher concentrations of suspended sediment were observed in the early part of the storm events.

The majority of nutrients did show some first-flush effects. Ammonia showed a strong first-flush effect during both Wet Weather Events 1 and 2 with ratios above 2.0. CBOD demonstrate a moderate first-flush effect during Wet Weather Event 1 and a minor first-flush effect during Wet Weather Event 2. Nitrate+nitrite showed a minor first-flush effect during the Wet Weather Event 2 and TN showed a minor first-flush effect during both Wet Weather Events 1 and 2. TP did not show a first-flush effect during either event.

Dry Weather – Seasonal Variations

Seasonal variations in dry weather concentrations can be significant and can have both positive and inverse relationships with flow, temperature, and other factors. In order to assess these variations and possible relationships with flow, Table 6-15 was developed.

**Table 6-15: Loma Alta Mass Emission Station Concentrations by Season and Flow Regime**

| Constituent | Season[3] | Flow Regime[1] | | | | | Season Mean[2] |
|---|---|---|---|---|---|---|---|
| | | High Flows | Moist Conditions | Mid-Range Flows | Dry Conditions | Low Flows | |
| *Enterococcus* (CFU/100 mL) | Winter | 17,474 | 2,052 | 164 | | | 170 |
| | Spring | | 86 | | | | 86 |
| | Summer | | | | 58 | | 58 |
| | Fall | | | | | 221 | 221 |
| | Flow Regime Average | 17,474 | 1,069 | 164 | 58 | 221 | 134 |
| Fecal Coliform (MPN/100 mL) | Winter | 7,043 | 5,987 | 96 | | | 276 |
| | Spring | | 222 | | | | 222 |
| | Summer | | | | 355 | | 355 |
| | Fall | | | | | 867 | 867 |
| | Flow Regime Average | 7,043 | 3,104 | 96 | 355 | 867 | 430 |
| Total Coliform (MPN/100 mL) | Winter | 32,897 | 17,465 | 604 | | | 662 |
| | Spring | | 496 | | | | 496 |
| | Summer | | | | 530 | | 530 |
| | Fall | | | | | 1,745 | 1,745 |
| | Flow Regime Average | 32,897 | 8,981 | 604 | 530 | 1,745 | 858 |
| TSS (mg/L) | Winter | 129 | 32 | 2 | | | 3 |
| | Spring | | 7 | | | | 7 |
| | Summer | | | | 12 | | 12 |
| | Fall | | | | | 54 | 54 |
| | Flow Regime Average | 129 | 19 | 2 | 12 | 54 | 19 |
| Ammonia (mg/L) | Winter | 0.14 | 0.05 | 0.03 | | | 0.02 |
| | Spring | | 0.03 | | | | 0.03 |
| | Summer | | | | 0.06 | | 0.06 |
| | Fall | | | | | 0.22 | 0.22 |
| | Flow Regime Average | 0.14 | 0.04 | 0.03 | 0.06 | 0.22 | 0.08 |

**Table 6-15: Loma Alta Mass Emission Station Concentrations by Season and Flow Regime (continued)**

| Constituent | Season[3] | Flow Regime[1] | | | | | Season Mean |
|---|---|---|---|---|---|---|---|
| | | High Flows | Moist Conditions | Mid-Range Flows | Dry Conditions | Low Flows | |
| Chlorophyll *a* (ug/L) | Winter | | 3.22 | 1.10 | | | 2.87 |
| | Spring | | 16.75 | | | | 16.75 |
| | Summer | | | | 7.35 | | 7.35 |
| | Fall | | | | | 31.70 | 31.70 |
| | Flow Regime Average | | 10.60 | 1.10 | 7.35 | 31.70 | 14.67 |
| N+N (mg/L) | Winter | 0.57 | 0.63 | 0.93 | | | 0.71 |
| | Spring | | 0.21 | | | | 0.21 |
| | Summer | | | | 0.34 | | 0.34 |
| | Fall | | | | | 1.07 | 1.07 |
| | Flow Regime Average | 0.57 | 0.42 | 0.93 | 0.34 | 1.07 | 0.59 |
| TN (mg/L) | Winter | 1.47 | 1.19 | 1.54 | | | 1.21 |
| | Spring | | 1.13 | | | | 1.13 |
| | Summer | | | | 0.93 | | 0.93 |
| | Fall | | | | | 2.39 | 2.39 |
| | Flow Regime Average | 1.47 | 1.16 | 1.54 | 0.93 | 2.39 | 1.42 |
| TP (mg/L) | Winter | 0.37 | 0.09 | 0.09 | | | 0.07 |
| | Spring | | 0.02 | | | | 0.02 |
| | Summer | | | | 0.02 | | 0.02 |
| | Fall | | | | | 0.05 | 0.05 |
| | Flow Regime Average | 0.37 | 0.06 | 0.09 | 0.02 | 0.05 | 0.04 |

(1) Flow regimes are based on percent days exceeded and broken down into the following categories: high flows are classified as < 10% days exceeded; moist conditions are classified as > 10% and < 40% days exceeded; mid-range flows are classified as > 40% and < 60% days exceeded; dry conditions are classified as > 60% and < 90% days exceeded; low flows are classified as > 90% days exceeded.
(2) Season average does not include wet weather high flow events.
(3) Index Period 1 represents winter, Index Period 2 represents spring, Index Period 3 represents summer, Index Period 4 represents fall.

Based on Table 6-15, variations in constituent concentrations within and between each season are discussed below:

Winter

Index Period Event 1 was representative of dry weather conditions during winter. Samples were collected between January 14, 2008 and February 11, 2008. The water temperature at the Mass Emission Station ranged from 8 to 17 degrees Celsius. During this sampling event, daily total discharges ranged from 140,436 to 337,135 cubic feet (Table 4-45), which contained the average daily dry weather discharge of 168,313 cubic feet (Table 5-15). As shown on Table 6-15, these discharges fell within the moist condition and mid-range flow regimes.

Spring

Index Period Event 2 was representative of dry weather conditions during spring. Samples were collected between March 31, 2008 and April 7, 2008. The water temperature at the Mass Emission Station ranged from 12.9 to 22 degrees Celsius. During this event, daily total discharges ranged from 281,018 to 990,151 cubic feet (Table 4-45), which contains the average daily dry weather discharge of 374,427 cubic feet (Table 5-15). As shown on Table 6-15, these discharges fell within the moist conditions and mid-range flow regimes.

Summer

Index Period Event 3 was representative of dry weather conditions during summer. Samples were collected between July 7, 2008 and July 16, 2008. The water temperature at the Mass Emission Station ranged from 21 to 28 degrees Celsius. During this period, daily total discharge ranged from 7,429 to 8,052 cubic feet (Table 4-45), which was below the average daily discharge (Table 5-15). As shown on Table 6-15, these discharges fell within the dry conditions flow regimes.

Fall

Index Period Event 4 was representative of baseline conditions during fall. Samples were collected between September 29, 2008 and October 8, 2008. The water temperature at the Mass Emission Station ranged from 17 to 25.2 degrees Celsius. During this event, daily total discharge ranged from 2,034 to 4,050 cubic feet (Table 4-45), which was below the average and median daily discharges (Table 5-15). As shown on Table 6-15, these discharges fell within the low flow regimes.

*Enterococcus*, fecal coliform, and total coliform had the highest mean concentrations during the high flow conditions that reflect the wet weather concentrations. Dry weather concentrations were orders of magnitude lower than the wet weather concentrations. *Enterococcus*, fecal coliform, and total coliform concentrations were highest during the fall, which was generally characterized by low flows and warmer temperatures.

TSS mean concentrations were highest during the high flow conditions which reflect wet weather concentrations; however, the winter seasonal mean, which does not include the wet weather concentrations, is the lowest seasonal mean concentration. In contrast, the fall TSS mean concentration was higher than TSS mean concentrations for the other seasons.

Although not shown in Table 6-15, DO and pH had similar seasonal trends based on Table 4-46; higher DO concentrations (and pH readings) during the winter season (characterized by higher flow regimes and lower temperatures) and lower DO concentrations (and pH readings) during the fall season (characterized by mid-range to dry condition flow regimes). DO concentrations and pH readings were the highest during the winter (Index Period Event 1) with DO concentrations ranging from 8.3 to 12.0 mg/L and pH readings between 8 to 8.1 pH units, as shown on Table 4-46. Higher DO concentrations during the winter season can typically be attributed to elevated DO saturation resulting from the higher flow conditions (Nezlin, 2009). Fall DO concentrations were lowest compared to other seasons, with concentrations ranging from 5.6 to 11.1 mg/L and pH readings ranging from 6.0 to 8.1 pH units.

All three monitoring locations at Loma Alta Slough were affected by restricted flow within the monitoring areas. Construction near the railroad trestle (between the Lagoon Segment and Ocean Inlet Sites) beginning in March 2008 affected primarily the Lagoon Segment as well as the Mass Emission Station. For construction purposes, a berm was installed and when the upstream level reached a certain point periodic water releases occurred. This caused greater than normal depths, relatively stagnant water, wide temperature ranges, and varying conductivity ranges, resulting in algal blooms at the Lagoon Segment Site in the spring.

The nutrient constituents at the Mass Emission Station demonstrated similar seasonal patterns based on highest mean concentrations and percent exceedances in the fall (Index Period Event 4) shown on Table 4-56. The fall nutrient mean concentrations were higher than the other seasonal mean concentrations, with the exception of CBOD and TP. The summer CBOD mean concentration was higher than the other seasons while TP mean concentration was the greater in the spring than the other seasons as shown on

Table 4-56. During fall, the lowest DO concentrations were recorded (ranging between 5.6 to 11.1 mg/L) at the Mass Emission Station corresponding with elevated nutrients concentrations at the Mass Emission Station in comparison to the other seasons. It should be noted that an algal bloom was observed in the lagoon during June 2008 maintenance activities and summer 2008 index period sampling.

### 6.3.3 Loma Alta Constituent Concentrations – Lagoon Segment Site

#### 6.3.3.1 Comparison to Water Quality Objectives

A summary of concentrations for the Buena Vista Lagoon Segment Site, including geometric and arithmetic mean concentrations, ranges, and exceedances as compared to WQOs, is provided on Table 4-51 for wet weather events and on Table 4-58 for index period events. A comparison of concentrations to WQOs established in the San Diego Basin Plan was conducted for the following constituents:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- Ammonia
- Chlorophyll *a*
- N+N
- TN
- TP

<u>Bacteria</u>

For all wet weather events, two bacteria samples were collected at the Lagoon Segment Site and each concentration was compared to the wet weather WQO to determine the percent exceedance. A 22 percent exceedance allowance was applied to the wet weather water quality objectives for indicator bacteria, for preliminary comparison purposes, based on a SDRWQCB Beachs and Creeks TMDL (2007) and a natual loading study by SCCWRP (2007). The development of this preliminary exceedance allowance is described in Section 1.3. A breakdown of water quality at the Lagoon Segment during all wet weather events is as follows:

- *Enterococcus*: For all wet weather events, 100 percent of samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Fecal Coliform: For all wet weather events, 100 percent of samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Total Coliform: For all wet weather events, 67 percent of samples exceeded the WQO, versus an allowable exceedance of 22 percent.

Dry weather standards for indicator bacteria require the application of two criteria; the geometric mean concentration and the single-sample maximum requirement. Per the Basin Plan, the geometric means must be derived from a minimum of five samples in a 30-day period and must not exceed the dry weather geometric mean WQOs. *Enterococcus* and total coliform samples may not exceed the single-sample maximum allowable concentrations that are presented as the wet weather WQOs in Table 1-4. However, fecal coliform samples have a ten percent allowable exceedance rate over a 30-day period when compared to the single-sample maximum allowable concentrations. The geometric means and single-sample exceedance frequencies for the index period events were compared to both dry weather WQO criteria. For each index period event, the geometric mean was calculated from the six samples collected. The breakdown of bacteria exceedance for index period events is as follows:

- *Enterococcus*: The geometric mean concentrations for the Lagoon Segment and transects exceeded the dry weather geometric mean-based WQO of 35 CFU/100mL during Index Period Events 1, 3, and 4 at the Lagoon Segment, and for all index period events at the transects. For the entire monitoring period, 15 percent of Lagoon Segment and transect concentrations exceeded the single-sample maximum allowable concentration of 276 CFU/100mL. These exceedances, listed by sample site, are as follows:
  - Lagoon Segment: 13 percent (6 of 48 samples) had concentrations greater than 276 CFU/100mL, which occurred during Index Period Events 1, 3, and 4.
  - Transects: 18 percent (7 of 40 samples) had concentrations greater than 276 CFU/100mL, which occurred during Index Period Events 1, 3, and 4.
- Fecal Coliform: The geometric mean concentrations for the Lagoon Segment and transects exceeded the dry weather geometric mean-based WQO of 200 MPN/100mL during Index Period Events 1 and 2 at the Lagoon Segment, and during Index Period Events 1, 3, and 4 at the transects. For the entire monitoring period, 17 percent of Lagoon Segment and transect concentrations exceeded the single-sample maximum allowable concentration of 400 MPN/100mL. These exceedances listed by sample site and index period, are as follows:
  - Lagoon Segment: Index Period Events 3 and 4 had concentrations greater than 400 MPN/100mL at a frequency of 25 percent (3 of 12 samples), and 17 percent (2 of 12 samples), respectively, which exceeded the ten percent allowable frequency (per 30-day period).
  - Transects: Index Period Events 1, 3, and 4 had concentrations greater than 400 MPN/100mL at a frequency of 20 percent (2 of 10 samples), 40 percent (4 of 10 samples), and 20 percent (2 of 10 samples), respectively, which exceeded the ten percent allowable frequency (per 30-day period).
- Total Coliform: The geometric mean concentrations for the Lagoon Segment and transects exceeded the dry weather geometric mean-based WQO of 1,000 MPN/100mL during Index Period Event 4 at the Lagoon Segment. For the entire monitoring period, no Lagoon Segment or transect concentrations exceeded the single-sample maximum allowable concentration of 10,000 MPN/100mL.

Nutrients

Based on the limited availability of site-specific criteria the following WQOs were used for preliminary analysis purposes. SCCWRP in collaboration with SWRCB, USEPA, and other agencies are working to develop nutrient numeric endpoints for coastal water bodies (SCCWRP, 2009).

Wet and dry weather standards for nutrients vary by constituent; WQOs are based on an allowable exceedance that consider background levels or numerical limits that represent the maximum levels of constituents. N+N, TN, and TP have a ten percent allowable annual exceedance frequency. For N+N, TN, and TP each concentration was compared to the wet weather WQO to determine the percent exceedance. Ammonia and chlorophyll *a* are based on a numerical objective. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were above the WQO. In addition, a percent exceedance was calculated for ammonia to provide a relative comparison with the other nutrients. For Wet Weather Events 1, 2 and 3, two samples were collected and each concentration was compared to the wet weather WQOs to determine the percent exceedance. A 10 percent exceedance allowance was applied to N+N, TN and TP wet weather WQOs. The breakdown of nutrient exceedances for wet weather events are as follows:

- Ammonia: For all wet weather events at the Lagoon Segment, the mean concentration was 0.09 mg/L, which exceeded the WQO of 0.025 mg/L. In total 83 percent of the Lagoon Segment samples exceeded the WQO.
- Chlorophyll *a*: For all wet weather events at the Lagoon Segment, the mean concentration was 34.9 ug/L, which exceeded the WQO of 20 ug/L. In total 33 percent of the Lagoon Segment samples exceeded the WQO.
- N+N: For all wet weather events at the Lagoon Segment, zero percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent.
- TN: For all wet weather events at the Lagoon Segment, 83 percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TP: For all wet weather events at the Lagoon Segment, 83 percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.

A total of 48 samples were collected during four index period events, and each concentration was compared to the dry weather WQO to determine the percent exceedance. N+N, TN, and TP percent exceedances were compared to the 10 percent allowable annual exceedance frequency. For each Index Period Event, two samples were collected at each of the eight transect locations and each concentration was compared to the WQO to determine the percent exceedance. The mean concentrations for ammonia

and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were above the WQO. The breakdown of nutrient exceedances for index period events is as follows:

- Ammonia: For all index period events at the Lagoon Segment, the mean concentration was 0.06 mg/L, which exceeded the WQO of 0.025 mg/L. In total, 67 percent of the Lagoon Segment samples exceeded the WQO. For all transects, 71 percent of samples exceeded the WQO.
- Chlorophyll *a*: For all index period events at the Lagoon Segment, the mean concentration was 54.3 ug/L, which exceeded the WQO of 20 ug/L. In total, 73 percent of the Lagoon Segment samples exceeded the WQO. For all transects, 47 percent of samples exceeded the WQO.
- N+N: For all index period events at the Lagoon Segment and transects, zero percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TN: For all index period events at the Lagoon Segment, 44 percent of samples exceeded the WQO, versus an allowable exceedance of ten percent. For all transects, 54 percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TP: For all index period events at the Lagoon Segment, ten percent of samples exceeded the WQO, versus an allowable exceedance of ten percent. For all transects, 13 percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.

#### 6.3.3.2 Event and Seasonal Variations

Variations in constituent concentrations between events throughout the season and during events are discussed for both wet and dry weather conditions for the following constituents. Both within-event and seasonal patterns can help better understand possible sources, processes, and mechanisms that affect water quality and associated constituent concentrations.

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- TSS
- Ammonia
- CBOD
- Chlorophyll *a*
- N+N
- TN
- TP

The total fraction of nitrogen and phosphorus will be the primary focus of the nutrient discussion, considering the dissolved fractions comprised a consistent amount of the total throughout the seasons.

Wet Weather – Seasonal Variations

As shown on Table 4-51, Wet Weather Event 2 had higher fecal coliform and total coliform concentrations while Wet Weather Event 2 had higher *Enterococcus* concentrations. Wet Weather Event 1 had the lowest TSS concentrations while Wet Weather Event 2 had the highest single-sample TSS concentration. Nutrient constituents demonstrated different patterns during wet weather events. During Wet Weather Event 1, CBOD, chlorophyll *a*, and TDP had higher concentrations that the other events whereas N+N, SRP, TN, and TP had higher concentrations during Wet Weather Event 3.

Wet Weather – Within-Event Variations

For all events, slack high tide samples were collected 6.5 to 7.5 hours prior to the collection of low tide samples. During Wet Weather Event 1, the high tide sample was collected six hours after rainfall began and the low tide sample was collected 13.5 hours after rainfall began. The timing of sample collection was similar for Wet Weather Events 2 and 3, as high tide samples were collected 15 and 13 hours after rainfall began and low tide samples were collected 21.5 and 20 hours after rainfall began, respectively.

Within-event variations at the Lagoon Segment were related to tidal conditions. During Wet Weather Events 1 and 3, higher concentrations of all bacteria (*Enterococcus*, fecal coliform, and total coliform) were associated with slack low tide conditions. During Wet Weather Event 2 *Enterococcus* and total coliform had higher concentrations associated with slack low tide conditions. However, for this event the higher concentration of fecal coliform was associated with slack high tide conditions.

During all wet weather events, higher TSS concentrations were associated with slack low tides.

During Wet Weather Event 1 at the Lagoon Segment Sites, nutrient samples had higher concentrations associated with slack high tide conditions, with the exception of N+N and TDP. In contrast, Wet Weather Event 2 had higher concentrations associated with low tide conditions. Elevated nutrient concentrations in Wet Weather 3 were not associated with a particular tidal condition.

Dry Weather – Seasonal Variations

As shown on Table 4-58, concentrations of indicator bacteria were generally low at the Lagoon Segment Sites during dry weather conditions. Bacteria concentrations were greater during fall (Index Period Event 4) than the other seasons. Seasonal low bacteria concentrations varied by constituent; however, were associated with the spring (Index Period Event 1). TSS concentrations were higher during the spring

(Index Period Event 2), while the lowest concentrations occurred during the summer (Index Period Event 3).

DO and pH concentrations are important factors when evaluating nutrient concentrations and possible eutrophic conditions in a water body. The DO WQO (5 mg/L) was established as the minimum allowable DO concentrations in inland surface waters to maintain levels protective of aquatic organisms and habitats. Low DO levels can be harmful or lethal to aquatic organisms. Furthermore, low DO concentrations can be a symptom of eutrophic conditions within a water body. Eutrophication produces excess organic matter that fuels the development of hypoxia (i.e., low surface water DO concentrations) as organic matter is respired (McLaughlin, 2007). The acceptable pH levels established as the WQO (ranging 6.5 to 8.5) are required to be supportive of aquatic life. A change in pH can impact the bioavailability of nutrients.

DO and pH followed a pattern of higher concentrations during the winter; higher DO concentrations (and higher pH readings) during the winter (characterized by higher flow regimes and lower temperatures) and lower DO concentrations (and lower pH readings) during the fall (characterized by mid-range to dry condition flow regimes). DO concentrations and pH readings were the highest during the winter (Index Period Event 1) with DO concentrations ranging from 7.2 to 21.8 mg/L and pH readings between 8.1 to 8.5 pH units, as shown on Table 4-47. Higher DO concentrations during the winter can typically be attributed to elevated DO saturation resulting from the higher flow conditions (Nezlin, 2009). At the Lagoon Segment Sites, the lowest DO concentrations occurred during the fall (Index Period Event 3) with 0.3 mg/L average and 0.2 mg/L to 2.2 mg/L range, and the lowest pH readings occurred in the summer (ranging from 6.9 to 7.6 pH). Low DO concentrations are a commonly-observed symptom in DO eutrophic estuaries and can result from one or more of three environmental factors: low solar radiation (resulting in reduced oxygen production via photosynthesis), increased freshwater discharge (resulting in enhanced haline stratification which prevents ventilation of bottom waters), and sluggish bottom water ventilation due to stratification often occurring during neap tidal phase (Nezlin, 2009). The lowest DO concentrations occurred in June 2008, which did not coincide with a monitoring event. However, algal blooms were observed during monthly maintenance of the data sondes at the lagoon and during monitoring activities of Index Period Event 3.

All three monitoring locations at Loma Alta Slough were affected by restricted flow within the monitoring areas. Construction near the railroad trestle beginning in March 2008 affected primarily the Lagoon Segment Sites as well as the Mass Emission Station. For construction purposes, a berm was

installed and when the upstream level reached a certain point periodic water releases occurred. This caused greater than normal depths, relatively stagnant water, wide temperature ranges, and varying conductivity ranges, resulting in algal blooms affecting DO concentrations and turbidity values for extended periods of time.

The nutrient constituents demonstrated different seasonal patterns based on highest mean concentrations although many of them had elevated concentrations in fall (Index Period Event 4). Based on percent exceedances shown on Table 4-58, ammonia, chlorophyll *a*, and TN maintained elevated concentrations during summer and fall (Index Period Events 3 and 4). It should be noted that ambient conditions in a water body can reflect biological processing and nutrient loading that has already occurred (McLaughlin, 2007). Chlorophyll *a* was highest during spring (Index Period Event 2) with a mean concentration of 74 ug/L and maintained elevated concentrations during summer (mean of 50 ug/L) and fall (mean 42 ug/L). During the dry season, higher concentrations of chlorophyll *a* corresponded with observed algal blooms. A nutrient study conducted by SCCWRP further supports the relationship of high concentrations of chlorophyll *a* to the overproduction of algae (McLaughlin, 2007).

### 6.3.4 Loma Alta Constituent Concentrations – Ocean Inlet Site

The Loma Alta Ocean Inlet Site sampling characterized the exchange between the lagoon and ocean during wet weather and index period events.

#### 6.3.4.1 Comparisons to Water Quality Objectives

A summary of concentrations for the Loma Alta Slough Ocean Inlet, including geometric and arithmetic mean concentrations, ranges, and exceedances as compared to WQOs are provided in Tables 4-52 for wet weather events and in Table 4-59 for index period events. A comparison of concentrations to WQOs was conducted for the following constituents with WQOs established in the San Diego Basin Plan:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- Ammonia
- Chlorophyll *a*
- N+N
- TN
- TP

Bacteria

For all wet weather events, two bacteria samples were collected at the Ocean Inlet Site and each concentration was compared to the wet weather WQO to determine the percent exceedance. A 22 percent exceedance allowance was applied to the wet weather water quality objectives for indicator bacteria, for preliminary comparison purposes, based on a SDRWQCB Beachs and Creeks TMDL (2007) and a natual loading study by SCCWRP (2007). The development of this preliminary exceedance allowance is described in Section 1.3. A breakdown of water quality for both lagoons during all wet weather events is as follows:

- *Enterococcus*: For all wet weather events, 100 percent of Ocean Inlet samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Fecal Coliform: For all wet weather events, 100 percent of Ocean Inlet samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Total Coliform: For all wet weather events, 100 percent of Ocean Inlet samples exceeded the WQO, versus an allowable exceedance of 22 percent.

For each index period event, the geometric mean concentrations for bacteria were calculated from the twelve samples collected at the Ocean Inlet Site. The geometric mean concentrations were also calculated for the five transect locations with bacteria results, based on ten samples collected per event. The geometric mean concentrations were then compared to the dry weather geometric mean-based WQOs. Each sample result was also compared to the single-sample maximum allowable concentration (wet weather WQO) to determine the overall percent exceedance. A breakdown of these comparisons is summarized below for each bacterial constituent:

- *Enterococcus*: The geometric mean concentrations exceeded the dry weather geometric mean-based WQO of 35 CFU/100mL during Index Period Events 1 and 4. For the entire monitoring period, 3 percent of Ocean Inlet concentrations exceeded the single-sample maximum allowable concentration of 276 CFU/100mL. This exceedance occurred during Index Period Event 4.
- Fecal Coliform: The geometric mean concentrations exceeded the dry weather geometric mean-based WQO of 200 MPN/100mL during Index Period Event 4. For the entire monitoring period, 14 percent of Ocean Inlet concentrations exceeded the single-sample maximum allowable concentration of 400 MPN/100mL. These exceedances, listed by index period event, are as follows:
  - Ocean Inlet: Index Period Events 2 and 4 had concentrations greater than 400 MPN/100mL at a frequency of 8 percent (1 of 12 samples) and 33 percent (4 of 12 samples), respectively. Index Period Event 4 exceeded the ten percent allowable frequency (per 30-day period).

- Total Coliform: The geometric mean concentrations did not exceeded the dry weather geometric mean-based WQO of 1,000 MPN/100mL for all four index period events. For the entire monitoring period, no Ocean Inlet concentrations exceeded the single-sample maximum allowable concentration of 10,000 MPN/100mL.

Nutrients

Wet and dry weather standards for nutrients vary by constituent; WQOs are based on an allowable exceedance that consider background levels or numerical limits that represent the maximum levels of constituents. N+N, TN, and TP have a ten percent allowable annual exceedance frequency. For N+N, TN, and TP each concentration was compared to the wet weather WQO to determine the percent exceedance. Ammonia and chlorophyll *a* are based on a numerical objective. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were above the WQO. In addition, a percent exceedance was calculated for ammonia to provide a relative comparison with the other nutrients. For Wet Weather Events 1, 2 and 3, two samples were collected and each concentration was compared to the wet weather WQOs to determine the percent exceedance. The breakdown of nutrient exceedances for wet weather events is as follows:

- Ammonia: For all wet weather events at the Ocean Inlet Site, the mean concentration was 0.06 mg/L, which exceeded the WQO of 0.025 mg/L. In total, 83 percent of Ocean Inlet samples exceeded the WQO.
- Chlorophyll *a*: For all wet weather events at the Ocean Inlet Site, the mean concentration was 17.5 ug/L, which exceeded the WQO of 20 ug/L. In total, 50 percent of Ocean Inlet samples exceeded the WQO.
- N+N: For all wet weather events at the Ocean Inlet Site, zero percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TN: For all wet weather events at the Ocean Inlet Site, 50 percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TP: For all wet weather events at the Ocean Inlet Site, 83 percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.

A total of 48 samples were collected during four index period events, and each concentration was compared to the dry weather WQO to determine the percent exceedance. N+N, TN, and TP percent exceedances were compared to the 10 percent allowable annual exceedance frequency. For each Index Period Event, two samples were collected at each of the eight transect locations and each concentration was compared to the WQO to determine the percent exceedance. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were above the WQO.

The breakdown of nutrient exceedances for index period events is as follows:

- Ammonia: For all index period events at the Ocean Inlet Site, the mean concentration was 0.13 mg/L, which exceeded the WQO of 0.025 mg/L. In total, 56 percent of samples exceeded the WQO.
- Chlorophyll *a*: For all index period events at the Ocean Inlet Site, the mean concentration was 91.3 ug/L, which exceeded the WQO of 20 ug/L. In total, 69 percent of samples exceeded the WQO.
- N+N: For all index period events at the Ocean Inlet Site, zero percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TN: For all index period events at the Ocean Inlet Site, 39 percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TP: For all index period events at the Ocean Inlet Site, 14 percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.

#### 6.3.4.2 Event and Seasonal Variations

Wet Weather – Seasonal Variations

As shown on Table 4-52, at the Ocean Inlet Site, Wet Weather Event 1 had higher bacteria (*Enterococcus,* fecal Coliform, and total coliform) and TSS concentrations. Generally, nutrient concentrations were greater during Wet Weather Event 1 with the exception of TN and TDN, which were higher during Wet Weather Event 3.

Wet Weather – Within-Event Variations

Within-event variations were related to tidal conditions. For all events, slack high tide samples were collected 6.5 to 7.5 hours prior to the collection of low tide samples. During Wet Weather Event 1, the high tide sample was collected six hours after rainfall began and the low tide sample was collected 13.5 hours after rainfall began. The timing of sample collection was similar for Wet Weather Events 2 and 3, high tide samples were collected 15 and 13 hours after rainfall and low tide samples were collected 21.5 and 20 hours after rainfall, respectively.

At Ocean Inlet 1, Wet Weather Events 1 and 3 had higher concentrations of all bacteria (Enterococcus, Enterococcus and fecal coliform) associated with slack high tide conditions with the exception of total coliform collected during Wet Weather Event 1. The highest TSS concentrations were from samples collected during the slack high tide conditions compared to low tide conditions for all wet weather events. During Wet Weather Events 2 and 3, nutrient concentrations had higher concentrations associated with

low tide conditions. However, Wet Weather Event 1 nutrient concentrations were not associated with a particular tidal condition.

Dry Weather – Seasonal Variations

The Ocean Inlet was closed from July 18, 2008 to October 8, 2008; therefore, this site was not monitored during Index Period Event 3 (July 10 to 16, 2008) per the requirements of the QAPP and Work Plan. During Index Period Event 4, most constituents had elevated concentrations due to restricted tidal exchange as the Ocean Inlet was partially blocked by a sand berm. As shown in Tables 4-59, concentrations of indicator bacteria were generally low at the ocean inlets during dry weather conditions with the exception of Index Period Event 4. In terms of high nutrient concentrations during this index period, it should be noted that ambient conditions in a water body can reflect biological processing and nutrient loading that has already occurred (McLaughlin, 2007). Contrary to the other constituents, TSS concentrations were the highest during the spring.

### 6.3.5 Loma Alta Site-to-Site Comparisons

Table 6-16 compares the WQO exceedance frequency at each site for wet and dry weather conditions based on single-sample maximum concentration allowable. Based on Table 6-16, during wet weather events, all sites had bacteria exceedances. However, exceedances were less frequent at the Lagoon Segment during both wet and dry conditions. During the index period events, the Mass Emission Station had the highest frequency of fecal coliform exceedances although the Ocean Inlet had more *Enterococcus* exceedances than the other sites.

During wet weather conditions, all sites had a higher frequency of nutrient exceedances than during dry weather conditions. However, exceedances were less frequent at the Lagoon Segment during both wet and dry conditions. During the index period events, the Mass Emission Station had the highest frequency of fecal coliform exceedances although the Ocean Inlet had more *Enterococcus* exceedances than the other sites.

Table 6-17 compares the mean concentrations at each site for wet and dry weather conditions. Based on Table 6-17, during wet weather events, the mean concentrations for bacteria samples collected at the Mass Emission Station and Lagoon Segment exceedances geometric mean-based WQOs. Lagoon Segment 1 samples had relatively greater bacteria concentrations than samples collected from Lagoon Segment 2 during all wet weather events.

For all wet weather events, TSS concentrations were greater at Lagoon Segment 1 compared to Lagoon Segment 2, although the variance was relatively smaller during Wet Weather Event 3. Throughout the dry season, TSS concentrations were greater at Lagoon Segment 1 as compared to Lagoon Segment 2.

The Mass Emission Station Enterococcus, total and fecal coliform mean concentrations exceeded the geometric mean-based WQOs for dry weather conditions. Mean TSS concentrations were highest at the Lagoon Segment 1 compared to the other sites. Generally, the lagoon segments had higher nutrient mean concentrations than the Mass Emission Station.

Table 6-17 compares the mean concentrations at each site for wet and dry weather conditions.

**Table 6-16: Loma Alta Comparison of WQO Exceedance Frequency**

| Constituent | WQO | Units | Wet Weather | | | WQO | Units | Dry Weather | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mass Emission[1] | Lagoon Segment | Ocean Inlet | | | Mass Emission[1] | Lagoon Segment | Ocean Inlet |
| *Enterococcus* | 276 | CFU/100mL | 100.0% | 100.0% | 100.0% | 276 | CFU/100mL | 8.3% | 12.5% | 2.8% |
| Fecal Coliform | 400 | MPN/100mL | 100.0% | 100.0% | 100.0% | 400 | MPN/100mL | 41.7% | 14.6% | 13.9% |
| Total Coliform | 10,000 | MPN/100mL | 90.9% | 66.7% | 100.0% | 10,000 | MPN/100mL | 0.0% | 0.0% | 0.0% |
| Ammonia | 0.025 | mg/L | 87.5% | 83.3% | 83.3% | 0.025 | mg/L | 75.0% | 66.7% | 55.6% |
| Chlorophyll *a* | 20 | ug/L | NA | 33.3% | 50.0% | 20 | ug/L | 12.5% | 72.9% | 69.4% |
| Nitrate+Nitrite | 10 | mg/L | 0.0% | 0.0% | 0.0% | 10 | mg/L | 0.0% | 0.0% | 0.0% |
| Total Nitrogen | 1.0 | mg/L | 87.5% | 83.3% | 50.0% | 1.0 | mg/L | 75.0% | 43.8% | 38.9% |
| Total Phosphorus | 0.1 | mg/L | 100.0% | 83.3% | 83.3% | 0.1 | mg/L | 12.5% | 10.4% | 13.9% |

(1) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.

**Table 6-17: Loma Alta Comparison of Mean Concentrations**

| Constituent | WQO | Units | Wet Weather[1] | | | WQO | Units | Dry Weather[2] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mass Emission[3,4] | Lagoon Segment | Ocean Inlet | | | Mass Emission[4] | Lagoon Segment | Ocean Inlet |
| *Enterococcus* | 276 | CFU/100mL | 15,927 | 9,467 | 9,377 | 35 | CFU/100mL | 100 | 55.0 | 47.2 |
| Fecal Coliform | 400 | MPN/100mL | 22,400 | 4,083 | 8,433 | 200 | CFU/100mL | 292 | 205 | 178 |
| Total Coliform | 10,000 | MPN/100mL | 64,844 | 131,415 | 123,500 | 1,000 | CFU/100mL | 709 | 414 | 358 |
| TSS | 500 | mg/L | 126 | 70.3 | 68.1 | 500 | mg/L | 18.9 | 28.9 | 39.8 |
| Ammonia | 0.025 | mg/L | 0.13 | 0.09 | 0.06 | 0.025 | mg/L | 0.08 | 0.06 | 0.13 |
| CBOD | NA | mg/L | 6.51 | 2.60 | 3.17 | NA | mg/L | 1.08 | 2.18 | 3.94 |
| Chlorophyll *a* | 20 | ug/L | NA | 34.9 | 17.5 | 20 | ug/L | 14.7 | 54.3 | 91.3 |
| Nitrate+Nitrite | 10 | mg/L | 0.54 | 0.58 | 0.41 | 10 | mg/L | 0.59 | 0.21 | 0.13 |
| SRP | NA | mg/L | 0.19 | 0.15 | 0.14 | NA | mg/L | 0.06 | 0.02 | 0.02 |
| Total Nitrogen | 1.0 | mg/L | 1.40 | 1.22 | 1.02 | 1.0 | mg/L | 1.42 | 1.05 | 1.05 |
| Total Dissolved Nitrogen | NA | mg/L | 1.01 | 1.13 | 0.91 | NA | mg/L | 1.43 | 0.92 | 0.84 |
| Total Phosphorus | 0.1 | mg/L | 0.29 | 0.21 | 0.19 | 0.1 | mg/L | 0.04 | 0.06 | 0.06 |
| Total Dissolved Phosphorus | NA | mg/L | 0.22 | 0.21 | 0.17 | NA | mg/L | 0.08 | 0.02 | 0.03 |

(1) Wet weather Mass Emission Station data omits Wet Weather Event 3 because pollutagraph samples were not collected.
(2) For general chemistry, means were calculated as arithmetic means. For bacteria (Enterococcus, fecal coliform, and total coliform), means were calculated as geometric means.
(3) Chlorphyll *a* was not sampled for wet weather pollutagraphs
(4) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.

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### 6.3.6 Loma Alta Mass Emission Station Constituent Loading

Constituent loading is an important factor when considering point and nonpoint source contaminant input to a receiving water body. While constituent concentrations provide information on specific contaminant levels at a given point in time, load estimations consider discharge amounts along with constituent concentrations to provide insight into the overall amount of targeted constituents introduced into a water body. For example, equal concentrations of a given constituent measured under different flow regimes will result in different load values, which contribute to a better understanding of the impacts of that given constituent.

Although, the watershed may contribute to the constituent loading, the lagoon is subject to other inputs and processes that influence water quality as presented in Figures 1-1 to 1-4 of Section 1.4. As part of the load assessment, load estimates were developed for the watershed associated with the Mass Emission Station only. It should be noted that the watershed for the mass emission station represents the majority of the entire watershed for the Loma Alta Slough. The remaining portion of the watershed comprises the area discharging into the lagoon (or the creek) from adjacent lands downstream from the mass emission station. Runoff from this area generally sheet flows into the lagoon from pervious surfaces or discharges into storm drains that then discharge directly into the lagoon. The total load entering the lagoon (and the lagoon's loading capacity) would, therefore, include loads from the watershed for the mass emission station and the loads for the watershed(s) downstream from the mass emission station. Although the load assessments in this section do not account for this additional area downstream from the Mass Emission Station, the assessments still provide snapshots of the potential impacts of loading from the mass emission station's watershed on the lagoon.

#### 6.3.6.1 Daily and Annual Loading

Total daily and annual flows for the Loma Alta Slough Mass Emission Station are reported in Section 4.3.1.2. Detailed continuous stage and flow data results for the entire monitoring period is presented in Appendix A-3. Section 4.3.2.1 contains hydrographs and hyetographs depicting total rainfall, rainfall intensity, and discharge for monitored wet weather events (Figures 4-8 through 4-10).

Total daily and annual loads for the Loma Alta Slough Mass Emission Station are reported in Section 5.3.1.3. Daily load estimates are provided for both wet weather and dry weather periods in Table 5-17. Total annual load estimates are provided in Table 5-18. Detailed daily and annual load calculations are provided in Appendix D-3.

As shown in Table 5-17 in Section 5, the average daily wet weather loads greatly exceed the daily average dry weather loads due to higher constituent concentrations for all constituents (not including chlorophyll *a* as it was not sampled during wet weather events) and significantly greater flows during wet weather conditions.

Also, as shown in Table 5-18, the total annual wet weather load for most constituents represents approximately 90 to 99 percent of the total annual dry and wet weather load. This is typical for Southern California watersheds. For example, for the bacteria TMDLs developed for beaches and creeks by SDRWQCB (2007), wet weather loads constituted approximately 99 percent of the total annual loads for bacteria.

For some of the constituents such as TN, TDN, Nitrate + Nitrite, the relative percentage of total annual load represented by wet weather loads was between 55 and 75 percent. Although the relative percentage was lower, the majority of total annual load for these constituents is due to wet weather load. Although the wet weather and dry weather concentrations were similar, total annual wet weather flows significantly exceeded the total dry weather flows resulting in a greater portion of annual load for these constituents due the wet weather events.

6.3.6.2 Event and Seasonal Variations

Variations in constituent loading between events throughout the season and during events are discussed for both wet and dry weather conditions. Both within-event and seasonal patterns can help provide a better understanding of possible sources, processes, and mechanisms that affect runoff and associated bacteria concentrations.

<u>Wet Weather - Seasonal Variations</u>

Seasonal wet weather variations in bacteria loading were assessed by reviewing the load duration curves in Appendix H-3 and comparing the total constituent loads for each event.

Load duration curves were generated for constituents with a corresponding WQO, which include the following:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- Ammonia

- Chlorophyll *a*
- N+N
- TN
- TP

Overall, Wet Weather Event 1 peak flows and bacteria loading rates were higher than the peak flows and loading rates that occurred during Wet Weather Event 2. Peak loading rates during Wet Weather Event 1were approximately four times the loading rates during Wet Weather Event 2.

For bacteria, the three bacteria constituents exceeded their associated wet weather loading capacities for all three wet weather events with the exception of one day during both Wet Weather Events 1 and 2 when total coliform fell just below the loading capacity. These exceedances occurred under high flow regimes, which also indicated these exceedances were likely resulting from non-point source inputs. These non-point source inputs include urban runoff resulting in the flushing of the storm water drainage and the washing of streets and yards in areas with significant domestic and wildlife populations.

Table 6-18 shows the total loads for bacteria during the three monitored wet weather events. Total loads for all three bacteria constituents were highest during Wet Weather Event 1. This is primarily due to the significantly higher total discharge volume associated with Wet Weather Event 1. Wet Weather Events 2 and 3 had discharge volumes that were more similar and this is reflected in the relative similarity in bacteria total loads calculated for those events. Differences in event total loads for Wet Weather Events 2 and 3 are primarily due to varied concentrations between constituents and events.

For nutrients examined, TN, TP, and Ammonia exceeded the wet weather loading capacity during all three wet weather events (TN data not available for Wet Weather Event 3) for all but one Ammonia sample during Wet Weather Event 1 which fell just below the loading capacity. Nitrate + Nitrite did not exceed the loading capacity during all three wet weather events.

Table 6-18 shows the total loads for nutrients and other monitored constituents during the three monitored wet weather events. Total loads for all constituents were highest during Wet Weather Event 1. This is primarily due to the significantly higher total discharge volume associated with Wet Weather Event 1. Wet Weather Events 2 and 3 had discharge volumes that were more similar and this is reflected by the relative similarity in nutrient total loads calculated for those events. The effect of discharge is apparent when comparing concentrations with loads as the concentrations between events are relatively similar yet when combined with total discharge for the event, the loads reflect greater differences.

**Table 6-18: Loma Alta Wet Weather Event Total Loads**

| Event | *Enterococcus* | Fecal Coliform | Total Coliform | TSS | Ammonia (as N) | CBOD | Nitrate + Nitrite (as N) | SRP | Total Nitrogen | Total Dissolved Nitrogen | Total Phosphorous | Total Dissolved Phosphorous |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 | 165,932 | 64,282 | 332,925 | 275,967 | 130 | 5,116 | 1,195 | 540 | 2,737 | 1,376 | 740 | 356 |
| Wet Weather Event 2 | 11,024 | 10,100 | 28,553 | 22,311 | 20 | 816 | 86 | 30 | 225 | 167 | 46 | 34 |
| Wet Weather Event 3 | 23,619 | 8,872 | 65,160 | 42,098 | 132 | 782[1] | 133 | 68[1] | 428[1] | 269[1] | 115 | 72 |

(1) Constituents were not analyzed for Wet Weather Event 3; therefore, the values presented are calculated values.

Wet Weather - Within-Event Variations

Pollutagraph sampling provided information on varying contaminant levels throughout Wet Weather Events 1 and 2. As flows varied throughout these wet weather events, contaminant loads varied as well. Results from pollutagraph sampling were used to calculate changing loading rates throughout both pollutagraph sampling events. These load pollutagraphs show loading rates along with discharge throughout each wet weather event. Based on the length of each monitored wet weather event, different time intervals were selected to calculate loading rates. A three-hour interval was selected for Wet Weather Event 1, which lasted approximately 53 hours. A one-hour interval was selected for Wet Weather Event 2, which lasted approximately 24 hours. Appendix G contains the load pollutagraphs for all monitored constituents during the first two wet weather events for the following constituents:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- TSS
- Ammonia
- CBOD
- Chlorophyll *a*
- N+N
- SRP
- TN
- TDN
- TP
- TDP

Wet Weather Event 1 had two discharge peaks, which affected loading rates during the event. Relative to discharge throughout the event, fecal and total coliform both had slightly higher loading rates during the first peak compared to the second peak, however both persisted at relatively high loading rates for a period of time after the first peak. Enterococcus showed relatively similar responses to both peaks. The loading rates for TSS appeared to correlate well with the response shown by fecal and total coliform but showed a relatively higher loading rate during the first peak and a relatively lower response during the second and did not persist after the first peak. CBOD and Ammonia also followed the trend demonstrated by TSS. N+N, SRP, TN, TDN, TP, and TDP all followed a pattern similar to Enterococcus with relatively similar responses to both peaks.

Wet Weather Event 2 was a shorter event and had a slight dual peak in discharge occurring within a few hours of each other. Most monitored constituents followed a similar pattern, correlating well with discharge throughout the event. However there were some notable exceptions. Enterococcus showed a

relatively high loading rate before the dual peaks and persisted for a period of a few hours after the peaks. Ammonia and CBOD both demonstrate relatively high loading rates prior the onset of the dual peaks in discharge but did not persist beyond the first of the two peaks.

Another method to evaluate the variability of loads within events is to assess the magnitude of the first flush loads relative to the rest of the event. Mass first-flush is similar to concentration first-flush discussed earlier, however, mass first-flush is based on a loading approach for an entire event. Mass first-flush describes the percent mass of monitored analytes that have been observed in the first 20 to 40 percent of storm discharge volume. Higher percent mass, those greater than 80 percent, for a given analyte has been suggested as an indicator that an analyte demonstrates a strong mass first-flush effect (Kayhanian and Stenstrom, 2008).

Table 6-19 presents the percent mass values along with the associated percent of storm discharge for both wet weather events.

**Table 6-19: Loma Alta First Flush Percent Mass**

| Analyte | Wet Weather 1 (at 29% of Flow) | | Wet Weather 2 (at 26% of Flow) | |
|---|---|---|---|---|
| | Mass First-Flush % | First-Flush Effect[1] | Mass First-Flush % | First-Flush Effect[1] |
| *Enterococcus* | 22 | None | 18 | None |
| Fecal Coliform | 43 | Minor | 43 | Minor |
| Total Coliform | 41 | Minor | 64 | Moderate |
| TSS | 23 | None | 29 | None |
| Ammonia (as N) | 40 | Minor | 40 | Minor |
| CBOD | 38 | Minor | 42 | Minor |
| N+N | 21 | None | 22 | None |
| SRP | 21 | None | 26 | None |
| TN | 18 | None | 24 | None |
| TDN | 31 | None | 21 | None |
| TP | 19 | None | 17 | None |
| TDP | 34 | None | 16 | None |

(1) For discussion purposes first-flush categories are defined as follows: strong = > 80%, moderate = < 80% and > 60%, minor = < 60% and > 35%, none = < 35%.

None of the constituents monitored at the Loma Alta Mass Emission Station demonstrated a strong mass first-flush effect. The strongest mass first-flush effect throughout both events was demonstrated total coliform showing a moderate first-flush effect during Wet Weather Event 2. Nearly all of the remaining

constituents did not show a mass first-flush effect with the exception some minor effects shown by fecal and total coliform, ammonia, and CBOD during Wet Weather Event 1 and fecal coliform, ammonia, and CBOD during Wet Weather Event 2.

Wet Weather Event 1 mass first-flush results are generally supported for most constituents compared to the concentration-based first-flush analysis with the exception of ammonia, TN, and CBOD. Ammonia showed a strong first-flush effect with a ratio above 2.0. CBOD showed a moderate first-flush effect and TN showed a minor first-flush effect. Ammonia and CBOD showed a corresponding mass first-flush effect however not at the same strengths as those reports by the concentration-based ratios. TN does have contrasting results as the concentration based first-flush is slightly above 1.0 while the mass first-flush effect is weak at 18 percent. Fecal and total coliform both reported a mass first-flush effect of minor and report a corresponding lack of concentration-based first-flush effects. The remaining results for mass first-flush correspond to the concentration first flush results in that neither show first-flush effects.

Wet Weather Event 2 mass first-flush results for fecal and total coliform reflect an opposite result to concentration first flush results. Total coliform demonstrated the strongest mass first-flush effect across all constituents and both wet weather events and fecal coliform was among the strongest of the remaining constituents reporting minor effects. However the concentration first-flush ratios demonstrate no first-flush effects. Conversely, Ammonia demonstrated a strong concentration first-flush effect but show a minor mass first-flush effect. CBOD reports a minor mass first-flush effect and report a similar response based on the concentration first-flush ratios. Total nitrogen and N+N report minor concentration-based first-flush effects but do not show a corresponding mass first-flush effect. Phosphorus-related analytes reflected similar results from both analysis types with neither reflecting a first-flush effect. These results highlight the importance volume when assessing first-flush effects as total discharge influences the overall amount of a constituent being input into a water body.

<u>Seasonal Variations – Dry Weather</u>

Seasonal dry weather variations in constituent loading were assessed by comparing the average constituent loads for each event in Table 5-20 and reviewing the load duration curves in Appendix H-3.

Average total load for bacteria constituents were highest during the spring months due to high discharge totals throughout the spring months. Winter loads were also relatively high and may be attributed to the high dry weather flows experienced during those months as the mean concentration for that period were among the lowest to mid-range for the four index period events. Loads during summer and fall were lower than the winter and spring due primarily to the low discharge totals reported during those months.

Although summer and fall discharge totals were similar, the average loads were higher during the fall months due to higher average concentrations during those months.

Total suspended solids, chlorophyll *a*, and nutrient loads generally corresponded to the patterns shown by bacteria, with highest dry weather loads recorded during spring when relatively high dry weather discharge rates occurred. N+N, SRP, TP, and TDP were the only exceptions to this pattern as they reported comparable or slightly higher dry weather loads during the winter and spring months. This is due to those constituents reporting higher concentrations in winter relative to spring when compared to most other constituents. This pattern reflects the influence of discharge when analyzing load versus concentration. Concentrations for nutrients during spring were generally lower in the spring months however the high dry weather discharge totals for those months resulted in generally the highest loads for the year. Discharge rates were similar in summer and fall months resulting in loads which correspond to relative concentrations during those months. Generally concentrations were higher in fall resulting in higher loads during those months.

Exceedances of the loading capacities varied throughout each season. *Enterococcus* exceeded the dry weather loading capacity during each of the four seasons with the exception of two days during Index Period Event 2 and one day during Index Period Event 3. These exceedances occurred under all flow regimes suggesting that *Enterococcus* exceedances are a result of both point and non-point sources. Influences from non-point sources appear to have occurred during the first index period which took place in winter with residual effects from wet weather events. Non-point influences appear to have continued through the spring as dry weather discharge at Loma Alta Slough remained high throughout the spring months. Dry weather fecal coliform samples collected during Index Period Event 1 and 2 occurred under moist conditions and mid-range flows and exceeded loading capacities approximately half of the time during both events. However fecal coliform samples collected during summer and fall consistently exceeded the loading capacities. These exceedances occurred during dry conditions for Index Period Event 3 and during low flow regimes for Index Period Event 4. Total coliform did not exceed loading capacities during Index Period Events 1, 2, and 3 with the exception of one day during Index Period Event 3. These events occurred during moist conditions, mid-range flows, and dry condition flow regimes. Index Period Event 4 occurred under low flow conditions and exceeded loading capacities each day.

Total nitrogen and ammonia were the primary nutrients to exceed loading capacities consistently through the seasons which represented moist conditions, mid-range flows, dry conditions, and low flow regimes. TP did exceed loading capacities on some occasions, particularly during Index Period Event 1 in the

winter which corresponds to elevated concentrations and, therefore, loads during those months. Chlorophyll *a* did exceed loading capacities on some occasions during the spring and fall months which occurred during moist conditions and low flows, respectively. These exceedances correspond to relatively high concentrations measured during those months. Nitrate + nitrite did not exceed loading capacities during any season or under any flow regimes.

### 6.3.7 Loma Alta Dissolved Oxygen Concentrations

Dissolved Oxygen (DO) concentration can be an important indicator of eutrophic conditions within a water body. Eutrophic conditions caused by excessive nutrient input (such as nitrogen and phosphorous) result in excessive plant growth, or algal blooms. When the algae begin to die and decompose, oxygen is consumed in the process by microorganisms feeding on the dead algae, leading to low DO concentrations. The eutrophication process can impair aquatic life and fisheries by causing depressed levels of oxygen which result in a change to the benthic community structure from aerobic to anaerobic organisms and stress or eliminate desirable aquatic life (USEPA, 1999). The DO WQO was established as a minimum concentration to maintain DO levels above 5 mg/L and average annual concentration of 7mg/L to be protective of aquatic life and habitats.

Fluctuations in DO can result from various environmental factors such as temperature, plant respiration, decomposition of organic matter, and stratification of the water column. Low DO concentrations are caused from one or more of three environmental factors: low solar radiation (resulting in reduced oxygen production via photosynthesis), increased freshwater discharge (resulting in enhanced haline stratification which prevents ventilation of bottom waters), and sluggish bottom water ventilation due to stratification often occurring during neap tidal phase (Nezlin, 2009). In the study conducted by SCCWRP, hypoxic events were defined as periods when either the DO daily average was below 3 mg/L or any observation during the 24-hr period was less than 1.0 mg/L (Nezlin, 2009).

#### 6.3.7.1 Comparison to DO WQOs

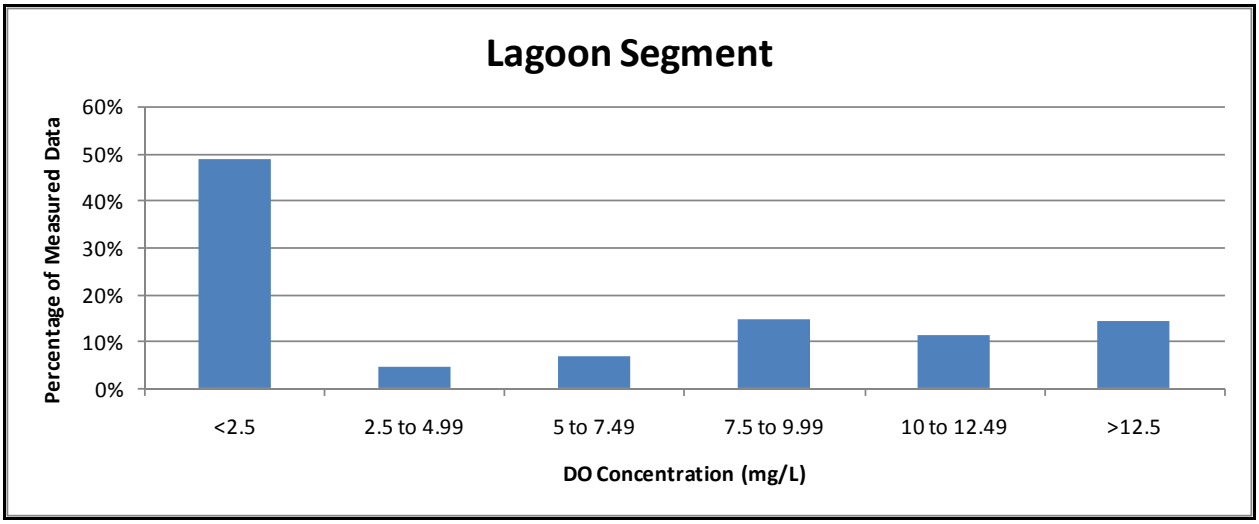
DO data for the Lagoon Segment is summarized in Table 4-47 in Section 4.2.1. Complete continuous DO data is reported in Appendix B-3. Detecting hypoxia is difficult because DO is exceptionally variable over short time scales, i.e., less than a day, due to variable rates of oxygen production and consumption, which fluctuate in response to different environmental factors (Nezlin, 2009). In general, DO data reflected eutrophic conditions at Lagoon Segment with wide ranges of DO concentrations and low minimum concentrations. Fifty percent of the monthly averages were below the WQO of 5 mg/L as shown in Table

4-47. This is the result of restricted flow and algal blooms ultimately causing low DO concentrations. For construction purposes, a berm was installed west of the Lagoon Segment in March causing greater than normal depths, relatively stagnant water, wide water temperature ranges, and varying conductivity ranges.

The WQO for DO requires that no single measurement fall below a concentration of 5 mg/L along with an annual mean objective of 7 mg/L as described in Table 1-4 in Section 1.3. Figure 6-8 is a frequency distribution of all measured DO concentrations throughout the entire monitoring period. The distribution is broken down into 2.5 mg/L bins. There are six bins with the last bin containing the percentage of measured concentrations of 12.5 mg/L and greater. The percentage of measured concentrations in the first two bins represents the percentage of concentrations not meeting the WQO.

Lagoon Segment shows approximately 55 percent of all measured concentrations falling below the single-sample minimum WQO. Approximately 25 percent of the concentrations occur between 5 and 10 mg/L, which surround the annual mean objective of 7 mg/L. The mean for the entire monitoring period at the Lagoon Segment is 5.5 mg/L as shown in Table 4-47. The higher percentage of low DO concentrations at the Lagoon Segment may be attributable to one or more of four environmental factors causing wide ranging DO concentrations: temperature, plant respiration, decomposition of organic matter, or stratification of the water column.

**Figure 6-8: Loma Alta Frequency Distribution of Measured DO Concentrations**




6.3.7.2 Seasonal Variations in DO Concentrations

Index period events are intended to represent seasonal variations within the lagoon. The Lagoon Segment had higher DO concentrations in the winter and spring and lower concentrations in the summer and fall. Water temperature is an important factor when considering DO as lower water temperatures can hold higher concentrations of DO. The lowest concentrations at the Lagoon Segment were observed in June during Index Period Event 2 (mean of 0.1 mg/L) corresponding with the highest water temperature (range 23.7 to29.7) which was affected by restricted flow causing highly stratified water body and algal blooms.

The Lagoon Segment was affected by restricted flow during construction that began in March near the railroad trestle between the Lagoon Segment and Ocean Inlet. For construction purposes, a berm was installed causing greater than normal depths, relatively stagnant water, wide water temperature ranges, and varying conductivity ranges. These conditions resulted in algal blooms affecting DO concentrations and turbidity values for extended periods of time. Furthermore, sensors were placed near the bottom of the water column where anoxic layers would occur regularly due to persistent algal blooms. This is reflected in DO minimum concentrations below 1.0 mg/L and relatively high turbidity values typical of algal blooms. During March, April, and May, DO concentrations had wide ranges that may be reflect one or more of the following factors: reduced oxygen production via photosynthesis, increased plant respiration, increased decomposition of organic matter, or a gradually more stratified water column. In June, the Lagoon Segment did not demonstrate wide fluctuations in DO concentrations with a range of 0.1

to 0.6 mg/L coinciding with the highest water temperature (range 23.7 to 29.7), highest turbidity (range 13.1 to 365 NTU) and observed algal blooms. While these data are accurate for the distinct location and water column depth measured, as a result of the construction and conditions at this site is that these data may not be representative of the overall water quality for Lagoon Segment during natural flow conditions. Instantaneous DO collected throughout the monitoring period are plotted for all sites and can be found in Appendix I-2.

### 6.3.8 Loma Alta Summary of Key Findings

For the 2008-2009 monitoring year, precipitation totaled 12.41 inches, which was slightly above the mean annual rainfall of approximately 12 inches. Approximately 179 million cubic feet of water discharged into Loma Alta Slough from Loma Alta Creek. Of that amount, approximately 98 percent was discharged during wet weather events during the winter. Based on the sampling results and data assessment, a summary of the key findings for each constituent category are presented below.

<u>Bacteria</u>

Comparison to WQOs:

- During wet weather conditions, WQOs were exceeded at all monitoring locations (Mass Emission Station, Lagoon Segment, and Ocean Inlet). In addition loading capacities were exceeded for all indicator bacteria at the Mass Emission Station, indicating that beneficial uses of the lagoon may have been impacted during wet weather conditions.
- During dry weather conditions, WQOs were exceeded at all monitoring locations (Mass Emission Station, Lagoon Segment, and Ocean Inlet) for *Enterococcus* and fecal coliform. In addition loading capacities were exceeded for *Enterococcus* and fecal coliform at the Mass Emission Station.

Seasonal Variations:

- Seasonal variations were observed at the mass emission station for both wet and dry weather conditions for all bacteria indicators. Wet weather concentrations were greater than dry weather concentrations by approximately 2,400 percent (for fecal coliform) and 11,400 percent (for *Enterococcus*). During wet weather conditions, Wet Weather Event 1 *Enterococcus* concentrations were greater than Wet Weather Events 2 and 3, however fecal coliform concentrations were greater for Wet Weather Event 2 than Wet Weather Events 1 and 3. Wet Weather Event 1had greater loading than Wet Weather Events 2 and 3, possibly due to a longer antecedent dry period and/or higher rainfall intensities and peak flows.
- During dry weather conditions, at the Mass Emission Station higher bacteria concentrations occurred during the fall months, characterized by lower flows and hotter temperatures. The lowest concentrations occurred during the spring and summer seasons.
- Within the lagoon, the highest concentrations occurred during wet weather conditions, with lower concentrations during dry weather conditions. For dry weather conditions at the

Lagoon Segment, the fall had the highest concentrations and the winter and spring had the lowest concentrations.

Within-Event Variations:

- Generally, bacteria concentrations at the mass emission station were similar throughout wet weather events, although during Wet Weather Event 2, the highest fecal coliform and *Enterococcus* concentrations occurred towards the end of the storm. With the exception of a moderate concentration first flush effect for total coliform for Wet Weather Event 1, no concentration first flush effects were seen at the mass emission station. Moderate mass first flush effects were seen, however, for total and fecal coliform for Wet Weather Event 2.
- Wet Weather Events 1 and 2 showed minor to moderate mass first flush effects for fecal coliform and total coliform, although low first-flush ratios for concentration demonstrated no such corresponding effect.

Site Differences:

- Differences in concentrations between sites were found for indicator bacteria during dry weather conditions. The Mass Emission Station mean concentrations of fecal coliform were greater than the Lagoon Segment and Ocean Inlet. Additionally, the Mass Emission Station mean concentrations of total coliform were significantly greater than the Ocean Inlet for all index periods.

<u>Sediment</u>

Seasonal Variations:

- Differences were found at the Mass Emission Station where TSS concentrations during wet weather conditions were greater than concentrations during dry weather conditions.
- During wet weather conditions, TSS concentrations and loadings were greater during Wet Weather Event 1 than Wet Weather Events 2, possibly due to a longer antecedent dry period and/or higher rainfall intensities and peak flows
- During dry weather conditions, TSS concentrations were the highest during fall under low flow conditions. TSS concentrations were lowest during winter under mid-range flow regimes.
- Within the lagoon, TSS concentrations during wet weather conditions were greater than dry weather conditions.

Within-Event Variations:

- For TSS, concentrations generally correlated with the flow rate, i.e., higher concentrations during higher flows and lower concentrations during lower flows.
- TSS did not show first-flush effects. TSS did not have concentration-based or mass-based first flush effects during Wet Weather Events 1 and 2.

Nutrients

Comparison to WQOs:

- WQOs and loading capacities for most nutrient constituents were exceeded during wet weather conditions at the Mass Emission Station and WQOs were exceeded at almost all locations.
- During dry weather conditions, WQOs were exceeded at locations for most nutrient constituents at all locations. However, the loading capacity for nitrogen at the Mass Emission Station was the only nutrient constituent to exceed during dry weather conditions.
- For the entire monitoring period, approximately, 50 percent of DO concentrations were below the single-sample minimum WQO. However, during the monitoring period a berm was installed for construction purposes between the lagoon and the ocean inlet causing greater than normal depths and relatively stagnant water within the lagoon. The restricted flow conditions and other environmental factors such as temperature and biological activity resulted in an algal bloom during this period.

Seasonal Variations:

- Seasonal variations were observed at the mass emission station for both wet and dry weather conditions for most nutrient constituents. During wet weather conditions, Wet Weather Event 1 concentrations and loadings were greater than Wet Weather Events 2 and 3 concentrations and loadings, possibly due to a longer antecedent dry period and/or higher rainfall intensities and peak flows.
- During dry weather conditions, higher nutrient concentrations occurred during the summer months, characterized by lower flows and hotter temperatures. The lowest concentrations occurred during the winter and spring seasons.
- Within the lagoon, the highest concentrations occurred during wet weather conditions, with lower concentrations during dry weather conditions. For dry weather conditions, the fall had the highest concentrations and the spring had the lowest concentrations.
- DO concentrations were highest during the winter (characterized by higher flow conditions and lower temperatures) and lowest during the fall (characterized by lower flow conditions and warmer temperatures).

Within-Event Variations:

- Generally, nutrient concentrations were similar throughout wet weather events. However, ammonia had a strong concentration first-flush effects during both events and CBOD had moderate first-flush effects during Wet Weather Event 1 although the corresponding mass-first flush effects were minor.

Site Differences:

- Differences in concentrations between sites were found, with mass emission station mean concentrations for the following constituents: SRP, TDP and TP greater than lagoon and ocean inlet mean concentrations during dry weather conditions; while Lagoon Segment 1 had higher chlorophyll *a* concentrations than the Mass Emission Station during dry weather

conditions. During dry weather conditions, Ocean Inlet had higher concentrations of chlorophyll *a* and CBOD were higher than the Lagoon Segment and Mass Emission Station.

## 6.4 SAN ELIJO LAGOON DISCUSSION

### 6.4.1 San Elijo Daily, Monthly, and Annual Rainfall

Based on measurements at the Mass Emission Station, San Elijo Lagoon received 10.59 inches of rain between October 1, 2007 and October 31, 2008. Daily and monthly rainfall totals are summarized in Table 4-63. January had the most rainfall, 3.54 inches, followed by February, which had 3.11 inches. The majority of the rainfall, 97 percent, occurred during the winter months of November through February.

Isopluvial maps from the San Diego County Hydrology Manual indicate that the mean annual rainfall for the San Elijo Watershed area is about 12 inches, ranging between approximately 11 to 14 inches (Chang, 2009). Based on this data, the total rainfall at the mass emission station (located near the 11-inch isopluvial) during the monitoring period was slightly (about 4 percent) less than average for the area.

#### 6.4.1.1 Watershed Response to Rainfall

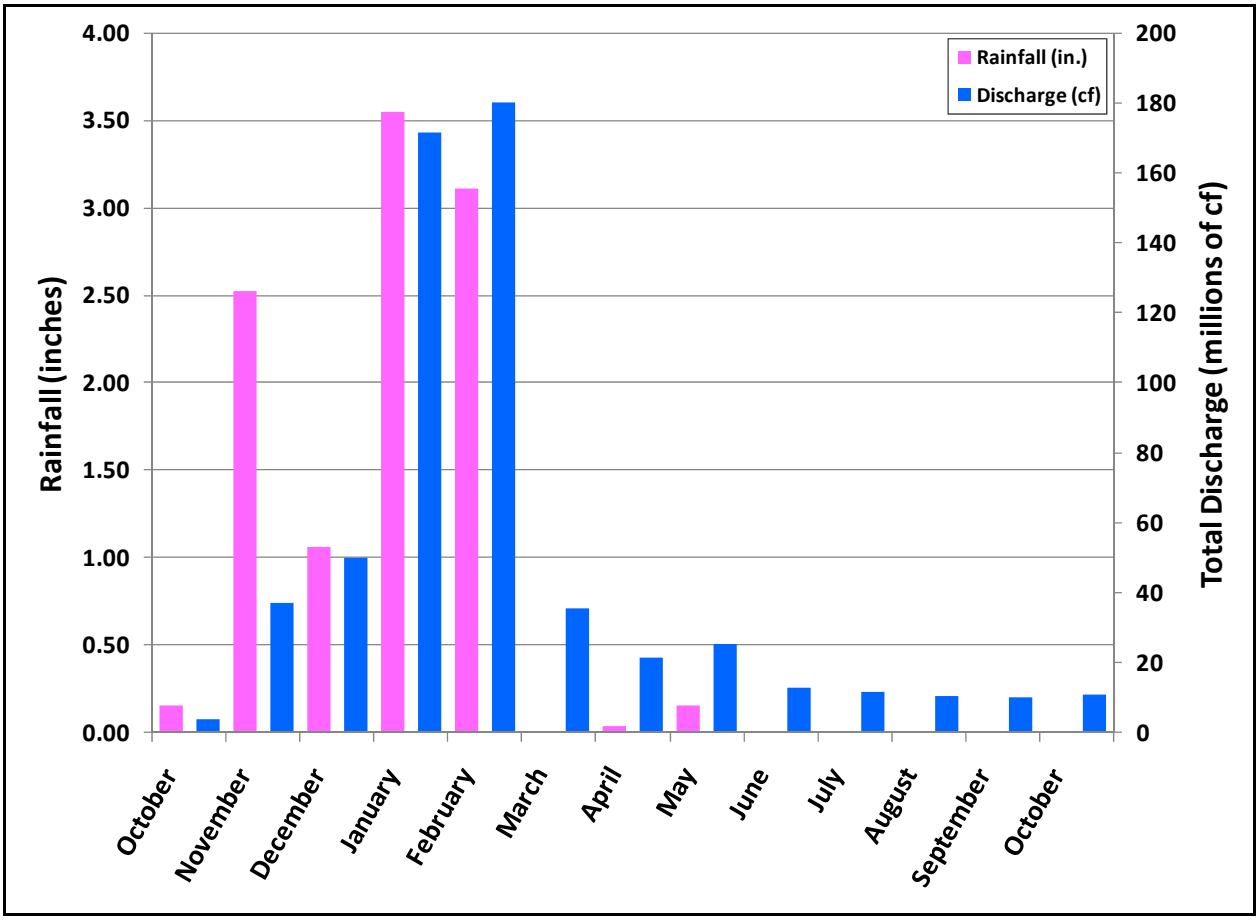
The San Elijo Watershed (also known as the Escondido Creek Watershed) is the largest watershed within the CHU. The drainage covers an area of approximately 54,112 acres and extends about 24.61 miles inland from the coast, representing 40 percent of the CHU. The San Elijo Watershed covers the most jurisdictional areas within the CHU and includes portions of the cities of San Marcos, Carlsbad, Escondido, Encinitas, Solana Beach, and unincorporated County of San Diego land. There are four reservoirs within the watershed, Lake Wohlford, Dixon Lake, San Dieguito Reservoir, and Olivenhain Reservoir. Land use within the watershed is widely varied. The middle basin, near Escondido, and the coastal areas of the lower basin are mostly residential and urban development. The central portion of the lower basin, along with the upper area of the watershed, is a mosaic of rural housing, agriculture, and natural habitat. Impervious surface in the San Elijo Watershed is estimated at 13 percent, which is the lowest in the CHU (Carlsbad Watershed Management Plan, 2002).

Watershed response to rainfall is characterized by the discharge volumes and peak flows of San Elijo Creek at the Mass Emission Station. Watershed response varies throughout the season based on factors such as antecedent soil moisture conditions, impervious area, rainfall amount, and rainfall intensity. Antecedent soil moisture condition throughout the watershed is the saturation levels of the soil from previous storm events. Earlier in the season, when the watershed soil conditions are drier, the ground can soak up more water and therefore discharge less. Later in the season after a few storm events, the ground is more saturated, resulting in greater discharge volumes and higher peak flows (UCANR, 2002). Impervious area is directly related to urban development and includes paved surfaces, structures, and

other land uses where soil is not exposed and able to absorb rainfall. These facilitates direct storm water runoff resulting in higher discharge volumes and higher peak flows as the response to rainfall is immediate.

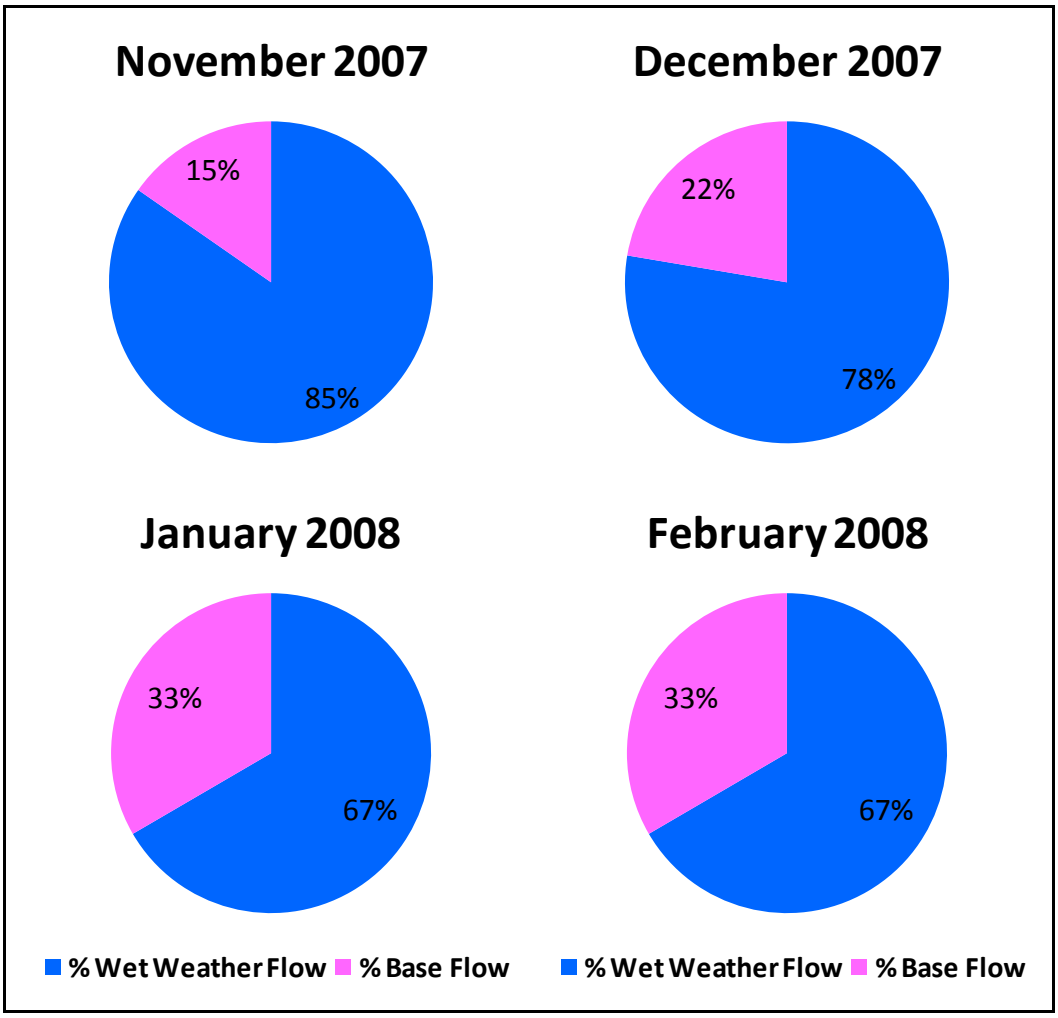
Daily and monthly discharge totals are summarized in Table 4-64. A total of 581,628,163 cubic feet was discharged into the San Elijo Lagoon via Escondido Creek between October 1, 2007 and October 31, 2008. The three largest events occurred on November 30, 2007, January 5 – 7, 2008 and February 22, 2008 and produced approximately 61 million, 96 million and 44 million cubic feet of discharge, respectively, and had peak discharge rates of approximately 1293 cfs, 1140 cfs and 161 cfs, respectively. The response to rainfall is depicted by the highest discharge totals corresponding to the months with the highest rainfall totals. The relationship between monthly rainfall and discharge totals are shown graphically in Figure 6-9.

**Figure 6-9: San Elijo Mass Emission Station Monthly Rainfall and Discharge Totals**



Rainfall intensity and amount affect the relationship between rainfall and watershed discharge. Although the overall relationship between rainfall and discharge was relatively stable, November reflected a fairly strong response to antecedent moisture condition (AMC). Despite a large amount of rainfall, there was a relatively low amount of discharge indicating that soils in the watershed were dry and absorbed some of the precipitation associated with the first major storm event of the year. The amount of discharge due to wet weather events can vary based on the intensity, timing, and amount of rainfall associated with a given storm event. Figure 6- 10 shows the percentage of discharge attributed to direct runoff during wet weather events as compared to base flow conditions. Base flows represent stream flow resulting from precipitation that infiltrates into the soil that eventually moves through the soil to the stream channel, as well as dry weather urban runoff such as irrigation. Discharge due to wet weather events includes water directly running off the surface from rainfall and does not include ground water discharge or seepage from saturated soils. November experienced the highest percentage of wet weather-related discharge due to direct runoff at 85 percent of the total discharge that month. This was primarily due to low base flows early in the season along with a relatively large storm event of 2.52 inches on the last day of the month, resulting in high discharge rates recorded throughout the day. December base flows were high due to the large event at the end of November and resulted in a lower percentage of wet weather related runoff. January and February had equal percentages of wet weather related runoff and were both less than December. This trend can be attributed to AMC effects through the season; the months earlier in the season progressively have more wet weather runoff and absorb less from storm events. By January and February the soils are saturated, absorption rates level off, and base flow contributes more to measured discharge resulting in more equitable percentages of wet weather runoff. Throughout the entire year approximately 513 million cubic feet of discharge was due to wet weather, accounting for 89 percent of the total amount discharged into San Elijo Lagoon.

**Figure 6-10: San Elijo Monthly Percentage of Watershed Discharge Due to Wet Weather Events Compared to Base Flow**




### 6.4.2 San Elijo Constituent Concentrations – Mass Emission Station

Constituent concentrations for the range of events monitored provide a snapshot of the variation in watershed input and the lagoon's response to different flow and seasonal conditions. A comparison of constituent concentrations to the associated WQOs provided in Table 1-4 in Section 1.3 helps assess the overall water quality of the lagoon during wet and dry weather conditions. The mass emission station characterizes the watershed contribution during wet and dry weather conditions. Although, the mass emission station is key contributor the lagoon is subject to other inputs and processes that influence water quality as presented in Figures 1-1 to 1-4 of Section 1.4. A summary of concentrations for the Mass Emission Station at San Elijo Lagoon, including geometric means, arithmetic means, ranges and

exceedances compared to WQOs, are provided in Tables 4-69 and 4-70 for wet weather events and in Table 4-77 for index period events.

6.4.2.1 Comparison to Water Quality Objectives

A comparison of concentrations to the WQOs was conducted for the following constituents with WQOs established in the Basin Plan:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- Ammonia as nitrogen
- Chlorophyll *a*
- Nitrate+Nitrite (N+N)
- Total Nitrogen (TN)
- Total Phosphorus (TP)

<u>Bacteria</u>

Saltwater WQOs were applied to mass emission station as the receiving water is a saltwater body. For Wet Weather Events 1 and 2, at least five bacteria samples were collected at the mass emission station and each concentration was compared to the wet weather WQOs to determine the percent exceedance. The EMCs for Wet Weather Event 3 were compared directly to the wet weather WQOs. A 22 percent exceedance allowance was applied to the wet weather water quality objectives for indicator bacteria, for preliminary comparison purposes, based on a SDRWQCB Beachs and Creeks TMDL (2007) and a natual loading study by SCCWRP (2007). The development of this preliminary exceedance allowance is described in Section 1.3. The breakdown of bacteria exceedances for wet weather events is as follows:

- *Enterococcus:* For all wet weather events, 100 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Fecal Coliform: For all wet weather events, 100 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Total Coliform: For all wet weather events, 83 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 22 percent. The Wet Weather Event 3 EMC at 22,000 MPN/100mL aslo exceeded the WQO.

Dry weather standards for indicator bacteria require the application of two criteria; the geometric mean concentration and the single-sample maximum requirement. Per the Basin Plan, the geometric means must be derived from a minimum of five samples in a 30-day period and must not exceed the dry weather

geometric mean WQOs. *Enterococcus* and total coliform samples may not exceed the single-sample maximum allowable concentrations that are presented as the wet weather WQOs in Table 1-4. However, fecal coliform samples have a ten percent allowable exceedance rate over a 30-day period when compared to the single-sample maximum allowable concentrations. The geometric means and single-sample exceedance frequencies for the index period events were compared to both dry weather WQO criteria. For each index period event, the geometric mean was calculated from the six samples collected. The breakdown of bacteria exceedance for index period events is as follows:

- *Enterococcus*: The geometric mean concentrations exceeded the dry weather geometric mean-based WQO of 35 CFU/100mL for Index Period Events 1, 3, and 4. For the entire monitoring period, 4 percent (1 of 24 samples) had concentrations that exceeded the single-sample maximum allowable concentration of 276 CFU/100mL. This exceedance occurred during Index Period Event 3.
- Fecal Coliform: The geometric mean concentrations exceeded the dry weather geometric mean-based WQO of 200MPN/100mL for Index Period Events 3 and 4. For the entire monitoring period, 13 percent (3 of 24 samples) had concentrations that exceeded the single-sample maximum allowable concentration of 400 MPN/100mL. These exceedances, listed by index period event are as follows:
  - Index Period Events 3 and 4 had concentrations greater than 400 MPN/100mL at a frequency of 17 percent (1of 6 samples), and 33 percent (2 of 6 samples), respectively, which exceeded the ten percent allowable frequency (per 30-day period).
- Total Coliform: The geometric mean concentrations did not exceed the dry weather geometric mean-based WQO of 1,000MPN/100mL for all four index period events. For the entire monitoring period, zero percent (0 of 24 samples) had concentrations that exceeded the single-sample maximum allowable concentration of 10,000 MPN/100mL.

Nutrients

Based on the limited availability of site-specific criteria the following WQOs were used for preliminary analysis purposes. SCCWRP in collaboration with SWRCB, USEPA, and other agencies are working to develop nutrient numeric endpoints for coastal water bodies (SCCWRP, 2009).

Wet and dry weather standards for nutrients vary by constituent; WQOs are based on an allowable exceedance that consider background levels or numerical limits that represent the maximum levels of constituents. N+N, TN, and TP have a 10 percent allowable annual exceedance frequency. Each N+N, TN, and TP concentration was compared to the wet weather WQO to determine the percent exceedance. Ammonia and chlorophyll *a* WQOs are based on a numerical objective. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were above the WQO. In addition, a percent exceedance was calculated for ammonia and chlorophyll *a* to

provide a relative comparison with the other nutrients. For Wet Weather Events 1 and 2, at least eight pollutagraphs were collected at the Mass Emission Station and each concentration was compared to the WQO. The EMCs for Wet Weather Event 3 were compared directly to the wet weather WQOs. The breakdown of nutrient exceedances for wet weather events is as follows:

- Ammonia: For Wet Weather Events 1 and 2, the mean concentration was 0.13 mg/L, which exceeded the WQO of 0.025 mg/L. In total, 100 percent of Mass Emission Station samples exceeded the WQO. The Wet Weathe 3 EMC at 0.1 mg/L also exceeded the WQO.
- Chlorophyll *a*: Wet weather samples collected at the Mass Emission Station were not required to be analyzed for Chlorophyll per the QAPP and Work Plan.
- N+N: For all wet weather events, zero percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TN: For Wet Weather Events 1 and 2, 79 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 10 percent. There was no Wet Weather 3 sample collected for Total Nitrogen.
- TP: For all wet weather events, 100 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of 10 percent.

A total of 24 samples were collected during four index period events and each concentration was compared to the dry weather WQO to determine the percent exceedance. N+N, TN, and TP percent exceedances were compared to the 10 percent allowable annual exceedance frequency. The breakdown of nutrient exceedances for index period events is as follows:

- Ammonia: For all index period events, the mean concentration was 0.06 mg/L, which exceeded the WQO of 0.025 mg/L. In total, 96 percent of Mass Emission Station samples exceeded the WQO.
- Chlorophyll *a*: For all index period events, the mean concentration was 2.7 ug/L, which did not exceed the WQO of 20 ug/L. In total, zero percent of Mass Emission Station samples exceeded the WQO.
- N+N: For all index period events, zero percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TN: For all index period events, 67 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TP: For all index period events, 17 percent of Mass Emission Station samples exceeded the WQO, versus an allowable exceedance of ten percent.

6.4.2.2 Event and Seasonal Variations

Both within-event and seasonal patterns can help better understand possible sources, processes, and mechanisms that affect runoff and associated concentrations. Variations in constituent concentrations between events throughout the season and during events are discussed for both wet and dry weather conditions for the following constituents:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- TSS
- Ammonia
- CBOD
- Chlorophyll *a*
- N+N
- TN
- TP

The total fraction of nitrogen and phosphorus will be the primary focus of the nutrient discussion, considering the dissolved fractions comprised a consistent amount of the total throughout the seasons.

Wet Weather – Seasonal Variations

For bacteria, Wet Weather Event 1 had higher concentrations of *Enterococcus* and total coliform at the Mass Emission Station than Wet Weather Events 2 and 3 (Tables 4-69 and 4-70). Fecal coliform concentrations were highest during Wet Weather Event 2. The following factors may have influenced the higher concentrations of *Enterococcus* and total coliform during Wet Weather Event 1: longer event duration, higher rainfall intensity, higher peak discharge, and a longer length of antecedent dry period and, therefore, potential for greater pollutant build-up prior to the event. In fact, SCCWRP found that antecedent dry period was strongly correlated with bacteria concentrations from mass emission sites in an exponential manner (Tiefenthaler, Stein and Shiff, 2008). Early season storms generally had higher bacteria concentrations than late season storms both within and between watersheds, even when rainfall quantities were similar. SCCWRP attributed this to likely bacteria buildup during dry periods that flushes to rivers during early season storms. SCCWRP found that storm size may be a less reliable predictor of the magnitude of bacterial concentrations and loading. Although *Enterococcus* and total coliform results are in accord with trends found by SCCWRP, fecal coliform did not follow this trend.

For TSS, the Wet Weather Event 2 EMC exceeded the Wet Weather Events 1 and 3 EMCs, although the Wet Weather Event 2 was only slightly higher than Wet Weather Event 3 EMC (Table 5-14).

For nutrients, TP, TDP, and ammonia samples had higher concentrations in Wet Weather Event 1, whereas TN, TDN, and N+N samples had higher concentrations in Wet Weather Event 2. During both wet weather events, nitrogen and phosphorus were mostly present in the dissolved state, based on the comparison between the total and dissolved mean values presented in Table 4-69.

Wet Weather – Within-Event Variations

Within-event variations were evaluated by assessing the concentrations graphs in Appendix E-4. For Wet Weather Events 1 and 2, bacteria concentrations appeared to remain fairly consistent throughout the events, with no apparent trends. The highest total and fecal coliform concentrations during Wet Weather Event 1 occurred towards the end of the storm and were associated with the second peak discharge. Bacteria concentrations during Wet Weather Event 2 were relatively consistent throughout the event and did not appear to have a response relative to peak discharges.

For Wet Weather Events 1 and 2, TSS concentrations appeared to correlate with the flow rate particularly during peak discharges; i.e., higher concentrations occurred during higher flow rates and lower concentrations occurred during lower flow rates. However there were some exceptions during both events. During Wet Weather Event 1, TSS concentrations were relatively high prior to the initial peak and correlated well with the initial peak, however, concentrations remained relatively low during the second peak and did not appear to respond in the same manner. TSS concentrations during Wet Weather Event 2 were relatively high prior to the peak in discharge.

During Wet Weather Event 1, nutrient concentrations were relatively low during the initial portion of the storm but remained relatively consistent with respect to flow after the onset of the first peak. However ammonia concentrations decreased with the onset of the storm and remained very low throughout the remainder of the event.

Another method to evaluate the variability of concentrations within events is to assess the magnitude of first flush concentrations relative to the rest of the event. First-flush effects describe the effect of the early flows of a storm carrying a higher level of contaminants relative to the latter flows. First-flush ratios were calculated for the first two wet weather events where pollutagraph sampling occurred. First-flush ratios are the result of a partial event mean concentration (PEMC) divided by the entire event mean concentration (EMC) at distinct intervals during a storm event. First-flush effects are indicated by a ratio of one and greater, with the effect being stronger with higher ratios. Table 6-20 presents the first-flush

ratios for the first six hours of discharge for each wet weather event. Appendix F-4 graphically present how the first flush ratios changed throughout each wet weather event.

**Table 6-20: San Elijo Concentration First-Flush Effects**

| Constituent | First-Flush Ratio[1] | | First-Flush Effect[2] |
|---|---|---|---|
| | Wet Weather Event 1 | Wet Weather Event 2 | |
| *Enterococcus* | 0.86 | 0.67 | None |
| Fecal Coliform | 0.22 | 3.35 | None to Strong |
| Total Coliform | 0.75 | 1.43 | None to Minor |
| TSS | 0.51 | 0.34 | None |
| Ammonia | 1.61 | 1.33 | Moderate to Minor |
| CBOD | 0.27 | 0.43 | None |
| N+N | 0.22 | 0.26 | None |
| TN | 0.23 | 0.56 | None |
| TP | 0.05 | 0.37 | None |

(1) The first flush ratio presented is based on the ratio for the first two samples collected within the first 6 hours of discharge just prior to peak flows.
(2) Ratios > 2.0 were considered to have strong first flush effects, ratios between 1.5 to 2.0 were considered to have moderate first flush effects, ratios between 1.0 and 1.5 were considered to have minor first flush effects, and ratios ≤ 1.0 were considered to have no first flush effects.

As shown in Table 6-20, during Wet Weather Event 2, total and fecal coliform were the only bacteria constituents to demonstrate a first-flush effect throughout both events. Fecal coliform showed a strong first-flush effect during Wet Weather Event 2 with a ratio of 3.35, however, total coliform showed a minor first-flush effect with a ratio of 1.43. It should be noted that the first flush effects displayed by fecal and total coliform during Wet Weather Event 2 are consistent with findings by SCCWRP (Tiefenthaler, et al., 2008). This study found that the greatest concentrations of bacteria occurred at or just before the first peak in discharge of the storm event for most of the 20 events sampled. Generally, more pronounced first flush effects are found in highly urbanized and impervious watersheds. All but two of the watersheds studied were urban, densely populated watersheds ranging from 49 to 94 percent developed (two relatively undeveloped, non-urban watersheds less than five percent developed were also monitored). By contrast, San Elijo watershed is listed as only 13 percent impervious in the Carlsbad Watershed Management Plan. The SCCWRP study found that for the two undeveloped, non-urban watersheds, peak concentrations tended to occur later in the storm and persist for a longer duration (although bacteria concentrations steadily decreased following the early peak in storm). Despite a high initial concentration, the decrease in concentration is similar to what occurred at the San Elijo Mass Emission Station.

TSS concentrations did not show first-flush effects during either wet weather event. These results were in contrast to the results of the study by SCCWRP (Tiefenthaler et al., 2008), where higher concentrations of suspended sediment were observed in the early part of the storm events, but were consistent with the findings of Chang (Chang, 2009).

None of the nutrients showed first-flush effects during both events with the exception of ammonia. Ammonia showed a moderate and a minor first-flush effect during Wet Weather Events 1 and 2, respectively.

Dry Weather – Seasonal Variations

Seasonal variations in dry weather concentrations can be significant and have both positive and inverse relationships with flow, temperature, and other factors. In order to assess these variations and possible relationships with flow, Table 6-21 was developed.

**Table 6-21: San Elijo Mass Emission Station Concentrations by Season and Flow Regime**

| Constituent | Season[3] | Flow Regime[1] | | | | | Season Mean[2] |
|---|---|---|---|---|---|---|---|
| | | High Flows | Moist Conditions | Mid-Range Flows | Dry Conditions | Low Flows | |
| *Enterococcus* (CFU/100 mL) | Winter | 14,357 | 1,859 | | | | 129 |
| | Spring | | 43 | | | | 43 |
| | Summer | | | 179 | | | 179 |
| | Fall | | | | 115 | | 115 |
| | Flow Regime Average | 14,357 | 869 | 179 | 115 | | 117 |
| Fecal Coliform (MPN/100 mL) | Winter | 3,922 | 2,456 | | | | 131 |
| | Spring | | 64 | | | | 64 |
| | Summer | | | 282 | | | 282 |
| | Fall | | | | 323 | | 323 |
| | Flow Regime Average | 3,922 | 1,151 | 282 | 323 | | 200 |
| Total Coliform (MPN/100 mL) | Winter | 38,250 | 5,198 | | | | 344 |
| | Spring | | 195 | | | | 195 |
| | Summer | | | 371 | | | 371 |
| | Fall | | | | 733 | | 733 |
| | Flow Regime Average | 38,250 | 2,469 | 371 | 733 | | 411 |
| TSS (mg/L) | Winter | 26 | 11 | | | | 2 |
| | Spring | | 74 | | | | 74 |
| | Summer | | | 8 | | | 8 |
| | Fall | | | | 7 | | 7 |
| | Flow Regime Average | 26 | 45 | 8 | 7 | | 23 |
| Ammonia (mg/L) | Winter | 0.07 | 0.13 | | | | 0.09 |
| | Spring | | 0.10 | | | | 0.10 |
| | Summer | | | 0.04 | | | 0.04 |
| | Fall | | | | 0.03 | | 0.03 |
| | Flow Regime Average | 0.07 | 0.11 | 0.04 | 0.03 | | 0.06 |
| Chlorophyll *a* (ug/L) | Winter | 3.00 | 4.38 | | | | 3.92 |
| | Spring | | 3.65 | | | | 3.65 |
| | Summer | | | 1.65 | | | 1.65 |
| | Fall | | | | 1.50 | | 1.50 |
| | Flow Regime Average | 3.00 | 3.94 | 1.65 | 1.50 | | 2.68 |

**Table 6-21: San Elijo Mass Emission Station Concentrations by Season and Flow Regime (continued)**

| Constituent | Season[3] | Flow Regime[1] | | | | | Season Mean |
|---|---|---|---|---|---|---|---|
| | | High Flows | Moist Conditions | Mid-Range Flows | Dry Conditions | Low Flows | |
| N+N (mg/L) | Winter | 3.16 | 0.91 | | | | 2.52 |
| | Spring | | 0.15 | | | | 0.15 |
| | Summer | | | 1.22 | | | 1.22 |
| | Fall | | | | 1.40 | | 1.40 |
| | Flow Regime Average | 3.16 | 0.49 | 1.22 | 1.40 | | 1.32 |
| TN (mg/L) | Winter | 3.73 | 1.29 | | | | 3.13 |
| | Spring | | 0.54 | | | | 0.54 |
| | Summer | | | 1.60 | | | 1.60 |
| | Fall | | | | 2.29 | | 2.29 |
| | Flow Regime Average | 3.73 | 0.88 | 1.60 | 2.29 | | 1.89 |
| TP (mg/L) | Winter | 0.25 | 0.07 | | | | 0.08 |
| | Spring | | 0.03 | | | | 0.03 |
| | Summer | | | 0.05 | | | 0.05 |
| | Fall | | | | 0.10 | | 0.10 |
| | Flow Regime Average | 0.25 | 0.05 | 0.05 | 0.10 | | 0.07 |

(1) Flow regimes are based on percent days exceeded and broken down into the following categories: high flows are classified as < 10% days exceeded; moist conditions are classified as > 10% and < 40% days exceeded; mid-range flows are classified as > 40% and < 60% days exceeded; dry conditions are classified as > 60% and < 90% days exceeded; low flows are classified as > 90% days exceeded.
(2) Season average does not include wet weather high flow events.
(3) Index Period 1 represents winter, Index Period 2 represents spring, Index Period 3 represents summer, Index Period 4 represents fall.

Based on Table 6-21, variations in constituent concentrations within and between each season are discussed below:

Winter

Index Period Event 1 was representative of dry weather conditions during the winter season. Samples were collected between January 14, 2008 and February 11, 2008. The water temperature at the Mass Emission Station ranged from 8.7 to 13.4 ˚C. During this sampling event, daily total discharges ranged from 820,680 to 20,939,458 cf (Table 4-64), which exceeded the average daily dry weather discharge of 553,366 cf (Table 5-24). As shown in Table 6-21, these discharges fell within the high flow and moist condition flow regimes.

Spring

Index Period Event 2 was representative of dry weather conditions during the spring season. Samples were collected between March 31, 2008 and April 10, 2008. The water temperature at the Mass Emission Station ranged from 13.3 to 17.8 degrees Celsius. During this event, daily total discharges ranged from 795,806 to 904,873 cubic feet (Table 4-64), which exceeded the average daily dry weather discharge of 553,366 cubic feet (Table 5-24). As shown in Table 6-21, these discharges fell within the moist conditions and mid-range flow regimes.

Summer

Index Period Event 3 was representative of dry weather conditions during the summer season. Samples were collected between July 7, 2008 and July 16, 2008. The water temperature at the mass emission station ranged from 21.1 to 23.7 degrees Celsius. During this period, daily total discharge ranged from 389,323to 495,067 cubic feet (Table 4-64), which was below the average daily discharge of 553,366 cubic feet (Table 5-24). As shown in Table 6-21, these discharges fell within the moist conditions and mid-range flow regimes.

Fall

Index Period Event 4 was representative of baseline conditions during the Fall season. Samples were collected between September 15, 2008 and September 24, 2008. The water temperature at the Mass Emission Station ranged from 18.0 to 21.4 degrees Celsius. During this event, daily total discharge ranged from 294,861 to 343,965 cubic feet (Table 4-64), which was below the average and median daily discharges of 553,366 cubic feet (Table 5-24). As shown in Table 6-21, these discharges fell within mid-range flows and dry conditions flow regimes.

*Enterococcus*, fecal coliform, and total coliform had the highest mean concentrations during the high flow conditions which reflect the wet weather concentrations. Dry weather concentrations were orders of magnitude lower than the wet weather concentrations. *Enterococcus*, fecal coliform, and total coliform concentrations were generally higher during the summer and fall seasons which were characterized by lower flows and warmer temperatures.

TSS mean concentrations were highest during the high flow conditions which reflect the wet weather concentrations, however, during winter dry weather conditions, the mean concentrations were the lowest. In contrast, the spring TSS mean concentration was higher than the TSS mean concentrations for the other seasons.

Although not shown in Table 6-21, DO and pH had similar seasonal trends based on Table 4-65; higher DO concentrations (and higher pH readings) during winter (characterized by higher flow regimes and lower temperatures) and lower DO concentrations (and lower pH readings) during summer and fall (characterized by mid-range to dry condition flow regimes and higher tempereatures). DO concentrations and pH readings were the highest during the winter (Index Period Event 1) with DO concentrations ranging from 8.8 to 10.5 mg/L and pH readings between 7.9 to 8.2 pH units, as shown in Table 4-28. Higher DO concentrations during the winter season can typically be attributed to elevated DO saturation resulting from the higher flow conditions (Nezlin, 2009). Summer DO concentrations were lower than the other seasons, with concentrations ranging from 6.3 to 7.8 mg/L and pH readings were ranging from 7.6 to 7.7 pH units.

The winter N+N, TN, and TP mean concentrations were higher than the other seasonal mean concentrations, however, the magnitude of variance between seasons differed by constituent. There was one exception to this trend where fall TP mean concentrations were slightly higher than winter concentrations. The spring mean ammonia concentration was slightly higher than winter although winter had the widest range of concentrations between 0.04 and 0.14 mg/L., as shown in Table 4-77. Both seasons were higher than summer and fall mean ammonia concentrations.

### 6.4.3 San Elijo Constituent Concentrations – Lagoon Segment Sites

The lagoon segment sampling characterized both seasonal and spatial variations, and helped establish baseline conditions to evaluate the lagoon's response during wet weather events.

#### 6.4.3.1 Comparison to Water Quality Objectives

A summary of concentrations for the San Elijo Lagoon Segments, including geometric and arithmetic mean concentrations, ranges, and exceedances as compared to WQOs are provided in Tables 4-71 and 4-72 for wet weather events and in Table 4-79 and 4-80 for index period events.

A comparison of concentrations to WQOs established in the San Diego Basin Plan was conducted for the following constituents:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- Ammonia

- Chlorophyll *a*
- N+N
- TN
- TP

Bacteria

For all wet weather events, two bacteria samples were collected at both lagoon segments and each concentration was compared to the wet weather WQO to determine the percent exceedance. A 22 percent exceedance allowance was applied to the wet weather water quality objectives for indicator bacteria, for preliminary comparison purposes, based on a SDRWQCB Beachs and Creeks TMDL (2007) and a natual loading study by SCCWRP (2007). The development of this preliminary exceedance allowance is described in Section 1.3. A breakdown of water quality for both lagoon segments during all wet weather events is as follows:

- *Enterococcus*: For all wet weather events at Lagoon Segments 1 and 2, 67 percent of samples and 50 percent of samples, respectively, exceeded the WQO. In total, 58 percent of Lagoon Segment samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Fecal Coliform: For all wet weather events at Lagoon Segments 1 and 2, 83 percent of samples and 33 percent of samples, respectively, exceeded the WQO. In total, 58 percent of Lagoon Segment samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Total Coliform: For all wet weather events at Lagoon Segments 1 and 2, 67 percent of samples and 17 percent of samples, respectively, exceeded the WQO. In total, 42 percent of Lagoon Segment samples exceeded the WQO, versus an allowable exceedance of 22 percent.

Dry weather standards for indicator bacteria require the application of two criteria; the geometric mean concentration and the single-sample maximum requirement. Per the Basin Plan, the geometric means must be derived from a minimum of five samples in a 30-day period and must not exceed the dry weather geometric mean WQOs. *Enterococcus* and total coliform samples may not exceed the single-sample maximum allowable concentrations that are presented as the wet weather WQOs in Table 1-4. However, fecal coliform samples have a ten percent allowable exceedance rate over a 30-day period when compared to the single-sample maximum allowable concentrations. The geometric means and single-sample exceedance frequencies for the index period events were compared to both dry weather WQO criteria. For each index period event, the geometric mean was calculated from the twelve samples collected per segment. The breakdown of bacteria exceedance for index period events is as follows:

- *Enterococcus*: The geometric mean concentrations for Lagoon Segments 1 and 2 exceeded the dry weather geometric mean-based WQO of 35 CFU/100mL for Index Period Event 1. The geometric mean concentrations for the transects also exceeded the WQO of 35

CFU/100mL for Index Period Event 1. For the entire monitoring period, 0.7 percent of Lagoon Segment and transect concentrations exceeded the single-sample maximum allowable concentration of 276 CFU/100mL. The exceedances, listed by sample site, are as follows:

- Lagoon Segment 1: 0 of 48 samples (0 percent) exceeded the WQO.
- Lagoon Segment 2: 1 of 48 samples (2.1 percent) exceeded the WQO, which occurred during Index Period Event 1.
- Transects: 0 of 40 (0 percent) samples exceeded the WQO.

- Fecal Coliform: The geometric mean concentrations for Lagoon Segments 1 and 2, and transects did not exceed the dry weather WQO of 200 MPN/100mL for all four index period events. For the entire monitoring period, 1.5 percent of Lagoon Segment and transect concentrations exceeded the single-sample maximum allowable concentration of 400 MPN/100mL. The breakdown of exceedances is as follows:
  - Lagoon Segment 1: Index Period Event 2 had concentrations greater than 400 MPN/100mL at a frequency of 17 percent (2 of 12 samples), which exceeded the ten percent allowable frequency (per 30-day period).
  - Lagoon Segment 2: Zero percent (0 of 48 samples) had concentrations greater than 400 MPN/100 mL.
  - Transects: Zero percent (0 of 40 samples) had concentrations greater than 400 MPN/100 mL.
- Total Coliform: The geometric mean concentrations for Lagoon Segments 1 and 2, and transects were below the dry weather WQO of 1,000 CFU/100mL for all four index period events. For the entire monitoring period, 0 percent of Lagoon Segment and transect concentrations exceeded the single-sample maximum allowable concentration of 10,000 MPN/100mL.

Nutrients

Wet and dry weather standards for nutrients vary by constituent; WQOs are based on an allowable exceedance that consider background levels or numerical limits that represent the maximum levels of constituents. N+N, TN, and TP have a ten percent allowable annual exceedance frequency. For N+N, TN, and TP each concentration was compared to the wet weather WQO to determine the percent exceedance. Ammonia and chlorophyll *a* are based on a numerical objective. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were above the WQO. In addition, a percent exceedance was calculated for ammonia to provide a relative comparison with the other nutrients. For Wet Weather Events 1, 2 and 3, two samples were collected and each concentration was compared to the wet weather WQOs to determine the percent exceedance. For The breakdown of nutrient exceedances for wet weather events is as follows:

- Ammonia: For all wet weather events at Lagoon Segment 1, the mean concentration was 0.04 mg/L, which exceeded the WQO of 0.025 mg/L. In total, 50 percent of Lagoon Segment 1 samples exceeded the WQO. At Lagoon Segment 2, the mean concentration was 0.04 mg/L,

which exceeded the WQO of 0.025 mg/L. In total, 67 percent of Lagoon Segement 2 samples exceeded the WQO.

- Chlorophyll *a*: For all wet weather events at Lagoon Segment 1, the mean concentration was 17.8 ug/L, which did not exceed the WQO of 20 ug/L. In total, 33 percent of Lagoon Segment 1 samples exceeded the WQO. At Lagoon Segment 2, the mean concentration was 13.7 ug/L, which did not exceed the WQO of 20 ug/L. In total, 17 percent of Lagoon Segment 2 samples exceeded the WQO.
- N+N: For all wet weather events at Lagoon Segments 1 and 2, zero percent of samples exceeded the WQO, versus an allowable exceedance of 10 percnet.
- TN: For all wet weather events at Lagoon Segment 1, 83 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent. At Lagoon Segment 2, 33 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent.
- TP: For all wet weather events at Lagoon Segment 1, 100 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent. At Lagoon Segment 2, 100 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent.

A total of 48 samples were collected during four index period events, and each concentration was compared to the dry weather WQO to determine the percent exceedance. For each Index Period Event, two samples were collected at each of the eighteen transect locations and each concentration was compared to the WQO to determine the percent exceedance.N+N, TN, and TP percent exceedances were compared to the 10 percent allowable annual exceedance frequency. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were above the WQO. The breakdown of nutrient exceedances for index period events is as follows:

- Ammonia: For all index period events at Lagoon Segment 1, the mean concentration was 0.12 mg/L, which exceeded the WQO of 0.025 mg/L. In total, 98 percent of Lagoon Segment 1 samples exceeded the WQO. At Lagoon Segment 2, the mean concentration was 0.05 mg/L, which exceeded the WQO of 0.025 mg/L. In total, 71 percent of Lagoon Segment 2 samples exceeded the WQO. For all transects, 90 percent of samples exceeded the WQO.
- Chlorophyll *a*: For all index period events at Lagoon Segment 1, the mean concentration was 16.9 ug/L, which did not exceed the WQO of 20 ug/L. In total, 21 percent of Lagoon Segment 1 samples exceeded the WQO. At Lagoon Segment 2, the mean concentration was 31.5 ug/L, which exceeded the WQO of 20 ug/L. In total, 17 percent of Lagoon Segment 2 samples exceeded the WQO. For all transects, 17 percent of samples exceeded the WQO.
- N+N: For all index period events at Lagoon Segments 1 and 2 and transects, zero percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent.
- TN: For all index period events at Lagoon Segment 1, 58 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent. At Lagoon Segment 2, 27 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent. For all transects, 47 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent.

- TP: For all index period events at Lagoon Segment 1, 92 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent. At Lagoon Segment 2, 54 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent. For all transects, 76 percent of samples exceeded the WQO, versus an allowable exceedance of 10 percent.

6.4.3.2 Event and Seasonal Variations

Both within-event and seasonal patterns can help better understand possible sources, processes, and mechanisms that affect runoff and associated concentrations. Variations in constituent concentrations between events throughout the season and during events are discussed for both wet and dry weather conditions for the following constituents:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- TSS
- Ammonia
- CBOD
- Chlorophyll *a*
- N+N
- TN
- TP

Wet Weather – Seasonal Variations

As shown in Table 4-71, Lagoon Segment 1 samples had higher bacteria concentrations during Wet Weather Event 3 with the exception of Enterococcus, which was highest during Wet Weather Event 1. Conversely, Lagoon Segment 2 samples had higher bacteria concentrations during Wet Weather Event 1 with the exception of total coliform which was highest during Wet Weather Event 3 in Table 4-72. Wet Weather Event 1 had the highest TSS concentrations for both lagoon segments.

Wet Weather – Within-Event Variations

For all events, the initial samples were collected 6.5 to 7.5 hours prior to the collection of the second set of samples. During Wet Weather Event 1, the initial samples were collected six hours after rainfall began, and the second set of samples was collected 13.5 hours after rainfall began. The timing of sample collection was similar for Wet Weather Events 2 and 3, initial sample were collected 15 and 13 hours after rainfall and second samples were collected 21.5 and 20 hours after rainfall, respectively.

During Wet Weather Event 1, Lagoon Segments 1 and 2 followed the same pattern where higher Enterococcus concentrations occurred in the initial set of samples while total and fecal coliform were

higher during the second set of samples collected later in the storm. Wet Weather Events 2 and 3 did not have elevated bacteria concentrations that corresponded to a particular sample time.

TSS concentrations did not appear to correspond to particular sample times during any of the three monitored events. During Wet Weather Event 1 at both lagoon segments, lower nutrient constituent concentrations occurred in the initial samples compared to samples collected later in the storm. This pattern was generally followed at Lagoon Segment 2 for Wet Weather Events 2 and 3. However, Lagoon Segment 2 showed the opposite result for Wet Weather Events 2 and 3 with generally higher concentrations earlier in the storm events and lower concentrations occurring in the second set of samples. Generally, most of the nutrient concentrations were greater during Wet Weather Event 3 at both lagoon segments than the other events. However, CBOD and chlorophyll *a* had higher concentrations during Wet Weather Event 1 at Lagoon Segment 1 and during Wet Weather Event 2 at Lagoon Segment 2.

Dry Weather – Seasonal Variations

As shown in Table 4-79 and 4-80, concentrations of indicator bacteria were generally low at the lagoon segments during dry weather conditions. Seasonal low bacteria concentrations varied by constituent, however, were mostly associated with the summer (Index Period Event 3).

TSS concentrations were higher during the spring (Index Period Event 2) at Lagoon Segments 1 and 2, while the lowest concentrations occurred during the summer (Index Period Event 3) for Lagoon Segments 1 and during the fall (Index Period Event 4) for Lagoon Segment 2. It should be noted that TSS concentrations for Lagoon Segment 1 were very similar throughout summer and fall.

DO and pH are important factors when evaluating nutrient concentrations and possible eutrophic conditions in a water body. The DO WQO (5 mg/L) was established as the minimum allowable DO concentrations in inland surface waters to maintain levels protective of aquatic organisms and habitats. Low DO levels can be harmful or lethal to aquatic organisms. Furthermore, low DO concentrations can be a symptom of eutrophic conditions within a water body. Eutrophication produces excess organic matter that fuels the development of hypoxia (i.e., low surface water DO concentrations) as organic matter is respired (McLaughlin, 2007). The acceptable pH levels established as the WQO (ranging 6.5 to 8.5) are required to be supportive of aquatic life. A change in pH can impact the bioavailability of nutrients.

DO concentrations had similar seasonal trends at the Lagoon Segment 1 and 2. At both segments, pH levels were consistent based on mean values (7.7 to 7.8) for all index period events, with the exception of

Index Period Event 3 which was lower than the other events with a mean of 7.5 pH units. DO concentrations followed a pattern of higher concentrations during the winter (characterized by higher flows from the creek and lower temperatures) and lower during summer (characterized by dry condition flow regimes). At Lagoon Segment 1, relatively higher DO concentrations and pH readings, ranging from 7.3 to 12.0 mg/L for DO and 7.5 to 8.4 pH units for pH during the winter (Index Period 1). The lowest DO concentrations occurred during the summer (3.5 mg/L average and 0.3 mg/L to 17.4 mg/L range). At Lagoon Segment 2, the lowest DO concentrations occurred during the summer (4.9 mg/L average and 0.9 mg/L to 9.3 mg/L range). Low DO concentrations are a commonly observed symptom in DO eutrophic estuaries and can result from one or more of three environmental factors: low solar radiation (resulting in reduced oxygen production via photosynthesis), increased freshwater discharge (resulting in enhanced haline stratification which prevents ventilation of bottom waters), and sluggish bottom water ventilation due to stratification often occurring during neap tidal phase (Nezlin, 2009).

Overall, nutrient concentrations at the lagoon segments were greater during wet weather conditions than the dry weather. However, dry weather nutrient concentrations during winter (Index Period Event 1) were comparable to concentrations measured during wet weather events. Nutrients concentrations were higher at the lagoon segments during the winter and spring (Index Period Events 1 and 2). During spring, algal growth was observed at both segments and summer at Lagoon Segment 1. During the winter, DO concentrations never fell below 5 mg/L at Lagoon Segment 1, with a minimum concentration of 7.3 mg/L. Lagoon Segment 2 did decline below 5 mg/L to 4.3 mg/L, however the mean concentration for that period was 8.8 mg/L. Higher concentrations of chlorophyll *a* were measured during winter and spring. During winter, chlorophyll *a* was elevated at Lagoon Segment 1, with mean concentration of 23.24 ug/L which is slightly above the WQO of 20 ug/L. During spring and summer at Lagoon Segment 1, algal growth was observed with chlorophyll *a* mean concentrations of 20.39 and 16.0 ug/L respectively. Throughout the rest of the monitoring period chlorophyll *a* was at or below the WQO although. At Lagoon Segment 2, the highest concentrations of chlorophyll *a* occurred in the spring (Index Period Event 2), with mean concentration of 112.05 ug/L, which is above the WOQ of 20 ug/L coinciding with observed algal growth. Throughout the rest of the monitoring period chlorophyll *a* was below the WQO with mean concentrations ranging from 1.98 to 8.93 ug/L. A nutrient study conducted by SCCWRP further supports the relationship of high concentrations of chlorophyll *a* to the overproduction of algae (McLaughlin, 2007). In both lagoon segments, the highest nutrient concentrations were measured during winter and the highest chlorophyll *a* concentrations occurred during winter at Lagoon Segment 1 and the subsequent season of spring at Lagoon Segment 2. Although the highest nutrient concentrations did not coincide directly with the algal bloom, it should be noted that ambient conditions in a water body can

reflect biological processing and nutrient loading that has already occurred (McLaughlin, 2007). For historical comparison purposes, the mean concentrations for TN and TP for all seasons except winter (which had peak nutrient concentrations) were below historical mean concentrations within the lagoon of 2.3 mg/L for TN and 0.40 mg/L for TP (RWQCB, 1985). This may be due to seasonal or spatial variations, or due to possible overall improvements in water quality.

### 6.4.4 San Elijo Constituent Concentrations – Ocean Inlet Site

The ocean inlet sampling characterized the exchange between the lagoon and ocean during wet weather and index period events.

#### 6.4.4.1 Comparison to Water Quality Objectives

A summary of concentrations for the San Elijo Lagoon Ocean Inlet, including geometric and arithmetic mean concentrations, ranges, and exceedances as compared to WQOs are provided in Tables 4-73 for wet weather events and in Table 4-81 for index period events. A comparison of concentrations to WQOs established in the San Diego Basin Plan was conducted to the following constituents:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- Ammonia
- Chlorophyll *a*
- N+N
- TN
- TP

<u>Bacteria</u>

For all wet weather events, two bacteria samples were collected at the Ocean Inlet and each concentration was compared to the wet weather WQO to determine the percent exceedance. A 22 percent exceedance allowance was applied to the wet weather water quality objectives for indicator bacteria, for preliminary comparison purposes, based on a SDRWQCB Beachs and Creeks TMDL (2007) and a natual loading study by SCCWRP (2007). The development of this preliminary exceedance allowance is described in Section 1.3. A breakdown of water quality at the Ocean Inlet during all wet weather events is as follows:

- *Enterococcus*: For all wet weather events, 50 percent of samples exceeded the WQO, versus an allowable exceedance of 22 percent.

- Fecal Coliform: For all wet weather events, 67 percent of samples exceeded the WQO, versus an allowable exceedance of 22 percent.
- Total Coliform: For all wet weather events, 17 percent of samples exceeded the WQO, versus an allowable exceedance of 22 percent.

Dry weather standards for indicator bacteria require the application of two criteria; the geometric mean concentration and the single-sample maximum requirement. Per the Basin Plan, the geometric means must be derived from a minimum of five samples in a 30-day period and must not exceed the dry weather geometric mean WQOs. *Enterococcus* and total coliform samples may not exceed the single-sample maximum allowable concentrations that are presented as the wet weather WQOs in Table 1-4. However, fecal coliform samples have a ten percent allowable exceedance rate over a 30-day period when compared to the single-sample maximum allowable concentrations. The geometric means and single-sample exceedance frequencies for the index period events were compared to both dry weather WQO criteria. For each index period event, the geometric mean was calculated from the six samples collected. The breakdown of bacteria exceedance for index period events is as follows:

- *Enterococcus*: The geometric mean concentrations at the Ocean Inlet did not exceed the dry weather geometric mean-based WQO of 35 CFU/100mL for all four index period events. For the entire monitoring period, 4 percent of Ocean Inlet concentrations exceeded the single-sample maximum allowable concentration of 276 CFU/100mL. These exceedances occurred during Index Period Event 2.
- Fecal Coliform: The geometric mean concentrations at the Ocean Inlet did not exceed the dry weather geometric mean-based WQO of 200 CFU/100mL for all four index period events. For the entire monitoring period, zero percent of Ocean Inlet concentrations exceeded the single-sample maximum allowable concentration of 400 MPN/100mL. There were no exceedances that were greater than the ten percent allowable frequency (per 30-day period).
- Total Coliform: The geometric mean concentrations at the Ocean Inlet were below the dry weather geometric mean-based WQO of 1,000 CFU/100mL for all four index period events. For the entire monitoring period, zero percent of the Ocean Inlet concentrations exceeded the single-sample maximum allowable concentration of 10,000 MPN/100mL.

<u>Nutrients</u>

Wet and dry weather standards for nutrients vary by constituent; WQOs are based on an allowable exceedance that consider background levels or numerical limits that represent the maximum levels of constituents. N+N, TN, and TP have a ten percent allowable annual exceedance frequency. For N+N, TN, and TP each concentration was compared to the wet weather WQO to determine the percent exceedance. Ammonia and chlorophyll *a* are based on a numerical objective. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were

above the WQO. In addition, a percent exceedance was calculated for ammonia to provide a relative comparison with the other nutrients. For Wet Weather Events 1, 2 and 3, two samples were collected and each concentration was compared to the wet weather WQOs to determine the percent exceedance. The breakdown of nutrient exceedances for wet weather events is as follows:

- Ammonia: For all wet weather events at the Ocean Inlet, the mean concentration was 0.04 mg/L, which exceeded the WQO of 0.025 mg/L. In total, 67 percent of the Ocean Inlet samples exceeded the WQO.
- Chlorophyll *a*: For all wet weather events at the Ocean Inlet, the mean concentration was 11.2 ug/L, which did not exceed the WQO of 20 ug/L. In total, zero percent of samples exceeded the WQO.
- N+N: For all wet weather events at the Ocean Inlet, zero percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TN: For all wet weather events at the Ocean Inlet, 33 percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TP: For all wet weather events at the Ocean Inlet, 100 percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.

A total of 48 samples were collected during four index period events, and each concentration was compared to the dry weather WQO to determine the percent exceedance. N+N, TN, and TP percent exceedances were compared to the 10 percent allowable annual exceedance frequency. The mean concentrations for ammonia and chlorophyll *a* were compared to the numerical objective to determine if the concentrations were above the WQO. The breakdown of nutrient exceedances for index period events is as follows:

- Ammonia: For all index period events at the Ocean Inlet, the mean concentration was 0.05 mg/L, which exceeded the WQO of 0.025 mg/L. In total, 55 percent of the Ocean Inlet samples exceeded the WQO.
- Chlorophyll *a*: For all index period events at the Ocean Inlet, the mean concentration was 10.2 ug/L, which did not exceed the WQO of 20 ug/L. In total, 17 percent of samples exceeded the WQO.
- N+N: For all index period events at the Ocean Inlet, zero percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TN: For all index period events at the Ocean Inlet, 13 percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.
- TP: For all index period events at the Ocean Inlet, 27 percent of samples exceeded the WQO, versus an allowable exceedance of ten percent.

#### 6.4.4.2 Event and Seasonal Variations

Both within-event and seasonal patterns can help better understand possible sources, processes, and mechanisms that affect runoff and associated concentrations. Variations in constituent concentrations between events throughout the season and during events are discussed for both wet and dry weather conditions for the following constituents:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- TSS
- Ammonia
- CBOD
- Chlorophyll *a*
- N+N
- TN
- TP

Wet Weather – Seasonal Variations

As shown in Table 4-73, the Ocean Inlet samples had higher bacteria and TSS concentrations during Wet Weather Event 3.

Wet Weather – Within-Event Variations

For all events, the initial samples were collected 6.5 to 7.5 hours prior to the collection of the second set of samples. During Wet Weather Event 1, the initial samples were collected six hours after rainfall began, and the second set of samples was collected 13.5 hours after rainfall began. The timing of sample collection was similar for Wet Weather Events 2 and 3, initial sample were collected 15 and 13 hours after rainfall and second samples were collected 21.5 and 20 hours after rainfall, respectively.

During Wet Weather Events 2 and 3, lower bacteria concentrations (Enterococcus, fecal coliform, and total coliform) generally occurred in the initial set of samples collected as compared to the subsequent set of samples collected later in the storm. Conversely, Wet Weather Event 1 elevated bacteria concentrations occurred during the initial set of samples when compared to the subsequent set of samples collected later in the storm.

TSS concentrations were greater in the initial sample collected as compared to the subsequent sample during Wet Weather Events 1 and 3. During Wet Weather Event 2 TSS concentrations were higher during the second set of samples when compared to the initial set of samples.

During all three monitored wet weather events, nutrient samples had lower constituent concentrations in the initial set of samples when compared to the subsequent samples collected later in the storm.

Dry Weather – Seasonal Variations

As shown in Table 4-81, concentrations of indicator bacteria were generally low at the Ocean Inlet Site during dry weather conditions. Seasonal low bacteria concentrations occurred during summer (Index Period Event 3).

TSS concentrations were highest during spring (Index Period Event 2) at the Ocean Inlet Site.

DO and pH are important factors when evaluating nutrient concentrations and possible eutrophic conditions in a water body. The DO WQO (5 mg/L) was established as the minimum allowable DO concentrations in inland surface waters to maintain levels protective of aquatic organisms and habitats. Low DO levels can be harmful or lethal to aquatic organisms. Furthermore, low DO concentrations can be a symptom of eutrophic conditions within a water body. Eutrophication produces excess organic matter that fuels the development of hypoxia (i.e., low surface water DO concentrations) as organic matter is respired (McLaughlin, 2007). The acceptable pH levels established as the WQO (ranging 6.5 to 8.5) are required to be supportive of aquatic life. A change in pH can impact the bioavailability of nutrients.

Overall, nutrient concentrations at the ocean inlet were greater during wet weather conditions than the dry weather conditions. However dry weather nutrient concentrations during winter were comparable to concentrations measured during wet weather conditions. During the winter, DO concentrations never fell below 5 mg/L, with minimum concentrations of 5.0 mg/L. During the subsequent seasonal period of spring, chlorophyll *a* was elevated, with a mean concentration of 10.2 ug/L (the highest concentrations occurred in the spring, with a mean concentration of 21.1 ug/L). A nutrient study conducted by SCCWRP further supports the relationship of high concentrations of chlorophyll *a* to the overproduction of algae (McLaughlin, 2007). Mean nitrogen and phosphorus concentrations, however, were relatively low, with mean concentrations of 0.72 and 0.1 mg/L, respectively (both below or at the WQO). Although the highest nutrient concentrations did not coincide directly with the algal bloom, it should be noted that ambient conditions in a water body can reflect biological processing and nutrient loading that has already occurred (McLaughlin, 2007). For historical comparison purposes, the mean concentrations for TN and TP for each season were below historical mean concentrations within the lagoon of 2.2 mg/L for TN and 0.24 mg/L for TP (RWQCB, 1985). This may be due to seasonal or spatial variations, or due to possible overall improvements in water quality.

### 6.4.5 San Elijo Site-to-Site Comparisons

Table 6-22 compares the WQO exceedance frequency at each site for wet and dry weather conditions based on single-sample maximum concentration allowable. Based on Table 6-22, during wet weather events, all sites had bacteria exceedances. However, exceedances were less frequent at the lagoon segments and the Ocean Inlet Site.

Table 6-23 compares the mean concentrations at each site for wet and dry weather conditions. Based on Table 6-23, during wet weather events, the mean concentrations for bacteria samples collected at all sites exceeds the geometric mean-based WQOs. The Mass Emission Station samples had relatively greater bacteria concentrations than samples collected from the lagoon segments and the Ocean Inlet Site during all wet weather events.

For all wet weather events, TSS concentrations were greater at the Mass Emission Station compared to the lagoon segments and the Ocean Inlet Site. Throughout the dry season, TSS concentrations were greater at Lagoon Segment 1 as compared to the other sites.

The Mass Emission Station Enterococcus, total and fecal coliform mean concentrations rarely exceeded the geometric mean-based WQOs for dry weather conditions, with the exception of Enterococcus at the Mass Emission Station.

During wet weather, nutrient concentrations were generally higher at the Mass Emission Station compared to the other sites. During dry weather the Mass Emission Station generally had the highest nutrient concentrations with the exception of ammonia, SRP, and TP, which were highest at the Lagoon Segment 1.

**Table 6-22: San Elijo Comparison of WQO Exceedance Frequency**

| Constituent | WQO | Units | Wet Weather | | | | WQO | Units | Dry Weather | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mass Emission[1] | Lagoon Segment 1 | Lagoon Segment 2 | Ocean Inlet | | | Mass Emission[1] | Lagoon Segment 1 | Lagoon Segment 2 | Ocean Inlet |
| *Enterococcus* | 276 | CFU/100mL | 100% | 66.7% | 50.0% | 50.0% | 276 | CFU/100mL | 4.2% | 0.0% | 2.1% | 4.2% |
| Fecal Coliform | 400 | MPN/100mL | 100% | 83.3% | 33.3% | 66.7% | 400 | MPN/100mL | 12.5% | 4.2% | 0.0% | 0.0% |
| Total Coliform | 10,000 | MPN/100mL | 83.3% | 66.7% | 16.7% | 16.7% | 10,000 | MPN/100mL | 0.0% | 0.0% | 0.0% | 0.0% |
| Ammonia | 0.025 | mg/L | 100% | 50.0% | 66.7% | 66.7% | 0.025 | mg/L | 95.8% | 97.9% | 70.8% | 55.3% |
| Chlorophyll *a* | 20 | ug/L | NA | 33.3% | 16.7% | 0.0% | 20 | ug/L | 0.0% | 20.8% | 16.7% | 16.7% |
| Nitrate+Nitrite | 10 | mg/L | 0.0% | 0.0% | 0.0% | 0.0% | 10 | mg/L | 0.0% | 0.0% | 0.0% | 0.0% |
| Total Nitrogen | 1.0 | mg/L | 78.9% | 83.3% | 33.3% | 33.3% | 1.0 | mg/L | 66.7% | 58.3% | 27.1% | 12.5% |
| Total Phosphorus | 0.1 | mg/L | 100% | 100% | 100% | 100% | 0.1 | mg/L | 16.7% | 91.7% | 54.2% | 27.1% |

(1) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.

**Table 6-23: San Elijo Comparison of Mean Concentrations**

| Constituent | WQO | Units | Wet Weather[1] | | | | WQO | Units | Dry Weather[2] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mass Emission[3] | Lagoon Segment 1 | Lagoon Segment 2 | Ocean Inlet | | | Mass Emission[3] | Lagoon Segment 1 | Lagoon Segment 2 | Ocean Inlet |
| *Enterococcus* | 276 | CFU/100mL | 19,275 | 3,010 | 2,666 | 1,005 | 35 | CFU/100mL | 81.9 | 31.2 | 8.2 | 10.0 |
| Fecal Coliform | 400 | MPN/100mL | 8,650 | 1,462 | 660 | 1,070 | 200 | CFU/100mL | 149 | 109 | 35.7 | 25.2 |
| Total Coliform | 10,000 | MPN/100mL | 40,500 | 14,083 | 17,067 | 10,024 | 1,000 | CFU/100mL | 341 | 218 | 58.7 | 53.8 |
| TSS | NA | mg/L | 36.5 | 23.7 | 27.9 | 27.3 | NA | mg/L | 22.5 | 59.8 | 16.1 | 15.7 |
| Ammonia | 0.025 | mg/L | 0.13 | 0.04 | 0.04 | 0.04 | 0.025 | mg/L | 0.06 | 0.12 | 0.05 | 0.05 |
| CBOD | NA | mg/L | 1.91 | 1.28 | 1.30 | 1.18 | NA | mg/L | 0.95 | 1.17 | 2.09 | 1.74 |
| Chlorophyll *a* | 20 | ug/L | NA | 17.8 | 13.7 | 11.2 | 20 | ug/L | 2.68 | 16.9 | 31.5 | 10.2 |
| Nitrate+Nitrite | 10 | mg/L | 2.14 | 1.35 | 0.48 | 0.47 | 10 | mg/L | 1.32 | 1.12 | 0.58 | 0.27 |
| SRP | NA | mg/L | 0.15 | 0.10 | 0.06 | 0.05 | NA | mg/L | 0.05 | 0.12 | 0.06 | 0.04 |
| Total Nitrogen | 1.0 | mg/L | 1.81 | 1.84 | 0.68 | 0.70 | 1.0 | mg/L | 1.89 | 1.79 | 1.13 | 0.58 |
| Total Dissolved Nitrogen | NA | mg/L | 1.76 | 1.56 | 0.79 | 0.85 | NA | mg/L | 1.85 | 1.83 | 0.95 | 0.50 |
| Total Phosphorus | 0.1 | mg/L | 0.20 | 0.16 | 0.08 | 0.08 | 0.1 | mg/L | 0.07 | 0.20 | 0.11 | 0.06 |
| Total Dissolved Phosphorus | NA | mg/L | 0.15 | 0.13 | 0.07 | 0.06 | NA | mg/L | 0.07 | 0.18 | 0.08 | 0.05 |

(1) Wet weather Mass Emission data omits Wet Weather Event 3 because pollutagraph samples were not collected.
(2) For general chemistry, means were calculated as arimetic means. For bacteria (Enterococcus, Fecal colifor, and Total Coliform), means were calculated as geometric means.
(3) Saltwater WQOs were applied to Mass Emission Station data as the receiving water body is saltwater.

### 6.4.6 San Elijo Mass Emission Station Constituent Loading

Constituent loading is an important factor when considering point and nonpoint source contaminant input to a receiving water body. While constituent concentrations provide information on specific contaminant levels at a given point in time, load estimations consider discharge amounts along with constituent concentrations to provide insight into the overall amount of targeted constituents introduced into a water body. For example, equal concentrations of a given constituent measured under different flow regimes will result in different load values, which contribute to a better understanding of the impacts of that given constituent.

Although, the watershed may contribute to the constituent loading, the lagoon is subject to other inputs and processes that influence water quality as presented in Figures 1-1 to 1-4 of Section 1.4.
As part of the load assessment, load estimates were developed for the watershed associated with the Mass Emission Station only. It should be noted that the watershed for the mass emission station represents the majority of the entire watershed for the San Elijo Lagoon. The remaining portion of the watershed comprises the area discharging into the lagoon (or the creek) from adjacent lands downstream from the mass emission station. Runoff from this area generally sheet flows into the lagoon from pervious surfaces or discharges into storm drains that then discharge directly into the lagoon. The total load entering the lagoon (and the lagoon's loading capacity) would, therefore, include loads from the watershed for the mass emission station and the loads for the watershed(s) downstream from the mass emission station. Although the load assessments in this section do not account for this additional area downstream from the Mass Emission Station, the assessments still provide snapshots of the potential impacts of loading from the mass emission station's watershed on the lagoon.

#### 6.4.6.1 Daily and Annual Loading

Total daily and annual flows for the San Elijo Lagoon Mass Emission Station are reported in Section 4.4.1. Detailed continuous stage and flow data results for the entire monitoring period is presented in Appendix A-4. Section 4.4.2 contains hydrographs and hyetographs depicting total rainfall, rainfall intensity, and discharge for monitored wet weather events (Figures 4-12 through 4-14).

Total daily and annual loads for the San Elijo Lagoon Mass Emission Station are reported in Section 5.4.1. Daily load estimates are provided for both wet weather and dry weather periods in Table 5-24. Total annual load estimates are provided in Table 5-25. Detailed daily and annual load calculations are provided in Appendix D-4.

As shown in Table 5-24 in Section 5, the average daily wet weather loads greatly exceed the daily average dry weather loads due to higher constituent concentrations for all constituents (not including chlorophyll *a* as it was not sampled during wet weather events) and significantly greater flows during wet weather conditions.

Also, as shown in Table 5-25, the total annual wet weather load for most constituents represents approximately 90 to 99 percent of the total annual dry and wet weather load. This is typical for Southern California watersheds. For example, for the bacteria TMDLs developed for beaches and creeks by SDRWQCB (2007), wet weather loads constituted approximately 99 percent of the total annual loads for bacteria.

For some of the constituents including TN, TDN, ammonia, N+N, and TSS, the relative percentage of total annual load represented by wet weather loads was between 70 and 77 percent. Although the relative percentage was lower, the majority of total annual load for these constituents is due to wet weather load. Although the wet weather and dry weather concentrations were similar, total annual wet weather flows significantly exceeded the total dry weather flows resulting in a greater portion of annual load for these constituents due the wet weather events.

#### 6.4.6.2 Event and Seasonal Variations

Variations in constituent loading between events throughout the season and during events are discussed for both wet and dry weather conditions. Both within-event and seasonal patterns can help provide a better understanding of possible sources, processes, and mechanisms that affect runoff and associated bacteria concentrations, as well as assist in the next step of the TMDL process.

<u>Wet Weather - Seasonal Variations</u>

Seasonal wet weather variations in bacteria loading were assessed by reviewing the load duration curves in Appendix H-4 and comparing the total constituent loads for each event. Load duration curves were generated for constituents with a corresponding WQO, which include the following:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- Ammonia
- Chlorophyll *a*
- N+N

- TN
- TP

Overall, Wet Weather Event 1 peak flows and bacteria loading rates were higher than the peak flows and loading rates that occurred during Wet Weather Event 2. Peak loading rates during Wet Weather Event 1 were approximately four times the loading rates during Wet Weather Event 2.

For bacteria, the three bacteria constituents exceeded their associated wet weather loading capacities for all three wet weather events with the exception of one day during Wet Weather Events 1 when total coliform fell just below the loading capacity. These exceedances occurred under high flow regimes with the exception of one day during Wet Weather Event 2 during moist conditions, which may indicate these exceedances were likely resulting from non-point source inputs. These non-point source inputs include urban runoff resulting in the flushing of the storm water drainage and the washing of streets and yards in areas with significant domestic and wildlife populations.

Table 6-24 shows the total loads for bacteria during the three monitored wet weather events. Total loads for all three bacteria constituents were highest during Wet Weather Event 1. This is primarily due to the significantly higher total discharge volume associated with Wet Weather Event 1. Wet Weather Event 2 had discharge volumes that were less than those of Wet Weather Event 3. This is reflected by higher bacteria loads during Wet Weather Event 3 despite lower concentrations during that event when compared to Wet Weather Event 2.

For nutrients examined, TN, TP, and Ammonia exceeded the wet weather loading capacity during all three wet weather events (TN data not available for Wet Weather Event 3). Nitrate + Nitrite did not exceed the loading capacity during all three wet weather events.

Table 6-24 shows the total loads for nutrients and other monitored constituents during the three monitored wet weather events. Total loads for all constituents were highest during Wet Weather Event 1. This is primarily due to the significantly higher total discharge volume associated with Wet Weather Event 1. Wet Weather Events 2 had discharge volumes that were less than those of Wet Weather Event 3. This is reflected by higher loads during Wet Weather Event 3 despite lower concentrations during that event when compared to Wet Weather Event 2. These results further highlight the important effect of discharge when assessing constituent data over time.

**Table 6-24: San Elijo Wet Weather Event Total Loads Estimates**

| Event | *Enterococcus* | Fecal Coliform | Total Coliform | TSS | Ammonia (as N) | CBOD | Nitrate + Nitrite (as N) | SRP | Total Nitrogen | Total Dissolved Nitrogen | Total Phosphorus | Total Dissolved Phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wet Weather Event 1 | 697,132 | 232,691 | 2,174,859 | 189,354 | 543 | 17,933 | 8,936 | 1,554 | 13,842 | 9,984 | 2,414 | 1,140 |
| Wet Weather Event 2 | 90,966 | 17,321 | 131,987 | 46,566 | 94 | 2,344 | 2,783 | 158 | 2,059 | 2,104 | 214 | 175 |
| Wet Weather Event 3 | 145,713 | 53,568 | 477,182 | 13,6091 | 323 | 13,328 | 5,855 | 522 | 5,904 | 5,256 | 1,221 | 827 |

Wet Weather - Within-Event Variations

Pollutagraph sampling provided information on varying contaminant levels throughout Wet Weather Events 1 and 2. As flows varied throughout these wet weather events, contaminant loads varied as well. Results from pollutagraph sampling were used to calculate changing loading rates throughout both pollutagraph sampling events. These load pollutagraphs show loading rates along with discharge throughout each wet weather event. Based on the length of each monitored wet weather event, different time intervals were selected to calculate loading rates. A three-hour interval was selected for Wet Weather Event 1, which lasted approximately 53 hours. A one-hour interval was selected for Wet Weather Event 2, which lasted approximately 24 hours. Appendix G-4 contains the load pollutagraphs for all monitored constituents during the first two wet weather events for the following constituents:

- *Enterococcus*
- Fecal Coliform
- Total Coliform
- TSS
- Ammonia
- CBOD
- Chlorophyll *a*
- N+N
- SRP
- TN
- TDN
- TP
- TDP

Wet Weather Event 1 had two discharge peaks, which affected loading rates during the event. Relative to discharge throughout the event, nearly all constituents followed the same pattern with a relatively strong response to the first discharge peak and a weaker response to the second peak in discharge. One exception to this trend was shared by fecal coliform, N+N, SRP, and TDP which all persisted at higher loading rates for a short period of time after the first peak and also demonstrated a relatively stronger response to the second discharge peak when compared to the other constituents.

Wet Weather Event 2 was a shorter event and had a single peak in discharge throughout the event. Most monitored constituents followed a similar pattern, correlating well with discharge throughout the event. However one notable exception was displayed by fecal coliform which demonstrated a spike in loading rate for a short period of time before the main discharge peak of the storm.

Another method to evaluate the variability of loads within events is to assess the magnitude of the first flush loads relative to the rest of the event. Mass first-flush is similar to concentration first-flush discussed earlier; however, mass first-flush is based on a loading approach for an entire event. Mass first-flush describes the percent mass of monitored analytes that have been observed in the first 20 to 40 percent of storm discharge volume. Higher percent mass, those greater than 80 percent, for a given analyte has been suggested as an indicator that an analyte demonstrates a strong mass first-flush effect (Kayhanian and Stenstrom, 2008).

Table 6-25 presents the percent mass values along with the associated percent of storm discharge for both wet weather events.

**Table 6-25: San Elijo First-Flush Percent Mass**

| Analyte | Wet Weather 1 (at 30% Storm Flow) | | Wet Weather 2 (at 32% Storm Flow) | |
|---|---|---|---|---|
| | Mass First-Flush % | First-Flush Effect[1] | Mass First-Flush % | First-Flush Effect[1] |
| *Enterococcus* | 40 | Minor | 14 | None |
| Fecal Coliform | 26 | None | 21 | None |
| Total Coliform | 24 | None | 18 | None |
| TSS | 44 | Minor | 28 | None |
| Ammonia (as N) | 38 | Minor | 24 | None |
| CBOD | 46 | Minor | 20 | None |
| Nitrate + Nitrite (as N) | 27 | None | 28 | None |
| SRP | 29 | None | 27 | None |
| Total Nitrogen | 31 | None | 21 | None |
| TDN | 30 | None | 23 | None |
| Total Phosphorus | 33 | None | 26 | None |
| TDP | 34 | None | 26 | None |

(1) For discussion purposes first-flush categories are defined as follows: strong = >80%, moderate = <80% and >60%, minor = <60% and > 35%, none = <35%.

None of the constituents monitored at the San Elijo Mass Emission Station demonstrated a strong mass first-flush effect. The strongest mass first-flush effect throughout both events was demonstrated CBOD showing the highest percentage associated with a minor first-flush effect during Wet Weather Event 1. Nearly all of the remaining constituents did not show a mass first-flush effect with the exception some minor effects shown by *Enterococcus*, TSS, and ammonia during Wet Weather Event 1.

Wet Weather Event 1 mass first-flush results compared to concentration-based first-flush analyses reflect the importance of discharge when analyzing data and considering mangament approaches. Ammonia was the only constituent to show first-flush effect based on concentration, reporting a moderate effect. In contrast *Enterococcus*, TSS, ammonia, CBOD, TP, and TDP reported a minor mass first-flush effect. The remaining constituents report results for mass first-flush which correspond to the concentration first flush results in that neither shows first-flush effects.

Wet Weather Event 2 mass first-flush results for all constituents do not show any first-flush effect. Although these results are generally supported by the concentration-based first-flush ratios, there are some exceptions. Ammonia, as well as fecal and total coliform, reflects an opposite result to mass first flush results in that those constituents report first-flush effect when assessing concentrations. Most notably fecal coliform reported a strong concentration first-flush with a high concentration first-flush ratio of 3.35.

These results highlight the importance volume when assessing first-flush effects as total discharge influences the overall amount of a constituent being input into a water body.

Seasonal Variations – Dry Weather

Seasonal dry weather variations in constituent loading were assessed by comparing the average constituent loads for each event in Table 5-27 and reviewing the load duration curves in Appendix H-4.

Average total load for bacteria constituents were highest during the winter months. High winter loads may be attributed to the higher flows experienced during those months as the mean concentration for that period were among the lowest of the four index period events. Average bacteria loads were lowest during the spring months that correspond to the lowest concentrations throughout the year. Although summer and fall concentrations were similar, the average loads were higher during the summer months due to higher discharge rates during those months with the exception of total coliform. Total coliform concentrations were the highest during the fall months resulting in a higher load when compared to summer.

Nutrient loads were highest during the winter months primarily due to high discharge rates experienced during those months but also due to relatively high concentrations as well. Summer and fall months had relatively high loading rates primarily due to the relatively high concentrations reported during those periods. Spring reported the lowest average loads that correspond to the lowest concentrations measured

throughout the year. Chlorophyll *a* does not follow this general trend as concentration decreased from winter to fall as did average loads. TSS also did not share the trend demonstrated by most nutrients as the highest average concentration and load occurred during spring when other constituents were relatively low.

Exceedances of the loading capacities varied throughout each season. *Enterococcus* exceeded the dry weather loading capacity during each of the four seasons with the exception of three days during Index Period Event 2. These exceedances occurred under all flow regimes suggesting that *Enterococcus* exceedances are a result of both point and non-point sources. Influences from non-point sources appear to have occurred during the first index period which took place in winter with residual effects from wet weather events. Non-point influences appear to have continued through the spring as dry weather discharge at San Elijo Lagoon remained relatively high throughout the spring months. Dry weather fecal coliform samples collected during Index Period Event 3 and 4 occurred under mid-range flows and dry conditions exceeded loading capacities the majority of the time during both events. However fecal coliform samples collected during winter and spring did not exceeded the loading capacities with the exception of one day during Index Period Event 1. These exceedances occurred during mid-range flows for Index Period Event 3 and during dry conditions for Index Period Event 4. Total coliform did not exceed loading capacities during any of the seasonal events with the exception of one day during Index Period Event 4. These events occurred during high flows, moist conditions, mid-range flows, and dry condition flow regimes.

TN and Ammonia were the primary nutrients to exceed loading capacities consistently through the seasons which represented high flows, moist conditions, mid-range flows, and dry conditions. TP did exceed loading capacities on some occasions, particularly during Index Period Event 1 and 4. These exceedances correspond to some of the highest concentrations throughout the year, and, therefore, some of the highest loads during those occasions. Chlorophyll *a* and N+N did not exceed loading capacities during any season or under any flow regimes.

### 6.4.7 San Elijo Dissolved Oxygen Concentrations

Dissolved Oxygen (DO) concentration can be an important indicator of eutrophic conditions within a water body. Eutrophic conditions caused by excessive nutrient input (such as nitrogen and phosphorous) result in excessive plant growth, or algal blooms. When the algae begin to die and decompose, oxygen is consumed in the process by microorganisms feeding on the dead algae, leading to low DO concentrations. The eutrophication process can impair aquatic life and fisheries by causing depressed levels of oxygen

which result in a change to the benthic community structure from aerobic to anaerobic organisms and stress or eliminate desirable aquatic life (USEPA, 1999). The DO WQO was established as a minimum concentration to maintain DO levels above 5 mg/L and average annual concentration of 7 mg/L to be protective of aquatic life and habitats.

Fluctuations in DO can result from various environmental factors such as temperature, plant respiration, decomposition of organic matter, and stratification of the water column. Low DO concentrations are caused from one or more of three environmental factors: low solar radiation (resulting in reduced oxygen production via photosynthesis), increased freshwater discharge (resulting in enhanced haline stratification which prevents ventilation of bottom waters), and sluggish bottom water ventilation due to stratification often occurring during neap tidal phase (Nezlin, 2009). In the study conducted by SCCWRP, hypoxic events were defined as periods when either the DO daily average was below 3 mg/L or any observation during the 24-hr period was less than 1.0 mg/L (Nezlin, 2009).

#### 6.4.7.1 Comparison to WQO

DO data for the lagoon segment sites is summarized in Table 4-66 and 4-67 in Section 4.4.1. Complete continuous DO data is reported in Appendix B-4. Detecting hypoxia is difficult because DO is exceptionally variable over short time scales, i.e., less than a day, due to variable rates of oxygen production and consumption, which fluctuate in response to different environmental factors (Nezlin, 2009). In general, DO data indicated potential eutrophic conditions at both Lagoon Segment sites with wide ranges of DO concentrations and low minimum concentrations. Nearly 50 percent of monthly mean concentrations at Lagoon Segment 1 were above the WQO of 5 mg/L and nearly all of the monthly mean concentrations at Lagoon Segment 2 with the exception of June and July with the mean concentrations of 4.7 and 4.8 mg/L, respectively. The low DO concentrations were associated with a rise in turbidity at Lagoon Segment 1, which is also a common aspect to algal bloom events resulting from increased particulate matter.

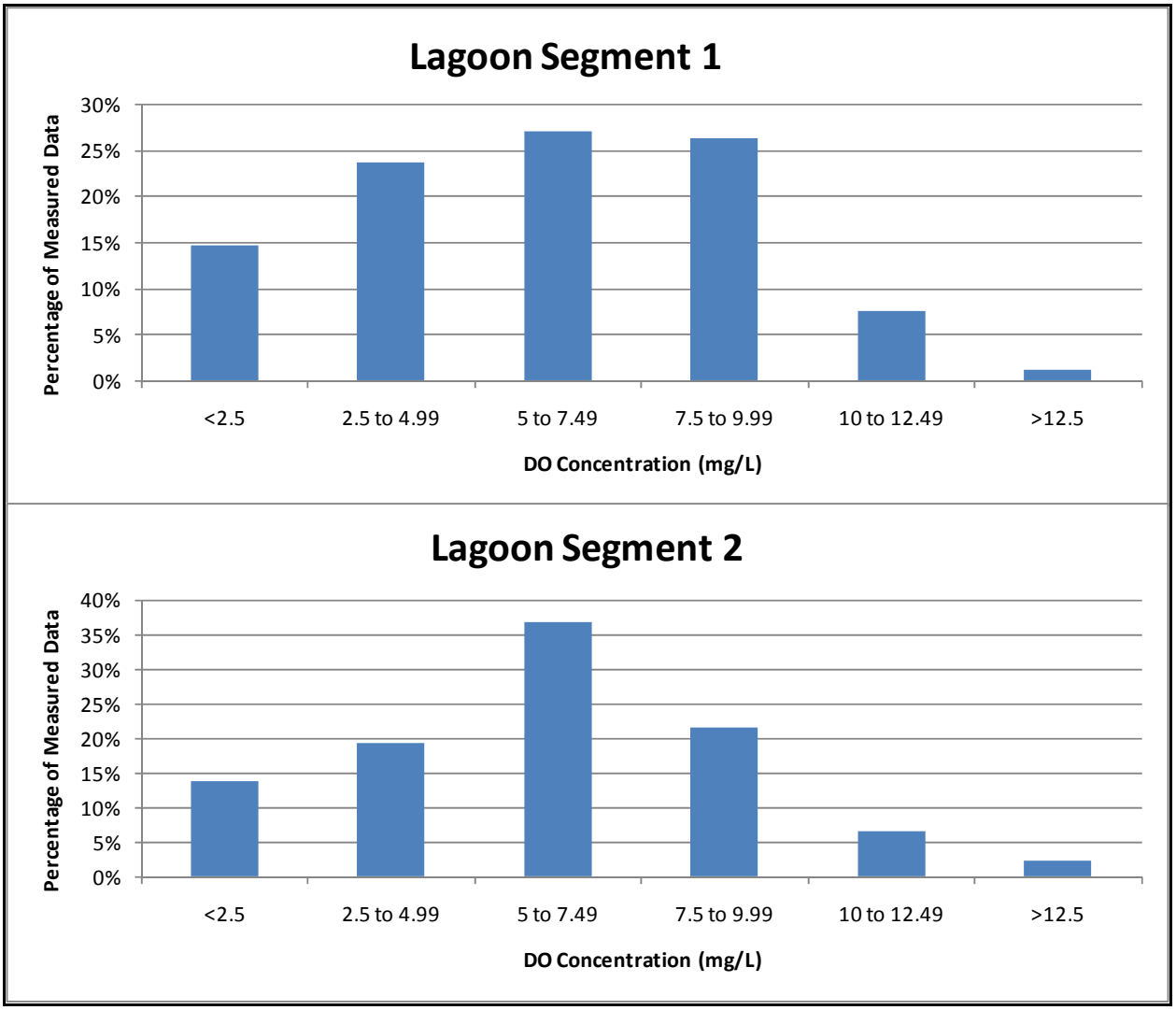
The WQO for DO requires that no single measurement fall below a concentration of 5 mg/L along with an annual mean objective of 7 mg/L as described in Table 1-4 in Section 1.3. Figure 6-11 is a frequency distribution of all measured DO concentrations throughout the entire monitoring period. The distribution is broken down into 2.5 mg/L bins. There are six bins with the last bin containing the percentage of measured concentrations of 12.5 mg/L and greater. The percentage of measured concentrations in the first two bins represents the percentage of concentrations not meeting the WQO.

Lagoon Segment 1 shows approximately 40 percent of all measured concentrations falling below the single-sample minimum WQO. Approximately 50 percent of the concentrations occur between 5 and 10 mg/L, which surround the annual mean objective of 7 mg/L. The mean for the entire monitoring period at Lagoon Segment 1 is 6.1 mg/L. Lagoon Segment 2 shows approximately 32 percent of measured concentrations below the single-sample minimum WQO along with approximately 58 percent within the range of 5 to 10 mg/L.

#### 6.4.7.2 Seasonal Variations in DO Concentrations

Index period events are intended to represent seasonal variations within the lagoon. Both Lagoon Segment sites reflected similar patterns, with higher DO concentrations in the winter and spring and lower concentrations in the summer and fall. Water temperature is an important factor when considering DO, as water with lower water temperatures can hold higher concentrations of DO. DO concentrations appeared to correspond to temperature values at both lagoon segments (Table 4-66 and Table 4-67). The lowest concentrations at both lagoon segments were observed in the summer during Index Period Event 3 which coincided with observed algal growth at Lagoon Segment 1. Mean concentrations for Index Period Event 3 at Lagoon Segments 1 and 2 were 3.5 and 4.6 mg/L, respectively and values of 0.3 and 0.9 mg/L, respectively. During June through October, DO concentrations had wide ranges that may reflect one or more of the following factors: reduced oxygen production via photosynthesis, increased plant respiration, increased decomposition of organic matter, or a gradually more stratified water column. Instantaneous DO data collected throughout the monitoring period are plotted for all sites and can be found in Appendix I-3.

**Figure 6-11: Frequency Distribution of Measured DO Concentrations**




### 6.4.8 San Elijo Lagoon Summary of Key Findings

For the 2008-2009 monitoring year, precipitation totaled 10.59 inches, which was slightly below the mean annual rainfall of approximately 12 inches. Approximately 640 million cubic feet of water discharged into the lagoon from Escondido Creek. Of that amount, approximately 89 percent was discharged during wet weather events during the winter. Based on the sampling results and data assessment, a summary of the key findings for each constituent category are presented below.

Bacteria

Comparison to WQOs:

- During wet weather conditions, WQOs and loading capacities were exceeded at almost all locations, indicating that beneficial uses of the lagoon may have been impacted during wet weather conditions.
- During dry weather conditions, WQOs and loading capacities were exceeded at the mass emission station.

Seasonal Variations:

- Seasonal variations were observed at the mass emission station for both wet and dry weather conditions for all bacteria indicators. During wet weather conditions, Wet Weather Event 1 concentrations and loadings were greater than Wet Weather Events 2 and 3 concentrations and loadings, possibly due to a longer antecedent dry period and/or higher rainfall intensities and peak flows.
- During dry weather conditions, higher bacteria concentrations occurred during the summer months, characterized by lower flows and hotter temperatures. The lowest concentrations occurred during the winter and spring seasons.
- Within the lagoon, the highest concentrations occurred during wet weather conditions, with lower concentrations during dry weather conditions. For dry weather conditions, the winter had the highest concentration and the spring and fall had the lowest concentrations.

Within-Event Variations:

- Generally, bacteria concentrations at the mass emission station were similar throughout wet weather events, although during Wet Weather Event 1, the highest fecal coliform and total coliform concentrations occurred towards the end of the storm and were associated with the second peak flow. With the exception of a strong concentration first flush effect for *Enterococcus* for Wet Weather Event 2 and a minor first-flush effect for total coliform for Wet Weather Event 3, no concentration first-flush effects were seen at the mass emission station.
- During Wet Weather Event 1 within the lagoon, *Enterococcus* was generally higher during slack high tide conditions although fecal and total coliform were higher during low tide conditions. Elevated bacteria concentrations during Wet Weather Events 2 and 3 did not correspond to a particular tidal condition.

Site Differences:

- Differences in concentrations between sites were found, with mass emission station mean concentrations *Enterococcus* and fecal coliform generally greater than all other sites mean concentrations during wet and dry weather conditions.

Sediment

Seasonal Variations:

- During wet weather conditions, TSS concentrations and loadings were greater during Wet Weather Event 1 than Wet Weather Events 2 and 3 concentrations and loadings, possibly due to a longer antecedent dry period and/or higher rainfall intensities and peak flows
- During dry weather conditions, TSS concentrations were the highest during spring under moist conditions flows. TSS concentrations were lowest during winter under moist condition flow regimes.
- Within the lagoon, TSS concentrations were not similar between wet weather and dry weather conditions. Lagoon Segment 1 TSS mean concentrations during wet weather conditions were lower than concentrations during dry weather. Lagoon Segment 2 TSS mean concentrations were slightly lower during dry weather compared to wet weather conditions (which reflected a similar trend as the Ocean Inlet site that is located closer to the lagoon mouth).

Within-Event Variations:

- For TSS, concentrations generally correlated with the flow rate, i.e., higher concentrations during higher flows and lower concentrations during lower flows, however there were some exceptions during both events.
- Generally, TSS did not show first-flush effects. TSS had a no concentration-based first flush effects during Wet Weather Events 1 and 2. Little to no mass-based first flush effects were found.

Site Differences:

- During dry weather conditions, Lagoon Segment 1 had statistically higher concentrations than the other sites.

Nutrients

Comparison to WQOs:

- WQOs and loading capacities for most nutrient constituents were exceeded during wet weather conditions at almost all locations.
- Within the lagoon, approximately 30 - 40 percent of all measurements DO concentrations were below the single-sample minimum WQO (5mg/L).

Seasonal Variations:

- Seasonal variations were observed at the mass emission station for both wet and dry weather conditions for most nutrient constituents. During wet weather conditions, Wet Weather Event 1 loadings were greater than Wet Weather Events 2 and 3 loadings, despite some concentrations being lower during this event. This is possibly due to a longer antecedent dry period and/or higher rainfall intensities and peak flows.

- During dry weather conditions, higher nutrient concentrations occurred during the winter and spring, characterized by higher flows and lower temperatures. In winter and spring, DO concentrations and pH values were higher than summer and fall.
- Within the lagoon, the highest concentrations occurred during wet weather conditions, with lower concentrations during dry weather conditions. For dry weather conditions, the winter had the highest concentrations and the spring and fall had the lowest concentrations.
- Generally for all sites, DO concentrations were higher during winter (characterized by higher flows and lower temperatures) and lower DO concentrations during summer and fall (characterized by mid-range to dry condition flows and higher temperatures). During the summer, the lowest DO concentrations and highest temperatures coincided with observed algal growth with the lagoon.

Within-Event Variations:

- Generally, nutrient concentrations were similar throughout wet weather events. As a result, no concentration or mass-based first flush effects were found. This lack of a first flush effect is generally characteristic of watersheds that are less urbanized and not highly impervious.
- Within-event variations at the ocean inlet correlated with the tides, with higher nutrient concentrations generally occurring during slack low tides. However, at the segments, tidal variations in concentrations varied by event and ocean inlet sites.

Site Differences:

- Differences in concentrations between sites were found, with mass emission station mean concentrations greater than lagoon and ocean inlet mean concentrations during wet and dry weather conditions.
- During dry weather conditions, Lagoon Segment 1 concentrations of chlorophyll *a* and CBOD were higher than the Mass Emission Station.

# 7.0 CONCLUSIONS

The following paragraphs summarize the key findings and conclusions of this report for each constituent category. These conclusions apply to the entire CHU watershed based on the lagoon-specific findings and overall patterns observed in Section 6.0. It should be noted that these conclusions are preliminary and based on tentative WQOs (and other assumptions stated herein) that may be revised and/or fine-tuned through the TMDL development process.

Bacteria

These conclusions apply to Agua Hedionda Lagoon, Buena Vista Lagoon, Loma Atla Slough and San Elijo Lagoon, which are 303(d) listed for bacteria impairments. Fecal and total coliform and *Enterococcus* results for both dry and wet weather conditions at the mass emission stations exceeded their respective WQOs at all four lagoons. Bacteria results within the lagoons and at the ocean inlets also exceeded WQOs during wet weather conditions, indicating that beneficial uses may be impaired during wet weather conditions.

Wet Weather Event 1 concentrations generally exceeded Wet Weather Events 2 and 3 concentrations, possibly due to higher rainfall intensities, higher peak flows, and/or a longer antecedent dry period (and, therefore, there was more bacteria build-up and wash off).

In most cases, little or no concentration first-flush effects were found at the mass emission stations during wet weather events. Some events, however, had minor to moderate mass first-flush effects. Studies have shown that an absence of a first-flush effect for bacteria is more typical of less-developed, less-impervious (5 to 30 percent) watersheds. The CHU watershed averages about 18 percent imperviousness.

Wet weather samples had higher concentrations than dry weather sample concentrations at most locations within each lagoon, suggesting that non-point sources are the primary contributors to elevated bacteria concentrations and annual loadings. Also, as wet weather flows contribute between 84 and 98 percent of the total annual flow volume, nearly all of the bacteria loadings into the lagoons are during wet weather storm events.

It should be noted that the bacteria concentrations at the mass emission stations were similar to concentrations measured by SCCWRP from undeveloped watersheds. Therefore, natural sources may be contributing significant bacteria concentrations and a larger portion of the bacteria loads than

anthropogenic sources, such as poorly-managed livestock operations, and/or improper handling of pet waste. Also, due to the relatively low imperviousness of the CHU watershed (18 percent impervious), BMPs targeted to impervious areas only may have limited impact on downstream water quality. Ultimately, the development of a TMDL model can assist with not only assessing the relative contribution of bacteria concentrations and loads.

Dry weather periods do not generally appear to be associated with beneficial use impairments from bacteria for Buena Vista Lagoon and San Elijo Lagoon, as all within-lagoon samples were below the dry weather WQOs. Buena Vista Lagoon's East Basin and the Loma Alta Lagoon did, however, slightly exceed dry weather WQOs during dry weather conditions. The exceedance rate for these lagoons ranged from 12.5 percent to 14.6 percent, versus an allowable exceedance frequency of 10 percent.

Concentrations during the summer and fall months were generally higher than concentrations during the fall and winter. However, within the lagoons, concentrations during the winter were the highest.

The highest WQO exceedance frequencies were associated with *Enterococcus* and fecal coliform. As USEPA studies have demonstrated that *Enterococcus* is a better predictor of the presence of gastrointestinal illness-causing pathogens than fecal and total coliform (RWQCB, 2007).

Nutrients

These conclusions apply to Buena Vista Lagoon, Loma Alta Slough, and San ELijo Lagoon, which are 303(d) listed for nutrient/eutrophication impairements. Results for TN, TP, and ammonia for both dry and wet weather conditions at the mass emission stations, lagoon segments, and ocean inlets exceeded their respective WQOs at all three of the lagoons 303(d)-listed for nutrients/eutrophication. Concentrations for these constituents were, with some exceptions, only slightly greater than WQOs. In some instances, the mean concentration was lower than the WQO, but several samples that exceeded the WQO resulted in an exceedance rate that was slightly greater than the 10 percent allowable exceedance frequency.

Additionally, concentrations for TN and TP at Buena Vista and San Elijo Lagoons were below historical concentrations and site-specific TN and TP criteria proposed by the RWQCB in 1985 to prevent any further degradation in water between approximately 50 and 100 percent. It should be noted that no historical concentrations for Loma Alta were readily available and therefore not included in the 1985 study by the RWQCB. Although seasonal and/or spatial variations may have been responsible for this

difference, improvements in water quality since the time of the RWQCB study, however difference in study period may also have led to this difference.

It should be noted that the WQO exceedances were based on comparisons to non site-specific nutrient WQOs. These WQOs may not be reflective of the San Diego coastal lagoon environment, as the objectives in the San Diego Basin Plan were originally developed based on non site-specific temperate, freshwater lake criteria. SCCWRP has been conducting a study to meet some of the requirements of the Investigative Order to help address the issue of appropriate nutrient criteria for the coastal lagoons in San Diego. Additionally, there is a state-wide effort to develop nutrient criteria for coastal water bodies.

Two of the three lagoons (Loma Alta and San Elijo) had DO concentrations that fell below the single sample minimum concentration (5 mg/L) between 30 and 50 percent of the time. For Buena Vista, DO concentrations were below the single-sample minimum concentration only slightly more than 10 percent of the time. Most of the DO concentrations that fell below the single-sample minimum occurred during the summer and fall.

During the summer and fall, algal growth was observed by field crews at the Buena Vista Lagoon and Loma Alta Slough, and during the summer and spring at the San Elijo Lagoon. The extent of coverage was not recorded, but generally, it appeared to be less than 10 to 15 percent of the each of the lagoon's total surface area. During these periods, low DO concentrations (below the 5 mg/L single-sample minimum) occurred, which is a commonly observed symptom of eutrophic water bodies. Also during these periods, chlorophyll *a* concentrations (typically related to the overproduction of algae) and ammonia were generally above the WQOs of 20 ug/L and 0.025 mg/L, respectively. Conversely, at most locations, TN and TP during the summer and fall were below WQOs, while the winter and spring concentrations. Although the highest nutrient concentrations did not coincide directly with the observed algal growth, ambient conditions in a water body can reflect biological processing and nutrient loading that has already occurred.

Wet Weather Event 1 nutrient concentrations and loadings exceeded Wet Weather Events 2 and 3 nutrient concentrations and loadings, possibly due to higher rainfall intensities, higher peak flows, and/or a longer antecedent dry period (and, therefore, there was more bacteria build-up and wash-off).

Generally, nutrient concentrations were similar throughout wet weather events. As a result, no or little first flush effects were found for most constituents. Ammonia showed the greatest concentration and mass first flush effects of the nutrients, however, the effects were still considered minor.

As indicated, the first step in the nutrient TMDL process should be the development of site-specific nutrient criteria that can be applied to each lagoon's unique environment. As seasonal differences were found, these criteria should be seasonally based. After these criteria are developed, the comparison of concentrations measured and loadings calculated in this study to the site-specific criteria should be reassessed. As multiple sources of nutrients can contribute to potential impairments of the lagoons, further source identification and/or characterization would help target the largest contributors, whether that's sediment, air deposition, urban runoff, and/or lagoon dynamics. Similar to bacteria, the development of a TMDL model can assist with assessing the relative contribution of nutrient concentrations.

Total Dissolved Solids

These conclusions apply to Agua Hedionda Creek, which is 303(d) listed for TDS. The WQO and mass loading capacity for TDS were exceeded during wet and dry weather conditions at the Agua Hedionda Mass Emission Statio. (TDS samples were not required at the other lagoons, as they aren't 303(d) listed for dissolved solids. However, because TDS samples were not required for collection within the lagoon, the potential impact on lagoon water quality could not be assessed. Possible sources for relatively high salt loads (TDS) include agricultural runoff, urban run-off, wastewater, seawater (typical TDS concentrations are greater than 35,000 mg/L), seepage of groundwater with a high salt content (particularly groundwater with sea water intrusion concerns), imported drinking water, and natural sources such as leaves, silt, plankton, and rocks.

TDS concentrations at the mass emission stations were similar for Wet Weather Events 1 and 2 and slightly lower for Wet Weather Event 3, so it does not appear that any of the factors that may have contributed to higher bacteria and nutrient concentrations (e.g., antecedent dry period, higher rainfall intensities, and greater peak flows) contributed to higher TDS concentrations for Wet Weather Event 1.

Generally inconsistent first-flush effects were found. The highest TDS concentrations tended to occur within the first six hours of each event prior to peak flow conditions. As a result, TDS had moderate to strong concentration-based first-flush effects. However, TDS did not have a mass-based first-flush effect. This was due to relatively high concentrations during the first six hours of discharge, but only on the early

part of the rising limb of the hydrograph. As these concentrations occurred during a relatively low flow period, only minor loading occurred. Concentrations remained fairly consistent throughout the rest of the event.

During dry weather conditions, TDS concentrations were similar throughout the different seasons and flow regimes, with the lowest concentrations associated with higher flow regimes during the winter.

Sediment

These conclusions apply to Agua Hedionda Lagoon, Buena Vista Lagoon, Loma Alta Slough, and San Elijo Lagoon, which are 303(d) listed for sediment impairements. The San Diego Basin Plan only specifies narrative WQOs only for sediment. Therefore, no comparisons between TSS concentrations and WQOs could be made. TSS concentrations at the mass emission station during Wet Weather Events 2 and 3 were higher than Wet Weather Event 1 concentrations. During wet weather events, TSS concentrations generally correlated with the flow rate, i.e., higher concentrations during higher flows and lower concentrations during lower flows. TSS had a moderate concentration-based first -flush effect during Wet Weather Event 1, but no concentration-based first-flush effect during Wet Weather Event 2. Little to no mass-based first-flush effects were found.

Wet weather samples from mass emission stations were also analyzed for aqueous grain size distribution. The results of these samples indicated that greater than 80 percent of the sediment measured in most of the mass emission station samples was present in the silt size range and smaller (less than 0.0625 mm). This has potential implications in the feasibility of implementing source and/or treatment control BMPs to remove sediment (and other constituents, depending on their associated particle size distributions), as smaller colloidal and suspended particles (< 10 um) will generally remain suspended and not settle out of water as opposed to the larger suspended particles that settle fairly quickly.

Similar to sediment TMDLs developed for other regions and states for streams where the TMDLs have consisted of particle size range limits (or minimums) to protect habitat suitability for aquatic life (e.g., salmon), an appropriate grain sediment size distribution range could be developed for the four lagoons to protect beneficial uses.

During dry weather conditions, TSS concentrations were the highest for the high flow regime during the winter. TSS concentrations were relatively consistent throughout the rest of the year, with the lowest concentrations occurring during the spring.

Differences in concentrations between sites were found, with lagoon and ocean inlet sites TSS mean concentrations greater than that of mass emission stations TSS mean concentrations during dry weather conditions.

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