CITY OF LONG BEACH
STORMWATER MONITORING REPORT 2008/2009
NPDES Permit No. CAS004003 (CI 8052)

July 2009

KINNETIC LABORATORIES INCORPORATED

CITY OF LONG BEACH

DEPARTMENT OF PUBLIC WORKS

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The City of Long Beach is pleased to submit their eighth annual "Stormwater Monitoring Report 2008/2009" in compliance with Order No. 99-060, for the Municipal National Pollutant Discharge Elimination System (NPDES) Permit No. CAS004003 (CI8052).

We have worked collaboratively with our contractor, Kinnetic Laboratories, Inc., and their subcontractors to produce a report that we believe contains extremely useful information for the City and the Regional Board. As required in our permit, all analyses were conducted at laboratories certified for such analyses by the Department of Health Services or approved by the Executive Officer and in accordance with current EPA guideline procedures or as specified in this Monitoring Program.

I certify under penalty of law that this document and all attachments were prepared under my directions or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted.

Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility, of a fine and imprisonment for knowing violations.

Executed on the 15th day of July, 2009
at Long Beach, California.

Mark A Christoffels

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Deputy Director/City Engineer

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Date

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CITY OF LONG BEACH
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ACRONYMNS AND ABBREVIATIONS LIST

ASTM - American Society for Testing and Materials
BMP - Best Management Practice
BOD- Biological Oxygen Demand
CCC – Criterion Continuous Concentration
CD - Compact Disk
CFU - Colony Forming Units
CMC – Criterion Maximum Concentration
COD - Chemical Oxygen Demand
CRWQCB – California Regional Water Quality Control Board
CTR - California Toxics Rule
DDD - dichloro (p-chlorophenyl)ethane
DDE - dichloro (p-chlorophenyl)ethylene
DDT - dichlorodiphenyl trichloroethane
DF - dilution factor
DI - Deionized
DL - Detection Limit (considered the same as RL)
DO - Dissolved Oxygen
EC_{50} - Concentration causing effects to 50% of the test population
EDTA - ethylene diamine triacetic acid
EMC - Event mean concentration
GIS - Geographic Information System
IC_{25} - Concentration causing 25% inhibition in growth or reproduction
IC_{50} - Concentration causing 50% inhibition in growth or reproduction
ICID - Illegal Connection Illicit Discharge
ICP-MS - Inductively Coupled Plasma-Mass Spectrometry
Halocline – a locally steepened vertical gradient of salinity
KLASS - Kinnetic Laboratories Automated Sampling System
KLI - Kinnetic Laboratories, Inc.
LC_{50} - Bioassay concentration that produces 50% lethality
LDPE - Low Density Polyethylene
LOEC - Lowest Observed Effect Concentration
MBAS - methylene-blue-active substances
ML – Minimum level as defined in State Implementation Plan
MPN- Most Probable Number
MS4 - Multiple Separate Storm Sewer System
NADP - National Atmospheric Deposition Program
NCDC - National Climate Data Center
NPDES – National Pollutant Discharge Elimination System
NOEC - No observed effect concentration
NTU - nephelometric turbidity units
PCB - Polychlorinated biphenyls
PDF - Portable Document Format
PMSDs - Percent Minimum Significant Differences
ppb - Parts per Billion
ppt – Parts per Thousand
Q - Flow

QA/QC - Quality Assurance/Quality Control
RL - Reporting Limit (considered the same as DL)
RPD - Relative Percent Difference
sf - Square Feet
SIP – State Implementation Plan
SM- Standard Methods for the Examination of Water and Wastewater
SOP - Standard Operating Procedure
SRM - Standard Reference Material
STS - sodium tetradecyl sulfate
SWRCB-State Water Resource Control Board
TDS – Total Dissolved Solids
TIE – Toxicity Identification Evaluation
TKN - Total Kjeldahl Nitrogen
TOC - Total Organic Carbons
TPH - total petroleum hydrocarbons
TSI - ToxScan, Inc.
TSS – Total Suspended Solids
TU - Toxicity Unit
TU_a – Acute Toxicity Unit ($1/LC_{50}$ or EC_{50})
TU_c – Chronic Toxicity Unit (1/NOEC)
USEPA - U.S. Environmental Protection Agency
WQO - Water Quality Objective
WQS - Water Quality Standard

EXECUTIVE SUMMARY

This report provides a summary of the results of the tenth year of monitoring conducted under the terms of Order No. 99-060 National Pollutant Discharge Elimination Systems Municipal Permit No. CAS004003 (CI 8052) for City of Long Beach. Included in this report is a synthesis of key elements of the data set as developed over the duration of the program. The following section provides a summary of the background and purpose of the monitoring program. This is followed by a summary of key findings based upon the full ten years of monitoring.

BACKGROUND AND PURPOSE

Under the terms of Order No. 99-060, the City of Long Beach was required to conduct a water quality monitoring program for stormwater and dry weather discharges through the City's municipal separate storm sewer system (MS4) beginning in the 1999/2000 wet weather season. The permit was initially issued for the term of five years. At the end of the initial five years the City was directed by the Regional Board to continue operating under the 1999 permit until further notice. It is expected that the recently approved NPDES permit for Ventura County will serve a model for both Los Angeles County and City of Long Beach NPDES permits.

Major elements of the current monitoring and reporting program include 1) mass emission monitoring during storm events, 2) monitoring of dry weather discharges at each mass emission site, and 3) special studies. Two special studies were conducted during the past monitoring season to assist in addressing sources and sinks for contaminants in the Los Cerritos Channel watershed and estuary.

Mass emission monitoring is conducted at four sites during four wet weather storm events each year. Monitoring sites specified in the permit are as follows:

- Basin 14: Dominguez Gap Pump Station Monitoring Site
- Basin 20: Bouton Creek Monitoring Site
- Basin 23: Belmont Pump Station Monitoring Site
- Portions of Basins 18, 19, 27 and 29: Los Cerritos Channel Monitoring Site

This element of the program is intended to characterize stormwater discharges, identify contaminants of concern and develop pollutant load estimates for each major watershed. Monitoring is required to be conducted during the first significant rainfall event of the season. Flow-rated, whole storm composite samples are obtained at each site and analyzed for major constituents of concern which include conventional constituents, total and dissolved metals, organophosphate pesticides and herbicides. Toxicity testing using sea urchin fertilization tests and water flea survival and reproduction is conducted on the composite storm samples from three of the four mass emission sites. Phase 1 Toxicity Identification Evaluations (TIEs) are performed on samples with toxicity in order to determine the likely contaminants contributing to the observed toxicity.

Dry weather monitoring consists of inspections at each mass emission site and the collection and analysis of dry weather discharges over two different separate 24-hour periods during each dry season. This element of the program is intended to identify pollutants of concern and associated toxicity at the mass emission sites during the dry season. Dry weather discharge samples are subjected to the same chemical analysis and toxicity testing used for the stormwater monitoring program.

The purpose of this present report is to submit the results of the City of Long Beach's stormwater monitoring program for the tenth year (2008/2009) under the current permit.

SUMMARY OF RESULTS

The 2008/2009 season marked the fourth season in a row of below normal precipitation, further intensifying Southern California drought conditions. The last storm season with above normal precipitation was 2004/2005 when rainfall was approximately twice the seasonal averages. Normal precipitation for September through April at the Long Beach Airport is 12.51 inches. This season, a total of 9.29 inches of rainfall was recorded at the airport. Compared to normal precipitation at this site, there was a 3.22 inch deficit for the season or 74% of normal.

Two dry weather inspections/monitoring events were conducted during the 2008/2009 monitoring year. These surveys are conducted during the summer dry weather period at each of the four mass emission stations. A total of 20 dry weather surveys have now been conducted since issuance of the permit in 1999. Dry weather surveys are scheduled around periods with extreme low tides since the Bouton Creek site is intertidal and requires an extended period of low water to flush out the saltwater such that only dry weather discharges can be sampled. No dry weather sampling was conducted at the Belmont Pump Station this year since all dry weather flows have been diverted to the sanitary system.

The first dry weather survey was conducted on July 2, 2008. The second dry weather survey was initiated on May 7th, 2009 once winter rains had subsided. Dry weather inspections were conducted at all four mass emission sites. This included inspections at the Belmont Pump Station to verify that the sanitary bypass was working and the Dominguez Gap Pump Station which, to date, has not had dry weather discharges. During both the July and May surveys, dry weather flows at Bouton Creek were not sufficient to obtain a representative sample. Due to the low flows, saltwater from Alamitos Bay represented significant percentages of the water draining from the channel. This condition persisted up to the time tidal waters once again began to enter Bouton Creek.

Stormwater monitoring was intended to be conducted during four events at each site. Due to a variety of factors including drought conditions, a set of defective batteries and the lack of rainfall events meeting the necessary antecedent conditions, the full complement of storm events was not captured at each site. Two to three full sampling events were captured at the Belmont Pump Station, the Los Cerritos Channel, Bouton Creek and the Dominguez Gap Pump Station. The first storm event occurred on November 25th and 26th, 2008. Representative stormwater samples were collected at the two pump station sites that were not dependent upon deep cycle batteries. The next two monitored events, December 15, 2008 and February 5 and 6, 2009, resulted in successful sampling at all four stations for the complete suite of water quality analyses. An attempt was made to sample another storm event on February 13th and 14th but rainfall was below levels predicted by the NOAA quantitative precipitation forecast and, as a result, failed to meet minimal volume requirements for a full storm event. Runoff samples from both the Bouton Creek and Los Cerritos Channel sites were used as TSS events.

Included in this year's report are the results of two special studies. The first was designed to document concentrations and loads of both copper and bacteria in dry weather flows to the open channel portion of the Los Cerritos Channel. The second was a study designed to obtain contemporary information on the distribution and concentrations of chlordane, other organochlorine pesticides and trace metals in sediments from the estuarine portion of the Los Cerritos Channel. These special studies are detailed in Appendix B and C.

The following sections provide a brief synopsis of the results of the City of Long Beach's 2008/2009 stormwater monitoring program.

Wet Weather Chemical and Bacterial Results

For the purpose of this report, water quality criteria or objectives were used to provide reference points for assessing the relative importance of various stormwater contaminants, though specific receiving water studies are necessary to quantify the presence and magnitude of any actual water quality impacts. The 2005 California Ocean Plan (SWRCB, 2006), the Los Angeles Region Basin Plan (CRWQCB, Los Angeles Region, 1994), California Department of Fish and Game (Siepmann and Finlayson, 2002) criteria for chlorpyrifos and diazinon, and both saltwater and freshwater criteria from the California Toxics Rule (USEPA, 2000) were used as benchmarks as requested by Regional Board staff. In addition, National Recommended Water Quality Criteria (USEPA, 2002) were used as benchmarks for compounds such as malathion that are not considered to be priority pollutants. Comparisons of stormwater concentrations with various water quality criteria are intended to provide a framework for evaluating constituents of concern and allow for identification of watersheds that could benefit from additional BMPs or source identification/reduction efforts.

Benchmark reference values have been often exceeded for dissolved forms of copper, lead and zinc throughout the life of the permit (Kinnetic Laboratories, Inc., 2007). These metals continue to exceed benchmark criteria at all sites. Dissolved copper exceeded both CTR freshwater criteria and CTR saltwater criteria in 100% of the stormwater samples this wet season. Concentrations of dissolved lead and zinc only exceeded the CTR freshwater criteria. Concentrations of dissolved lead exceeded the CTR freshwater criterion in 70% of the samples. Dissolved zinc exceeded the CTR freshwater criteria in 60% of the stormwater samples.

Other than bacteria, few other contaminants have exceeded benchmark values but the persistence of low levels of certain chlorinated pesticides is a concern. Chlorinated pesticides are far less common in stormwater both due to strong associations with sediment and the fact that most have been banned for over 20 years. Despite this fact, chlordane compounds were detected in 70 percent of the stormwater samples and in all three monitored events at the Belmont Pump Station. The Event Mean Concentration (EMC) for chlordane during the first monitored event at the Belmont Pump Station was 0.336 µg/L. This is the highest concentration measured at any monitoring station since the program was initiated 10 years ago.

Another organochlorine compound, toxaphene, was detected in stormwater from all monitoring locations during the December storm event but was again highest in stormwater discharges from the Belmont Pump Station.

Among the most substantive long term changes continues to be the increased frequency of stormwater discharges from the Dominguez Gap Pump Station. During the early years of the City's stormwater monitoring program, discharges from this site were unusual. They typically only happened after a series of large, closely spaced storm events caused the infiltraton basin to fill to the point that additional rainfall would induce discharges. In addition to the limited numbers of discharge events, concentrations of stormwater contaminants were consistently low. Since construction started on development of the Dominguez Gap wetlands, discharges have increased in frequency despite rainfall being well below normal during the past two year. Stormwater discharges at this location are expected to remain a common occurrence with completion of the wetland construction, development of the wetland vegetation and the installation of the summer pump.

Along with the increase in frequency of discharges, measured concentrations of TSS and several trace metals have been elevated relative to previous concentrations measured at this site. During the construction phase, TSS and dissolved lead concentrations were among the highest recorded at this site. During the 2008/2009 season, concentrations of TSS and dissolved lead associated with stormwater

discharges showed signs of returning to levels more consistent with the preconstruction period. As this site is still not operating as designed, we expect to see further improvements in water quality as the flow regimes are stabilized and water levels within the wetlands are better managed in anticipation of storm events.

Dry Weather Chemical and Bacterial Results

Water quality of dry weather discharges has been generally consistent over the past nine years. Dry season water quality has not tended to vary greatly between sites or sampling dates. This year dry weather monitoring was limited to the Los Cerritos Channel due to the diversion to the sanitary system at the Belmont Pump Station and insufficient flow at the Bouton Creek site. In general, the concentrations of suspended particulates and total recoverable metal concentrations are low in dry weather runoff monitored by the City. Trace metals are predominantly in the dissolved form and hardness is also consistently high which tends to mitigate the effects of the dissolved metals. As a result, most trace metals were below CTR freshwater criteria during both dry weather sampling events.

As in all previous years, copper remains the primary constituent of concern in dry weather discharges. The chronic CTR freshwater and the Ocean Plan criteria were both exceeded in one of the two surveys conducted at the Los Cerritos Channel site. The chronic CTR saltwater criterion for copper was exceeded in both surveys. Overall it is relatively uncommon for dissolved copper to exceed the CTR freshwater criterion due to the elevated hardness of dry weather discharges but historically exceedances of these benchmarks have been most frequent at the Los Cerritos Channel site. Dissolved copper was 5.7 µg/L in July, 2008 and 13 µg/L in May 2009.

As in all previous years, no dry weather discharges were observed from the Dominguez Gap Pump Station. Dry weather discharges are expected to become common at this site as water diversions from the Los Angeles River are increased to support the constructed wetlands. At the time of the last dry weather survey, the system was still not operating as expected due to maintenance work necessary to bring the new, electric summer pump back on line.

Temporal Trends in Constituents of Concern

Each year, long term trends have been examined for selected trace metals and organic compounds, TSS, and bacteria. With extremely few exceptions, data from the 2008/2009 storm events continue to confirm patterns that were established in the first few years of monitoring. These include the following:

- Dissolved concentrations of cadmium, copper, and nickel do not vary substantially between wet and dry weather periods.
- Concentrations of dissolved zinc and lead are often higher during storm events than during dry weather sampling events.
- Concentrations of total copper, lead and zinc are consistently higher in association with storm flows.
- The decline in concentrations of chlorpyrifos and diazinon in stormwater at all sites remains one of the most significant temporal trends. Neither of these organophosphate compounds was detected in stormwater or dry weather discharges during the 2008/2009 monitoring year.
- Malathion, another organophosphate pesticide, continues to be commonly detected in stormwater at levels exceeding national nonpriority pollutant guidelines but has not been implicated as a source of significant toxicity.
- Historically, concentrations of total trace metals in stormwater from the Dominguez Gap Pump Station were notably lower than the other monitoring locations but over the past two years

concentrations of total copper, lead and zinc are showing signs of increases to levels comparable to other sites. This is concurrent with increasing concentrations of suspended solids.

- Fecal indicator bacteria typically exceed Basin Plan water quality criteria during both wet and dry weather monitoring although dry weather monitoring was limited to the Los Cerritos Channel site this past year

Toxicity Results

No significant daphnid mortality was seen at any of the three stations in any of the three storms collected. Minor water flea reproductive toxicity (2 TU_c) was detected at the Belmont Pump station during the first and second storms of the year. In the second storm, Bouton Creek data showed fairly high reproductive toxicity (16 TU_c) and Cerritos Channel data showed 4 TU_c of reproductive inhibition. The complete absence of acute toxicity and the very low within-test variability in this test event suggests that the apparent toxicity of these samples reflects statistical sensitivity rather than "real" sample toxicity. No chronic toxicity to water fleas was detected any station in samples from the third storm.

Toxicity to sea urchin fertilization was not detected at any of the stations, during the first storm event, nor was there measurably decreased fertilization in Belmont Pump samples from any of the three storms. The December storm produced moderate urchin toxicity (8 TU_c) at the Bouton Creek station, but no toxicity at the Los Cerritos Channel monitoring station. The Bouton Creek sample data showed very low within-test variability, and the 8 TU_c observed was probably unrealistically high. There were 4 TU_c in the Los Cerritos Channel sample from the third storm but no toxicity in stormwater runoff from the Bouton Creek watershed.

The frequency of stormwater toxicity to sea urchins at the Long Beach mass emission monitoring sites during this monitoring period (29%) was decreased from 42% last year, from 100% in the 2006/2007 study, and also decreased from the 70-75% seen in the 2004/2005 and 2005/2006 programs. The magnitude of stormwater toxicity to sea urchins was also decreased from that seen in previous years. Compared with stormwater samples from other southern California watersheds the Chollas Creek (San Diego) and Ballona Creek (Santa Monica) urchin results were overall more similar to Long Beach than were the Los Angeles River and San Gabriel River results, as the Chollas and Ballona Creek samples were obtained from smaller highly urbanized watersheds.

- No dry weather toxicity testing was done at Belmont Pump because dry weather flows are now bypassed to the sanitary sewer. Bouton Creek did not have sufficient flow for sampling in either spring or fall so there are no dry weather data for Bouton either. Minor lethal and reproductive toxicity (2 TU_c) to *Ceriodaphnia* was measured in the July dry weather samples from the Los Cerritos Channel.
- Dry weather samples from Los Cerritos Channel produced substantial chronic toxicity to sea urchins in July (16 TU_c) but not in the May sample (2 TU_c).
- Toxicity to urchins at the Los Cerritos Channel station was present in both wet and dry weather samples with the dry weather sample showing a higher TU_c value. With the exception of the problematic elevated TU_c in the second storm, toxicity to water fleas was very low at Cerritos in both wet and dry weather samples.
- The low acute toxicity values observed in both wet and dry weather bioassays did not trigger performance of any TIEs in the 2008/2009 monitoring program. Correlation analyses of chemical data with toxicity data were performed on combined data from all stations and also on data from each of the individual stations. Conventional pollutants are correlated with daphnid toxicity at Bouton Creek and the Los Cerritos Channel but not at Belmont. Dissolved cadmium copper, lead, nickel, and zinc are positively correlated with daphnid toxicity at the Bouton Creek

and/or Los Cerritos Channel stations, but only with cadmium and lead at the Belmont Pump Station. Urchin toxicity is correlated only with cadmium and lead and only at the Los Cerritos Channel station. The observed versus predicted acute toxicity approach was of limited use in the present program because of the absence of sufficient acute toxicity. Although acute toxicity was not evident, concentrations of the key constituents of concern also did not indicate that toxicity should have been expected.

Los Cerritos Channel Dry Weather Copper and Bacteria Source Tracking (Appendix B)

Three dry weather surveys were conducted in open channel portion of the Los Cerritos Channel Watershed located within the City of Long Beach.

- Flows measured at the Los Cerritos Channel Stearns Street monitoring station were 1.32 cfs during the first survey, 0.67 cfs during the second and 0.37 cfs during the final survey. These reflect a general decrease in dry weather runoff at this location.
- The percentage of copper in the dissolved form ranged from 62% in the second survey to 88% in the first survey. This compares to the roughly 80% dissolved copper in Ballona Creek dry weather investigations but is far less than the CTR default value of 96% used for developing the draft TMDL limits in terms of total recoverable copper.
- Dry weather discharges sampled in from the main channels and the outfalls had very different water quality characteristics. Water in the main channels was typically warmer by 2-3°C, had pH levels in excess of 1 full unit higher, had twice the oxygen content and twice the turbidity. There was no consistent pattern of differences between dry weather flows sampled in the main channel and water from outfalls. Concentrations of fecal indicator bacteria were consistently higher in water sampled from the outfalls but this was most evident in the case of total coliform where the geometric mean of water from outfalls was an order of magnitude greater than in water from the main channels.
- Copper was measured at 1500 ug/L (total) and 750 ug/L (dissolved) in water coming from the enclosed portion of the Clark Channel at the northern boundary of the City of Long Beach. The water was high in conductivity (4.92 mS/cm) and hardness (1800 mg/L). The water also had the lowest pH (7.7) of any channel site. The water temperature was among the lowest measured in the open channels but comparable to other channel sites where water was exiting a closed conveyance.
- Exceedances of the CTR chronic criterion for dissolved copper occurred commonly during all three dry weather surveys (**Error! Reference source not found.**). Overall 23 of the 70 samples taken in the main channels exceeded the chronic CTR criterion. Six of these exceeded the acute CTR criterion. A similar fraction of the 48 outfall samples also exceeded the CTR chronic criterion. Six of the outfall samples also exceeded the acute criterion.
- A few cases of exceptionally high concentrations of total recoverable and dissolved copper were encountered during the study but no systematic pattern was evident through all surveys. During the first survey, copper was measured at 1500 ug/L (total) and 750 ug/L (dissolved) in water coming from the enclosed portion of the Clark Channel at the northern boundary of the City of Long Beach.

- Total copper loads measured at the Stearns Street monitoring site were 38.6 g/day during the first survey, 31.3 g/day during the second survey and just 6.8 g/day during the third survey**. In all cases, loading rates for total copper were far below the proposed TMDL Waste Load Allocation of 108.26 g/day**. Thus the highest loading rate measured anywhere in the watershed during all three surveys was still just 40% of the proposed dry weather WLA for the stormwater permittees.

Los Cerritos Channel Estuary Chlordane and Metals Sediment Survey (Appendix C)

Much of the upper Los Cerritos Estuary between Atherton and Seventh St. was found to be actively scoured by tidal currents and storm events. The 1.3 miles of the estuary extending from the Atherton St. Bridge to the LCE 4 sampling location had similar bottom characteristics. All four sites along this portion of the Estuary were characterized by hard, dry clay layer that was difficult to penetrate. At LCE 1 there was no evidence of depositional sediments. The bottom consisted of a hard, dry clay covered by a thin algal mat. Sampling sites LCE 2, LCE 3, and LCE 4 showed evidence of thin layers of sediment over the top of the clay layer. A depositional layer was first evident at LCE 2 but the layer of unconsolidated sediment was thin (approximately 5 centimeters) and relatively sandy. The thickness of the depositional layer increased slightly at LCE 3 and LCE 4 and showed evidence of increasing levels of finer grained material.

The physical characteristics of the sediment at both the LCE 5 and LCE 6 sampling sites were substantially different. The hard clay layer underlying the very channelized, upper 1.3 miles of the Estuary was not evident at these sites. The sediment at both these sites was less than 50% solids compared to sediments from the upper portion of the estuary (LCE 1 through LCE 4) that contained 68 to 83 percent solids.

Chlordane compounds remain an issue of concern in sediments of the Los Cerritos Estuary. Concentrations were at or near the Effects Range Median (ERM) level at three of the four sites sampled in the upper portion of the Estuary. Only traces of two chlordane compounds, chlordane-gamma and trans-nonachlor, were detected at the LCE 1 sampling site. This was clearly due to the fact that tidal currents and storm flows are preventing the accumulation of any substantial quantities of sediment. Chlordane compounds measured in sediments from the lower portion of the estuary were over four times the ERM and concentrations at both sites far exceeded the 1994 BPTCP and 2003 Bight survey results.

DDT compounds followed similar distributional patterns except that concentrations never exceeded ERMs. Concentrations in sediments from the four sites in the upper Los Cerritos Estuary ranged from below detection limits at LCE 1 to 10.2 at LCE 3. Concentrations of DDT were again highest at LCE 5 (23.8 ng/g-dry wt) and LCE 6 (19 ng/g – dry wt). These values represent roughly a three-fold increase relative to the Bight ’03 survey results at the same locations

Trace metals were moderately elevated at the two survey locations in the lower portion of the Estuary. Five metals exceeded the Effects Range Lows (ERLs) at each of these sites but none exceeded ERM benchmarks. ERLs were exceeded by two to three metals at most other survey sites. There is little evidence of substantive changes in concentrations of metals at LCE 5 and LCE 6 since they were lasted sampled in the Bight ’03 Survey.

Overall, the two survey sites in the lower portion of the Los Cerritos Channel Estuary showed the highest level of contamination. Storm events which transport thousands of tons of sediment every year are the most likely source of contamination since organochlorine pesticides, in particular, are strongly

associated with suspended sediment. Alternative sources from Marine Stadium and Alamitos Bay cannot entirely be eliminated due to the flow reversals in this portion of the estuary caused by the pumping of cooling water for the AES power plant.

RECOMMENDED PROGRAMATIC CHANGES

Several minor adjustments to the NPDES monitoring program are recommended based upon the results of the 2008/2009 monitoring period as well as work conducted over the past ten years. Two of these recommendations were also suggested last year but, lacking official authorization, these changes were not incorporated into the 2008/2009 monitoring year. These minor adjustments include elimination of 1) analysis of the triazine pesticides and 2) dry weather monitoring at the Dominguez Gap Pump Station. In addition, we recommend establishing a new upstream sampling location for the Bouton Creek watershed that would enable successful quantification and sampling of the lower dry weather flows now being experienced in this watershed.

Triazine Pesticides

Over the past two years we have recommended that triazine pesticides should be excluded from the analytical set. The only triazine pesticides detected in stormwater or dry weather discharges have been prometon, simazine, and atrazine. All typically occur at levels of less than 10 times the reporting limits which have been progressively lowered over time.

Simazine was the only compound in this group that was detected in stormwater during the 2008/2009 monitoring season. It is also the most common triazine herbicide detected in stormwater since the start of the monitoring program. Simazine was measured in stormwater from the Los Cerritos Channel at a concentration of 0.0861 µg/L with a reporting limit of 0.01 µg/L.

Prometon was not detected this year but historically it has been most common triazine in dry weather discharges. Atrazine was measured in a dry weather sample from the Los Cerritos Channel on only one occasion during the 2007/2008 season. The reported concentration for atrazine was 0.014 µg/L which is less than twice the reporting limit of 0.01 µg/L. The uncommon occurrence of the triazine pesticides in both stormwater and dry weather flows combined with the very low concentrations measured in stormwater and dry weather flow continue to provide support for elimination of these constituents from the analytical suite.

Suspension of Dominguez Gap Dry Weather Monitoring

Since this program started in early 2000, the Dominguez Gap Pump Station has never been observed to have dry weather discharges due the large infiltration basin adjacent to the site. This continues to be the case but it is still expected that the Pump Station will be operating as originally designed. The County anticipates that problems with the electric pump will be resolved by August such that constant flow can be maintained through the wetlands. Since the Los Angeles River will be providing the source water for maintenance of the wetlands any discharges during the summer months will not be representative of dry weather flows from the City of Long Beach storm drains. We therefore recommend removal of requirements to inspect this site and measure water quantity and quality associated with any dry weather discharges that might be observed at this site in the future.

Wet weather monitoring at the Dominguez Gap Pump Station should continue until the effects of operating the Pump Station for both management of the wetlands and stormwater are better understood. An alternative mass emission site may need to be considered if maintenance of the wetland system continues to result in substantial and unquantifiable contributions from the diverted Los Angeles River water.

Investigation of Alternative Site for Bouton Creek Dry Weather Monitoring

Although the decrease in dry weather flows in Bouton Creek over the past few years has been a positive result for the stormwater program and water conservation efforts, better documentation of the diminishing flows and associated water quality would be beneficial. A reconnaissance effort is scheduled to be conducted during the summer to locate an upstream site that is accessible and either unimpacted by tidal effects or where tidal effects are at least minimized. If a reasonably secure, accessible site can be located, portable sampling equipment will be used for the 24-hour dry weather sampling efforts. Observations would be conducted to identify outfalls with dry weather flows that are located between the existing mass emission site and the dry weather sampling location to qualitatively identify potential sources that would be missed while conducting dry weather sampling at an alternative upstream site. It is expected that any dry weather discharges missed by moving the dry weather sampling site would be compensated by better flow measurements and less influence of residual saltwater draining from the algal growths that impede low flow in the channel.

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INTRODUCTION

The City of Long Beach received an NPDES Permit issued by the California Regional Water Quality Control Board, Los Angeles Region on 30 June 1999 (Order No 99-060, NPDES No. CAS004003, [CI 8052]). This order defined Waste Discharge Requirements for Municipal Stormwater and Urban Runoff discharges within the City of Long Beach. Specifically, the permit regulates discharges of stormwater and urban runoff from municipal separate storm sewer systems (MS4s), also called storm drain systems, into receiving waters of the Los Angeles Basin.

Since issuance of the 1999 NPDES permit, the population served by City of Long Beach has increased by 9 percent. When the permit was first issued, the population was estimated at 452,000. Current estimates place the City's population at 492,682[1] people in an area of approximately 50 square miles. The latest population estimates (Figure 1) provided by the State of California, Department of Finance (2009) indicates that the City's population had been growing at a rate of roughly 8,000 residents per year from 1999 up until 2005 at which time the growth rate decreased substantially. Between 1999 and 2005, the population increased by 7.5 percent. Over the next four years, the population growth slowed to just over 1,000 people per year.

During this same time period, the population of the State of California increased by 13.4 percent. As a result slow growth rates during recent years, the City of Long Beach has been surpassed in total population by Fresno and is now considered the sixth most populated city in the California.

The discharges from the MS4 system consist of surface runoff (non-stormwater and stormwater) from various land uses in the hydrologic drainage basins within the City. Approximately 44% of the land area discharges to the Los Angeles River, 7% to the San Gabriel River, and the remaining 49% drains directly to Long Beach Harbor and San Pedro Bay (City of Long Beach Municipal Stormwater Permit, 1999). The quality and quantity of these discharges vary considerably and are affected by the hydrology, geology, and land use characteristics of the watersheds; seasonal weather patterns; and frequency and duration of storm events. Impairments or threatened impairments of beneficial uses of water bodies in Long Beach include Alamitos Bay, Los Angeles River, El Dorado Lake, Los Angeles River Reach 1 and Reach 2, San Gabriel River Estuary, San Gabriel River Reach 1, Colorado Lagoon, and Los Cerritos Channel. These areas also include coastal shorelines, including Alamitos Bay Beaches, Belmont Shore Beach, Bluff Park Beach, and Long Beach Shore[2].

ANNUAL PROGRAM ADJUSTMENTS

The 1999 NPDES permit requires the City of Long Beach to prepare, maintain, and update if necessary a monitoring plan. The original monitoring plan required the City to monitor three (Year 1) and four (Years 2 through 5) discharge sites draining representative urban watersheds (mass emission sites) during the program. Flow, chemical analysis of water quality, and toxicity were to be monitored at each of these sites for four representative storm events each year. During the dry season, inspections and monitoring of these same discharge sites were to be carried out, with the same water quality characterization and toxicity tests to be run. In addition, one receiving water body (Alamitos Bay) was to be monitored during the first two years of the program for bacteria and toxicity. Monitoring at the Alamitos Bay site was to be conducted during both the wet and the dry seasons and was to be used to

[1] State of California, Department of Finance, E-4 Population Estimates for Cities, Counties and the State, 2001–2009, with 2000 Benchmark. Sacramento, California, May 2009.

[2] Los Angeles Regional Water Quality Control Board, 2006 303(d) list

document the effect of a dry weather diversion. In most years the program has been reviewed and adjustments are made as a result of discussions with Regional Board staff.

This past year, no recommended changes were provided by the Regional Board staff. Nevertheless, the City determined that additional special studies were needed to further address stormwater issues in the Los Cerritos Channel watershed. Two separate special studies were conducted. The first of these was an upstream investigation of sources and loads of copper and bacteria. The second was a survey of sediment contamination in the estuary to update historical sampling efforts and collect additional information at upstream sites. Evolution of the program is summarized in Table 1.

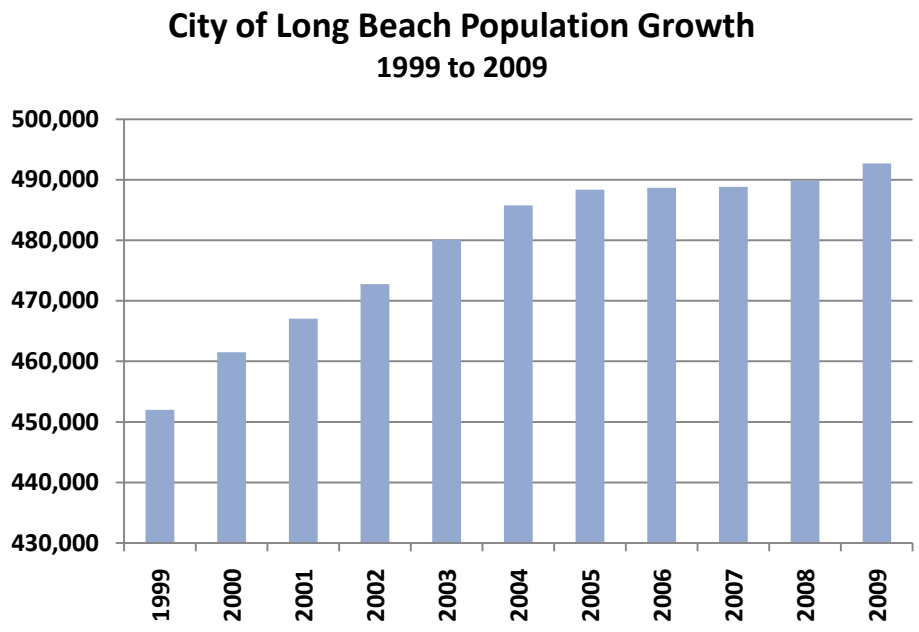

Figure 1. City of Long Beach Population Growth over the Past Ten Years.

Table 1. Summary of the City of Long Beach Stormwater NPDES Monitoring and Reporting Program with Annual Adjustments.

1999 Monitoring and Reporting Program

Mass Emission Site Monitoring

- Monitor 3 mass emission sites (Belmont Pump Station, Bouton Creek and Dominguez Gap Pump Station) during the 1st year of the permit. Add a 4th mass emission site (Los Cerritos Channel) during the 2nd and subsequent years. Flow-rated composites to be obtained during 4 storm events at each site and analyzed for:
  - ✓ conventionals, total and dissolved metals, semivolatile organic compounds, organochlorine pesticides, organophosphate pesticides, herbicides and MBTE.
  - ✓ toxicity testing using mysids, sea urchin and water flea.
  - ✓ Phase 1 Toxicity Identification Evaluations (TIEs) to be conducted when 3 consecutive wet weather or 2 consecutive dry weather samples from the same monitoring station show toxicity.
  - ✓ Grab samples for indicator bacteria and oil and grease.

  Dry season inspections and monitoring to be conducted at each mass emission site 2 times per year. Sampling of dry weather flows to be conducted over 24-hour periods to provide representative samples. Samples from each site to be tested consistent with stormwater monitoring.

Receiving Waters

- Conduct receiving water quality monitoring in Alamitos Bay for the first two years of the program to document effects of a dry weather diversion. Testing to consist of indicator bacteria and toxicity.

Special Studies

- Conduct a special study to examine characteristics of stormwater runoff from parking lots (one year only).

2001 - M&R Program Modifications

- List of constituents and reporting limits modified for consistency with minimum levels (MLs) listed in the State's *Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays and Estuaries of California* (SIP).
- TIE triggers altered to enhance opportunities for defining toxicity whenever it occurs.
- Use of the mysid toxicity test reduced to include only the first event of the season.

2002 - M&R Program Modifications

- Suspend toxicity monitoring at the Dominguez Pump Station monitoring site.
- Suspend monitoring of semivolatile organic compound.
- Conduct a pilot plume monitoring program in Alamitos Bay to document the horizontal and vertical extent of the stormwater plume in the receiving waters, measure the concentration of selected metals and organophosphate pesticides at four points in the plume and conduct sea urchin bioassay tests to document potential toxicity in the plume.
- Immediate upstream investigations were to be conducted if elevated pH was detected during dry weather surveys at mass emission monitoring sites in order to document the source or cause.

2003 - M&R Program Modifications

- Suspend analyses of parameters infrequently detected and/or typically detected at low levels.
- Continue the pilot plume monitoring program targeting the first storm of the season.
- Adjust TIE triggers – TIEs to be conducted using water flea when toxicity exceeds 2 toxicity units (TUs). TIEs to be conducted using sea urchins when toxicity exceeds 3 TUs.
- Change monitoring strategy to emphasize sampling during early season events.
- Monitor TSS and stormwater flow for all storm events at all four mass emission sites.

2004 - M&R Program Modifications

- Recommended setting minimum of 7 days between monitored events.
- Include daily records of rainfall for current and previous seasons in report.
- Submit draft work plan for identification of PBT sources to Stormwater Monitoring Coalition (SMC) for input and participation.

2005 – 2006 M&R Program Modifications

- No changes; continue with current program.

2007 - M&R Program Modifications

- Completed PBT source study in the Colorado Lagoon storm drains and suspended Stormwater Runoff Plume Monitoring in Alamitos Bay.

2008 - M&R Program Modifications

- City independently implemented two Special Studies in the Los Cerritos Channel to investigate the source and fate of constituents of concern in the freshwater the watershed and the estuarine segments.

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STUDY AREA DESCRIPTION

The following sections describe the regional setting. This includes the general geographic characteristic, the storm drain system, annual rainfall and climate as well as population trends experienced over the past 10 years.

GEOGRAPHY

The City of Long Beach is located in the center and southern part of the Los Angeles Basin (Figure 2) and is part of the highly urbanized Los Angeles region. In addition to residential and other uses, the City also encompasses heavy industrial and commercial areas and includes a major port facility, one of the largest in the United States. The City's waterfront is protected from the open Pacific Ocean by the extensive rock dikes encircling the outer harbor area of the Port of Los Angeles/Port of Long Beach complex. The waterfront includes port facilities along with a downtown commercial/residential area that includes small boat marinas, recreational areas, and convention facilities. Topography within the City boundaries can be generally characterized as low relief, with Signal Hill being the most prominent topographic feature (Figure 3).

MAJOR WATERSHEDS

Major water bodies receiving stormwater discharges from the City of Long Beach include the Los Angeles River located near the western boundary of the City, the San Gabriel River located near the eastern boundary, and the outer Harbor of the Los Angeles/Long Beach area. The City of Long Beach has fifteen pump stations that discharge into the Los Angeles River, and one pump station that discharges into the San Gabriel River. Receiving water sub-areas of importance include the extensive Alamitos Bay, heavily developed for marina and recreational uses, and the inner harbor areas of the City, heavily developed as port facilities. Other receiving water sub-areas include the Los Angeles River, El Dorado Lake, Los Angeles River Reach 1 and Reach 2, San Gabriel River Estuary, San Gabriel River Reach 1, Colorado Lagoon, and Los Cerritos Channel. These areas also include coastal shorelines, including Alamitos Bay Beaches, Belmont Shore Beach, Bluff Park Beach, and Long Beach Shore. The drainage from the City is characterized by major creeks or storm channels, usually diked and/or concrete lined such as the Los Cerritos Channel that originates in Long Beach, flows near the eastern City boundary, and discharges into the Marine Stadium and then into Alamitos Bay. Other such regional drains include:

- Coyote Creek, which passes through a small portion of Long Beach before it discharges to the San Gabriel River;
- Heather Channel and Los Cerritos Line E that both enter Long Beach from the City of Lakewood and discharge into the Los Cerritos Channel; and the
- Artesia-Norwalk Drain that enters Long Beach from Hawaiian Gardens and discharges into Coyote Creek.

The City of Long Beach, including the City of Signal Hill, is divided into 30 watersheds as shown in Figure 4. Data presently in the City of Long Beach GIS database on total areas and specific land use categories for each basin are given in Table 2 (City of Long Beach, 2000). Specific watersheds selected by the City of Long Beach for this present stormwater monitoring program are described in more detail in the Monitoring Program section of this report.

ANNUAL RAINFALL AND CLIMATE

The City of Long Beach is located in the semi-arid Southern California coastal area and receives significant rainfall on a seasonal basis. The rain season generally extends from October through April, with the heavier rains more likely in the months of November through March (see Figure 12 for average rainfall by month and seasonal total rainfall as measured at the Long Beach Airport). The long-term average (1971-2000) rainfall for October through April (wet season) at the Long Beach Airport is 12.27 inches per year (http://mole.nacse.org/prism/nn/ - Prism Data Extractor). Average annual rainfall for the entire year is 12.94 inches.

The City lies in the Los Angeles Plain, which is south of the Santa Monica and San Gabriel Mountains and west of the San Jose and the Puente Hills. The Los Angeles River is the largest stream on the Plain and it drains the San Fernando Valley and much of the San Gabriel Mountains. Most of the streams are dry during the summer and there are no lakes or ponds, other than temporary ponding behind dunes (Miles & Goudey, 1998). The climate is mild, with a 30-year average temperature of 23.4 °C (74.1°F) at the Long Beach Daugherty Airport (NCDC, 2000).

POPULATION AND LAND USE CHARACTERISTICS

The population of the City of Long Beach was estimated at 492,682 residents on January 1, 2009 (California Department of Finance Demographic Research Unit, 2009). The total population of the County of Los Angeles, in which it resides, was 10,393,185. The independent city of Signal Hill, located on a promontory, is surrounded by the City of Long Beach. In January of 2009, Signal Hill's population was estimated to be 11,430. Signal Hill contributes runoff to drainage basins 6, 7, 8, 9 and 18. Drainage basin 18 discharges through the Los Cerritos Channel which, in turn, discharges to Alamitos Bay.

The City of Long Beach has a total area of 26,616 acres. Of that total 16,926 acres (64%) are classified as residential, 4,784 acres (18%) as commercial, 2,269 acres (8.5%) as industrial, 1,846 (7%) as institutional, and 786 acres (3%) as open space (City of Long Beach, 2000). The drainage basins sampled for the stormwater monitoring study follow this general pattern of land use.

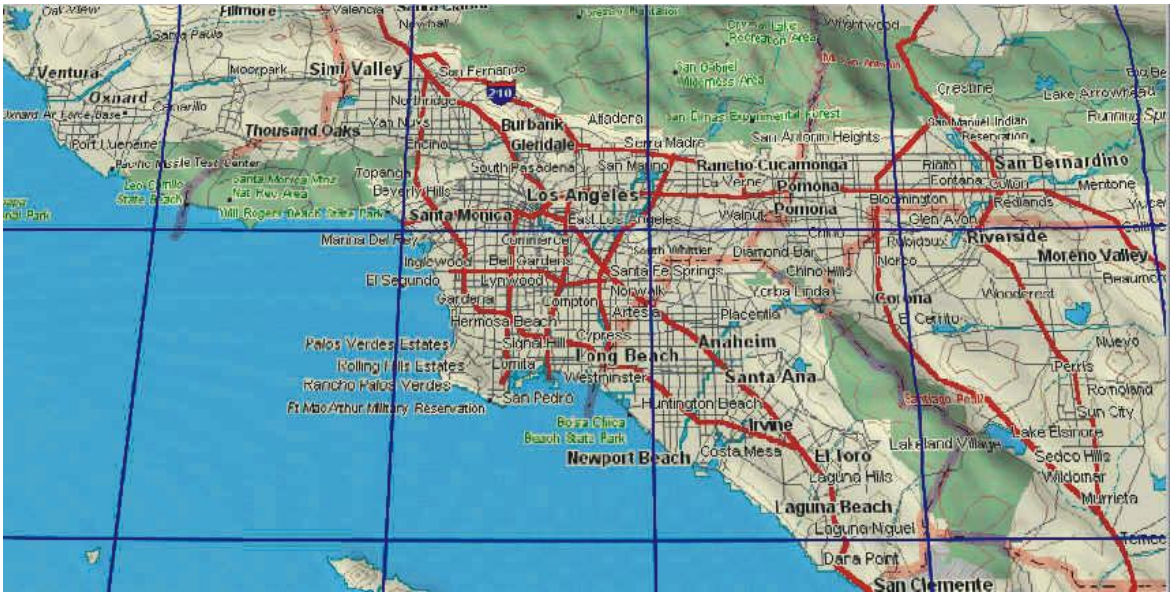

Figure 2. **Los Angeles Basin. (Source: 3-D TopoQuads, Copyright 1999, Del Lorme, Yarmouth, ME 04096)**

Figure 3. **City of Long Beach. (Source: Google Earth Pro, 2006)**

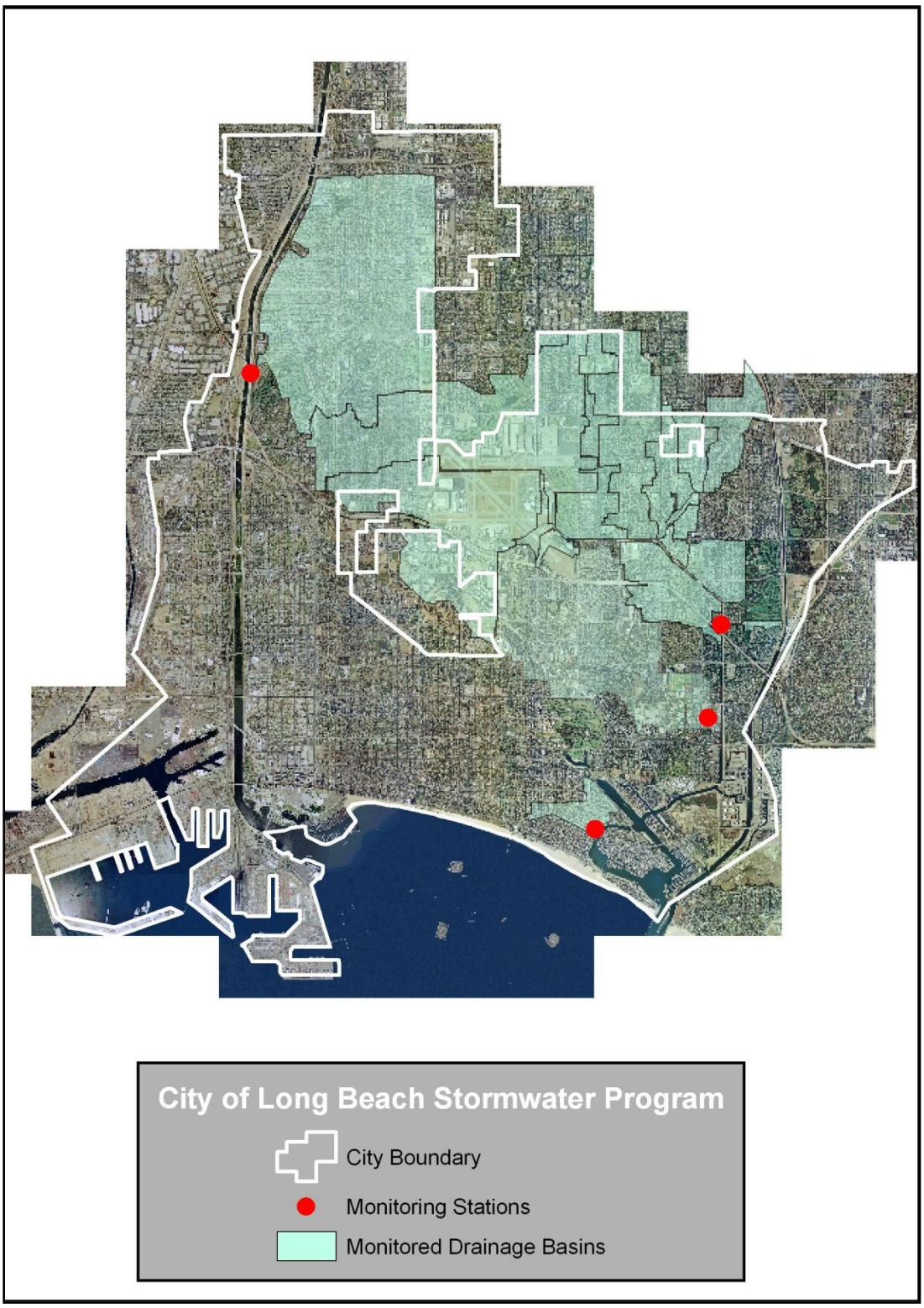

Figure 4. **City of Long Beach, Major Drainage Basins (Source: City of Long Beach, Department of Technology Services, last update 2006) and City of Long Beach Stormwater Monitoring Sites.**

Table 2. Total Area and Land Use for the City of Long Beach Watersheds.

Drainage Basin	Drainage Pattern	Sub-basins	Total Acres	Residential Acres	Commercial Acres	Industrial Acres	Institutional Acres	Open Space Acres
1	N to S	4	456	393	44	0	7	12
2	E to W	1	1,276	905	287	22	59	3
3	E to W	3	1,083	367	642	7	58	9
4	E to W	2	810	426	176	140	56	12
5	E to W	1	546	434	97	0	13	2
6	S & SE	1	695	475	125	0	73	17
7	to center	1	1,029	858	89	11	53	18
8	E to W	1	248	163	27	58	0	0
9	SW & NW	1	399	295	91	0	12	1
10	S & E	3	416	16	49	351	0	0
11	S & E	1	424	338	64	3	18	1
12	S & E	1	719	556	98	9	41	15
13	S & E	1	84	0	7	77	0	0
14	S & W	2	3,374	2,445	392	148	273	116
15	S & W	1	958	569	167	197	25	0
16	N to S	1	194	113	61	8	5	7
17	S & E	1	317	244	68	0	5	0
18	E	1	1,814	804	262	729	19	0
19	E	20	3,898	2,475	610	439	228	146
20	S & E	1	2,259	1,215	412	70	492	70
21	S & E	3	1,172	773	125	0	55	219
22	variable	9	520	38	428	0	54	0
23	S	1	213	110	85	0	14	4
24	SE & NW	1	281	188	30	0	0	63
25	W & E	2	90	70	9	0	4	7
26	S & W	3	355	304	22	0	29	0
27	E & S	9	1,083	825	109	0	143	6
28	S & E	1	630	386	179	0	65	0
29	S	8	727	633	10	0	26	58
30	SW(6) & SE(1)	7	546	508	19	0	19	0
	Total Acres		26,616	16,926	4,784	2,269	1,846	786

MONITORED WATERSHEDS

- **Dominguez Gap**
- **Belmont Pump Station**
- **Bouton Creek**
- **Los Cerritos Channel**

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MONITORING PROGRAM

This section of the report provides a complete description of the basic monitoring program including detailed program objectives, details with respect to each monitoring site and monitoring equipment, monitoring procedures, analytical methods and toxicity testing methods.

MONITORING PROGRAM OBJECTIVES

The stated long-term objectives of the stormwater monitoring program were established in the 1999 NPDES permit. These include:

1. Estimate annual mass emissions of pollutants discharged to surface waters through the MS4;
2. Evaluate water column and sediment toxicity in receiving waters;
3. Evaluate impact of stormwater/urban runoff on marine life in receiving waters;
4. Determine and prioritize pollutants of concern in stormwater;
5. Identify pollutant sources on the basis of flow sampling, facility inspections, and ICID (Illegal Connection Illicit Discharge) investigations; and
6. Evaluate BMP effectiveness.

Since initiation of the Long Beach Stormwater Monitoring Study in 1999, the core of the program has been development of accurate measurements of pollutant loads from mass emission sites and determining the chemical and toxicological characteristics of these discharges during both storm events and dry weather periods. A number of special studies have been conducted to address individual elements of the long-term objectives. The primary objectives of monitoring conducted during the 2008/2009 monitoring period include:

1. Obtain monitoring data from four (4) storm events for each mass emission station.
2. Carry out dry weather inspections and obtain samples of dry weather flow at each of the three mass emission stations. Perform this dry weather work twice during the dry season that extends from May through October.
3. Perform chemical analyses for the specified suite of analytes at the appropriate detection limits for all stormwater samples collected.
4. Perform toxicity testing of the stormwater samples collected, and Toxicity Identification Evaluations (TIEs) if warranted by the toxicity results at a given site. No toxicity testing was required for water from the Dominguez Gap Pump Station monitoring site.
5. Report the above results and evaluate the monitoring data with respect to receiving water quality criteria.

Two additional special studies were designed and implemented during the 2008/2009 monitoring year. The first special study was designed to identify dry weather sources of copper and bacteria in the Los Cerritos Channel drainage and to assess loads. The second was designed to develop contemporary information on the distribution and concentrations of pollutants of concern in sediments of the Los Cerritos Channel Estuary. These special studies are included as appendices (Appendices B and C) to the main body of this report.

MONITORING SITE DESCRIPTIONS

The four sites for mass emissions monitoring were originally selected by the City of Long Beach with the assistance of the Southern California Coastal Water Research Project (SCCWRP), with input from the Los Angeles Department of Public Works, the environmental community, and with the approval of the Regional Water Quality Control Board. These sites were then specified in the NPDES permit after an analysis of the drainage basins and receiving waters. They were selected to be representative of the stormwater discharges from the City's storm drain system, as well as to be practical sites to carry out stormwater and dry weather monitoring.

Four mass emission monitoring sites are routinely monitored as part of the City's stormwater program. The general locations of the drainage basins sampled by each of these sites and each monitoring location are shown in Figure 4. The latitude and longitude of each site are shown in Table 3. Brief descriptions of each drainage basin and land use are provided in the following sections.

Basin 23: Belmont Pump Station Monitoring Site

This site collects water from Basin 23 that covers 213 acres. Land use in the basin is 52% residential, 40% commercial, 0% industrial, 6% institutional, and 2% open space (Figure 5, Table 2). This basin is located in the southeastern portion of the City and is bounded on the north, south, east, and west by Colorado Street, Division Street, Ultimo Avenue and Belmont Avenue respectively. The Belmont Pump Station is located at 222 Claremont Avenue.

Changing Out Sample Bottles at the Belmont Pump Station

Water enters the forebay of the facility via a nine-foot diameter underground storm pipe. A trash rack catches debris before water drops four feet into the sump area. A small summer/sump pump exists at this facility. Prior to 2007, this pump turned on every evening at around 2300 hours and discharged approximately two feet of water that accumulates in the sump due to dry weather flows. Starting in 2007, all summer dry weather flows have been diverted to the sanitary system. Four main pumps are available to remove water during storm events. The summer/sump pump is operational during the winter to handle low flows and to lower the sump level once the main pumps are turned off. Water from these pumps is discharged into Alamitos Bay.

The storm monitoring equipment is interfaced with all five pumps to determine when each pump is activated. Water depth and pump discharge curves are then used to calculate discharges from this site for use in pacing the sampling equipment. Several pieces of equipment at this site are being replaced and updated as part of ongoing efforts to replace aging monitoring equipment. By the start of the 2009/2010 season, this site will be equipped with a new datalogger/control unit, updated monitoring program, and a new autosampler for the refrigeration unit.

Basin 20: Bouton Creek Monitoring Site

This site collects water from Basin 20 covering 2,259 acres. Basin 20 is 54% residential, 22% institutional, 18% commercial, 3% industrial, and 3% open space (Figure 6). This basin is located in the east central portion of the City and is bounded on the north, south, east, and west by Spring Street, 8th Avenue, the Los Cerritos Channel and Redondo Avenue, respectively. The sampling station is located a

short way upstream from the point of discharge into Los Cerritos Channel, along side of the Alamitos Maintenance Yard of the Los Angeles County Public Works Department.

Stormwater Runoff at the Bouton Creek Monitoring Station

At the sampling station, Bouton Creek is a 35 ft wide, 8.5 ft deep open concrete box channel. The elevation of the channel bed is approximately one inch lower at the side than the center. About a quarter of a mile to the southeast, Bouton Creek flows into Los Cerritos Channel. Based on numerous observations of conductivity at various tides, this site has saltwater influence at tide levels above three feet. The automatic sampling equipment was therefore configured and programmed to measure discharge flow and to obtain flow-composited samples of the freshwater discharge down the creek, avoiding the tidal contributions by using real-time conductivity sensors. A velocity sensor was mounted on the invert of the box channel near the center of flow. Two conductivity sensors were mounted on the wall of the channel near the bottom and 12 inches above the bottom. A third conductivity sensor and the sample intake were mounted on a floating arm that keeps them near the surface.

The process of refurbishing this site was started this year by replacing all conductivity sensors. A new CR-1000 datalogger/control module, along with an updated sampling program, is planned to be installed before the start of the 2009/1010 sampling season. The autosampler is scheduled for replacement next if sufficient funds are available.

Portions of Basins 18, 19, 27 and 29: Los Cerritos Channel Monitoring Site

The entire Los Cerritos Channel watershed has been estimated at 17,725 acres however the exact drainage area is in dispute. The Los Cerritos Channel Monitoring Site effectively samples all but 1000 acres of this watershed.

This watershed includes 7,535 acres of the City of Long Beach. Four drainage basins exist within the City limits. The boundaries of these basins do not necessarily coincide with boundaries of the municipalities. Small portions of segments of these basins are located outside of the City of Long Beach. This includes roughly 577 acres of the City of Lakewood and 581 acres of the City of Signal Hill.

Stormwater Runoff at the Los Cerritos Channel Monitoring Station

The total area of City of Long Beach watershed located above the sampling site is approximately 7,685 acres. Land use within the City of Long Beach's portion of the watershed consists of 65% residential, 12% commercial, 12% institutional and 5% open space (Figure 7). Aggregated data from the Southern California Association of Governments (SCAG) 2005 land use dataset indicates that the entire Los Cerritos Watershed is 93% urban (approximately 59% residential, 4% mixed urban, 22% commercial, and 8% industrial). Open space accounts for 6% of land use and agriculture is <1% of land use.

Great Blue Heron in the Estuary Portion of the Los Cerritos Channel

The stormwater monitoring station was installed in a steel utility box located on the west side of the channel south of Stearns Street. Flow sensors and sampling tubing were installed on the bottom of the large concrete lined channel. Flow rates based upon flow velocity and channel dimensions are used to control the composite sampler, and to calculate total flow at the end of the storm event.

This site will be the first to receive a new Campbell Scientific 1000 datalogger/control units along with an updated Kinnetic Laboratories, Inc. stormwater monitoring program. Mid season, the new equipment was installed in parallel with the existing monitoring equipment to field validate the new system subsequent to benchtop testing. The new system will be operable at the start of the 2009/2010 season. Other components of the monitoring equipment including a new autosampler and modem are scheduled for replacement the following year based upon budget availability.

This sampling site is normally above tidewater on Los Cerritos Channel. During extreme tides required for the dry weather surveys, this site can be impacted by backwater conditions.

Basin 14: Dominguez Gap Monitoring Site

The sampling station located at the Dominguez Gap Pump Station is intended to monitor Basin 14 that covers 3,374 acres. Land use in this basin is 72% residential, 12% commercial, 8% institutional, 4% industrial, and 4% open space (Figure 8). The basin is located in the northwestern portion of Long Beach just east of the Los Angeles River and is bounded on the north, south, east, and west by Artesia Boulevard, Roosevelt Road, the railroad, and the Los Angeles River respectively (City of Long Beach, 2000).

View of the Dominguez Gap Pump Station during Construction Activities (9/2007) related to Creation of Wetland Habitat in the Infiltration Basin

The Dominguez Gap Pump Station and adjacent infiltration/detention basin were undergoing major renovations during the summer of 2006 and through most of the 2007/2008 wet season. By the beginning of the 2008/2009 storm season, wetland vegetation was fully developed.

During dry weather periods, water will be

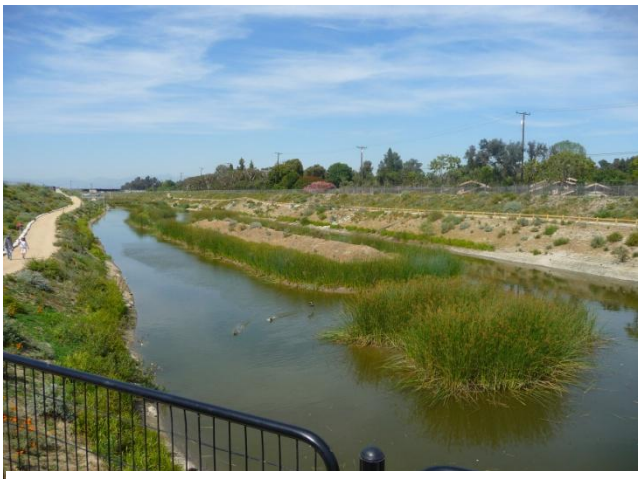
diverted from the Los Angeles River at the upper end of the wetlands. Water will then be siphoned across to the other side of the River to another wetland infiltration area. From there it will come back to the Dominguez Gap Pump Station where the summer pump will be discharging at a rate of about five cubic feet per second (cfs) around the clock. When storms are expected, Los Angeles County Public Works will shut down the diversion that directs water from the Los Angeles River into the new Dominguez Gap wetlands allowing time for water levels in the wetlands to infiltrate prior to events to help restore stormwater storage/infiltration capacity.

View of Dominguez Gap Pump Station Intake Bay and Wetland Vegetation (2009)

The stormwater monitoring equipment at this site is located within the Dominguez Gap Pump Station. The automatic sampler utilized a peristaltic pump to collect water from the pump station's sump. The configuration of monitoring equipment was updated two years ago to improve measurement of flow particularly during periods when the basin was being manually pumped down.

All five pumps have been individually instrumented to detect when each pump is activated. Flow is calculated based upon pump curves and water elevations in the sump as measured with a pressure transducer to determine instantaneous head. Flow from each pump is summed to determine discharge rates at any one point in time. Under normal operation, it is highly unusual for the complement of pumps to be activated.

As soon as the new summer/sump pump becomes operational, additional hardware will need to be installed to monitor operation of this sixth pump. New pump curves will also be needed at that time to incorporate flow estimates from the sump pump into the monitoring software. When the Dominguez Gap Pump Station and wetland system is operating as originally designed, this pump is expected to be routinely used to maintain flows.



Constructed Wetlands North of the Dominguez Gap Pump Station (2009)

A number of further upgrades and modifications are required at this site before the next storm season. A new Campbell CR1000 datalogger/control module will be installed at this site along with new autosampler head for the refrigeration unit. This will require use of new stormwater monitoring software that was under development this year. Further instrumentation will also be needed to allow the summer pump to be monitored once the County reaches a final resolution as to how this pump will be configured and operated. This will also require further discussions with the County to determine an acceptable method for monitoring this pump.

Communications at this site have been difficult at times since we have historically been limited to use of cellular modems which can be problematic at times, particularly during intense storm events. The County has indicated that new phone line brought into the Pump Station as part of the improvements will be available for the stormwater monitoring equipment.

MONITORING STATION DESIGN AND CONFIGURATION

Each of the four land use stations monitored in Long Beach is equipped with Kinnetic Laboratories Automatic Sampling System (KLASS). Figure 9 illustrates the configuration of a typical KLASS. This system consists of several commercially available components that Kinnetic Laboratories has integrated and programmed into an efficient flow-based stormwater compositing sampler.

The integral components of this system consist of an acoustic Doppler flow meter or a pressure transducer, a datalogger/controller module, cellular or landline telecommunications equipment, a rain gauge, and a peristaltic sampler. CR-10 datalogger/control modules used for the past ten years are being replaced with CR-1000 datalogger/control modules and updated monitoring software prior to the 2009/2010 storm season. The system installed at Bouton Creek also incorporated several conductivity cells for distinguishing tidal flow from fresh water runoff. Pump station incorporate a variety of sensors to monitor individual pump activity and head pressures.

The equipment was installed with intakes and sensors securely mounted, tubing and wires in conduits, and all above ground instruments protected within a security enclosure. The previous section described how the equipment was placed at each station.

All materials used in the collection of stormwater samples and in contact with the samples meet strict criteria in order to prevent any form of contamination of the sample. These materials allow both inorganic and organic trace toxicant analyses from the same sampler and composite bottle. Only the highest grade of borosilicate glass is suitable for both trace metal and organic analyses from the same composite sample bottle. All intake hoses are constructed of Teflon® which provides both rigidity against collapse at high head differentials and is non-contaminating for both organics and inorganics.

All bottles and hoses were cleaned according to EPA-approved protocols consistent with approved methodology for analysis of stormwater samples (USEPA, 1983). These bottles and hoses were then evaluated through a blanking process to verify that the hoses and composite bottles were contamination-free and appropriately cleaned for analyses of both inorganic and organic constituents.

FIELD MONITORING PROCEDURES

The following sections provide a summary of the field methods and procedures used to collect and process data for both the wet and dry weather surveys.

Wet Weather Monitoring

Stormwater runoff is collected using two primary methods. Composite sampling is conducted to collect water for both chemical analysis and toxicity testing. A few analytes such as bacteria are required to be sampled using grab sampling methods and thus reflect conditions only at the time of sampling.

Composite Sample Collection

A priority objective of the storm monitoring is to maximize the percent storm capture of the composite sample, while ensuring that the composite bottle collects enough water to support all the required analyses. The goal is to collect flow-weighted composite samples from 100% of the flow

resulting from the rainfall. This study requires volumes of 20 to 30 liters of sample from each of the four mass emission sites to meet these analytical needs.

All aspects of the sampling events are continuously tracked from an office command and control center (Storm Control) located at our Santa Cruz laboratory. The Storm Control computer can be securely accessed from any location with internet access. The status of each station is monitored through telecommunication links to each site. Station data are downloaded, and the stations are controlled and reprogrammed remotely. Weather information, including Doppler displays of rainfall for each area being monitored, are also available on screen at the Storm Control center. Personnel monitoring the centralized Storm Control system are in contact by cellular phone with the field crews to provide guidance and updates on the status of each sampling site.

When a storm is likely, all stations are made ready to sample. This preparation includes entering the correct volume of runoff required for each sample aliquot ("Volume to Sample"), setting the automatic sampler and the datalogger to sampling mode, pre-icing the composite sample bottle, and performing a general equipment inspection. A brief physical inspection of the equipment is made if possible to make certain that there were no obvious problems such as broken conduit, a kinked hose, or debris.

Once a storm event ended, the stations are shut down either on site or remotely by Storm Control. The station is left ready for the next storm event in case there is insufficient time for a maintenance visit between storms. Data are retrieved remotely via telecommunications from the datalogger on a daily basis throughout the wet weather season. During storm events, data are downloaded at intervals typically between 15 minutes and one hour.

All water samples are kept chilled (4°C) and transferred to the analytical laboratories within holding times. Prior to sample shipping, sub-sampling from the composite container into sample containers is accomplished using protocol cleaned Teflon® and silicone sub-sampling hoses and a peristaltic pump. Using a large, Teflon® coated magnetic stirrer, all composite water is first mixed together thoroughly and then continuously mixed while the sub-sampling takes place. All sub-sampling takes place at a staging area near Long Beach. Documentation accompanying samples to the laboratories includes Chain of Custody forms, and Analysis Request forms (complete with detection limits).

Grab Sampling

During each storm event, grab samples for oil and grease, total and fecal coliform, and enterococcus are collected. The timing of grab sampling efforts is often driven by the short holding times for the bacterial analyses. The ability to deliver samples to the microbiological laboratory within the 6-hour holding time is always a major consideration.

Except at the pump stations, all grab samples are taken near the center of flow as possible or at least in an area of sufficient velocity to ensure good mixing. At both the Dominguez Gap and Belmont Pump stations, grabs are taken from the sump. A specially constructed sampling pole is required to obtain samples at most sites. Poles used are fitted with special bottle holders to secure the sampling containers. Care is taken not to overfill the sample containers for some of the containers contain preservative.

Configuration of Grab Pole used for Oil & Grease and Fecal Indicator Bacteria Sampling

Dry Weather Monitoring

The City's NPDES Permit requires two dry weather inspections and sampling events to be conducted at each of the four mass emission stations during the summer dry weather period. These inspections occurred on July 1 and 2, 2008 and on May 6 and 7, 2009.

Site inspections were conducted to determine if water was present and water was flowing or just ponded. If flowing water was evident at one of these mass emission sites, *in situ* water quality measurements, flow estimates, and composite water samples were taken along with general observations of site conditions. Flowing water was present in Bouton Creek and in Los Cerritos Channel during both of the 2008/2009 dry weather inspections.

During both events a 24-hour composite sample was collected at Los Cerritos Channel site by use of an automatic peristaltic pump sampler that collected aliquots every half hour for a 24-hour period. After the 24-hour sampling was complete grab samples were collected and *in situ* measurements of water quality and flow were taken.

The Bouton Creek site experiences tidal influences which limit the times at which sampling can be performed. Dry weather sampling is conducted during time periods when extreme low tides allow the tidal water to drain from the channel such that flows are dominated by dry weather discharges. A composite sample is typically collected over a 30-minute period preceding tidal waters reentering the channel to isolate sampling to just the freshwater discharge down the creek. Salinity is monitored during a period of roughly two hours before tidal waters reenter the channel in order to determine when the dry weather flows were representative of at least 90% of the flow.

During both dry weather surveys at Bouton Creek, flows were not sufficient to flush seawater from the creek. The lowest salinity measured during the first event was 17 ppt. During the second event, salinities reached 10.8 ppt which was still high to be considered representative of dry weather discharges. At a salinity of 10.8 ppt, water in the channel was roughly 1/3 seawater. Water levels in the creek were lower than observed in the early years of the program. A large portion of the crown of the bottom of the channel was exposed during both surveys. Dense algal growth observed during both surveys tended to inhibit the limited flow of water from the channel.

Dry weather flows at the Belmont Pump Station have been diverted to the sanitary system since 2007. This diversion has completely eliminated discharges from this site during the summer dry weather period of May through September.

The renovation of the pumps and the wet basin behind the Dominguez Gap Pump House was completed in time for the 2007/2008 storm season and continued to be operational for the 2008/2009 storm season. The official dedication of the facility occurred in April, 2008 but the site is still not operating as designed. The summer pump that was supposed to maintain flow through the wet basin failed almost immediately. It had not been placed in operation yet by the time of either the 1st or 2nd 2008/2009 dry weather inspections was performed. Therefore, there was no discharge into the Los Angeles River, and no samples were collected.

Temperature, conductivity, salinity and pH were measured with a YSI Model 63 Handheld pH, Conductivity, Salinity, and Temperature System. Dissolved oxygen was measured with a YSI Model 58 Dissolved Oxygen Meter.

Flows in channels were measured by the Area/Velocity method. Water depths are consistently too low for use of flow meters. The cross sectional area of the flow was determined by measuring the width of the flowing water and the maximum depth, and calculating the area. The velocity was determined by observing the time it took for a particle embedded in the flow to transit a measured stretch of the stream. Observations were made of the transit time of several particles and the times were averaged.

LABORATORY ANALYSES

The water quality constituents selected for this program were established based upon the requirements of the City of Long Beach NPDES permit for stormwater discharges as modified through the annual review process. All analyses were conducted at laboratories certified for such analyses by the Department of Health Services or approved by the Executive Officer and in accordance with current EPA guideline procedures or as specified in this Monitoring Program. Analytical methods are based upon approved USEPA methodology. The following sections detail laboratory methods for chemical and biological testing.

Analytical Suite and Methods

Conventional, bacteriological, and chemical constituents selected for inclusion in this stormwater quality program are presented in Table 4. Analytical method numbers, holding times, and reporting limits are also indicated for each analysis.

Laboratory QA/QC

Quality Assurance/Quality Control (QA/QC) activities associated with laboratory analyses are detailed in Appendix A.

The laboratory QA/QC activities provide information needed to assess potential laboratory contamination, analytical precision and accuracy, and representativeness. Analytical quality assurance for this program included the following:

- Employing analytical chemists trained in the procedures to be followed.
- Adherence to documented procedures, USEPA methods and written SOPs.
- Calibration of analytical instruments.
- Use of quality control samples, internal standards, surrogates and SRMs.
- Complete documentation of sample tracking and analysis.

Internal laboratory quality control checks included the use of internal standards, method blanks, matrix spike/spike duplicates, duplicates, laboratory control spikes and Standard Reference Materials (SRMs).

Data validation was performed in accordance with the USEPA Functional Guidelines for Low Level Concentration Organic Data Review (USEPA, 2001), USEPA Functional Guidelines for Inorganic Data Review (USEPA, 2002), and Guidance on the Documentation and Evaluation of Trace Metals Data Collected for the Clean Water Act Compliance Monitoring (USEPA, 1995a).

Toxicity Testing Procedures

Upon receipt in the laboratory, stormwater discharge and receiving water samples were stored at 4 °C, in the dark until used in toxicity testing. Toxicity testing commenced within 72 hours of sample collection for most samples. The relative toxicity of each discharge sample was evaluated using two chronic test methods: the water flea (*Ceriodaphnia dubia*) reproduction and survival test (freshwater) and the purple sea urchin (*Strongylocentrotus purpuratus*) fertilization test (marine). Each of the methods is recommended by the USEPA for the measurement of effluent and receiving water toxicity. Water samples were diluted with laboratory water to produce a concentration series using procedures specific to each test method.

Water Flea Reproduction and Survival Test

Toxicity tests using the water flea, *Ceriodaphnia dubia*, were conducted in accordance with methods recommended by USEPA (2002). The test procedure consisted of exposing 10 *C. dubia* neonates (less than 24 hours old) to the samples for six or seven days. One animal was placed in each of 10 individual polystyrene cups containing approximately 20 mL of test solution. The test temperature was 25 $\pm$ 1°C and the photoperiod was 16 hours light: 8 hours dark. Daily water changes were accomplished by transferring each individual to a fresh cup of test solution; water quality measurements and observations of survival and reproduction (number of offspring) were made at this time also. Prior to transfer, each cup was inoculated with food (200 μL of a 3:1 mixture of *Selenastrum* culture, density approximately 3.5 x 10^7 cells/mL, and YCT).

The test organisms were obtained from in-house cultures that were established from broodstock obtained from Aquatic Biosystems (Fort Collins, CO). The laboratory water used for cultures, controls, and preparation of sample dilutions was synthetic moderately hard freshwater, prepared with deionized water and Perrier Water. Test samples were poured through a 60 μm Nitex® screen in order to remove indigenous organisms prior to preparation of the test concentrations. Serial dilutions of the test sample were prepared, resulting in test concentrations of 100, 50, 25, 12.5, and 6.25 %.

The quality assurance program for this test consisted of three components. First, a control sample (laboratory water) was included in all tests in order to document the health of the test organisms. Second, a reference toxicant test consisting of a concentration series of potassium chloride (KCl) was conducted with each batch of samples to evaluate test sensitivity and precision. Third, the results were compared to established performance criteria for control survival, reproduction, reference toxicant sensitivity, sample storage, and test conditions. Any deviations from the performance criteria were noted in the laboratory records and prompted corrective action, ranging from a repeat of the test to adjustment of laboratory equipment.

Sea Urchin Fertilization Test

All stormwater and dry weather discharge samples were also evaluated for toxicity using the purple sea urchin fertilization test (USEPA 1995b). This test measures toxic effects on sea urchin sperm, which are expressed as a reduction in their ability to fertilize eggs. The test consisted of a 20-minute exposure of sperm to the samples. Eggs were then added and given 20 minutes for fertilization to occur. The eggs were then preserved and examined later with a microscope to assess the percentage of successful fertilization. Toxic effects are expressed as a reduction in fertilization percentage. Purple sea urchins (*Strongylocentrotus purpuratus*) used in the tests were supplied by U.C. Davis MPSL – Granite Canyon or by David Gutoff, San Diego CA, The tests were conducted in glass shell vials containing 5 mL of solution at a temperature of 12 $\pm$ 1°C. Four replicates were tested at each sample concentration.

All samples were adjusted to a salinity of 34 g/kg for the fertilization test. Previous experience has determined that many commercially available sea salt mixes are toxic to sea urchin sperm. Therefore, the salinity for the urchin test was adjusted by the addition of hypersaline brine. The brine was prepared by partially freezing seawater. Since the addition of brine dilutes the sample, the highest stormwater concentration that could be tested for the sperm cell test was 50%. The adjusted samples were diluted with seawater to produce test concentrations of 50, 25, 12.5, 6.25, and 3.125%.

Seawater control (1.0 μm filtered natural seawater from ToxScan's Long Marine Laboratory facility) and brine control samples (50% deionized water and 50% brine) were included in each test series for quality control purposes. Water quality parameters (temperature, dissolved oxygen, pH, ammonia, and salinity) were measured on the test samples to ensure that the experimental conditions were within desired ranges and did not create unintended stress on the test organisms. In addition, a reference

toxicant test was included with each stormwater test series in order to document intralaboratory variability. Each reference toxicant test consisted of a concentration series of copper sulfate with four replicates tested per concentration. The 25th percentile effective concentration (EC_{25}) was estimated from the data and compared to control limits based upon the cumulative mean and two standard deviations of recent experiments.

Toxicity Identification Evaluations (TIEs)

Phase I TIEs were planned to be conducted on selected runoff samples from stations that exhibited substantial toxicity (> 2 TU_a for *Ceriodaphnia*, > 3 TU_a for sea urchins), in order to determine the characteristics of the toxicants present. The TIE process involves subjecting each sample to treatments designed to selectively remove or neutralize classes of compounds (e.g., metals, nonpolar organics) and thus the toxicity that may be associated with them. Treated samples would then be tested to determine the change in toxicity using the sea urchin fertilization test.

None of the stormwater or dry weather discharge samples exhibited the level of toxicity necessary to trigger Phase I TIEs.

Statistical Analysis

The toxicity test results were normalized to the control response in order to facilitate comparisons of toxicity between experiments. Normalization was accomplished by expressing the test responses as a percentage of the control value. Four statistical parameters (NOEC, LOEC, median effect, and TU_c) were calculated to describe the magnitude of stormwater toxicity. The NOEC (highest test concentration not producing a statistically significant reduction in fertilization or survival) and LOEC (lowest test concentration producing a statistically significant reduction in fertilization or survival) were calculated by comparing the response at each concentration to the dilution water control. Various statistical tests were used to make this comparison, depending upon the characteristics of the data. Water flea survival and reproduction data were usually tested against the control using Fisher's Exact and Steel's Many-One Rank test, respectively. Sea urchin fertilization data were evaluated for significant differences using Dunnett's multiple comparison test, provided that the data met criteria for homogeneity of variance and normal distribution. Data that did not meet these criteria were analyzed by the non-parametric Steel's Many-One Rank or Wilcoxon's tests.

Measures of median effect for each test were calculated as the LC_{50} (concentration producing a 50% reduction in survival) for water flea survival, the EC_{50} (concentration effective on 50% of eggs) for sea urchin fertilization, or the IC_{50} (concentration inhibitory to 50% of individuals) for water flea reproduction as well as the IC_{25}. The LC_{50} or EC_{50} was calculated using probit analysis, the trimmed Spearman-Karber method or linear interpolation (bootstrap). The IC_{25} and IC_{50} were calculated using probit or linear interpolation analysis. All procedures for calculation of median or percentile effects followed USEPA guidelines.

The toxicity results were also expressed as chronic Toxic Units (TU_c) and acute Toxic Units (TU_a). Chronic TUs were calculated as 100/NOEC, while acute TUs were calculated as 100/LC or EC_{50} for water fleas or 100/EC_{50} for urchins. Increased values of toxic units indicate relatively greater toxicity, whereas greater toxicity for the NOEC, LOEC, and median effect statistics is indicated by a lower value.

Comparisons of chemical or physical parameters with toxicity results were made using the non-parametric Spearman rank order correlation.

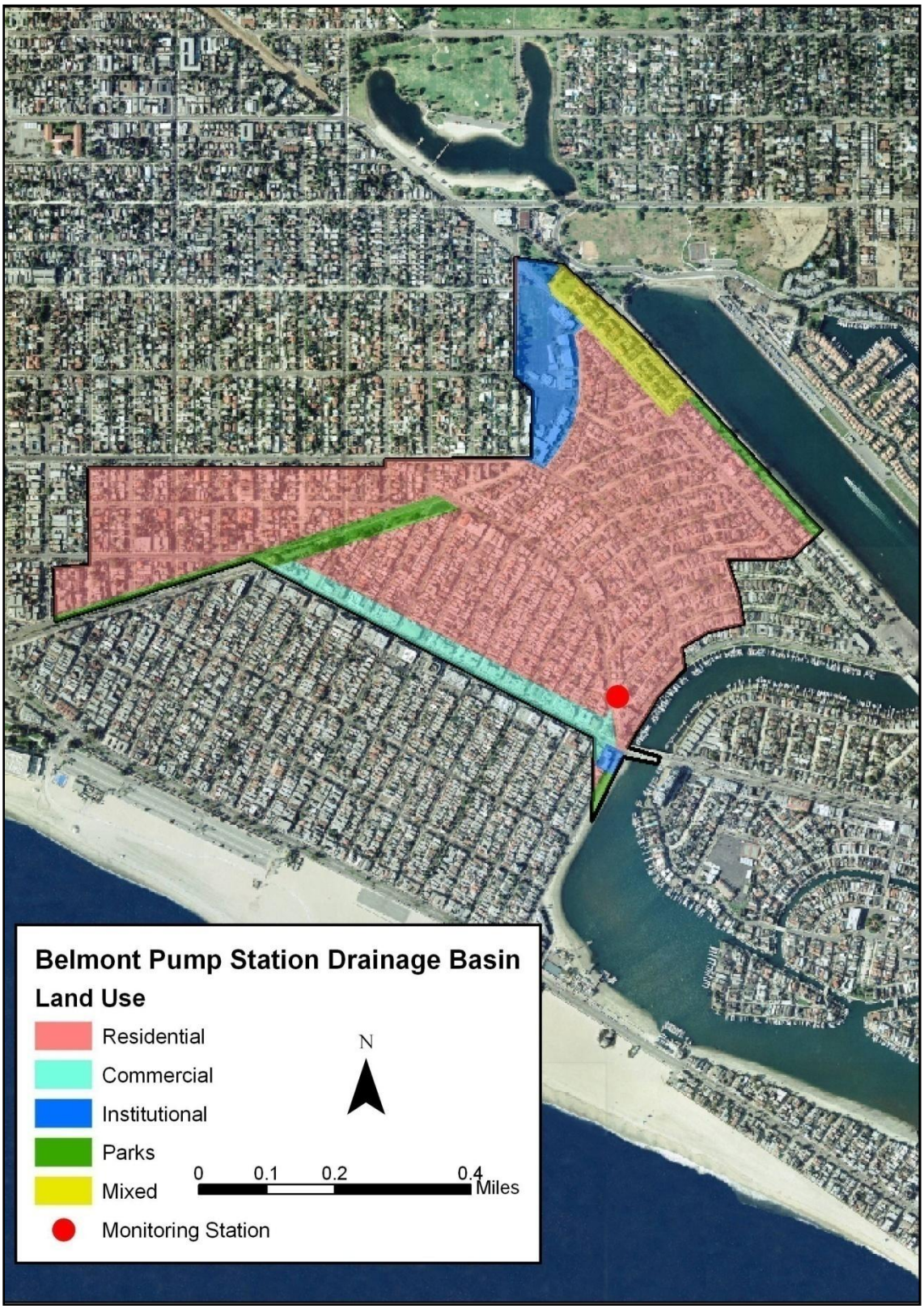


Figure 5. **Land Use of Drainage Basin #23 which Drains to the Belmont Pump Station Mass Emission Site. (Source: City of Long Beach, Department of Technology Services, last updated 2006).**

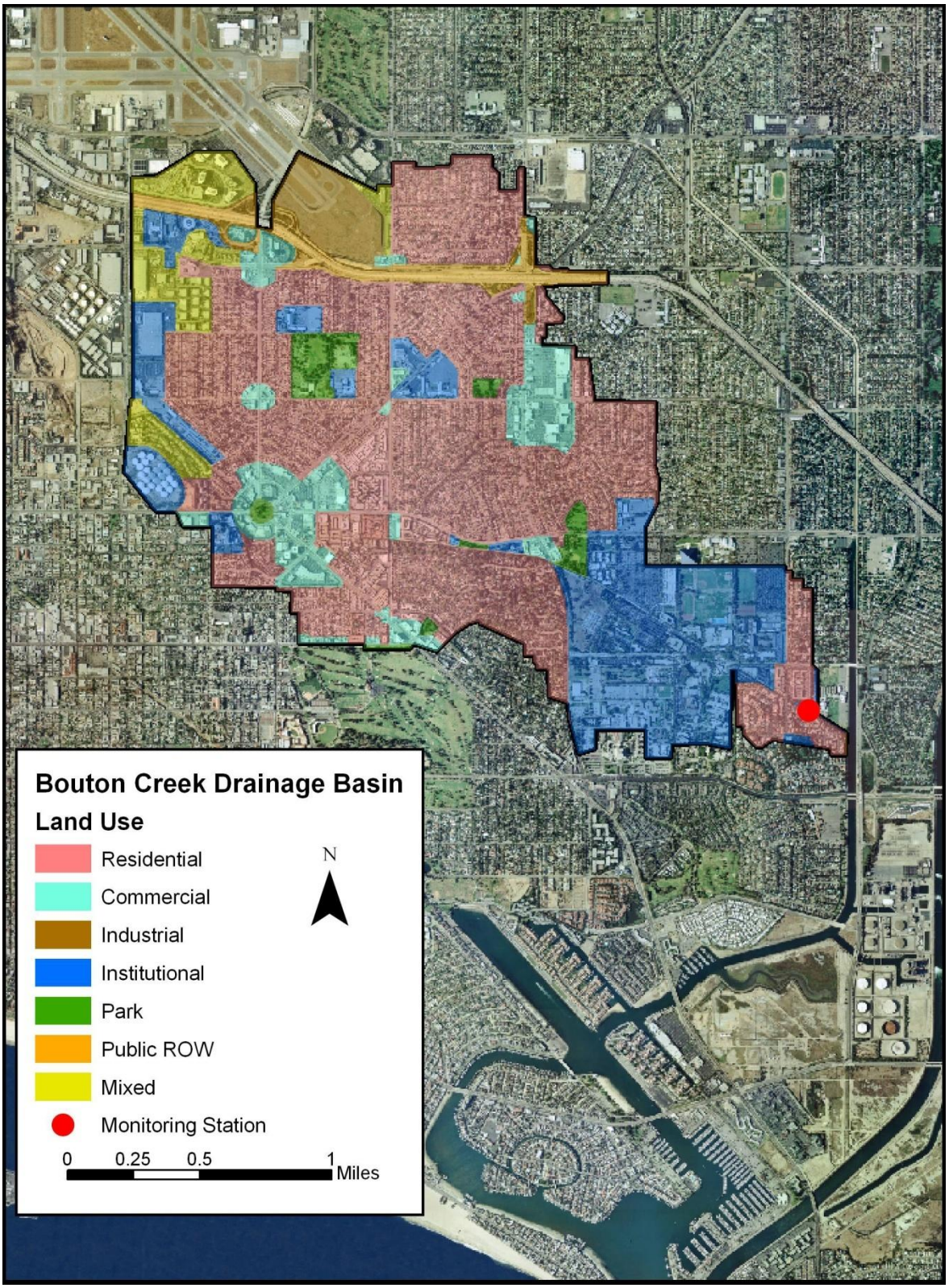


Figure 6. **Land Use of Drainage Basin #20 which Drains to the Bouton Creek Mass Emission Site. (Source: City of Long Beach, Department of Technology Services, last updated 2000).**

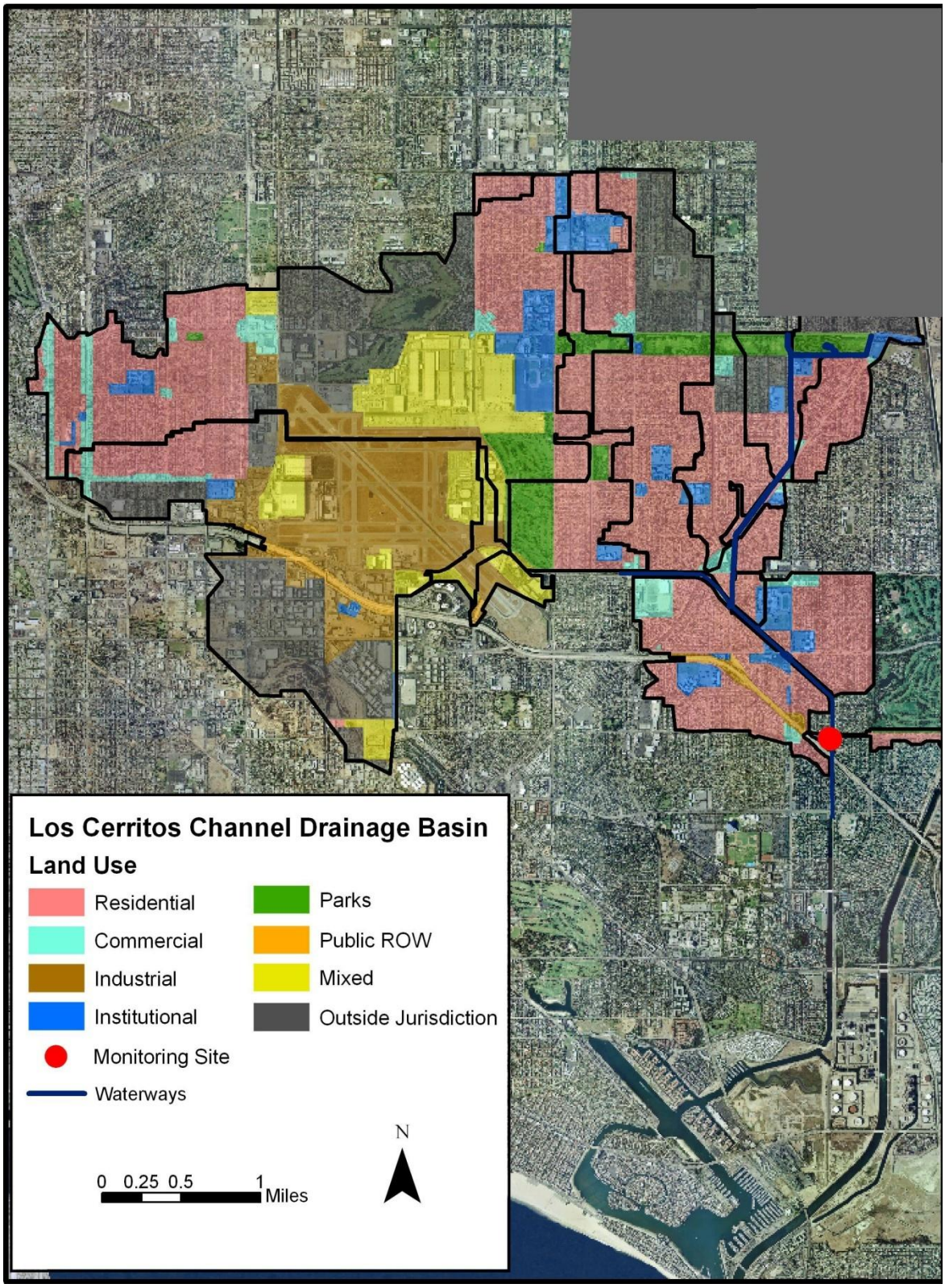


Figure 7. **Land Use of Drainage Basins which Drain to the Los Cerritos Channel Monitoring Site. (Source: City of Long Beach, Department of Technology Services, last update 2006).**

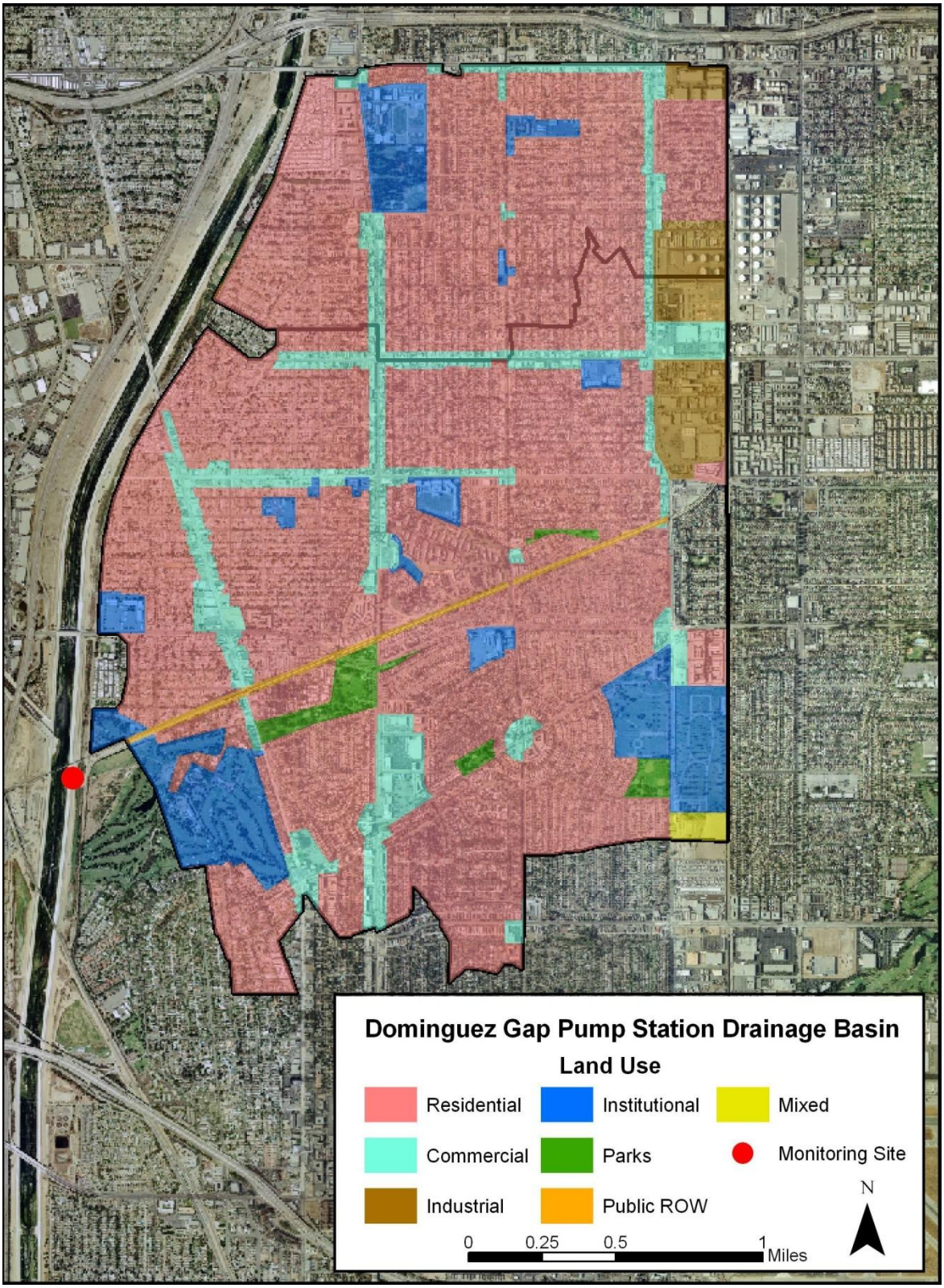


Figure 8. **Land Use of Drainage Basin #14 which Drains to the Dominguez Gap Mass Emission Site. (Source: City of Long Beach, Department of Technology Services, last update 2006).**

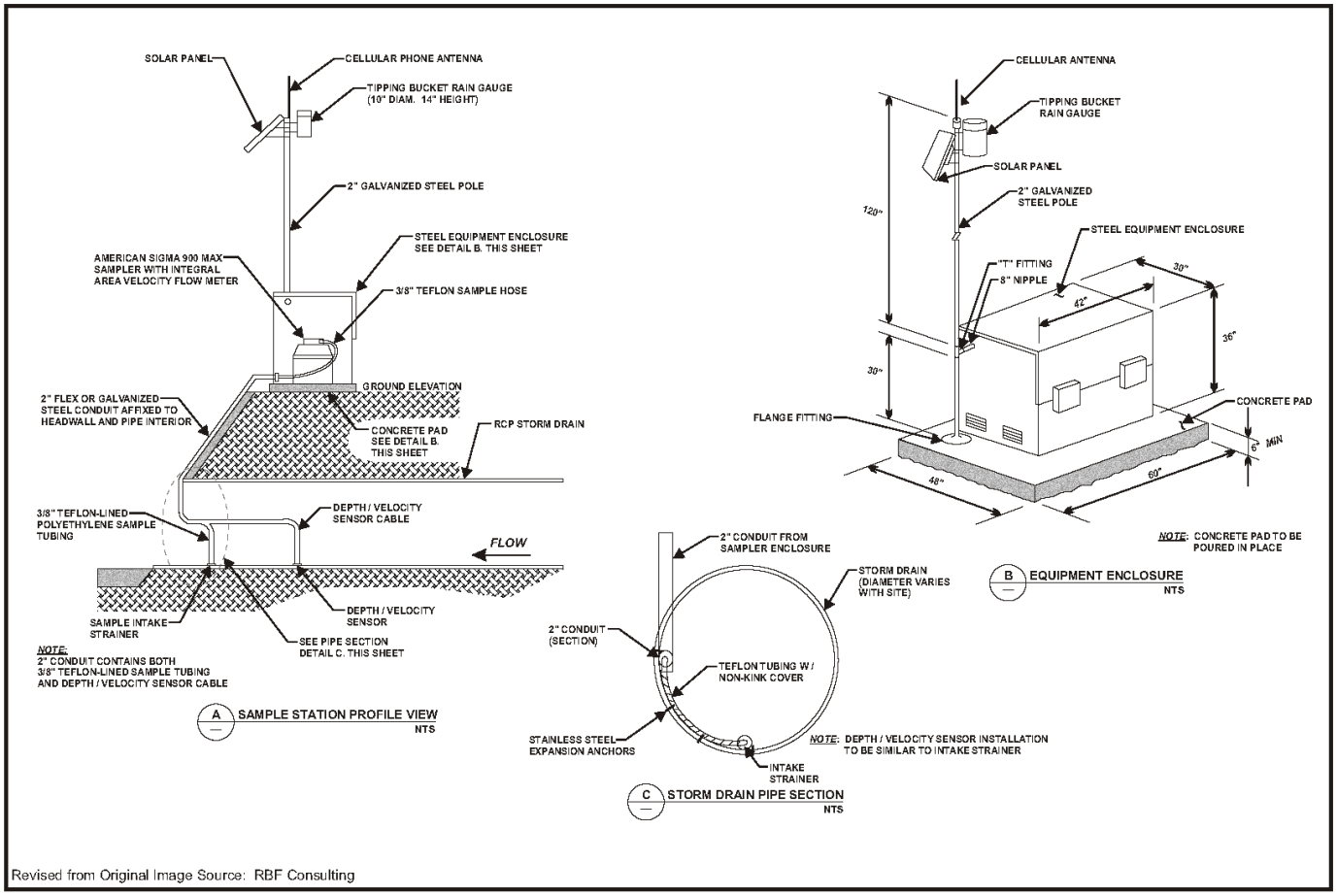


Figure 9. Typical KLASS Stormwater Monitoring Station.

Table 3. Location Coordinates of Monitoring Stations for the City of Long Beach Stormwater Monitoring Program.

	State Plane Coordinates: Zone 5		North American Datum (NAD) 83	
Station Name	**Northing (ft)**	**Easting (ft)**	**Latitude**	**Longitude**
Belmont Pump	1734835	6522091	33° 45’ 36.6”N	118° 07’ 48.7”W
Bouton Creek	1741961	6529305	33° 46’ 44.3”N	118° 06’ 23.4”W
Los Cerritos Channel	1747936	6530153	33° 47’ 43.3”N	118° 06’ 13.4”W
Dominguez Gap Pump	1764025	6500043	33° 50’ 22.1”N	118° 12’ 10.5”W

Table 4. Analytical Methods, Holding Times, and Reporting Limits.

Analyte and Reporting Unit	EPA Method Number	Holding Time	Target Reporting Limit or ML
CONVENTIONAL PARAMETERS			
Oil and Grease (mg/L)	1664	28 days	5.0
Total Phenols (mg/L)	420.1	28 days	0.1
pH (units)	150.1	ASAP	0 – 14
Orthophosphate-P (mg/L)	365.2	48 hours	0.01
Total Phosphorus (mg/L)	365.2	28 days	0.05
Turbidity (NTU)	180.1	48 hours	1.0
Total Suspended Solids (mg/L)	160.2	7 days	1.0
Total Dissolved Solids (mg/L)	160.1	7 days	1.0
Volatile Suspended Solids (mg/L)	160.4	7 days	1.0
Total Organic Carbon (mg/L)	415.1	28 days	1.0
Biochemical Oxygen Demand (mg/L)	405.1	48 hours	4.0
Chemical Oxygen Demand (mg/L)	410.1	28 days	4.0
Total Ammonia-Nitrogen (mg/L)	350.1	28 days	0.1
Total Kjeldahl Nitrogen (mg/L)	351.1	28 days	0.1
Nitrite Nitrogen (mg/L)	300.0	48 hours	0.1
Nitrate Nitrogen (mg/L)	300.0	48 hours	0.1
Alkalinity, as CaCO3 (mg/L)	310.1	48 hours	5.0
Specific Conductance (umhos/cm)	120.1	48 hours	1.0
Total Hardness (mg/L)	130.2	180 days	1.0
MBAS (mg/L)	425.1	48 hours	0.025
Chloride (mg/L)	300.0	48 hours	1.0
Fluoride (mg/L)	300.0	48 hours	0.1
BACTERIA (MPN/100ml)			
Total Coliform	SM 9221B	6 hours	<20
Fecal Coliform	SM 9221E	6 hours	<20
Enterococcus	1600	6 hours	<10
TOTAL AND DISSOLVED METALS (µg/L)[1]			
Aluminum	200.8	180 days	100
Arsenic	200.8	180 days	0.5
Cadmium	200.8	180 days	0.25
Chromium	200.8	180 days	0.5
Copper	200.8	180 days	0.5
Iron	200.8	180 days	25
Lead	200.8	180 days	0.2
Nickel	200.8	180 days	0.5
Selenium	200.8	180 days	1.0
Silver	200.8	180 days	0.2
Zinc	200.8	180 days	1.0

1. Samples to be analyzed for dissolved metals are to be filtered within 48 hours.

Table 4. Analytical Methods, Holding Times, and Reporting Limits. (continued)

Analyte and Reporting Unit	EPA Method Number	Holding Time	Target Reporting Limit
CHLORINATED PESTICIDES (µg/L)			
Aldrin	645m	7 days	0.005
alpha-BHC	645m	7 days	0.005
beta-BHC	645m	7 days	0.005
delta-BHC	645m	7 days	0.005
gamma-BHC (lindane)	645m	7 days	0.005
alpha-Chlordane	645m	7 days	0.005
gamma-Chlordane	645m	7 days	0.005
4,4'-DDD	645m	7 days	0.005
4,4'-DDE	645m	7 days	0.005
4,4'-DDT	645m	7 days	0.005
Dieldrin	645m	7 days	0.005
Endosulfan I	645m	7 days	0.005
Endosulfan II	645m	7 days	0.005
Endosulfan sulfate	645m	7 days	0.005
Endrin	645m	7 days	0.005
Endrin Aldehyde	645m	7 days	0.005
Heptachlor	645m	7 days	0.005
Heptachlor Epoxide	645m	7 days	0.005
Toxaphene	645m	7 days	0.005
PCBs (µg/L)			
Aroclor-1016	645m	7 days	0.02
Aroclor-1221	645m	7 days	0.02
Aroclor-1232	645m	7 days	0.02
Aroclor-1242	645m	7 days	0.02
Aroclor-1248	645m	7 days	0.02
Aroclor-1254	645m	7 days	0.02
Aroclor-1260	645m	7 days	0.02
Total PCBs	645m	7 days	0.02
ORGANOPHOSPHATE PESTICIDES (µg/L)			
Diazinon	645m	7 days	0.004
Chlorpyrifos (Dursban)	645m	7 days	0.002
Malathion	645m	7 days	0.006
Triazine Pesticides (µg/L)			
Prometryn	645m	7 days	0.01
Atrazine	645m	7 days	0.01
Simazine	645m	7 days	0.01
Cyanazine	645m	7 days	0.01

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RAINFALL AND HYDROLOGY

Maintenance was conducted on the four Long Beach stormwater runoff monitoring stations in late September prior to the start of the 2008/2009 wet weather season. This allowed for the continuous monitoring of precipitation and discharge throughout the season. There are, however, small gaps in some of the data due to periodic malfunction of a sensor or sampler. Unfortunately, two of the stations (at Bouton Creek and Los Cerritos Channel) unexpectedly malfunctioned during the first monitored rain event. Because of these malfunctions, drought conditions and the lack of rainfall events meeting the necessary antecedent conditions, the full complement of storm events could not be sampled. Only two or three storm events were sampled, depending on the station, instead of the required number of four.

The "first flush" event of the 2008/2009 season came on November 4, 2008 and produced between 0.38 and 0.47 inches of rain. This event was forecasted to be light and under a quarter of an inch. It was therefore not targeted for sampling. The first monitored event occurred 21 days later and produced well over an inch at all stations. As mentioned previously, the flow meters at Bouton Creek and Los Cerritos Channel malfunctioned due to defective batteries and were thus not sampled. Stormwater runoff samples at the Belmont and Dominguez Pump Stations were successfully collected and analyzed for a complete suite of water quality analytes.

The next two monitored events, December 15, 2008 and February 5 and 6, 2009, resulted in successful sampling at all four stations for the complete suite of water quality analyses. The event in February marked the completion of full monitoring at all stations since insufficient rain fell after antecedent conditions required by the Regional Board (less than 0.1 inches of rain in a one week period) were met. Despite the requirement of antecedent rainfall, a rainfall event was targeted on February 13, 2009, but there was insufficient rainfall to produce enough runoff to perform most of the analyses. Total suspended solids samples were analyzed from the Bouton Creek and Los Cerritos Channel sites for this event. A significant rainfall event did occur on February 15, 2009 but was not sampled because antecedent conditions were not met. There was also a significant event a few days after the December 15 event that was not sampled because antecedent conditions were not met.

PRECIPITATION DURING THE 2008/2009 WET WEATHER SEASON

The 2008/2009 season marked the fourth season in a row of below normal precipitation, further intensifying Southern California drought conditions. Normal precipitation for September through April at the Long Beach Airport is 12.51 inches (Figure 10). The baseline for "normal" precipitation at the Airport is 1977 through 2000. This season, a total of 9.29 inches of rainfall was recorded at the airport during the same period (Figure 10 and Figure 11), which is slightly below the 10-year average precipitation of 9.53 inches for the months of September through April. Compared to normal precipitation, there is a 3.22 inch deficit for the season or 74% of normal.

A direct comparison of daily rainfall measured at each site during the 2007/2008 and 2008/2009 wet weather seasons (Table 5 through Table 8) illustrates similar rainfall over the past two seasons. This is in contrast to the 2006/2007 season where there were large differences evident in terms of the number of days of precipitation, the daily precipitation totals, and monthly precipitation totals.

Rainfall was varied somewhat among the four monitoring stations, suggesting that most events were showery in nature. Belmont Pump Station had a season total of 9.25 inches, the Los Cerritos Channel had a season total of 10.11 inches, Bouton Creek had a season total of 8.94 inches, and the

Dominguez Gap Pump Station had a season total of 10.28 inches (Figure 11). A total of 9.29 inches was recorded at the Long Beach Airport. It appears that the rain gauge at Los Cerritos Channel was temporarily clogged throughout the November 25 and 26, evident by 0.6 inches of rain in a five minute period, not realistic of true rainfall. Therefore, Bouton Creek rain data was used to augment Los Cerritos Channel rain data for this event. The Dominguez Gap Pump Station rain gauge suffered from a malfunction during the later part of the season as well. As a result, rainfall data from the Los Angeles County Department of Public Works Los Angeles River at West Wardlow Road rain gauge station was substituted for February 1, 2009 data on. Hawks tend to create periodic problems at the Dominguez Gap Pump Station rain gauge. Both droppings and prey items are occasionally found in the rain gauge despite measures taken to discourage birds. Station data for the initial portion of the year at the Dominguez Gap Pump Station were valid.

Monthly Precipitation

Below normal precipitation occurred during the months of September, October, January, March and April for the 2008/2009 wet weather season, while above normal precipitation occurred during the months of November, December and January. After February, the season saw well-below normal precipitation (Figure 12). March and April totals were on par with those of the 2006/2007 season, continuing the drought conditions in Southern California. Daily totals for all stations are summarized in Table 5 through Table 8.

Precipitation during Monitored Events

Precipitation during each storm event has been characterized by total rainfall, duration of rainfall, maximum intensity, days since last rainfall, and the magnitude of the event immediately preceding the monitored storm event (antecedent rainfall). Precipitation characteristics for each monitored event are summarized in Table 9. Cumulative descriptive statistics between all monitored events, including TSS only events, for each monitoring station are presented in Table 10. Cumulative rainfall and intensity are summarized graphically for each monitored event at each station in Figure 13 through Figure 24.

For the 2008/2009 wet weather season, total rainfall during all two or three full testing events varied between 0.96 and 1.58 inches at the Belmont Pump Station, 0.81 and 1.87 inches at Bouton Creek, 0.92 and 1.69 inches at Los Cerritos Channel, and 0.7 and 1.43 inches at the Dominguez Gap Pump Station.

The mean total rainfall between all fully tested events during the 2008/2009 wet weather season ranged from 1.08 inches at the Dominguez Gap Pump Station to 1.27 inches at the Belmont Pump Station. Mean total rainfall between monitored events during the 2007/2008 season were generally less.

Mean maximum rainfall intensities among monitored events (based on five minutes of data) ranged from 0.66 inches per hour at Los Cerritos Channel to 1.16 inches per hour at the Dominguez Gap Pump Station. Although rainfall totals for the 2008/2009 season were similar to the 2007/2008 season, rainfall intensities were less on average than those recorded last year.

All storm events were fairly sporadic with the most rain falling in February, including several events occurring within a few days of each other. Overall, the mean period of dry conditions prior to monitored events ranged from 15.5 days at Los Cerritos Channel to 17.6 days at the Belmont Pump Station. Generally speaking, events with full analytical monitoring were preceded by at least 12 days of dry conditions.

STORMWATER RUNOFF DURING MONITORED EVENTS

In order to properly estimate Event Mean Concentrations (EMCs) and constituent loadings, monitoring was designed to quantify rainfall events in their entirety and the majority of runoff created by those events. Table 11 summarizes flow characteristics among monitored events at each station including the duration of discharge/flow, total discharge volume, and peak discharge/flow. Table 10 provides descriptive statistics for all monitored events during the 2008/2009 season. This information complements the calculated EMCs for each monitored analyte at these sites. Figure 13 through Figure 24 graphically depict flow during each monitored event at each station in response to rainfall. These figures also show how the aliquoting of each composite sample was conducted and when grab samples were collected.

Flow duration or the period of discharge varied between stations and events. Flow duration was typically greatest at Bouton Creek due to tidal effects and at Los Cerritos Channel due to the large drainage area. During incoming tides at Bouton Creek, low flows are backed up and held back by the tide. As the tide recedes, stormwater is detected at the station using the conductivity sensors and sampling continues. In contrast, the period of discharge at the pump stations was much less. In past years, the Dominguez Pump Station usually had the smallest duration of discharge since most of the runoff from this drainage is used to fill a reservoir prior to discharge. However, now the system is designed with less retention, which facilitates more frequent discharges.

The duration of discharge is reported in Table 11 for the 2008/2009 monitoring season. Belmont and Dominguez Gap pump stations are often overestimated because of the on and off cycling of the pumps. The discharge durations reported in these tables represent the period between the times the first pump came on until all pumps became silent. One should refer to the hydrographs developed for the pump stations for a better estimate of the duration of discharge.

For the 2008/2009 wet weather season, mean total flow or discharge for full testing events ranged from 388,000 cubic feet (cf) at the Belmont Pump Station to 32,368,000 cf at the Los Cerritos Channel. These volumes were substantially higher than the mean total flow volumes for monitored events recorded the previous wet weather season (290,000 cf at the Belmont Pump Station to 18,052,000 cf at the Los Cerritos Channel site).

The percent storm captures (percentage of the total storm event volume effectively represented by the flow-weighted composite sample) met the optimal objectives (>90%) in most cases. The only exceptions occurred at the Belmont Pump Station where the percent storm capture was around 87% for the first and third full testing events. Sampling was taking place during the time of peak discharge in all cases.

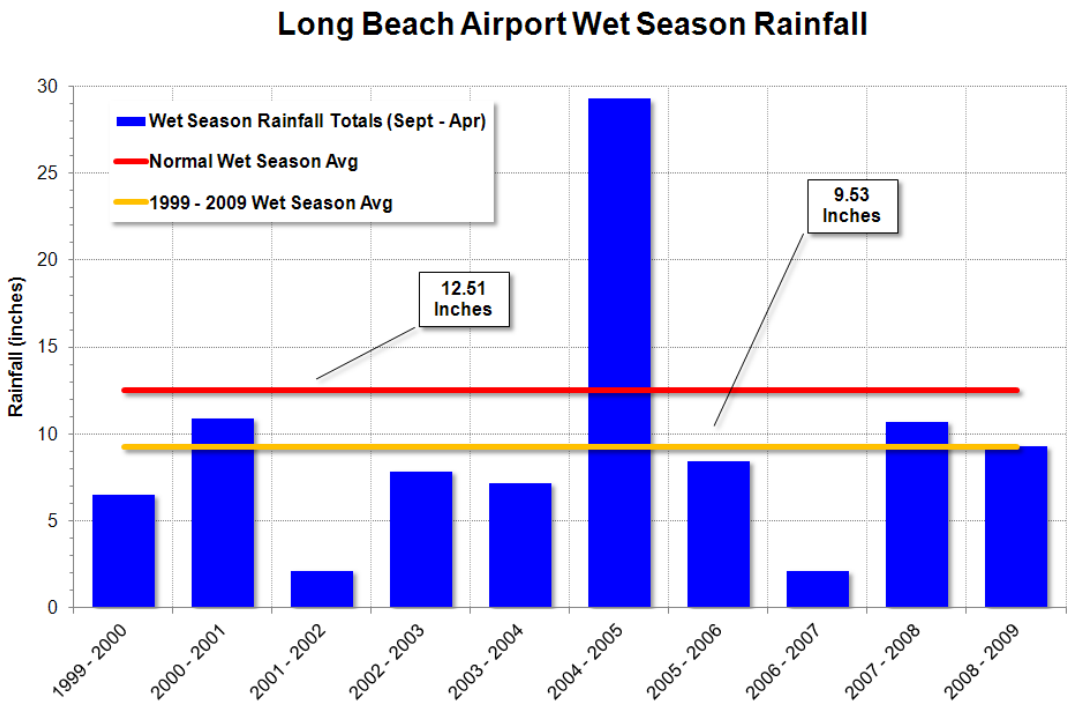


Figure 10. Annual Rainfall (October –May) at Long Beach Daugherty Airport over Past Ten Years

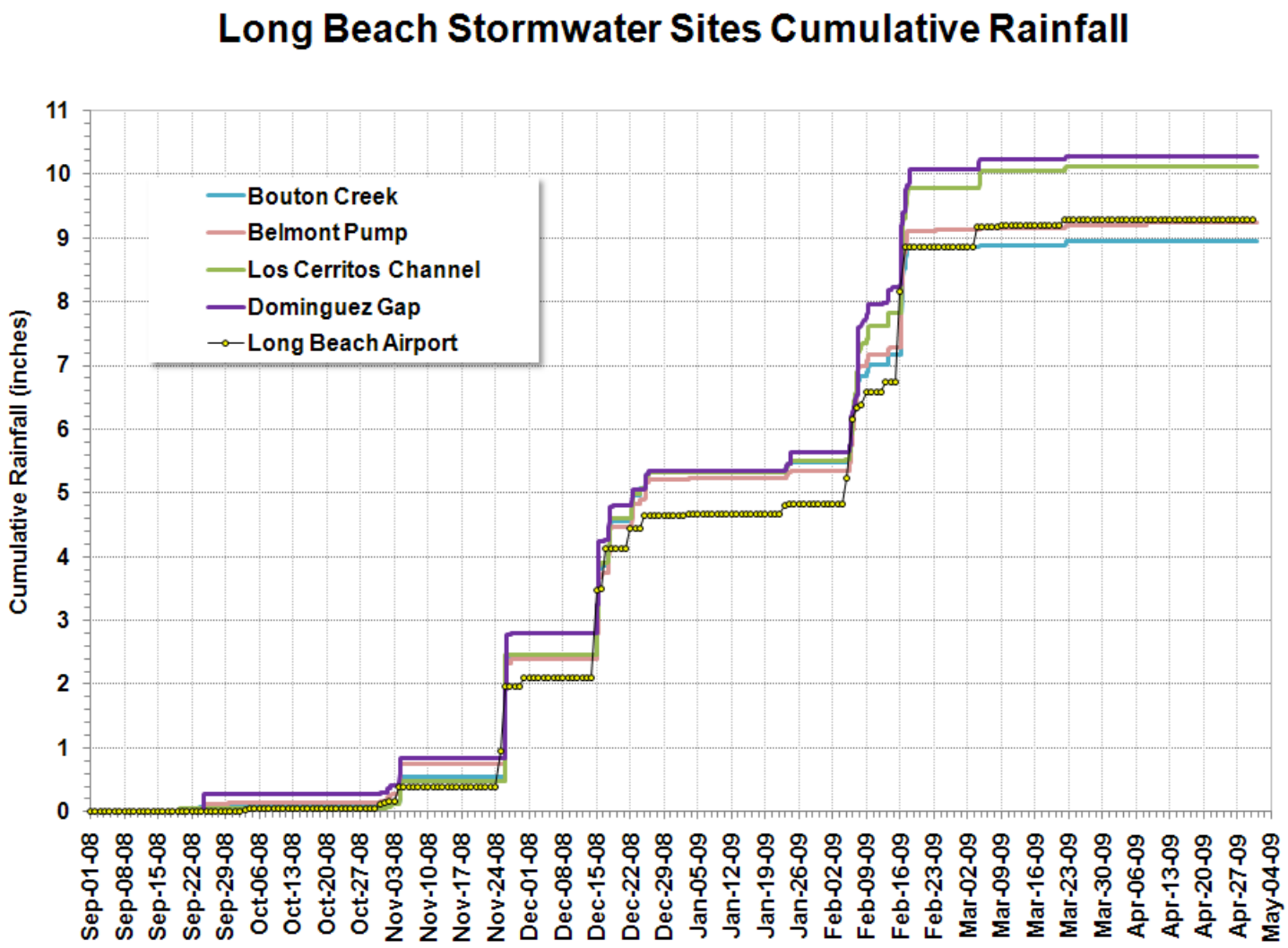
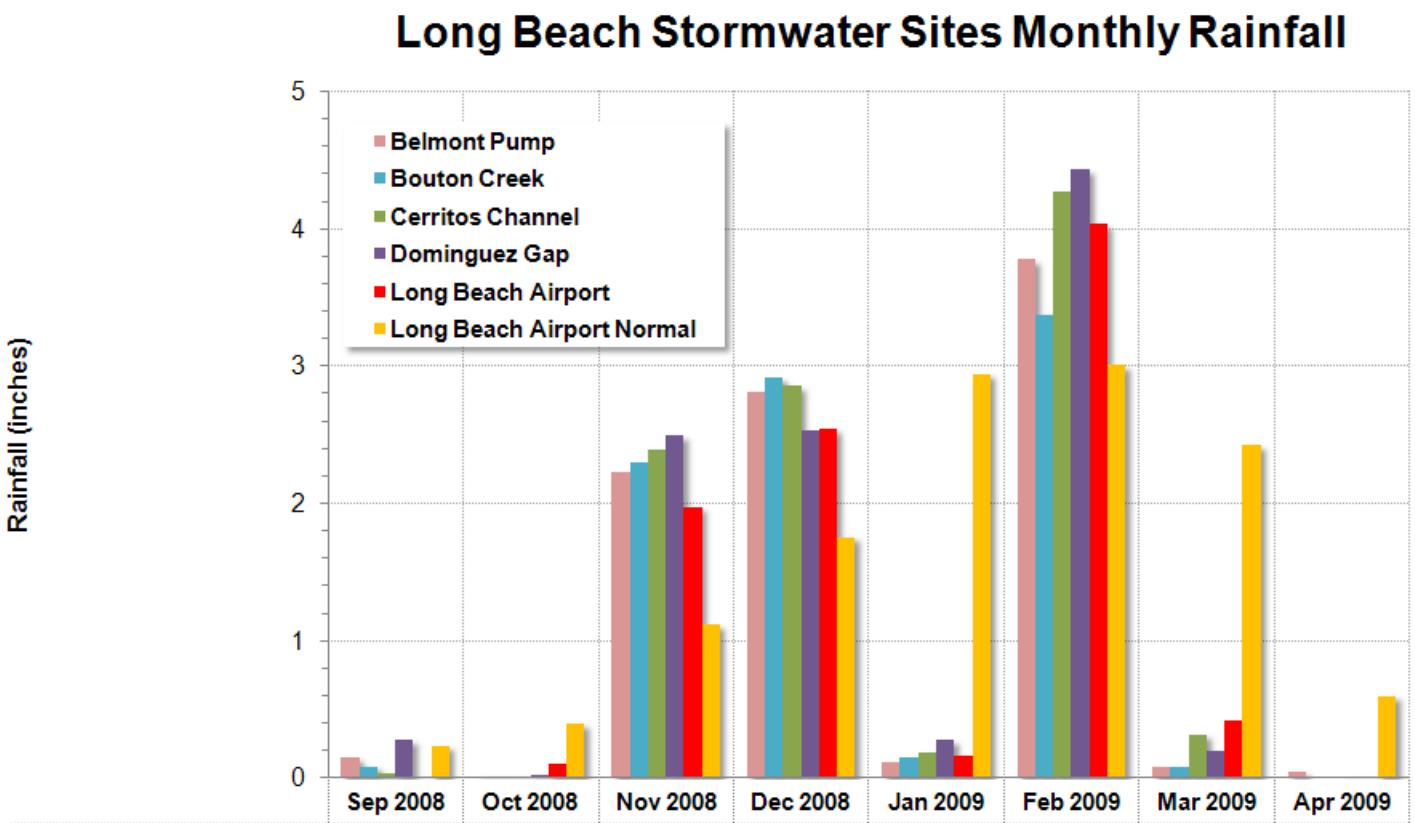


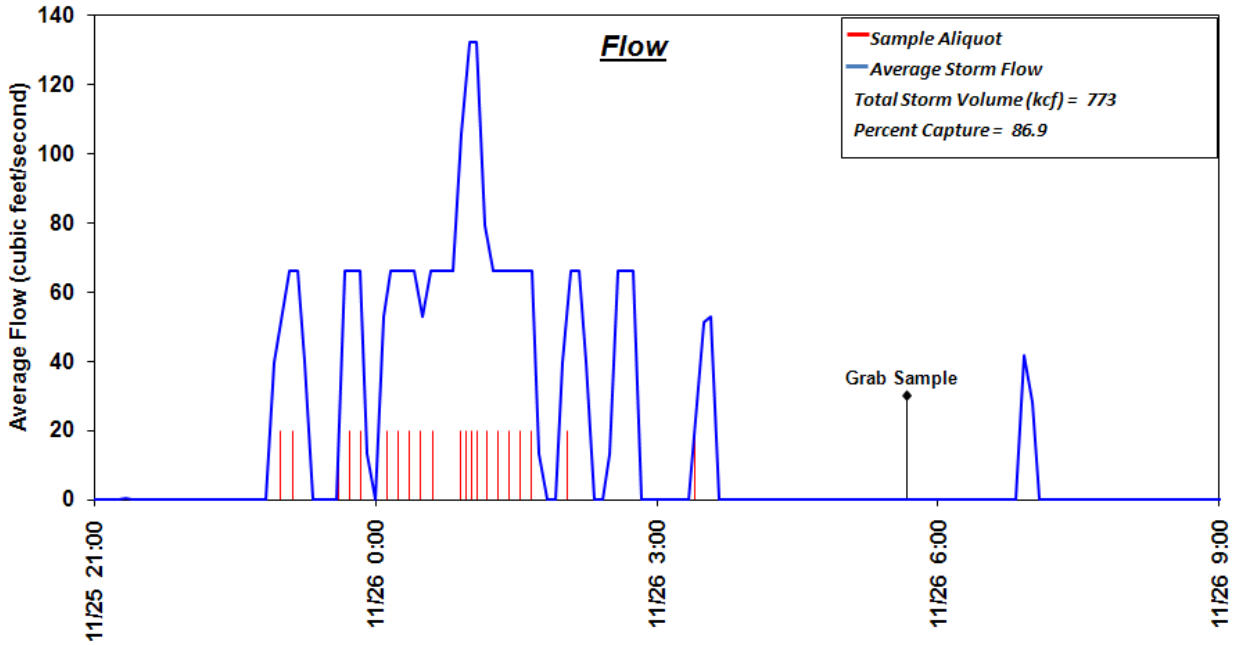
Figure 11. Cumulative Rainfall for the 2008/2009 Wet Weather Season.



	Sep 2008	Oct 2008	Nov 2008	Dec 2008	Jan 2009	Feb 2009	Mar 2009	Apr 2009
Belmont Pump	0.15	0.02	2.23	2.82	0.12	3.78	0.08	0.05
Bouton Creek	0.09	0.02	2.30	2.92	0.15	3.38	0.08	0.00
Cerritos Channel	0.04	0.02	2.40	2.86	0.19	4.28	0.32	0.00
Dominguez Gap	0.28	0.03	2.50	2.54	0.28	4.44	0.20	0.01
Long Beach Airport	0.01	0.11	1.98	2.55	0.17	4.04	0.42	0.01
Long Beach Airport Normal	0.24	0.40	1.12	1.76	2.95	3.01	2.43	0.60

Figure 12. Monthly Rainfall Totals for each Monitoring Site during the 2008/2009 Wet Weather Season and Normal Rainfall at Long Beach Daugherty Air Field.

(*Rainfall data from the Los Cerritos Channel station substituted for the month of September 2006 and Los Angeles County Department of Public Works LA River at West Wardlow Road rain gauge station substituted for October 1, 2007 through November 30, 2007 due to equipment malfunction)



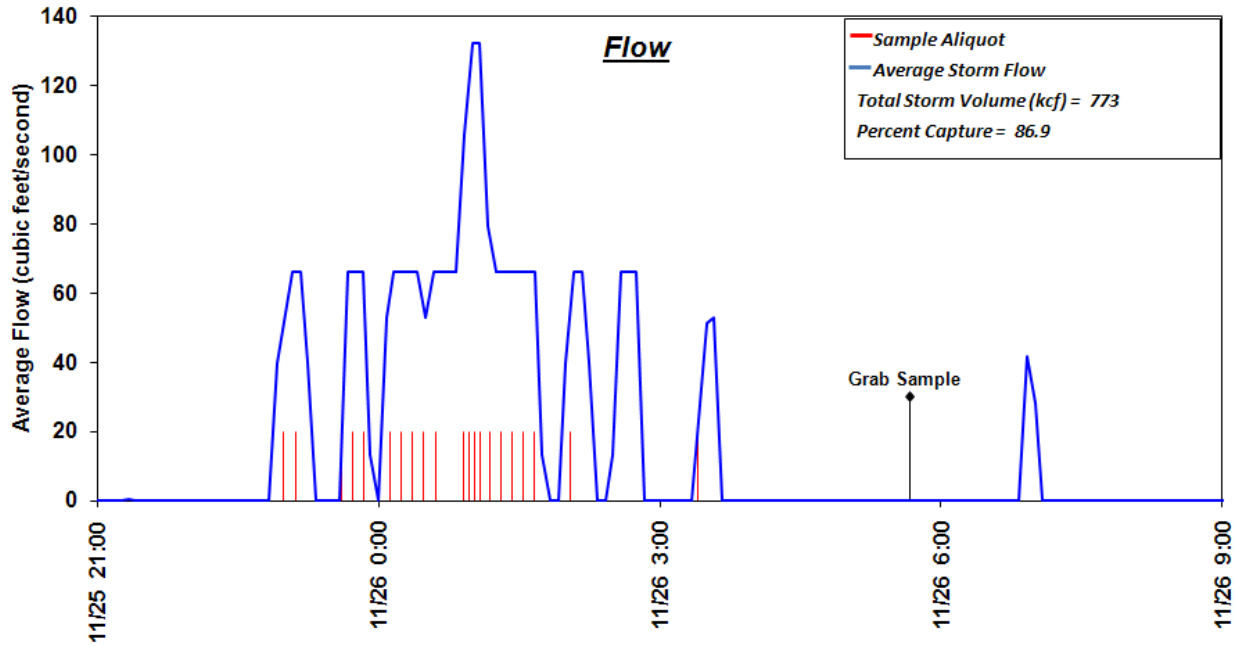


Figure 13. Belmont Pump Station – Event 1 (November 25 – 26, 2008 – Global Event 1)

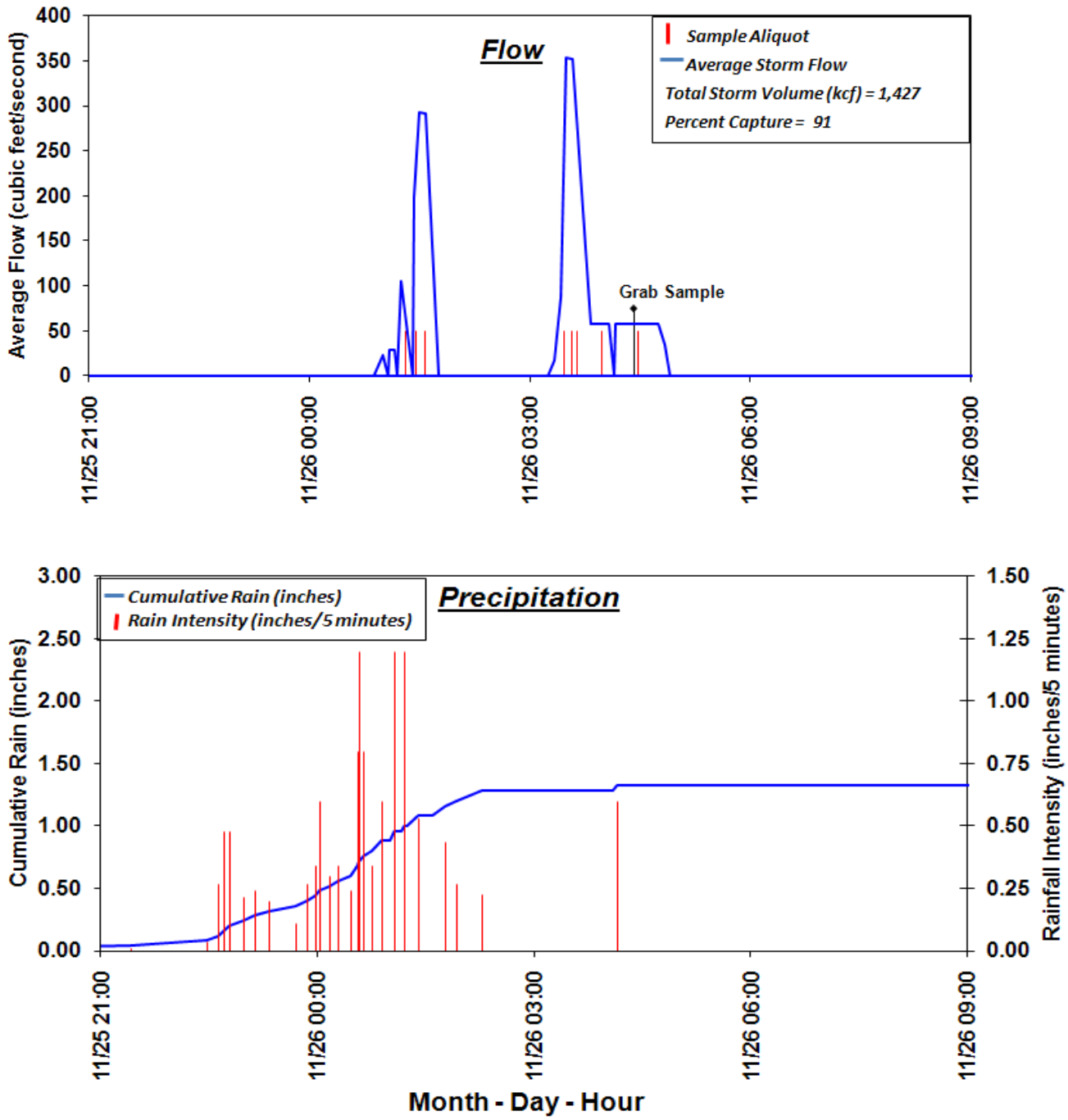


Figure 14. Dominguez Gap Pump Station – Event 1 (November 25 – 26, 2008 – Global Event 1)

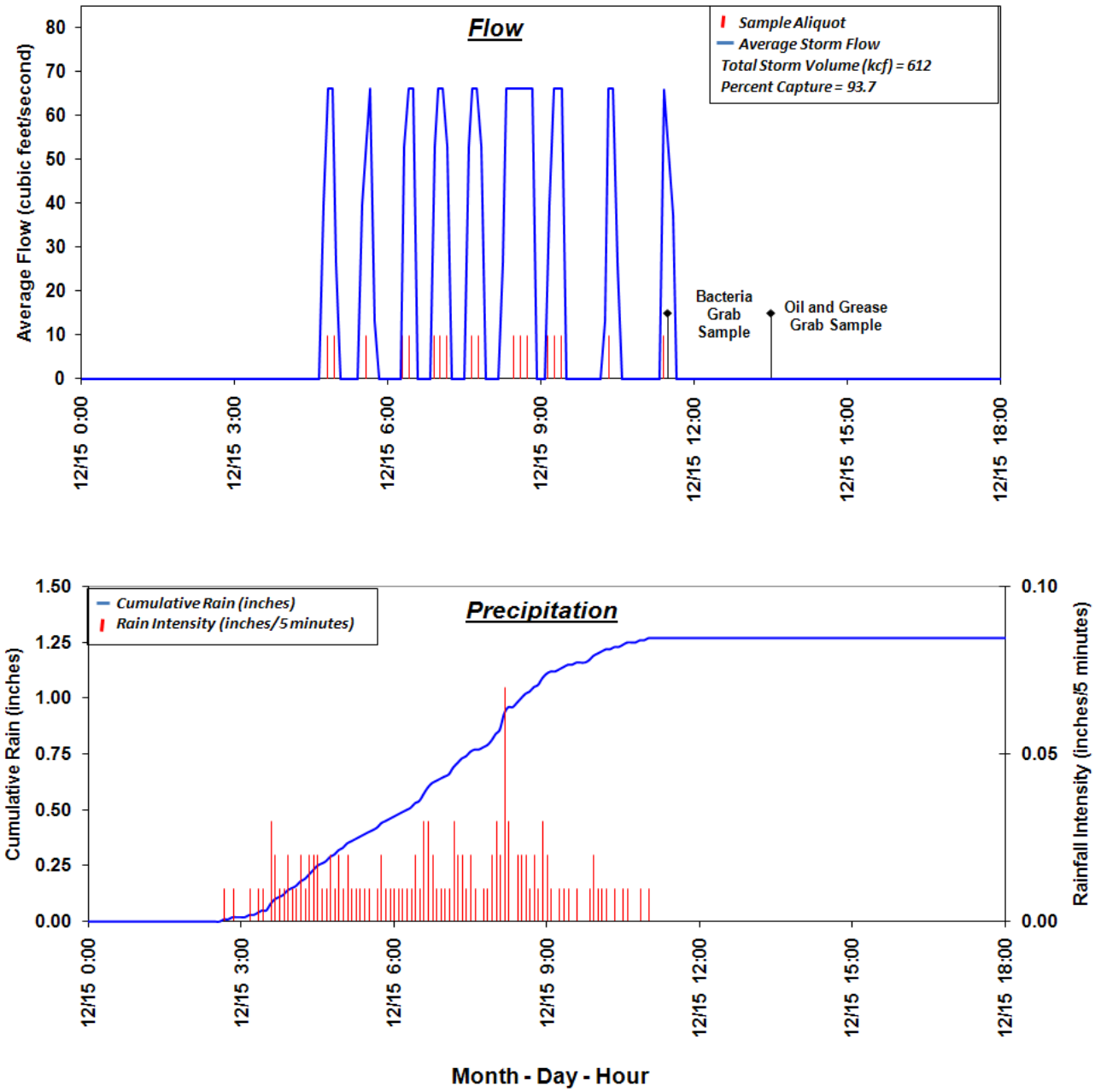


Figure 15. Belmont Pump Station – Event 2 (December 15, 2008 – Global Event 2).

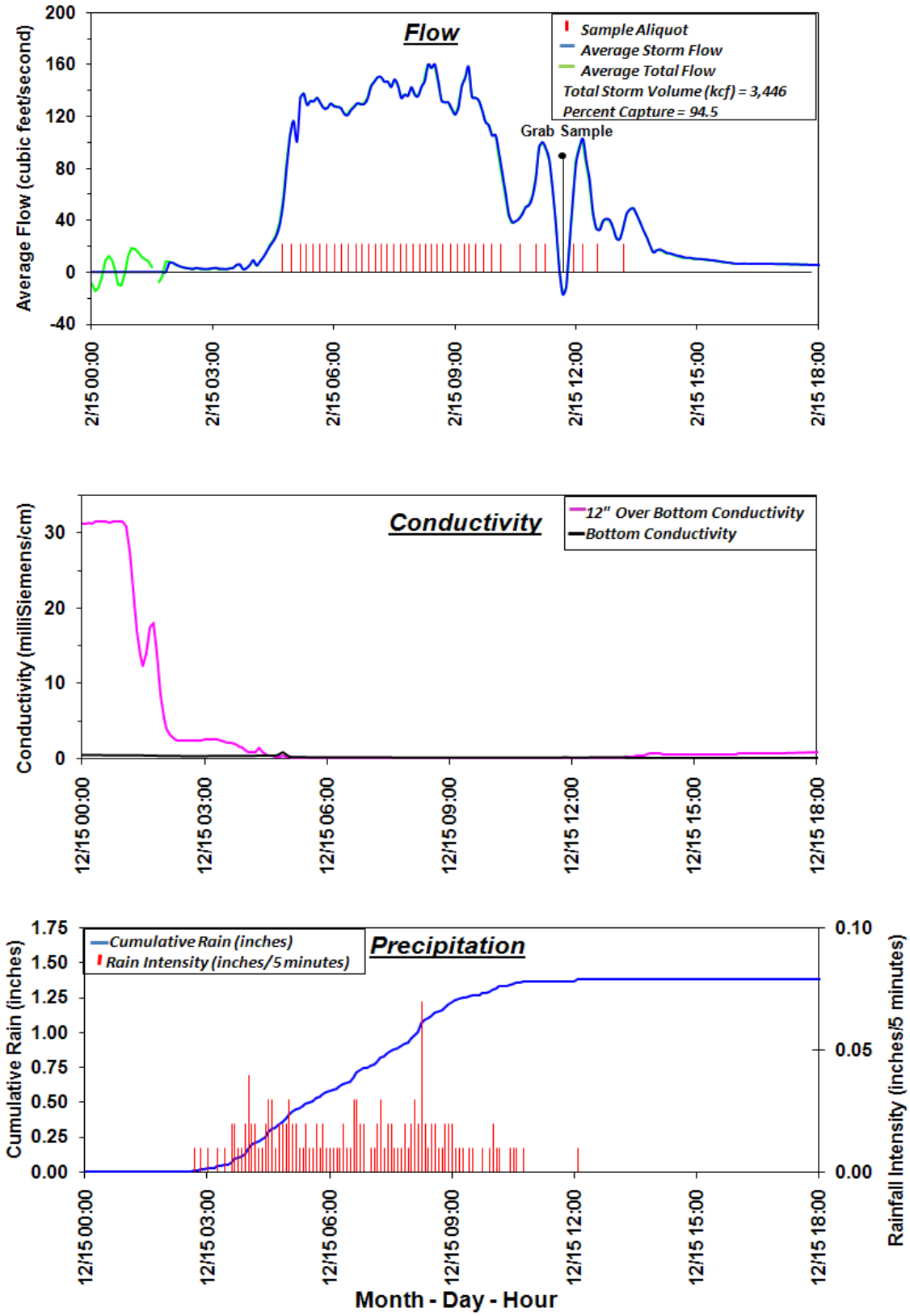


Figure 16. Bouton Creek – Event 1 (December 15, 2008 – Global Event 2).

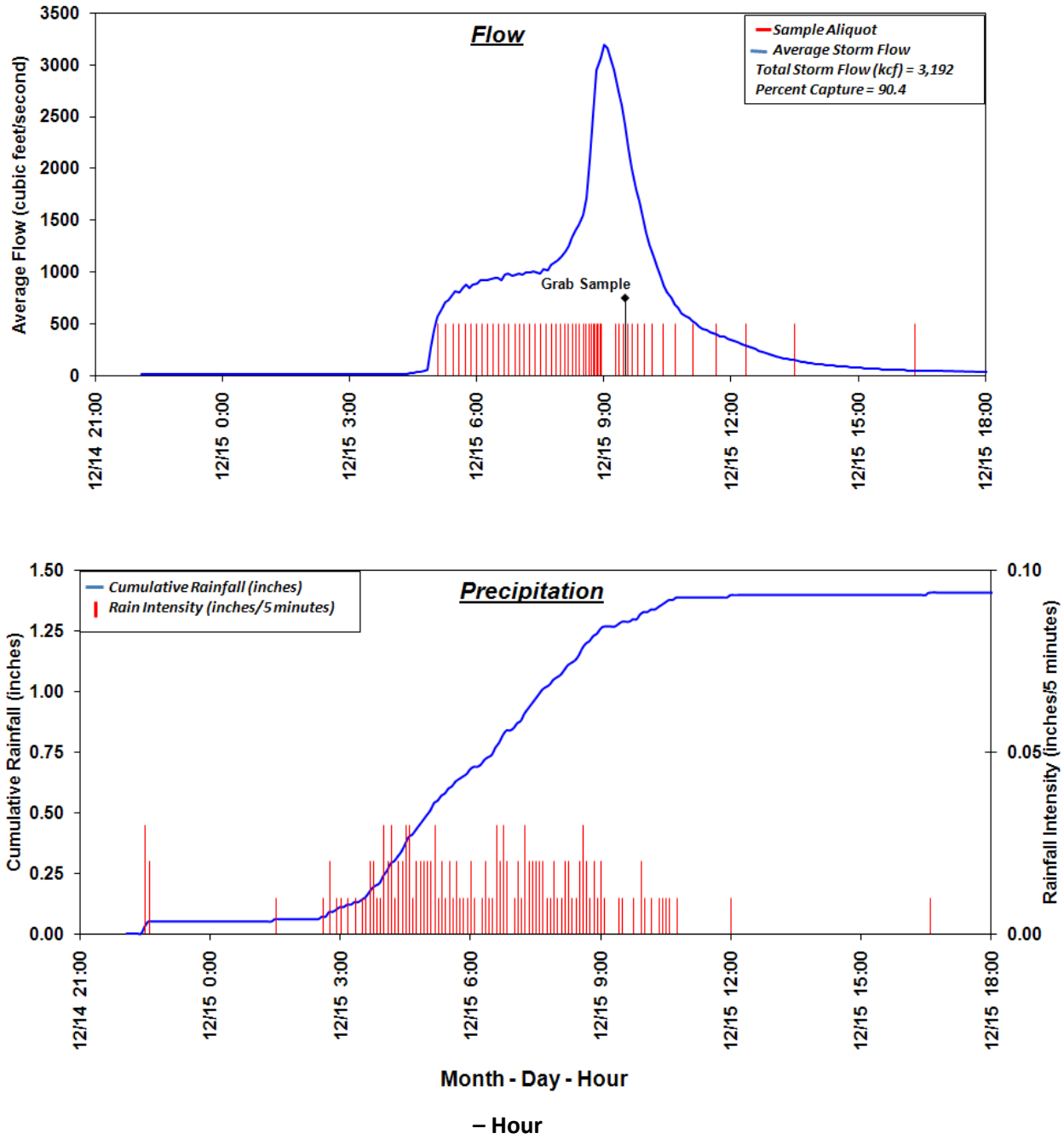


Figure 17. Los Cerritos Channel – Event 1 (December 15, 2008 – Global Event 2).

(Precipitation data from Belmont Pump Station due to malfunction)

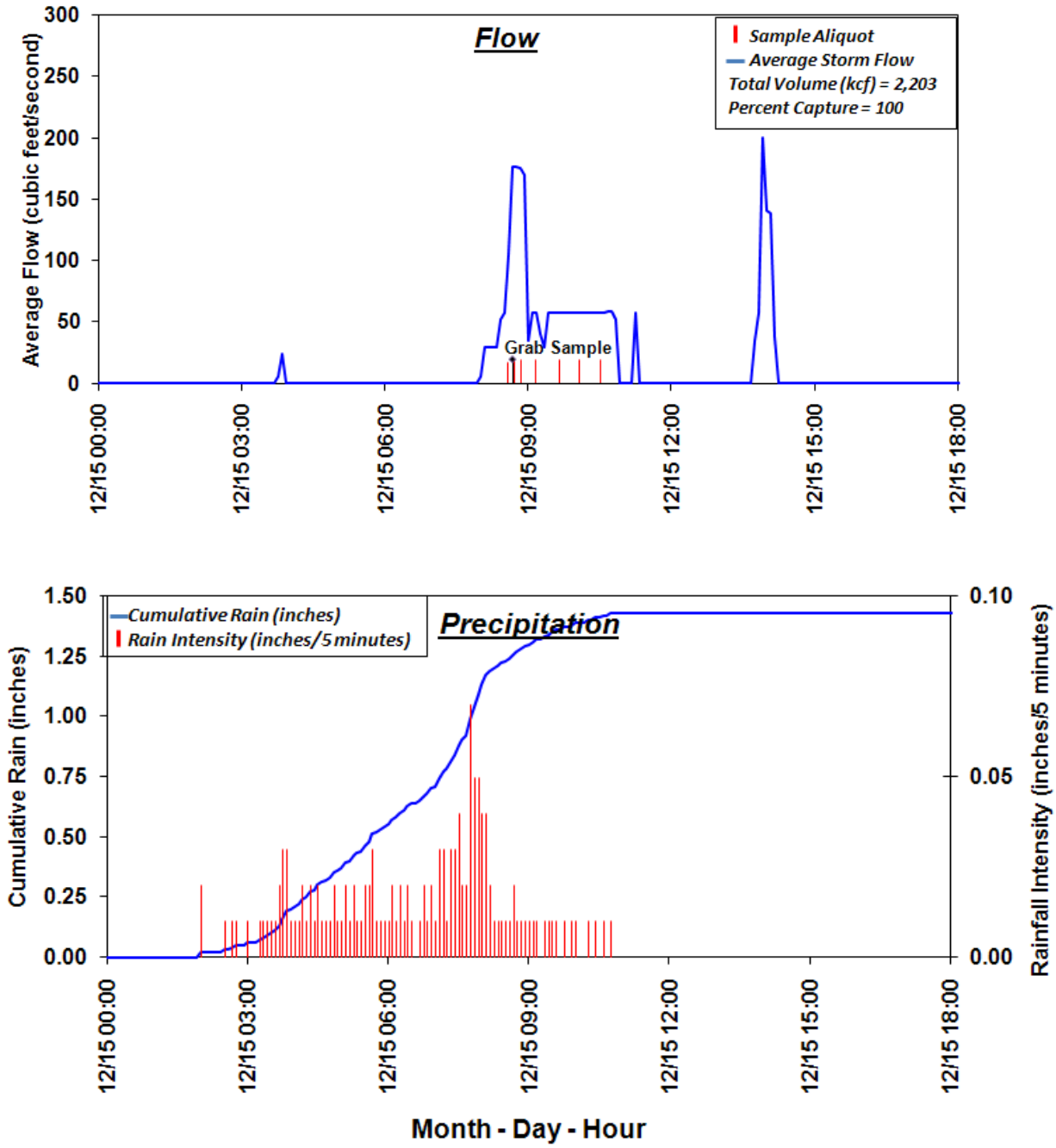


Figure 18. Dominguez Gap Pump Station – Event 2 (December 15, 2008– Global Event 2).

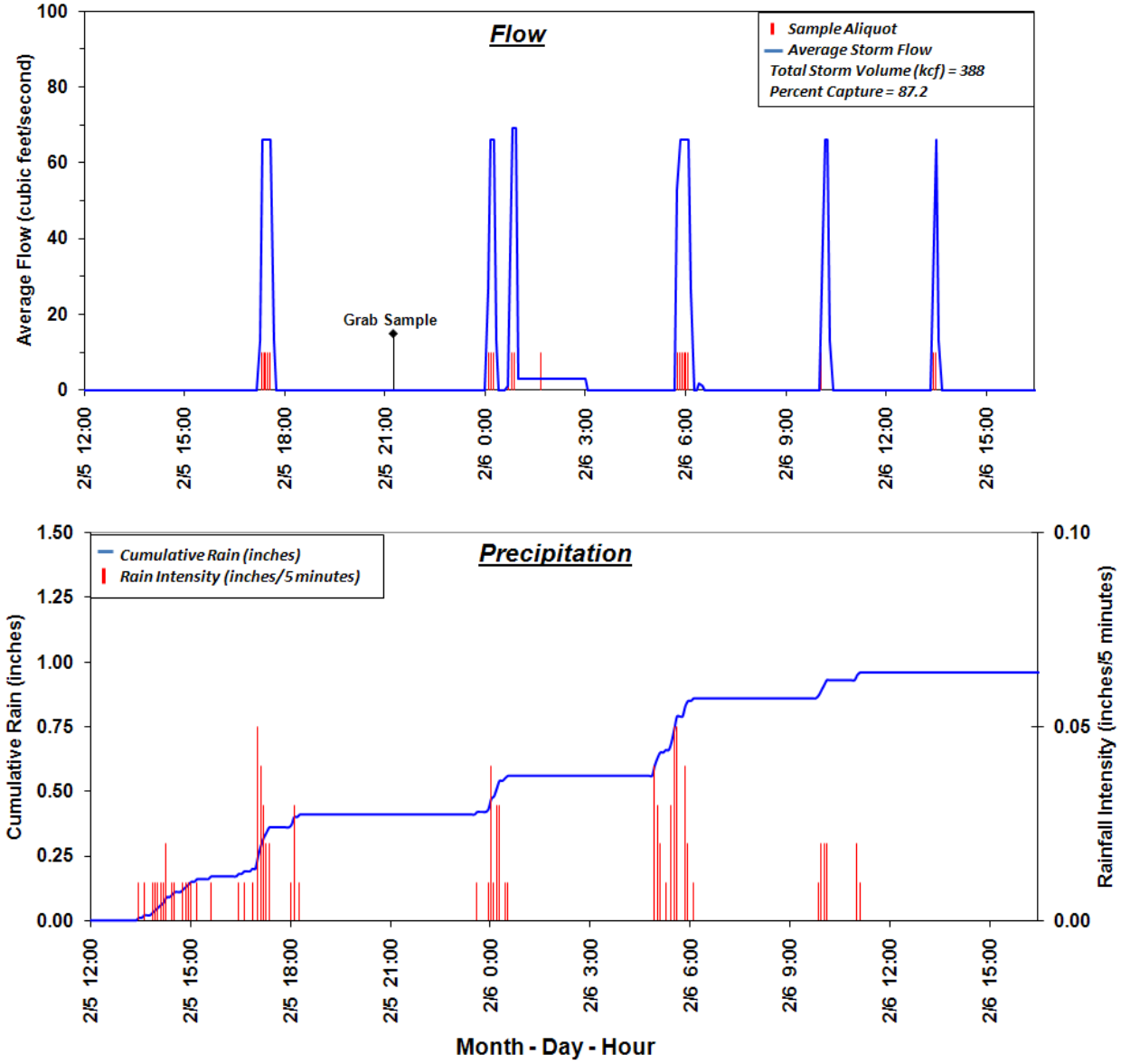


Figure 19. Belmont Pump Station – Event 3 (February 5 – 6, 2009 – Global Event 4).

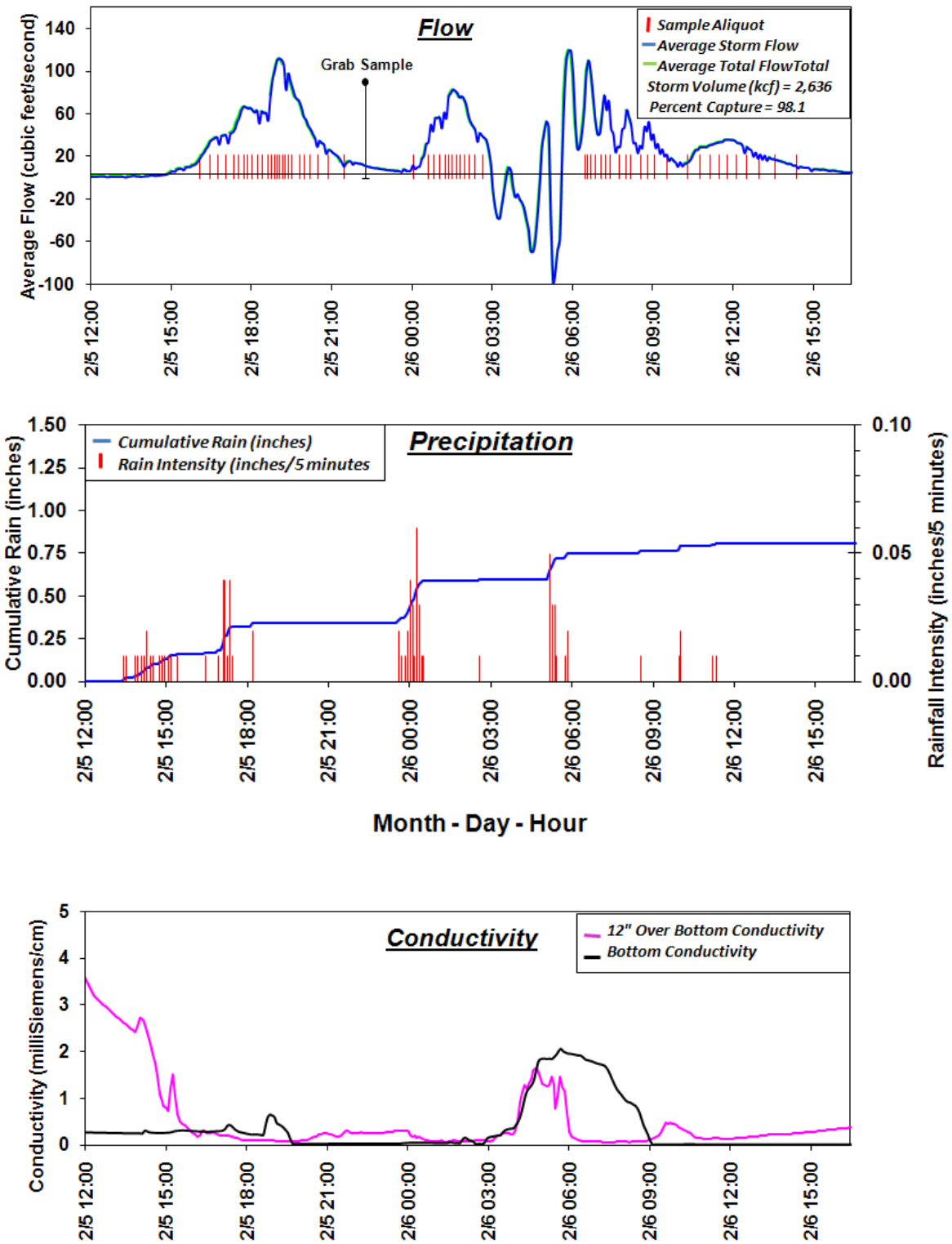


Figure 20. Bouton Creek – Event 2 (February 5-6, 2009 – Global Event 4)

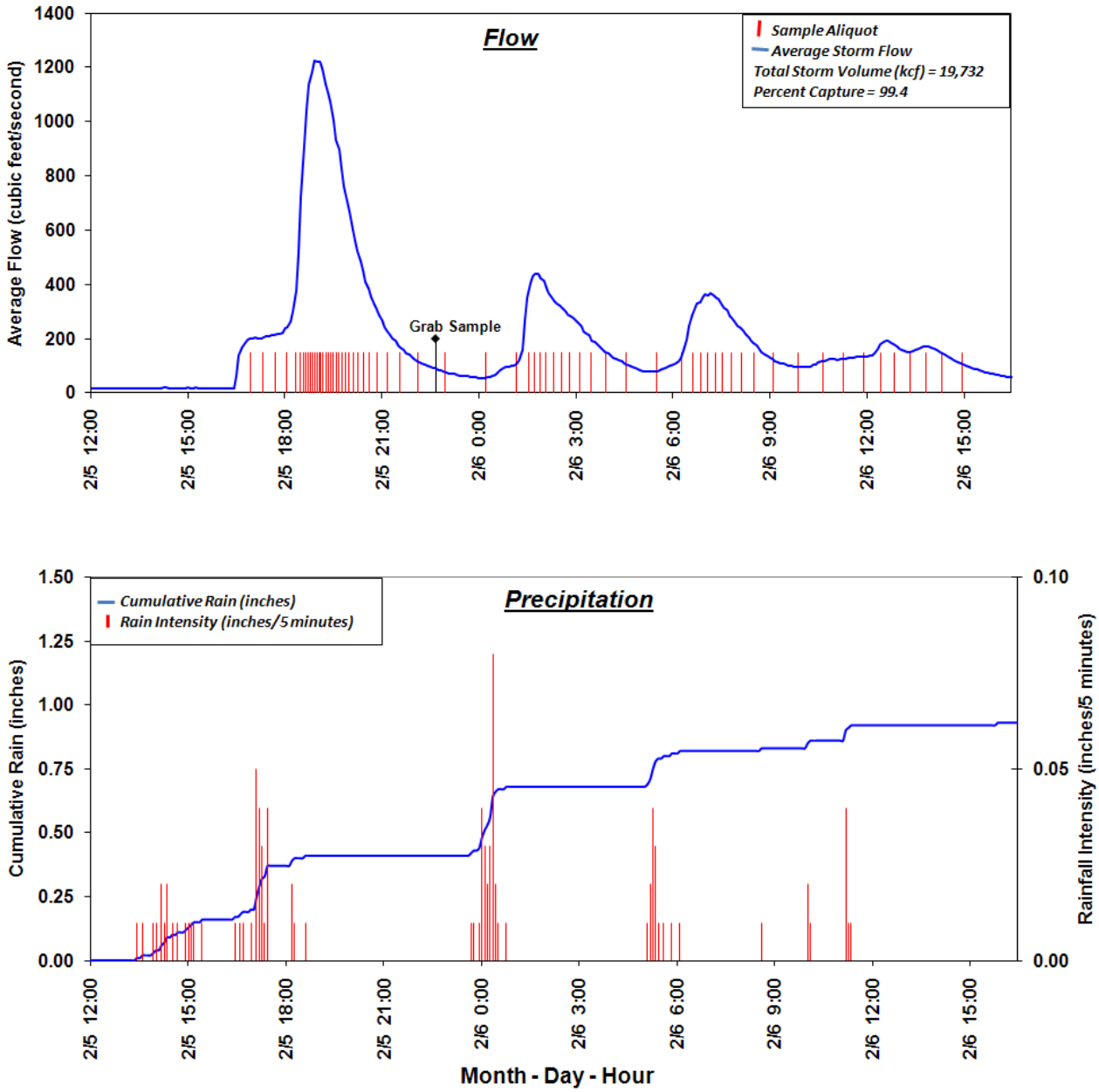


Figure 21. Los Cerritos Channel – Event 2 (February 5-6, 2009 – – Global Event 4).

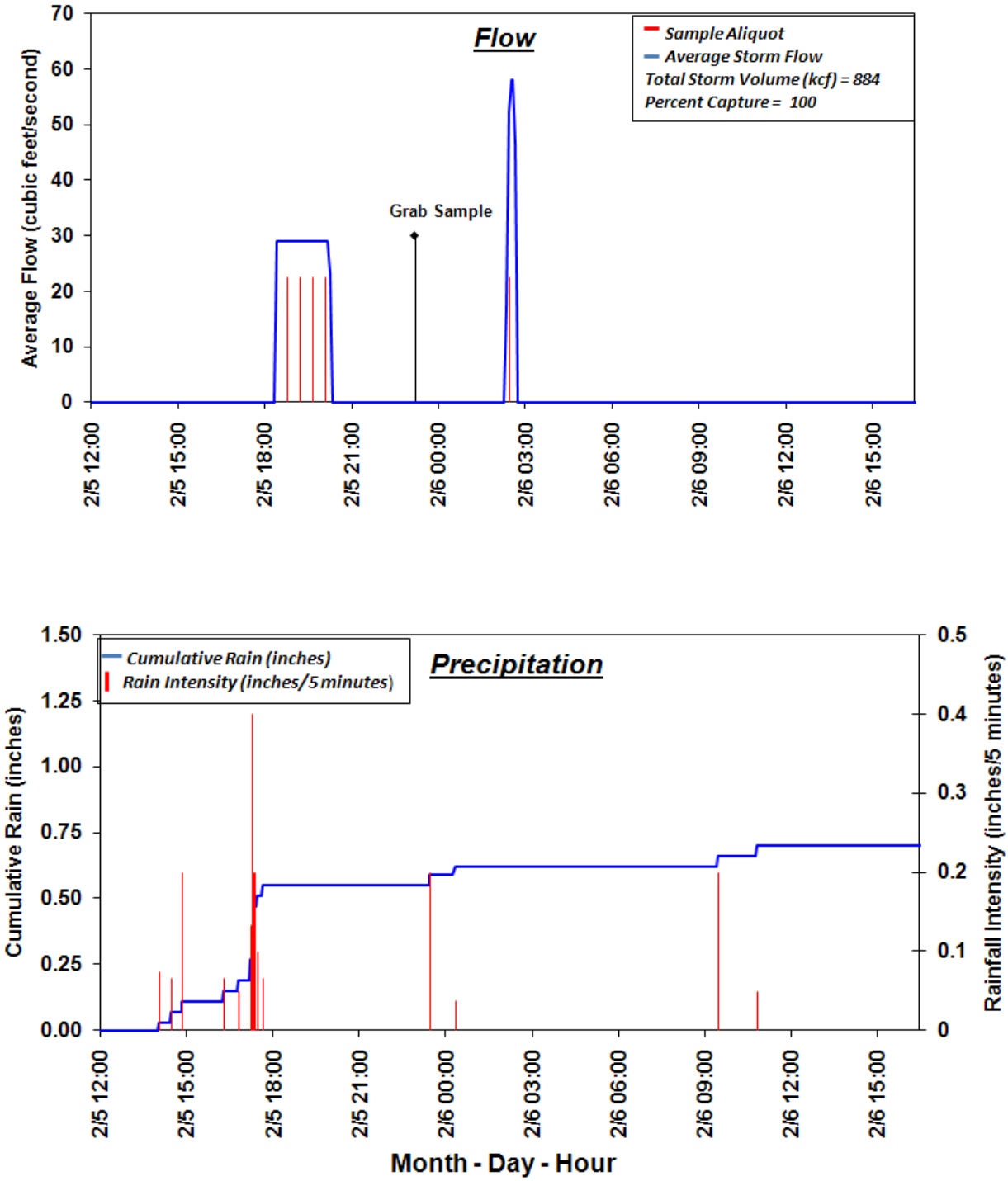


Figure 22. Dominguez Gap Pump Station – Event 3 (February 5-6, 2009 – – Global Event 4).

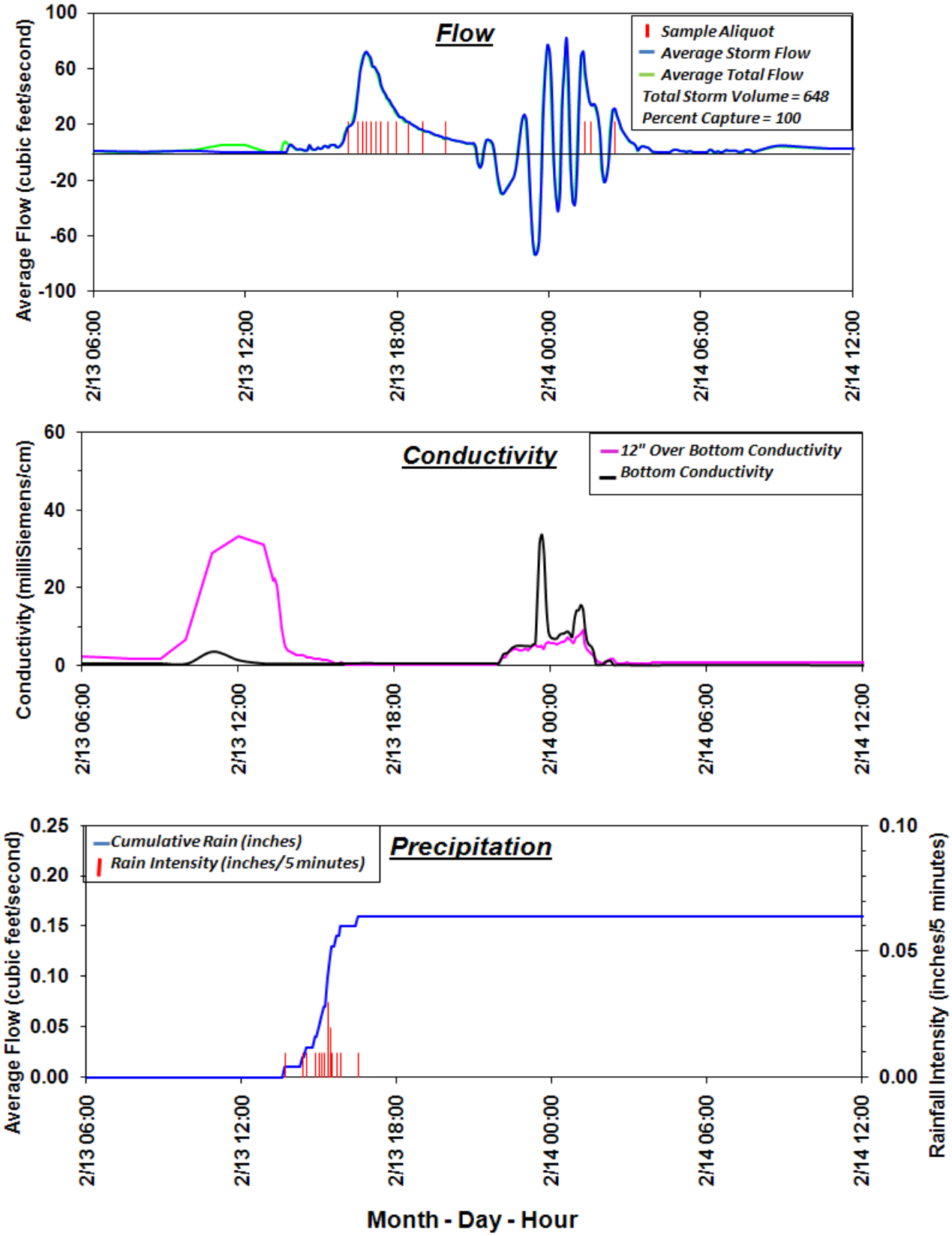


Figure 23. Bouton Creek – Event 3 (February 13-14, 2009 – Global Event 5)

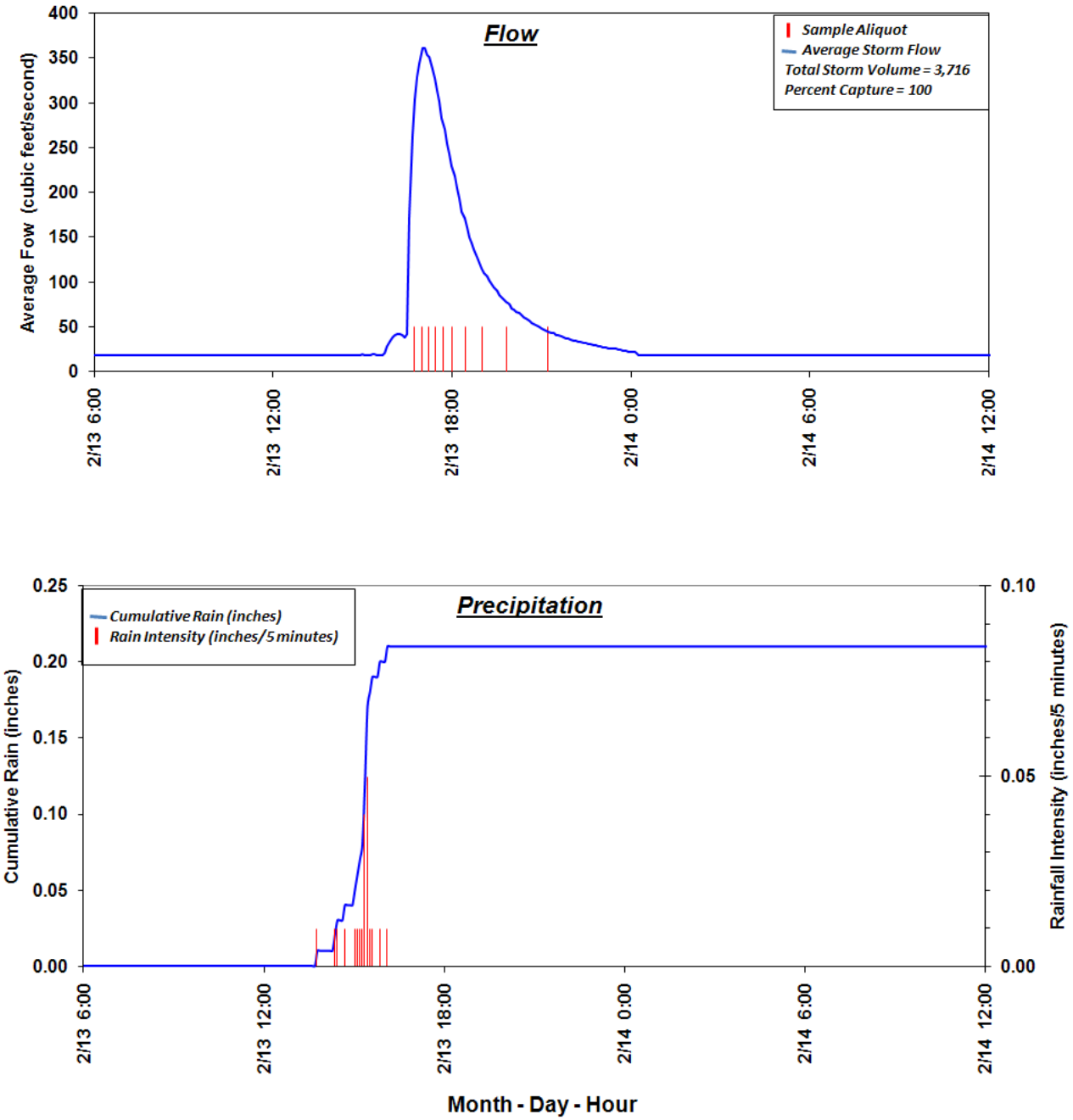


Figure 24. Los Cerritos Channel – Event 3 (February 13-14, 2009 – Global Event 5).

Table 5. Daily Rainfall Data at the Belmont Pump Station during the 2007/2008 and 2008/2009 Wet Weather Seasons.

	September		October		November		December		January		February		March		April		Season Total	
Day	2007	2008	2007	2008	2007	2008	2007	2008	2008	2009	2008	2009	2008	2009	2008	2009	2007/2008	2008/2009
1	0.00	0.00	0.00	0.00	0.00	0.05	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	0.06	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	0.00	0.00	0.00	0.00	0.00	0.01	0.38	0.00	0.00	0.00	0.06	0.00		
4	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.04	0.00	0.00		
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00	0.00	0.43	0.00	0.00	0.00	0.00		
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.00	0.98	0.00	0.00	0.00	0.00		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.01	0.00	0.00	0.24	0.00	0.00	0.00	0.00		
8	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.05		
9	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.17	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	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	0.00	0.00	0.00		
12	0.00	0.00	0.06	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	0.00	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00		
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	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	1.28	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	0.06	0.00	0.00	0.00	1.49	0.00	0.00	0.00	0.00		
17	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00		
18	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
19	0.00	0.00	0.00	0.00	0.00	0.00	0.17	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	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00		
21	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.29	0.00	0.00	0.00	0.00	0.00		
22	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.29	0.00	0.30	0.00	0.00	0.04	0.00	0.00		
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01	0.09	0.04	0.01	0.00	0.00	0.00	0.00		
24	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.08	0.56	0.02	1.33	0.00	0.00	0.00	0.00	0.00		
25	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.32	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
26	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
27	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.83	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	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
29	0.00	0.03	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	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00		
31			0.00	0.02			0.00	0.00	0.00	0.00			0.00	0.00				
Total	**0.36**	**0.15**	**0.71**	**0.02**	**0.96**	**2.23**	**0.93**	**2.82**	**4.53**	**0.12**	**2.57**	**3.78**	**0.00**	**0.08**	**0.06**	**0.05**	**10.12**	**9.25**

Table 6. Daily Rainfall Data at Bouton Creek during the 2007/2008 and 2008/2009 Wet Weather Seasons.

	September		October		November		December		January		February		March		April		Season Total	
Day	2006	2007	2006	2007	2006	2007	2006	2007	2007	2008	2007	2008	2007	2008	2007	2008	2006/2007	2007/2008
1	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00		
2	0.00	0.00	0.00	0.00	0.00	0.01	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	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00		
4	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.00	0.45	0.00	0.41	0.00	0.00	0.03	0.00	0.00		
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.40	0.00	0.00	0.00	0.00		
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.00	0.72	0.00	0.00	0.00	0.00		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.00	0.01	0.00	0.00	0.23	0.00	0.00	0.00	0.00		
8	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00		
9	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.17	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	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	0.00	0.00	0.00		
12	0.00	0.01	0.19	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	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00		
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.05	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	1.38	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	0.05	0.00	0.00	0.00	1.36	0.00	0.00	0.00	0.00		
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.00		
18	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
19	0.00	0.00	0.00	0.00	0.00	0.00	0.13	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	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00		
21	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00		
22	0.16	0.00	0.00	0.01	0.00	0.00	0.00	0.41	0.01	0.00	0.36	0.00	0.00	0.05	0.00	0.00		
23	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.11	0.03	0.00	0.00	0.00	0.00	0.00		
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.98	0.03	1.04	0.00	0.00	0.00	0.00	0.00		
25	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.25	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
26	0.00	0.00	0.00	0.00	0.00	1.10	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	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	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
29	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00		0.00	0.00	0.00	0.00		
30	0.00	0.00	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00		
31			0.00	0.01			0.00	0.00	0.00	0.00			0.00	0.00				
Total	**0.36**	**0.09**	**0.83**	**0.02**	**1.03**	**2.30**	**1.03**	**2.92**	**4.62**	**0.15**	**2.24**	**3.38**	**0.00**	**0.08**	**0.02**	**0.00**	**10.13**	**8.94**

Table 7. Daily Rainfall Data at Los Cerritos Channel during the 2007/2008 and 2008/2009 Wet Weather Seasons.

	September		October		November		December		January		February		March		April		Season Total	
Day	2006	2007	2006	2007	2006	2007	2006	2007	2007	2008	2007	2008	2007	2008	2007	2008	2006/2007	2007/2008
1	0.00	0.00	0.00	0.00	0.00	0.02	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	0.03	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	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.03	0.00		
4	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.49	0.00	0.00	0.01	0.00	0.26	0.00	0.00		
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.44	0.00	0.00	0.00	0.00		
6	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.54	0.00	0.00	0.93	0.00	0.00	0.00	0.00		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00		
8	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00		
9	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.28	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	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	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	0.00	0.00	0.00		
13	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00		
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.06	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	1.36	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	0.03	0.00	0.00	0.00	1.47	0.00	0.00	0.00	0.00		
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00		
18	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
19	0.00	0.04	0.00	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		
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00		
21	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.22	0.00	0.00	0.00	0.00	0.00		
22	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.30	0.00	0.38	0.00	0.00	0.06	0.00	0.00		
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.14	0.03	0.01	0.00	0.00	0.00	0.00		
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.54	0.05	0.98	0.00	0.00	0.00	0.00	0.00		
25	0.00	0.00	0.00	0.00	0.00	0.76	0.00	0.25	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
26	0.00	0.00	0.00	0.00	0.00	1.21	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	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	0.21	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	0.00	0.00		
30	0.00	0.00	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00		
31			0.00	0.02			0.00	0.00	0.00	0.00			0.00	0.00				
Total	**0.97**	**0.04**	**0.54**	**0.02**	**0.65**	**2.40**	**1.22**	**2.86**	**5.08**	**0.19**	**2.27**	**4.28**	**0.00**	**0.32**	**0.03**	**0.00**	**10.76**	**10.11**

Table 8. Daily Rainfall Data at the Dominguez Gap Pump Station during the 2007/2008 and 2008/2009 Wet Weather Seasons.

	September		October		November		December		January		February		March		April		Season Total	
Day	2007	2008	2007	2008	2007	2008	2007	2008	2008	2009	2008	2009	2008	2009	2008	2009	2007/2008	2008/2009
1	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00		
2	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00		
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.04	0.00		
4	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.16	0.00	0.00		
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.60	0.00	0.00	0.00	0.00		
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.32	0.00	0.00	0.00	0.00		
7	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	1.08	0.00	0.00	0.00	0.00		
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.01		
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	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	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	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	0.04	0.00	0.00	0.00	0.00		
13	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00		
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.00	0.00	0.00	0.00		
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.44	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	0.01	0.00	0.00	0.00	1.16	0.00	0.00	0.00	0.00		
17	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00		
18	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
19	0.00	0.00	0.00	0.00	0.00	0.00	0.45	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	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00		
21	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.16	0.00	0.00	0.00	0.00	0.00		
22	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.09	0.00	0.26	0.00	0.00	0.04	0.00	0.00		
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.11	0.02	0.00	0.00	0.00	0.00	0.00		
24	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.02	0.30	0.17	0.73	0.00	0.00	0.00	0.00	0.00		
25	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.27	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
26	0.00	0.00	0.00	0.00	0.00	1.84	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00		
27	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.46	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	0.48	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	0.14	0.00	0.00		0.00	0.00	0.00	0.00		
30	0.00	0.00	0.00	0.00	1.07	0.00	0.00	0.00	0.06	0.00			0.00	0.00	0.00	0.00		
31			0.00	0.03			0.00	0.00	0.03	0.00			0.00	0.00				
Total	**0.97**	**0.28**	**0.35**	**0.03**	**1.07**	**2.50**	**1.30**	**2.54**	**3.70**	**0.28**	**1.87**	**4.44**	**0.00**	**0.20**	**0.07**	**0.01**	**9.33**	**10.28**

Table 9. Rainfall for Monitored Events during the 2008/2009 Wet-Weather Season.

Site/Event	Start Rain Date	Start Rain Time	End Rain Date	End Rain Time	Duration Rain (hours:minutes)	Total Rain (inches)	Max Intensity (Inches/5 minutes)	Antecedent Rain (days)	Antecedent Rain (inches)	Sampling Code
Event 1										
BELMONT PUMP ST.	11/25/2008	21:20	11/26/2008	7:00	9:40:00	1.58	0.84	21.6	0.47	Full
BOUTON CREEK	11/25/2008	21:15	11/26/2008	3:20	6:05:00	1.87	0.72	21.6	0.41	NS
LOS CERRITOS CHANNEL[1]	11/25/2008	21:15	11/26/2008	3:20	6:05:00	1.87	0.72	21.6	0.41	NS
DOMINGUEZ PUMP ST.	11/25/2008	20:55	11/26/2008	10:45	13:50:00	1.12	0.40	21.6	0.41	Full
Event 2										
BELMONT PUMP ST.	12/15/2008	2:40	12/15/2008	11:00	8:20:00	1.27	0.84	18.8	1.58	Full
BOUTON CREEK	12/15/2008	2:40	12/15/2008	12:05	9:25:00	1.38	0.84	19.0	1.87	Full
LOS CERRITOS CHANNEL	12/14/2008	22:30	12/15/2008	17:00	18:30:00	1.41	0.36	18.8	1.69	Full
DOMINGUEZ PUMP ST.	12/15/2008	2:00	12/15/2008	10:45	8:45:00	1.43	0.84	18.6	1.12	Full
Event 3										
BELMONT PUMP ST.	2/5/2009	13:25	2/6/2009	11:05	21:40:00	0.96	0.60	12.3	0.11	Full
BOUTON CREEK	2/5/2009	13:25	2/6/2009	11:20	21:55:00	0.81	0.72	12.3	0.12	Full
LOS CERRITOS CHANNEL	2/5/2009	13:25	2/6/2009	11:20	21:55:00	0.92	0.96	12.3	0.14	Full
DOMINGUEZ PUMP ST. [2]	2/5/2009	14:02	2/6/2009	10:49	20:47:00	0.70	0.60	12.2	0.26	Full
Event 4										
BOUTON CREEK	2/13/2009	13:40	2/13/2009	16:30	2:50:00	0.16	0.36	4.1	0.17	TSS
LOS CERRITOS CHANNEL	2/13/2009	13:45	2/13/2009	16:04	2:19:00	0.21	0.60	4.1	0.28	TSS

Sampling Codes
Full = Sampled for full suite of chemical constituents
TSS = Sampled for TSS only
NS = No samples collected by autosampler

[1]Precipitation data from Bouton Creek used for Los Cerritos Channel due to debris in rain gauge.
[2]Precipitation data from Wardlow Road ALERT gauge (314-LA River) used for Dominguez Gap due to equipment malfunction.

Table 10. Descriptive Statistics - Rainfall and Flow Data for All Monitored Events (2008/2009).

Site / Parameter	n	Missing Values	Min	Max	Mean	Standard Deviation	1st Quartile	Median	3rd Quartile
BELMONT PUMP ST.									
Duration Flow (days)	3	0	0.28	0.85	0.49	0.31	0.31	0.34	0.59
Total Flow (kcf)	3	0	388	773	591	193	500	612	692
Duration Rain (days)	3	0	0.35	0.90	0.55	0.31	0.38	0.40	0.65
Total Rain (inches)	3	0	0.96	1.58	1.27	0.31	1.12	1.27	1.43
Max Intensity (inches/hr)	3	0	0.60	0.84	0.76	0.14	0.72	0.84	0.84
Antecedent Dry (days)	3	0	12.30	21.60	17.57	4.77	15.56	18.82	20.21
Antecedent Rain (inches)	3	0	0.11	1.58	0.72	0.77	0.29	0.47	1.03
BOUTON CREEK									
Duration Flow (days)	2	1	0.75	0.85	0.80	0.06	0.78	0.80	0.82
Total Flow (kcf)	2	1	388	3446	1917	2162	1152	1917	2681
Duration Rain (days)	2	1	0.39	0.90	0.65	0.36	0.52	0.65	0.78
Total Rain (inches)	2	1	0.96	1.38	1.17	0.30	1.07	1.17	1.28
Max Intensity (inches/hr)	2	1	0.60	0.84	0.72	0.17	0.66	0.72	0.78
Antecedent Dry (days)	2	1	12.30	18.97	15.64	4.72	13.97	15.64	17.30
Antecedent Rain (inches)	2	1	0.11	1.87	0.99	1.24	0.55	0.99	1.43
LOS CERRITOS CHANNEL									
Duration Flow (days)	2	1	0.69	0.97	0.83	0.19	0.76	0.83	0.90
Total Flow (kcf)	2	1	19732	32368	26050	8935	22891	26050	29209
Duration Rain (days)	2	1	0.77	0.91	0.84	0.10	0.81	0.84	0.88
Total Rain (inches)	2	1	0.92	1.41	1.17	0.35	1.04	1.17	1.29
Max Intensity (inches/hr)	2	1	0.36	0.96	0.66	0.42	0.51	0.66	0.81
Antecedent Dry (days)	2	1	12.30	18.80	15.55	4.60	13.92	15.55	17.17
Antecedent Rain (inches)	2	1	0.14	1.69	0.92	1.10	0.53	0.92	1.30
DOMINGUEZ GAP PUMP ST.									
Duration Flow (days)	3	0	0.16	0.35	0.25	0.09	0.21	0.26	0.30
Total Flow (kcf)	3	0	884	2203	1504	662	1155	1427	1815
Duration Rain (days)	3	0	0.36	0.87	0.60	0.25	0.47	0.58	0.72
Total Rain (inches)	3	0	0.70	1.43	1.08	0.37	0.91	1.12	1.28
Max Intensity (inches/hr)	3	0	0.60	2.04	1.16	0.77	0.72	0.84	1.44
Antecedent Dry (days)	3	0	12.20	21.58	17.47	4.80	15.42	18.64	20.11
Antecedent Rain (inches)	3	0	0.26	1.12	0.60	0.46	0.34	0.41	0.77

Table 11. Flow for Monitored Events during the 2008/2009 Wet Weather Season.

Site/Event	Start Flow Date	Start Flow Time	End Flow or Date	End Flow or Time	Flow or Discharge Duration (hrs:mins)	Total Flow (kilo- cubic feet)	No. of Sample Aliquots Collected	Peak Flow (cfs)	% Storm Capture	Peak Capture	Sampling Code
Event 1											
BELMONT PUMP ST.	11/25/2008	22:52	11/26/2008	6:58	8:06	773	21	132	86.9	Y	Full
BOUTON CREEK											NS
LOS CERRITOS CHANNEL											NS
DOMINGUEZ PUMP ST	11/26/2008	0:56	11/26/2008	4:48	3:52	1427	8	292	91.0	Y	Full
Event 2											
BELMONT PUMP ST.	12/15/2008	4:42	12/15/2008	11:31	6:49	612	19	134	93.7	Y	Full
BOUTON CREEK	12/15/2008	1:55	12/15/2008	20:00	18:05	3446	40	160	94.5	Y	Full
LOS CERRITOS CHANNEL	12/15/2008	4:20	12/15/2008	21:00	16:40	32368	53	3192	90.4	Y	Full
DOMINGUEZ PUMP ST	12/15/2008	7:59	12/15/2008	14:07	6:08:	2203	7	60	100	Y	Full
Event 3											
BELMONT PUMP ST.	2/5/2009	17:14	2/6/2009	13:31	20:17	388	22	69	87.2	Y	Full
BOUTON CREEK	2/5/2009	15:00	2/6/2009	15:15	24:15:00	2636	64	120	98.1	Y	Full
LOS CERRITOS CHANNEL	2/5/2009	16:27	2/6/2009	15:41	23:14:00	19732	68	1254	99.4	Y	Full
DOMINGUEZ PUMP ST	2/5/2009	18:20	2/6/2009	2:39	8:19:00	884	5	191	100	Y	Full
Event 4											
BOUTON CREEK	2/13/2009	13:19	2/14/2009	5:45	16:26:00	648	15	82	100	Y	TSS
LOS CERRITOS CHANNEL	2/13/2009	15:50	2/14/2009	0:10	8:20:00	3716	10	361	100	Y	TSS

Sampling Codes

Full = Sampled for full suite of chemical constituents
TSS = Sampled for TSS only
ND = No discharge
None = No samples collected by autosampler
Grab Only = Only Bacteria and Oil & Grease grab samples collected

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CHEMISTRY RESULTS

The following sections separately summarize the results of wet weather and dry weather monitoring efforts.

WET WEATHER CHEMISTRY RESULTS

A total of four storm events were monitored during the 2008/2009 season (Table 12). Three full storm events were monitored at each of the Belmont Pump and Dominguez Gap mass emission stations while two full storm events were monitored at the Bouton Creek and Los Cerritos Channel mass emission stations. In addition, one TSS event was monitored at both the Bouton Creek and Los Cerritos Channel stations. These two sites were sampled for TSS only due to the lack of sufficient rainfall (0.16 to 0.21 inches) and runoff to conduct all required analyses.

The results of the chemical analysis of these composite and grab stormwater samples are summarized in Table 13 and Table 14. Any values exceeding benchmarks are highlight and footnoted to indicate which of the benchmarks are exceeded. Toxicity results for the composite samples from these monitored events are presented separately in the following section (Toxicity Results).

WET WEATHER LOAD CALCULATIONS

Estimates of total pollutant loads associated with stormwater runoff during each storm event are provided in Table 15 and Table 16. Load calculations were made by multiplying the measured concentration times the total stormwater discharge along with the appropriate unit conversion factors. The following calculation is an example of the process used for analytes such as TSS that are measured in mg/L. The specific example is for the first storm event at the Los Cerritos Channel mass emission monitoring station.

$$(150 \text{ mg/L}) \times [(32368 \text{ kcf})(28317 \text{ L/kcf})] \times (1 \text{ pound}/453592 \text{ mg}) = 303{,}102 \text{ pounds}$$

Consistent with sound scientific practice, total pollutant loads are reported to two significant figures since all chemical data are also reported to two significant figures. Thus the TSS load for the first monitored event at the Los Cerritos Channel is reported as 300,000 pounds or 150 tons of sediment.

As one would expect, pollutant loads are largely controlled by the size of the watershed. Over the past eight years, the Los Cerritos Channel (Table 16) has consistently produced the highest overall loads of solids and total metals simply due to the large size of the watershed and lack of infiltration capacity.

Of the two mass emission sites successfully monitored during the first storm event of the season (November 26, 2008) only the Belmont Pump Station showed evidence of dramatically higher pollutant loads than measured in later season events. As an example, load estimates for total metals such as copper, lead, nickel and zinc were two to four times higher during this first flush event than measured in either of the other two events. The substantially higher loads during the first event were associated with the highest rainfall of the season but it was only 20% greater than the subsequent event.

Pollutant loads are consistently lowest at the Belmont Pump Station (Table 15) which has the smallest catchment area. This site was estimated to discharge 2,900 to 8,700 pounds of solids in association with the three events. The load of total copper discharged from the Belmont Pump Station during the three fully monitored events was estimated at 0.87 and 3.0 pounds.

Loading estimates for solids from the Dominguez Gap Pump Station have typically been lower than all other sites but for the third year in a row, total solid loads were found to exceed those measured at

the Belmont Pump Station on two out of three events when both sites were monitored (Table 15 and Table 16). A total of 8,900 pounds of sediment were discharged from the Dominguez Gap Pump Station during the November 26th storm event compared to 8,700 pounds of sediment discharged at the Belmont Pump Station. During the December 15th, 2008 event sediment load estimates from the Dominguez Gap Pump Station were 17,000 pounds compared to only 2,900 pounds from the Belmont Pump Station. Historically, estimated loads of total recoverable metals such as copper and lead from the Dominguez Gap Pump Station have been the lowest encountered at all mass emission sites but since the reconfiguration of the Pump Station to accommodate development of the wetlands, metal loads estimated for the Dominguez Gap and Belmont Pump Stations have been comparable.

DRY WEATHER CHEMISTRY RESULTS

The NPDES Permit requires that two dry weather inspections and sampling events are to be conducted each year. These surveys are conducted during the summer dry weather period at each of the four mass emission stations. A total of 20 dry weather surveys have been conducted since issuance of the permit in 1999 (Table 17). Events 19 and 20 conducted during the 2008/2009 season are shaded. Field measurements are provided in Table 18 for the 2008/2009 season. Chemical analyses performed in the laboratory are summarized in Table 19 for the 2008/2009 season.

Dry weather flow at the Belmont Pump Station continues to be pumped into the sanitary sewer system for treatment. Since this site no longer discharges dry weather flow to the receiving waters, no water samples or field measurements were taken. The site was still visited during each of the dry weather surveys to verify that the bypass was operational.

Basin 20: Bouton Creek Monitoring Site

Bouton Creek was inspected during both of the 2008/2009 dry weather events. The inspections occurred 2-3 hours after the low-low tide of the day and continued until the rising tide began to flood the channel with seawater again. During these periods, flow in the creek was not impeded by seawater backing into the creek. In previous years the flow has usually been freshwater flowing downstream and the volume of fresh flow had been sufficient to flush residual saltwater from the channel.

This year no samples were collected during either inspection. Flow was very low during both inspections. Portions of the crown of the channel bottom were exposed, and there was extensive algae growth across the entire bottom. The salinity of the flow did not fall below 17 ppt during the July 2008 inspection and did not fall below 10.8 ppt during the May 2009 inspection

Portions of Basins 18, 19, 27 and 29: Los Cerritos Channel Monitoring Site

Twenty-four hour, time-weighted samples were collected during each of the 2008/2009 dry weather surveys. Sampling began on July 1, 2008 and ended on July 2nd. The sampling for the second event began on May 6, 2009 and ended on May 7th.

Samples were taken from the middle of the channel using the automated sampler installed on the bank of the channel. Dry weather flows consisted of a shallow, narrow stream located near the middle of the channel. To reach the water, the sampling hose that is used for sampling storm water was extended an additional 33 feet to reach the low flow channel. Every half-hour for 24 hours, an aliquot of approximately 0.75 liters of water was pumped into a 20-liter bottle. The bottles were changed every 12 hours and chilled to 4°C with ice during sampling and transportation. Following completion of the sampling, the bottles of water were combined into a composite sample. Grab samples were manually collected for oil and grease and bacteria at the end of the 24-hour sampling on July 2nd at 0900 and at the end of the 24-hour sampling on May 7th at 0920.

Basin 14: Dominguez Gap Monitoring Site

Inspections for dry weather flow were conducted at the Dominguez Gap Pump Station on July 1, 2008 and on May 6, 2009. There were pools of standing water in the concrete channel east of the infiltration basin, but no flowing water was observed on either occasion. During both inspections the maintenance pump that is supposed to maintain flow through the wet basin during the dry weather season was not operational. There were no samples collected or field measurements made during the 2008/2009 dry weather season

The maintenance pump failed due to overload almost immediately following its installation. After some delay due to budget restrictions the pump was replaced. The new pump experienced similar problems. The Flood Control Department of the Los Angeles County Department of Public Works is continuing to work towards resolution of this problem. Once a solution is reached, sensors will need to be installed to estimate flow from the summer pump.

Table 12. Monitored Storm Events, 2008/2009.

Global Event	Event 1	Event 2	Event 3	Event 4
Date	26-Nov-08	15-Dec-08	5-Feb-09	13-Feb-09
Belmont Pump	S-1	S-2	S-3	
Bouton Creek	*	S-1	S-2	TSS-1
Los Cerritos Channel	*	S-1	S-2	TSS-1
Dominguez Gap	S-1	S-2	S-3	

S=Full Storm Composites
TSS=Storm Events monitored for TSS only
* Battery failure – defective units

Table 13. Belmont Pump and Bouton Creek Stormwater Chemistry Results, 2008/2009.

	Belmont Pump			Bouton Creek		
Valid Name	**26-Nov-08**	**15-Dec-08**	**5-Feb-09**	**15-Dec-08**	**5-Feb-09**	**14-Feb-09**
Conventionals (mg/L unless noted)						
pH (pH Units)	6.87	7.31	7.56	7.42	7.17	
Alkalinity as CaCO3	17	17	57	16	22	
Biochemical Oxygen Demand	15	17	12	24	12	
Chemical Oxygen Demand	85	63	120	69	110	
Chloride	8.7	16	36	21	22	
Conductivity (uS/cm)	100	120	220	140	150	
Fluoride	0.11	0.12	0.17	0.17	0.17	
Hardness as CaCO3	20	21	32	23	27	
MBAS	0.059J	0.11	0.21	0.11	0.19	
Nitrate (as N)	0.76	0.52	0.59	0.61	0.53	
Nitrite (as N)	0.028J	0.021J	0.063J	0.023J	0.061J	
Oil and Grease	5U	3.2J	2.6J	2.1J	1.2J	
Total Ammonia (as N)	0.27	0.18	0.39	0.35	0.29	
Total Dissolved Solids	64	77	140	86	110	
Total Kjeldahl Nitrogen	2.2	1.6	2.2	1.7	1.7	
Total Organic Carbon	14	9.1	16	13	16	
Orthophosphate (as P)	0.71	0.38	0.25	0.27	0.16	
Total Phosphorus	1.2	1	0.89	0.87	0.87	
Total Recoverable Phenolics	0.1U	0.1U	0.1U	0.1U	0.1U	
Total Suspended Solids	180	100	120	62	96	96
Total Volatile Solids	84	48	53	23	34	
Turbidity (NTU)	53	28	48	24	59	
Dissolved Metals (µg/L)						
Aluminum	20J	18J	17J	21J	30	
Arsenic	0.97	0.97	1.1	1.1	1.2	
Cadmium	0.05J	0.05J	0.063J	0.17J	0.057J	
Chromium	0.4J	0.72	0.61	1.7	1.3	
Copper	**9.5** [5,6]	**11** [5,6]	**13** [5,6]	**9.8** [5,6]	**11** [5,6]	
Iron	56	39	46	50	59	
Lead	**0.92** [5]	**0.7** [5]	0.53	**1** [5]	**0.73** [5]	
Nickel	2.5	2.2J	2.4	2.9J	2.1	
Selenium	1U	1U	1U	1U	1U	
Silver	0.019J	0.045J	0.2U	0.015J	0.026J	
Zinc	**57** [5]	**60** [5]	**61** [5]	**53** [5]	**50** [5]	
Total Metals (µg/L)						
Aluminum	**2800** [2,7]	**950** [7]	**1300** [2,7]	**830** [7]	**1900** [2,7]	
Arsenic	2.7	1.5	1.7	1.7	2	
Cadmium	0.85	0.3	0.34	0.43	0.37	
Chromium	7.9	3.8	3.9	17	6.4	
Copper	**62** [1]	**32** [1]	**36** [1]	**21** [1]	**34** [1]	
Iron	**5100** [7]	**1900** [7]	**2100** [7]	**1500** [7]	**3000** [7]	
Lead	**41** [1]	**14** [1]	**19** [1]	8	**15** [1]	
Nickel	9.5	4.8	5.6	4.9	5.8	
Selenium	1U	1U	1U	1U	1U	
Silver	0.15J	0.039J	0.057J	0.016J	0.064J	
Zinc	**380** [1]	**180** [1]	**190** [1]	**130** [1]	**190** [1]	

Bolded values with superscripts exceed criteria 1-Ocean Plan, 2-LA Basin Plan, 3-Cal. Fish&Game Freshwater, 4-Cal Fish&Game Saltwater, 5-Cal. Toxics Rule Freshwater, 6-Cal. Toxics Rule Saltwater, 7-National Non-Priority Freshwater, 8-National Non-Priority Pollutant Saltwater. U=not detected at the detection limit, J=value is considered an estimate, J- = value is considered to be a low estimate, J+=value is considered to be a high estimate.

Table 13. Belmont Pump and Bouton Creek Stormwater Chemistry Results, 2008/2009. (Continued).

	Belmont Pump			Bouton Creek		
Valid Name	**26-Nov-08**	**15-Dec-08**	**5-Feb-09**	**15-Dec-08**	**5-Feb-09**	**14-Feb-09**
Bacteria						
Enterococcus (CFU/100 ml)	**19000** [1,2]	**32000** [1,2]	**20000** [1,2]	**9800** [1,2]	**22000** [1,2]	
Fecal Coliform (MPN/100 ml)	**90000** [1,2]	**17000** [1,2]	**5000J** [1,2]	**5000** [1,2]	**3000J** [1,2]	
Total Coliform (MPN/100 ml)	**90000J** [1,2]	**30000** [1,2]	**50000** [1,2]	**30000** [1,2]	**22000** [1,2]	
Aroclors (µg/L)						
Aroclor 1016	0.02U	0.02U	0.02U	0.02U	0.02U	
Aroclor 1221	0.02U	0.02U	0.02U	0.02U	0.02U	
Aroclor 1232	0.02U	0.02U	0.02U	0.02U	0.02U	
Aroclor 1242	0.02U	0.02U	0.02U	0.02U	0.02U	
Aroclor 1248	0.02U	0.02U	0.02U	0.02U	0.02U	
Aroclor 1254	0.02U	0.02U	0.02U	0.02U	0.02U	
Aroclor 1260	0.02U	0.02U	0.02U	0.02U	0.02U	
Total Aroclors	0	0	0	0	0	
Chlorinated Pesticides (µg/L)						
2,4'-DDD	0.005U	0.005U	0.005U	0.005U	0.005U	
2,4'-DDE	0.005U	0.005U	0.005U	0.005U	0.005U	
2,4'-DDT	0.005U	0.005U	0.005U	0.005U	0.005U	
4,4'-DDD	0.005U	0.005U	0.005U	0.005U	0.005U	
4,4'-DDE	0.0159	0.0091	0.005U	0.005U	0.005U	
4,4'-DDT	0.005U	0.005U	0.005U	0.005U	0.005U	
Total DDT	0.0159	0.0091	0	0	0	
Aldrin	0.005U	0.005U	0.005U	0.005U	0.005U	
Dieldrin	0.005U	0.005U	0.005U	0.005U	0.005U	
Endrin	0.005U	0.005U	0.005U	0.005U	0.005U	
Endrin aldehyde	0.005U	0.005U	0.005U	0.005U	0.005U	
Endrin ketone	0.005U	0.005U	0.005U	0.005U	0.005U	
alpha-BHC	0.005U	0.005U	0.005U	0.005U	0.005U	
beta-BHC	0.005U	0.005U	0.005U	0.005U	0.005U	
delta-BHC	0.005U	0.005U	0.005U	0.005U	0.005U	
gamma-BHC (Lindane)	0.005U	0.005U	0.005U	0.005U	0.005U	
Endosulfan I	0.005U	0.005U	0.005U	0.005U	0.005U	
Endosulfan II	0.005U	0.005U	0.005U	0.005U	0.005U	
Endosulfan sulfate	0.005U	0.005U	0.005U	0.005U	0.005U	
alpha-Chlordane	0.1193	0.0229	0.0233	0.0058	0.005U	
gamma-Chlordane	0.1168	0.0229	0.0164	0.0065	0.005U	
Heptachlor	0.005U	0.005U	0.005U	0.005U	0.005U	
Heptachlor epoxide	0.005U	0.005U	0.005U	0.005U	0.005U	
Oxychlordane	0.005U	0.005U	0.005U	0.005U	0.005U	
cis-Nonachlor	0.0158	0.0033J	0.005U	0.005U	0.005U	
trans-Nonachlor	0.0842	0.0176	0.0101	0.0036J	0.005U	
Total Chlordane	**0.3361** [2,5,6]	**0.0667** [5,6]	**0.0498** [5,6]	**0.0159** [5,6]	0	
Methoxychlor	0.005U	0.005U	0.005U	0.005U	0.005U	
Mirex	0.005U	0.005U	0.005U	0.005U	0.005U	
Toxaphene	**0.04975J** [1,5,6]	**0.325** [1,5,6]	0.05U	0.05U	0.05U	

Bolded values with superscripts exceed criteria 1-Ocean Plan, 2-LA Basin Plan, 3-Cal. Fish&Game Freshwater, 4-Cal Fish&Game Saltwater, 5-Cal. Toxics Rule Freshwater, 6-Cal. Toxics Rule Saltwater, 7-National Non-Priority Freshwater, 8-National Non-Priority Pollutant Saltwater. U=not detected at the detection limit, J=value is considered an estimate, J- = value is considered to be a low estimate, J+=value is considered to be a high estimate.

Table 13. Belmont Pump and Bouton Creek Stormwater Chemistry Results, 2008/2009. (Continued).

	Belmont Pump			Bouton Creek		
Valid Name	**26-Nov-08**	**15-Dec-08**	**5-Feb-09**	**15-Dec-08**	**5-Feb-09**	**14-Feb-09**
Organophosphates (µg/L)						
Bolstar (Sulprofos)	0.004U	0.004U	0.004U	0.004U	0.004U	
Chlorpyrifos	0.002U	0.002U	0.002U	0.002U	0.002U	
Demeton	0.002U	0.002U	0.002U	0.002U	0.002U	
Diazinon	0.004U	0.004U	0.004U	0.004U	0.004U	
Dichlorvos	0.006U	0.006U	0.006U	0.006U	0.006U	
Dimethoate	0.006U	0.006U	0.006U	0.006U	0.006U	
Disulfoton	0.002U	0.002U	0.002U	0.002U	0.002U	
Ethoprop	0.002U	0.002U	0.002U	0.002U	0.002U	
Fensulfothion	0.002U	0.002U	0.002U	0.002U	0.002U	
Fenthion	0.004U	0.004U	0.004U	0.004U	0.004U	
Malathion	**0.8746J+** [7,8]	**0.398J+** [7,8]	**0.3306** [7,8]	0.0794J+	0.0262	
Merphos	0.002U	0.002U	0.002U	0.002U	0.002U	
Methyl Parathion	0.002U	0.002U	0.002U	0.002U	0.002U	
Mevinphos	0.016U	0.016U	0.016U	0.016U	0.016U	
Phorate	0.012U	0.012U	0.012U	0.012U	0.012U	
Tetrachlorvinphos (Stirophos)	0.004U	0.004U	0.004U	0.004U	0.004U	
Tokuthion (Prothiofos)	0.006U	0.006U	0.006U	0.006U	0.006U	
Trichloronate	0.002U	0.002U	0.002U	0.002U	0.002U	
Triazine (µg/L)						
Ametryn	0.01U	0.01U	0.01U	0.01U	0.01U	
Atraton	0.01U	0.01U	0.01U	0.01U	0.01U	
Atrazine	0.01U	0.01U	0.01U	0.01U	0.01U	
Cyanazine	0.01U	0.01U	0.01U	0.01U	0.01U	
Prometon	0.01U	0.01U	0.01U	0.01U	0.01U	
Prometryn	0.01U	0.01U	0.01U	0.01U	0.01U	
Propazine	0.01U	0.01U	0.01U	0.01U	0.01U	
Secbumeton	0.01U	0.01U	0.01U	0.01U	0.01U	
Simazine	0.01U	0.01U	0.01U	0.01U	0.01U	
Simetryn	0.01U	0.01U	0.01U	0.01U	0.01U	
Terbutryn	0.01U	0.01U	0.01U	0.01U	0.01U	
Terbutylazine	0.01U	0.01U	0.01U	0.01U	0.01U	

Bolded values with superscripts exceed criteria 1-Ocean Plan, 2-LA Basin Plan, 3-Cal. Fish&Game Freshwater, 4-Cal Fish&Game Saltwater, 5-Cal. Toxics Rule Freshwater, 6-Cal. Toxics Rule Saltwater, 7-National Non-Priority Freshwater, 8-National Non-Priority Pollutant Saltwater. U=not detected at the detection limit, J=value is considered an estimate, J- = value is considered to be a low estimate, J+=value is considered to be a high estimate.

Table 14. Los Cerritos Channel and Dominguez Gap Stormwater Chemistry Results, 2008/2009.

	Los Cerritos Channel			Dominguez Gap		
Valid Name	**15-Dec-08**	**5-Feb-09**	**13-Feb-09**	**26-Nov-08**	**15-Dec-08**	**5-Feb-09**
Conventionals (mg/L unless noted)						
pH (pH Units)	6.84	7.62		7.7	7.53	7.45
Alkalinity as CaCO3	17	19		29	18	28
Biochemical Oxygen Demand	14	10		17	15	14
Chemical Oxygen Demand	62	100		73	58	73
Chloride	4.7	4.9		15	7	14
Conductivity (uS/cm)	70	75		170	86	160
Fluoride	0.11	0.13		0.18	0.12	0.16
Hardness as CaCO3	18	22		38	19	34
MBAS	0.11	0.23		0.055J	0.047J	0.15
Nitrate (as N)	0.51	0.48		0.77	0.43	0.57
Nitrite (as N)	0.1U	0.059J		0.028J	0.1U	0.056J
Oil and Grease	1.8J	5.4		5U	2.6J	4.7J
Total Ammonia (as N)	0.29	0.33		0.37	0.26	0.36
Total Dissolved Solids	78	59		99	74	100
Total Kjeldahl Nitrogen	1.4	2.2		1.8	1.6	1.6
Total Organic Carbon	14	11		11	8.7	11
Orthophosphate (as P)	0.36	0.14		0.53	0.35	0.2
Total Phosphorus	1	0.91		1.1	1	0.93
Total Recoverable Phenolics	0.1U	0.1U		0.1U	0.1U	0.1U
Total Suspended Solids	150	190	226	100	120	120
Total Volatile Solids	28	70		1.2J	32	28
Turbidity (NTU)	100	70		57	60	71
Dissolved Metals (µg/L)						
Aluminum	35	25U		26	35	19J
Arsenic	1.1	1.1		1.1	1.1	0.86
Cadmium	0.077J	0.078J		0.04J	0.049J	0.071J
Chromium	0.91	1.1		0.26J	0.66	0.57
Copper	**7.4** [5,6]	**8.1** [5,6]		**6.1** [5,6]	**6.4** [5,6]	**7.2** [5,6]
Iron	51	160		54	67	40
Lead	0.34	**1.1** [5]		**1.2** [5]	**0.9** [5]	0.6
Nickel	1.8J	2.4		1.9	4.5J	1.6
Selenium	1U	1U		1U	1U	1U
Silver	0.2U	0.016J		0.2U	0.019J	0.013J
Zinc	26	**46** [5]		36	26	32
Total Metals (µg/L)						
Aluminum	**4000** [2,7]	**2900** [2,7]		**2200** [2,7]	**2600** [2,7]	**2800** [2,7]
Arsenic	2.5	2.4		2.2	2.2	2
Cadmium	0.45	0.71		0.31	0.28	0.28
Chromium	9.9	7.5		4.8	6.2	5.8
Copper	**26** [1]	**33** [1]		**22** [1]	**26** [1]	**28** [1]
Iron	**6300** [7]	**4300** [7]		**3700** [7]	**4300** [7]	**4100** [7]
Lead	**13** [1]	**21** [1]		**16** [1]	**18** [1]	**17** [1]
Nickel	7.9	7.9		5.6	5.9	6.2
Selenium	1U	1U		1U	1U	1U
Silver	0.054J	0.16J		0.048J	0.062J	0.059J
Zinc	**160** [1]	**230** [1]		**140** [1]	**140** [1]	**130** [1]

Bolded values with superscripts exceed criteria 1-Ocean Plan, 2-LA Basin Plan, 3-Cal. Fish&Game Freshwater, 4-Cal Fish&Game Saltwater, 5-Cal. Toxics Rule Freshwater, 6-Cal. Toxics Rule Saltwater, 7-National Non-Priority Freshwater, 8-National Non-Priority Pollutant Saltwater. U=not detected at the detection limit, J=value is considered an estimate, J- = value is considered to be a low estimate, J+=value is considered to be a high estimate.

Table 14. Los Cerritos Channel and Dominguez Gap Stormwater Chemistry Results, 2008/2009. (Continued).

	Los Cerritos Channel			Dominguez Gap		
Valid Name	**15-Dec-08**	**5-Feb-09**	**13-Feb-09**	**26-Nov-08**	**15-Dec-08**	**5-Feb-09**
Bacteria						
Enterococcus (CFU/100 ml)	**25000** [1,2]	**18000** [1,2]		**38000** [1,2]	**23000** [1,2]	**34000** [1,2]
Fecal Coliform (MPN/100 ml)	**50000** [1,2]	**3000J** [1,2]		**30000** [1,2]	**11000** [1,2]	**5000J** [1,2]
Total Coliform (MPN/100 ml)	**90000** [1,2]	**30000** [1,2]		**30000J** [1,2]	**50000** [1,2]	**17000** [1,2]
Aroclors (µg/L)						
Aroclor 1016	0.02U	0.02U		0.02U	0.02U	0.02U
Aroclor 1221	0.02U	0.02U		0.02U	0.02U	0.02U
Aroclor 1232	0.02U	0.02U		0.02U	0.02U	0.02U
Aroclor 1242	0.02U	0.02U		0.02U	0.02U	0.02U
Aroclor 1248	0.02U	0.02U		0.02U	0.02U	0.02U
Aroclor 1254	0.02U	0.02U		0.02U	0.02U	0.02U
Aroclor 1260	0.02U	0.02U		0.02U	0.02U	0.02U
Total Aroclors	0	0		0	0	0
Chlorinated Pesticides (µg/L)						
2,4'-DDD	0.005U	0.005U		0.005U	0.005U	0.005U
2,4'-DDE	0.005U	0.005U		0.005U	0.005U	0.005U
2,4'-DDT	0.005U	0.005U		0.005U	0.005U	0.005U
4,4'-DDD	0.005U	0.005U		0.005U	0.005U	0.005U
4,4'-DDE	0.0106	0.005U		0.005U	0.0113	0.005U
4,4'-DDT	0.005U	0.005U		0.005U	0.005U	0.005U
Total DDT	0.0106	0		0	0.0113	0
Aldrin	0.005U	0.005U		0.005U	0.005U	0.005U
Dieldrin	0.005U	0.005U		0.005U	0.005U	0.005U
Endrin	0.005U	0.005U		0.005U	0.005U	0.005U
Endrin aldehyde	0.005U	0.005U		0.005U	0.005U	0.005U
Endrin ketone	0.005U	0.005U		0.005U	0.005U	0.005U
alpha-BHC	0.005U	0.005U		0.005U	0.005U	0.005U
beta-BHC	0.005U	0.005U		0.005U	0.005U	0.005U
delta-BHC	0.005U	0.005U		0.005U	0.005U	0.005U
gamma-BHC (Lindane)	0.005U	0.005U		0.005U	0.005U	0.005U
Endosulfan I	0.005U	0.005U		0.005U	0.005U	0.005U
Endosulfan II	0.005U	0.005U		0.005U	0.005U	0.005U
Endosulfan sulfate	0.005U	0.005U		0.005U	0.005U	0.005U
alpha-Chlordane	0.0047J	0.005U		0.0064	0.0059	0.005U
gamma-Chlordane	0.0036J	0.005U		0.0061	0.0084	0.005U
Heptachlor	0.005U	0.005U		0.005U	0.005U	0.005U
Heptachlor epoxide	0.005U	0.005U		0.005U	0.005U	0.005U
Oxychlordane	0.005U	0.005U		0.005U	0.005U	0.005U
cis-Nonachlor	0.005U	0.005U		0.0012J	0.005U	0.005U
trans-Nonachlor	0.0035J	0.005U		0.0046J	0.0086	0.005U
Total Chlordane	**0.0118** [5,6]	0		**0.0183** [5,6]	**0.0229** [5,6]	0
Methoxychlor	0.005U	0.005U		0.005U	0.005U	0.005U
Mirex	0.005U	0.005U		0.005U	0.005U	0.005U
Toxaphene	**0.241** [1,5,6]	0.05U		0.05U	**0.242** [1,5,6]	0.05U

Bolded values with superscripts exceed criteria 1-Ocean Plan, 2-LA Basin Plan, 3-Cal. Fish&Game Freshwater, 4-Cal Fish&Game Saltwater, 5-Cal. Toxics Rule Freshwater, 6-Cal. Toxics Rule Saltwater, 7-National Non-Priority Freshwater, 8-National Non-Priority Pollutant Saltwater. U=not detected at the detection limit, J=value is considered an estimate, J- = value is considered to be a low estimate, J+=value is considered to be a high estimate.

Table 14. Los Cerritos Channel and Dominguez Gap Stormwater Chemistry Results, 2008/2009. (Continued).

	Los Cerritos Channel			Dominguez Gap		
Valid Name	**15-Dec-08**	**5-Feb-09**	**13-Feb-09**	**26-Nov-08**	**15-Dec-08**	**5-Feb-09**
Organophosphates (µg/L)						
Bolstar (Sulprofos)	0.004U	0.004U		0.004U	0.004U	0.004U
Chlorpyrifos	0.002U	0.002U		0.002U	0.002U	0.002U
Demeton	0.002U	0.002U		0.002U	0.002U	0.002U
Diazinon	0.004U	0.004U		0.004U	0.004U	0.004U
Dichlorvos	0.006U	0.006U		0.1234J+	0.006U	0.0322
Dimethoate	0.006U	0.006U		0.006U	0.006U	0.006U
Disulfoton	0.002U	0.002U		0.002U	0.002U	0.002U
Ethoprop	0.002U	0.002U		0.002U	0.002U	0.002U
Fensulfothion	0.002U	0.002U		0.002U	0.002U	0.002U
Fenthion	0.004U	0.004U		0.004U	0.004U	0.004U
Malathion	**0.2866J+** [7,8]	**0.1617** [7,8]		**0.4977J+** [7,8]	**0.1146J+** [7,8]	0.0847
Merphos	0.002U	0.002U		0.002U	0.002U	0.002U
Methyl Parathion	0.002U	0.002U		0.002U	0.002U	0.002U
Mevinphos	0.016U	0.016U		0.016U	0.016U	0.016U
Phorate	0.012U	0.012U		0.012U	0.012U	0.012U
Tetrachlorvinphos (Stirophos)	0.004U	0.004U		0.004U	0.004U	0.004U
Tokuthion (Prothiofos)	0.006U	0.006U		0.006U	0.006U	0.006U
Trichloronate	0.002U	0.002U		0.002U	0.002U	0.002U
Triazine (µg/L)						
Ametryn	0.01U	0.01U		0.01U	0.01U	0.01U
Atraton	0.01U	0.01U		0.01U	0.01U	0.01U
Atrazine	0.01U	0.01U		0.01U	0.01U	0.01U
Cyanazine	0.01U	0.01U		0.01U	0.01U	0.01U
Prometon	0.01U	0.01U		0.01U	0.01U	0.01U
Prometryn	0.01U	0.01U		0.01U	0.01U	0.01U
Propazine	0.01U	0.01U		0.01U	0.01U	0.01U
Secbumeton	0.01U	0.01U		0.01U	0.01U	0.01U
Simazine	0.0861J+	0.01U		0.01U	0.01U	0.01U
Simetryn	0.01U	0.01U		0.01U	0.01U	0.01U
Terbutryn	0.01U	0.01U		0.01U	0.01U	0.01U
Terbutylazine	0.01U	0.01U		0.01U	0.01U	0.01U

Bolded values with superscripts exceed criteria 1-Ocean Plan, 2-LA Basin Plan, 3-Cal. Fish&Game Freshwater, 4-Cal Fish&Game Saltwater, 5-Cal. Toxics Rule Freshwater, 6-Cal. Toxics Rule Saltwater, 7-National Non-Priority Freshwater, 8-National Non-Priority Pollutant Saltwater. U=not detected at the detection limit, J=value is considered an estimate, J- = value is considered to be a low estimate, J+=value is considered to be a high estimate.

Table 15. Total Load in Pounds at the Belmont Pump and Bouton Creek Stations for 2008/2009 Storm Events.

Valid Analyte Name	Belmont Pump 26-Nov-2008	Belmont Pump 15-Dec-2008	Belmont Pump 5-Feb-2009	Bouton Creek 15-Dec-2008	Bouton Creek 5-Feb-2009	Bouton Creek 13-Feb-2009
Conventionals						
Alkalinity as CaCO3	820	650	1400	3400	3600	
Hardness as CaCO3	970	800	780	4900	4400	
Biochemical Oxygen Demand	720	650	290	5200	2000	
Chemical Oxygen Demand	4100	2400	2900	15000	18000	
Total Organic Carbon	680	350	390	2800	2600	
Chloride	420	610	870	4500	3600	
Fluoride	5.3	4.6	4.1	37	28	
MBAS	2.8	4.2	5.1	24	31	
Oil and Grease	0	120	63	450	200	
Total Ammonia (as N)	13	6.9	9.4	75	48	
Total Kjeldahl Nitrogen	110	61	53	370	280	
Nitrate (as N)	37	20	14	130	87	
Nitrite (as N)	1.4	0.8	1.5	4.9	10	
Orthophosphate (as P)	34	15	6.1	58	26	
Total Phosphorus	58	38	22	190	140	
Total Recoverable Phenolics	0	0	0	0	0	
Total Dissolved Solids	3100	2900	3400	19000	18000	
Total Suspended Solids	8700	3800	2900	13000	16000	3900
Total Volatile Solids	4100	1800	1300	4900	5600	
Dissolved Metals						
Aluminum	0.97	0.69	0.41	4.5	4.9	
Arsenic	0.047	0.037	0.027	0.24	0.2	
Cadmium	0.0024	0.0019	0.0015	0.037	0.0094	
Chromium	0.019	0.028	0.015	0.37	0.21	
Copper	0.46	0.42	0.31	2.1	1.8	
Iron	2.7	1.5	1.1	11	9.7	
Lead	0.044	0.027	0.013	0.22	0.12	
Nickel	0.12	0.084	0.058	0.62	0.35	
Selenium	0	0	0	0	0	
Silver	0.00092	0.0017	0	0.0032	0.0043	
Zinc	2.8	2.3	1.5	11	8.2	
Total Metals						
Aluminum	140	36	31	180	310	
Arsenic	0.13	0.057	0.041	0.37	0.33	
Cadmium	0.041	0.011	0.0082	0.093	0.061	
Chromium	0.38	0.15	0.094	3.7	1.1	
Copper	3	1.2	0.87	4.5	5.6	
Iron	250	73	51	320	490	
Lead	2	0.53	0.46	1.7	2.5	
Nickel	0.46	0.18	0.14	1.1	0.95	
Selenium	0	0	0	0	0	
Silver	0.0072	0.0015	0.0014	0.0034	0.011	
Zinc	18	6.9	4.6	28	31	

Table 15. Total Load in Pounds at the Belmont Pump and Bouton Creek Stations for 2008/2009 Storm Events. (continued)

	Belmont Pump			Bouton Creek		
Valid Analyte Name	26-Nov-2008	15-Dec-2008	5-Feb-2009	15-Dec-2008	5-Feb-2009	13-Feb-2009
Aroclors						
Aroclor 1016	0	0	0	0	0	
Aroclor 1221	0	0	0	0	0	
Aroclor 1232	0	0	0	0	0	
Aroclor 1242	0	0	0	0	0	
Aroclor 1248	0	0	0	0	0	
Aroclor 1254	0	0	0	0	0	
Aroclor 1260	0	0	0	0	0	
Chlorinated Pesticides						
2,4'-DDD	0	0	0	0	0	
2,4'-DDE	0	0	0	0	0	
2,4'-DDT	0	0	0	0	0	
4,4'-DDD	0	0	0	0	0	
4,4'-DDE	0.00077	0.00035	0	0	0	
4,4'-DDT	0	0	0	0	0	
Aldrin	0	0	0	0	0	
Dieldrin	0	0	0	0	0	
alpha-BHC	0	0	0	0	0	
beta-BHC	0	0	0	0	0	
delta-BHC	0	0	0	0	0	
gamma-BHC (Lindane)	0	0	0	0	0	
Endosulfan I	0	0	0	0	0	
Endosulfan II	0	0	0	0	0	
Endosulfan sulfate	0	0	0	0	0	
Endrin	0	0	0	0	0	
Endrin aldehyde	0	0	0	0	0	
Endrin ketone	0	0	0	0	0	
Heptachlor	0	0	0	0	0	
Heptachlor epoxide	0	0	0	0	0	
Methoxychlor	0	0	0	0	0	
Mirex	0	0	0	0	0	
alpha-Chlordane	0.0058	0.00087	0.00056	0.0012	0	
gamma-Chlordane	0.0056	0.00087	0.0004	0.0014	0	
Oxychlordane	0	0	0	0	0	
Total Chlordane	0.016	0.0025	0.0012	0.0034	0	
Toxaphene	0.0024	0.012	0	0	0	
cis-Nonachlor	0.00076	0.00013	0	0	0	
trans-Nonachlor	0.0041	0.00067	0.00024	0.00077	0	

Table 15. Total Load in Pounds at the Belmont Pump and Bouton Creek Stations for 2008/2009 Storm Events. (continued)

	Belmont Pump			Bouton Creek		
Valid Analyte Name	26-Nov-2008	15-Dec-2008	5-Feb-2009	15-Dec-2008	5-Feb-2009	13-Feb-2009
Organophosphates						
Bolstar (Sulprofos)	0	0	0	0	0	
Chlorpyrifos	0	0	0	0	0	
Demeton	0	0	0	0	0	
Diazinon	0	0	0	0	0	
Dichlorvos	0	0	0	0	0	
Dimethoate	0	0	0	0	0	
Disulfoton	0	0	0	0	0	
Ethoprop	0	0	0	0	0	
Fensulfothion	0	0	0	0	0	
Fenthion	0	0	0	0	0	
Malathion	0.042	0.015	0.008	0.017	0.0043	
Merphos	0	0	0	0	0	
Methyl Parathion	0	0	0	0	0	
Mevinphos	0	0	0	0	0	
Phorate	0	0	0	0	0	
Tetrachlorvinphos (Stirophos)	0	0	0	0	0	
Tokuthion (Prothiofos)	0	0	0	0	0	
Trichloronate	0	0	0	0	0	
Triazine						
Ametryn	0	0	0	0	0	
Atraton	0	0	0	0	0	
Atrazine	0	0	0	0	0	
Cyanazine	0	0	0	0	0	
Prometon	0	0	0	0	0	
Prometryn	0	0	0	0	0	
Propazine	0	0	0	0	0	
Secbumeton	0	0	0	0	0	
Simazine	0	0	0	0	0	
Simetryn	0	0	0	0	0	
Terbutryn	0	0	0	0	0	
Terbutylazine	0	0	0	0	0	

ND indicates that an analysis was performed but the analyte was not detected.
A blank cell (-) indicates that the analysis was not performed.

Table 16. Total Load in Pounds at the Los Cerritos Channel and Dominguez Gap Stations for 2008/2009 Events.

Valid Analyte Name	Los Cerritos Channel			Dominguez Gap		
	15-Dec-2008	5-Feb-2009	13-Feb-2009	26-Nov-2008	15-Dec-2008	5-Feb-2009
Conventionals						
Alkalinity as CaCO3	34000	23000		2600	2500	1500
Hardness as CaCO3	36000	27000		3400	2600	1900
Biochemical Oxygen Demand	28000	12000		1500	2100	770
Chemical Oxygen Demand	130000	120000		6500	8000	4000
Total Organic Carbon	28000	14000		980	1200	610
Chloride	9500	6000		1300	960	770
Fluoride	220	160		16	17	8.8
MBAS	220	280		4.9	6.5	8.3
Oil and Grease	3600	6700		0	360	260
Total Ammonia (as N)	590	410		33	36	20
Total Kjeldahl Nitrogen	2800	2700		160	220	88
Nitrate (as N)	1000	590		69	59	31
Nitrite (as N)	0	73		2.5	0	3.1
Orthophosphate (as P)	730	170		47	48	11
Total Phosphorus	2000	1100		98	140	51
Total Recoverable Phenolics	0	0		0	0	0
Total Dissolved Solids	160000	73000		8800	10000	5500
Total Suspended Solids	300000	230000	52000	8900	17000	6600
Total Volatile Solids	57000	86000		110	4400	1500
Dissolved Metals						
Aluminum	71	0		2.3	4.8	1
Arsenic	2.2	1.4		0.098	0.15	0.047
Cadmium	0.16	0.096		0.0036	0.0067	0.0039
Chromium	1.8	1.4		0.023	0.091	0.031
Copper	15	10		0.54	0.88	0.4
Iron	100	200		4.8	9.2	2.2
Lead	0.69	1.4		0.11	0.12	0.033
Nickel	3.6	3		0.17	0.62	0.088
Selenium	0	0		0	0	0
Silver	0	0.02		0	0.0026	0.00072
Zinc	53	57		3.2	3.6	1.8
Total Metals						
Aluminum	8100	3600		200	360	150
Arsenic	5.1	3		0.2	0.3	0.11
Cadmium	0.91	0.87		0.028	0.039	0.015
Chromium	20	9.2		0.43	0.85	0.32
Copper	53	41		2	3.6	1.5
Iron	13000	5300		330	590	230
Lead	26	26		1.4	2.5	0.94
Nickel	16	9.7		0.5	0.81	0.34
Selenium	0	0		0	0	0
Silver	0.11	0.2		0.0043	0.0085	0.0033
Zinc	320	280		12	19	7.2

Table 16. Total Load in Pounds at the Los Cerritos Channel and Dominguez Gap Stations for 2008/2009 Events. (continued)

	Los Cerritos Channel			Dominguez Gap		
Valid Analyte Name	15-Dec-2008	5-Feb-2009	13-Feb-2009	26-Nov-2008	15-Dec-2008	5-Feb-2009
Aroclors						
Aroclor 1016	0	0		0	0	0
Aroclor 1221	0	0		0	0	0
Aroclor 1232	0	0		0	0	0
Aroclor 1242	0	0		0	0	0
Aroclor 1248	0	0		0	0	0
Aroclor 1254	0	0		0	0	0
Aroclor 1260	0	0		0	0	0
Chlorinated Pesticides						
2,4'-DDD	0	0		0	0	0
2,4'-DDE	0	0		0	0	0
2,4'-DDT	0	0		0	0	0
4,4'-DDD	0	0		0	0	0
4,4'-DDE	0.021	0		0	0.0016	0
4,4'-DDT	0	0		0	0	0
Aldrin	0	0		0	0	0
Dieldrin	0	0		0	0	0
alpha-BHC	0	0		0	0	0
beta-BHC	0	0		0	0	0
delta-BHC	0	0		0	0	0
gamma-BHC (Lindane)	0	0		0	0	0
Endosulfan I	0	0		0	0	0
Endosulfan II	0	0		0	0	0
Endosulfan sulfate	0	0		0	0	0
Endrin	0	0		0	0	0
Endrin aldehyde	0	0		0	0	0
Endrin ketone	0	0		0	0	0
Heptachlor	0	0		0	0	0
Heptachlor epoxide	0	0		0	0	0
Methoxychlor	0	0		0	0	0
Mirex	0	0		0	0	0
alpha-Chlordane	0.0095	0		0.00057	0.00081	0
gamma-Chlordane	0.0073	0		0.00054	0.0012	0
Oxychlordane	0	0		0	0	0
Total Chlordane	0.024	0		0.0016	0.0031	0
Toxaphene	0.49	0		0	0.033	0
cis-Nonachlor	0	0		0.00011	0	0
trans-Nonachlor	0.0071	0		0.00041	0.0012	0

Table 16. Total Load in Pounds at the Los Cerritos Channel and Dominguez Gap Stations for 2008/2009 Events. (continued)

Valid Analyte Name	Los Cerritos Channel			Dominguez Gap		
	15-Dec-2008	5-Feb-2009	13-Feb-2009	26-Nov-2008	15-Dec-2008	5-Feb-2009
Organophosphates						
Bolstar (Sulprofos)	0	0		0	0	0
Chlorpyrifos	0	0		0	0	0
Demeton	0	0		0	0	0
Diazinon	0	0		0	0	0
Dichlorvos	0	0		0.011	0	0.0018
Dimethoate	0	0		0	0	0
Disulfoton	0	0		0	0	0
Ethoprop	0	0		0	0	0
Fensulfothion	0	0		0	0	0
Fenthion	0	0		0	0	0
Malathion	0.58	0.20		0.044	0.016	0.0047
Merphos	0	0		0	0	0
Methyl Parathion	0	0		0	0	0
Mevinphos	0	0		0	0	0
Phorate	0	0		0	0	0
Tetrachlorvinphos (Stirophos)	0	0		0	0	0
Tokuthion (Prothiofos)	0	0		0	0	0
Trichloronate	0	0		0	0	0
Triazine						
Ametryn	0	0		0	0	0
Atraton	0	0		0	0	0
Atrazine	0	0		0	0	0
Cyanazine	0	0		0	0	0
Prometon	0	0		0	0	0
Prometryn	0	0		0	0	0
Propazine	0	0		0	0	0
Secbumeton	0	0		0	0	0
Simazine	0.17	0		0	0	0
Simetryn	0	0		0	0	0
Terbutryn	0	0		0	0	0
Terbutylazine	0	0		0	0	0

ND indicates that an analysis was performed but the analyte was not detected.

A blank cell (-) indicates that the analysis was not performed.

Table 17. Monitored Dry Weather Events, 1999-2009.

Station	1 - 10/4/00	2 - 6/21/00	3 - 6/29/00	4 - 6/5/01	5 - 8/16/01	6 - 5/9,14/02	7 - 9/5/02	8 - 5/20/03	9 - 9/II/03	10 - 5/4/04	11 – 8/4/04	12 – 5/4/05	13 -8/18/05	14 -5/11/06	15 -9/7/06	16 -5/17/07	17 – 9/27/07	18 – 5/7/08	19 - 7/2/2008	20 – 5/7/2009
Bouton Creek		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●[3]	●[3]	●[3]
Belmont Pump		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	[5]	[5]	[5]	[5]
Los Cerritos Channel				●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Dominguez Gap		●[1]	●[1]	●[1]	●[1]	●[1]	●[1]	●[1]	●[1]	●[1]	●[1]	●[1]	●[1]	●[1]	●[1]	●[1]	●[2]	●[4]	●[1]	●[1]

1. The intake to the sump was observed to be dry. Therefore, no samples were collected.
2. The pump station was inoperative during renovation of the pumps and the wet basin behind the pump house. No samples were collected.
3. There was very low flow along both sides of the channel during each event. In each case flow was insufficient to flush the salt water out of the channel. Salinity never dropped below 17 ppt during Event 19 and 10.8 during Event 20 before the channel was flooded by the incoming tide. No samples were collected.
4. The pump station was returned to service for the 2007-08 storm season. At the time of both of the 2008-09 dry weather inspections the pump was not operational. The LADPW Flood Control Department is trying to determine a solution to the problem. No samples were collected
5. The Belmont Pump Station is currently diverting dry weather flow to the sanitary system.

Shading indicates 2008/2009 Dry Weather Surveys included in this report.

Table 18. Field Measurements for Bouton Creek and Los Cerritos Channel Dry Weather Season (2008/2009)

	Bouton Creek		Los Cerritos Channel	
Date	**26-Sept-07**	**07-May-08**	**26-Sept-07**	**07-May-08**
Time	**0500**	**0930**	**0620**	**0815**
Temperature (^{0}C)	17.4	20.1	16.5	16.9
pH	7.96	8.90	8.14	8.74
Specific Conductivity (mS/cm)	2.906	20.71	0.54	0.178
Flow (cfs)	0.46[(1)]	([2])	12.04[(1)]	7.71[(1)]
Dissolved Oxygen (mg/L)	3.65	17.46	7.66	12.85

1. Flow was calculated from measurements of the depth and width of the water stream, as well as the velocity of a floating object in the water.

2. The flow was not determined, and no sample was collected. Field measurements were made in the process of determining the conditions of the flow. The depth and velocity of the flow was so low that a meaningful estimation of flow could not be established. A large portion of the width of the crown of the channel invert was exposed and the channel invert had significant algae covering it. The salinity of the water never fell below 12.5 ‰ up until the channel was flooded by the incoming tide.

Table 19. Summary of Dry Weather Chemistry Results, 2008/2009.

Valid Name	Los Cerritos Channel Event-1 02-Jul-2008	Los Cerritos Channel Event-2 07-May-2009
Conventionals (mg/L unless noted)		
pH (pH Units)	**8.69** [2]	8.25
Alkalinity as CaCO3	120	120
Biochemical Oxygen Demand	20	15
Chemical Oxygen Demand	200	110
Chloride	2100	140
Conductivity (us/cm)	6200	690
Fluoride	1	0.83
Hardness as CaCO3	680	120
MBAS	0.036	0.025U
Nitrate (as N)	0.5U	0.2U
Nitrite (as N)	0.5U	0.2U
Oil and Grease	5U	5U
Total Ammonia (as N)	0.25	0.1U
Total Dissolved Solids	4400	660
Total Kjeldahl Nitrogen	3.5	2.5
Total Organic Carbon	36	44
Orthophosphate (as P)	0.023	0.0023J
Total Phosphorus	0.25	0.12
Total Recoverable Phenolics	100U	100U
Total Suspended Solids	69	6.8
Total Volatile Solids	29	6
Turbidity (NTU)	22	8.2
Dissolved Metals (µg/L)		
Aluminum	2.2J	25U
Arsenic	5.1	5.8
Cadmium	0.083J	0.16J
Chromium	0.41J	0.26J
Copper	**5.7** [6]	**13** [5,6]
Iron	21	22
Lead	0.54	1.1
Nickel	3	4.5
Selenium	1U	0.76J
Silver	0.015J	0.071J
Zinc	7.2	13
Total Metals (µg/L)		
Aluminum	**240** [7]	25
Arsenic	6.1	5.9
Cadmium	0.21	0.2
Chromium	1.2	0.33J
Copper	**13** [1]	**14** [1]
Iron	500	75
Lead	3.1	1.4
Nickel	4.1	4.5
Selenium	1U	0.87J
Silver	0.084J	0.074J
Zinc	33	16

Bolded values with superscripts exceed criteria 1-Ocean Plan, 2-LA Basin Plan, 3-Cal. Fish&Game Freshwater, 4-Cal Fish&Game Saltwater, 5-Cal. Toxics Rule Freshwater, 6-Cal. Toxics Rule Saltwater, 7-National Non-Priority Freshwater, 8-National Non-Priority Pollutant Saltwater. U=not detected at the detection limit, J=value is considered an estimate, J- = value is considered to be a low estimate, J+=value is considered to be a high estimate.

Table 19. Summary of Dry Weather Chemistry Results, 2008/2009. (continued)

Valid Name	Los Cerritos Channel Event-1 02-Jul-2008	Los Cerritos Channel Event-2 07-May-2009
Bacteria		
Enterococcus (CFU/100 ml)	**210** [1,2]	**910** [1,2]
Fecal Coliform (MPN/100 ml)	**2200** [1,2]	**2400** [1,2]
Total Coliform (MPN/100 ml)	**16000J** [1,2]	**5000** [1,2]
Aroclors (µg/L)		
Aroclor 1016	0.02U	0.02U
Aroclor 1221	0.02U	0.02U
Aroclor 1232	0.02U	0.02U
Aroclor 1242	0.02U	0.02U
Aroclor 1248	0.02U	0.02U
Aroclor 1254	0.02U	0.02U
Aroclor 1260	0.02U	0.02U
Total Aroclors	0	0
Chlorinated Pesticides (µg/L)		
2,4'-DDD	0.005U	0.005U
2,4'-DDE	0.005U	0.005U
2,4'-DDT	0.005U	0.005U
4,4'-DDD	0.005U	0.005U
4,4'-DDE	0.005U	0.005U
4,4'-DDT	0.005U	0.005U
Total DDT	0	0
Aldrin	0.005U	0.005U
Dieldrin	0.005U	0.005U
Endrin	0.005U	0.005U
Endrin aldehyde	0.005U	0.005U
Endrin ketone	0.005U	0.005U
alpha-BHC	0.005U	0.005U
beta-BHC	0.005U	0.005U
delta-BHC	0.005U	0.005U
gamma-BHC (Lindane)	0.005U	0.005U
Endosulfan I	0.005U	0.005U
Endosulfan II	0.005U	0.005U
Endosulfan sulfate	0.005U	0.005U
alpha-Chlordane	0.005U	0.005U
gamma-Chlordane	0.005U	0.005U
Heptachlor	0.005U	0.005U
Heptachlor epoxide	0.005U	0.005U
Oxychlordane	0.005U	0.005U
cis-Nonachlor	0.005U	0.005U
trans-Nonachlor	0.005U	0.005U
Total Chlordane	0	0
Methoxychlor	0.005U	0.005U
Mirex	0.005U	0.005U
Toxaphene	0.05U	0.05U
Bolstar (Sulprofos)	0.004U	0.004U

Bolded values with superscripts exceed criteria 1-Ocean Plan, 2-LA Basin Plan, 3-Cal. Fish&Game Freshwater, 4-Cal Fish&Game Saltwater, 5-Cal. Toxics Rule Freshwater, 6-Cal. Toxics Rule Saltwater, 7-National Non-Priority Freshwater, 8-National Non-Priority Pollutant Saltwater. U=not detected at the detection limit, J=value is considered an estimate, J- = value is considered to be a low estimate, J+=value is considered to be a high estimate.

Table 19. Summary of Dry Weather Chemistry Results, 2008/2009. (continued)

Valid Name	Los Cerritos Channel Event-1 02-Jul-2008	Los Cerritos Channel Event-2 07-May-2009
Organophosphates (µg/L)		
Chlorpyrifos	0.002U	0.002U
Demeton	0.002U	0.002U
Diazinon	0.004U	0.004U
Dichlorvos	0.006U	0.006U
Dimethoate	0.006U	0.006U
Disulfoton	0.002U	0.002U
Ethoprop	0.002U	0.002U
Fensulfothion	0.002U	0.002U
Fenthion	0.004UJ-	0.004U
Malathion	0.006U	0.006U
Merphos	0.002U	0.002U
Methyl Parathion	0.002U	0.002U
Mevinphos	0.016U	0.016U
Phorate	0.012U	0.012U
Tetrachlorvinphos (Stirophos)	0.004U	0.004U
Tokuthion (Prothiofos)	0.006U	0.006U
Trichloronate	0.002U	0.002U
Triazine (µg/L)		
Ametryn	0.01U	0.01U
Atraton	0.01U	0.01U
Atrazine	0.01U	0.01U
Cyanazine	0.01U	0.01U
Prometon	0.01U	0.01U
Prometryn	0.01U	0.01U
Propazine	0.01U	0.01U
Secbumeton	0.01U	0.01U
Simazine	0.01U	0.02
Simetryn	0.01U	0.01U
Terbutryn	0.01U	0.01U
Terbutylazine	0.01U	0.01U

Bolded values with superscripts exceed criteria 1-Ocean Plan, 2-LA Basin Plan, 3-Cal. Fish&Game Freshwater, 4-Cal Fish&Game Saltwater, 5-Cal. Toxics Rule Freshwater, 6-Cal. Toxics Rule Saltwater, 7-National Non-Priority Freshwater, 8-National Non-Priority Pollutant Saltwater. U=not detected at the detection limit, J=value is considered an estimate, J- = value is considered to be a low estimate, J+=value is considered to be a high estimate.

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TOXICITY RESULTS

Toxicity testing is required to be conducted at all sites except the Dominguez Gap Pump Station. Toxicity tests were conducted on subsamples of the composites collected for chemical analysis. Wet weather samples were collected from three storm events: November 26, 2008, December 15, 2008, and February 6, 2009. Composite samples were collected during each of the storm events and were tested with two species, the water flea (freshwater crustacean), and the sea urchin (marine echinoderm). Only the Belmont Pump Station was sampled during the November storm, and all three stations were sampled in December and February

Dry weather sampling occurred on July 1-2, 2008 and May 6-7 2009. Only the Los Cerritos Channel site had sufficient flow to be sampled in both dry weather periods.

WET WEATHER DISCHARGE

Wet weather toxicity testing is required to be conducted in association with full analytical chemical testing at the Belmont Pump Station, Bouton Creek and Los Cerritos Channel mass emission sites. Toxicity testing was eliminated at the Dominguez Gap Pump Station in 2002 due to infrequent discharges and lack of toxicity when discharges occurred.

Wet weather samples were collected from three storm events: November 26, 2008, December 15, 2008, and February 6, 2009. Composite samples were collected during each of the storm events and tested with two species, the water flea (freshwater crustacean), and the sea urchin (marine echinoderm). Results of tests from all three stations are presented in Table 20 through Table 22 and Figure 25 through Figure 27.

Ceriodaphnia Bioassays

During the 2008/2009 test period bioassay tests conducted on stormwater using *Ceriodaphnia* showed no impacts on mortality but early season events exhibited minor, but measurable impacts on reproduction. All survival NOECs were 100% sample and all LC_{50}s were >100%. During the November and December 2008 storms there was measurably decreased daphnid reproduction at all stations tested, with NOECs ranging from <6.25% to 50% sample. The low NOECs recorded in the Bouton and Los Cerritos Channel samples from the December storm were generally the result of low within-test variability (Percent Minimum Significant Differences (PMSDs) ranged from 10.1% to 12.6%) and resulting elevated test sensitivity. All EC_{50}s, however, were >100% sample. In February 2009 there was no measurable reproductive toxicity (NOEC = 100% and EC_{50} >100%).

Over the entire storm season there was <1 acute toxicity unit (TU_a) at all three stations, and no TIEs were triggered. Chronic toxicity ranged from 1 to >16 TU_cs.

All daphnid bioassays met all test acceptability criteria (TAC) and all concurrent reference toxicant test results were within laboratory control chart limits.

Strongylocentrotus Bioassays

Significantly decreased fertilization was measured at just two of the three sites but, in all cases, the magnitude of decreased fertilization was low. Acute toxicity in all sea urchin stormwater tests was < 2 TU_a thus no TIEs were triggered. Tests of the Belmont Pump station samples showed no measurable toxicity (no decreased fertilization) in any of the three storms. NOECs were 50% sample and EC_{50}s were

>50% sample. Bouton Creek station samples showed decreased fertilization in both the December 2008 storm (NOEC = 12.5%) and the February 2009 storm (NOEC = 25%). EC_{50}s and EC_{25}s were >50% in both storm samples. Los Cerritos Channel samples produced decreased fertilization in the February storm only (NOEC = 25%, EC_{50} > 50%). No decreased fertilization was seen in the December 2008 sample.

All sea urchin bioassays met all test acceptability criteria (TAC) and all concurrent reference toxicant test results were within laboratory control chart limits.

DRY WEATHER DISCHARGES

Toxicity results from the dry weather samples are presented in Table 23 and Figure 28. Toxicity tests were conducted on samples from dry weather sampling conducted on July 2, 2008 and May 7, 2009. As with the wet weather monitoring, dry weather discharges from the Dominguez Gap Pump Station are not required to be tested for toxicity. Since no dry weather discharges have been observed at the Dominguez Gap Pump Station since the start of the program nine years ago, this has not been an issue. The new configuration of this site is expected to eventually cause discharges during dry weather periods but the source of the water would be Los Angeles River diverted to provide infiltration and maintain the recently constructed Dominguez Gap wetlands system. This will not routinely occur until the problems with the summer pump are corrected. Dry weather flows at Belmont Pump are now bypassed to the sanitary sewer, so there was no dry weather testing at that station during the last two years.

Los Cerritos Channel

The July 2008 dry weather sample from Los Cerritos Channel showed both lethal and reproductive toxicity to water fleas and there was significant toxicity to sea urchin fertilization.

- The NOEC for both water flea survival and development was 50% sample (2 TU_c). The LC_{50} for survival was 59% sample (1.7 TU_a) and the EC_{50} for reproduction was 68% sample (1.5 TU_a).
- The sea urchin fertilization test showed a NOEC of 6.25% (16 TU_c) and an EC_{50} of 35.8% (2.8 TU_a).
- No TIEs were triggered by this sample.

The May 2009 Los Cerritos Channel dry weather sample showed no measurable decrease in either survival or reproduction in *Ceriodaphnia* and no decreased fertilization associated with the sea urchin tests.

- The NOEC for both daphnid test endpoints was 100% (1 TU_c) and the LC and EC_{50}s were >100% (<1 TU_a).
- The sea urchin fertilization test showed no significantly decreased fertilization in any concentration, with a NOEC was 50% (2 TU_c) and an EC50 of >50% (<2 TU_a).
- Again, no TIEs were triggered by this sample.

TOXICITY IDENTIFICATION EVALUATIONS (TIEs)

The trigger for TIE initiation in this program is occurrence of an LC_{50} of ≤50% (equivalent to ≥2 TU_a) for water flea survival or an EC_{50} of ≤33% (≥3 TU_a) for the sea urchin fertilization test**.** No bioassays performed during this monitoring period showed toxicity high enough to meet these criteria, and no TIEs were performed.

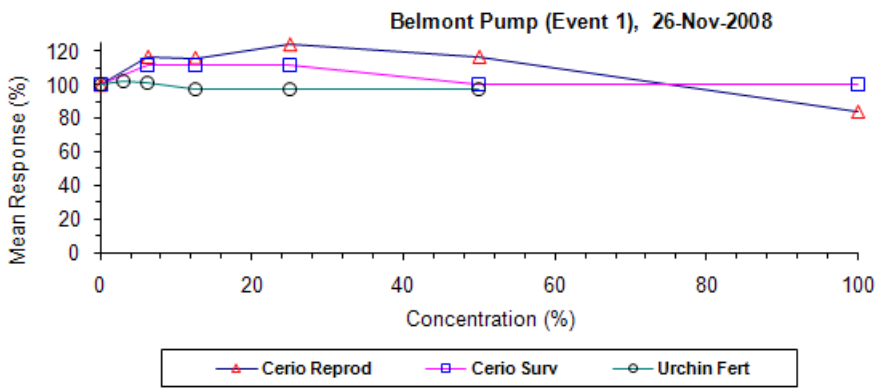


Figure 25. Toxicity Dose Response Plots for Stormwater Samples Collected during Event 1.

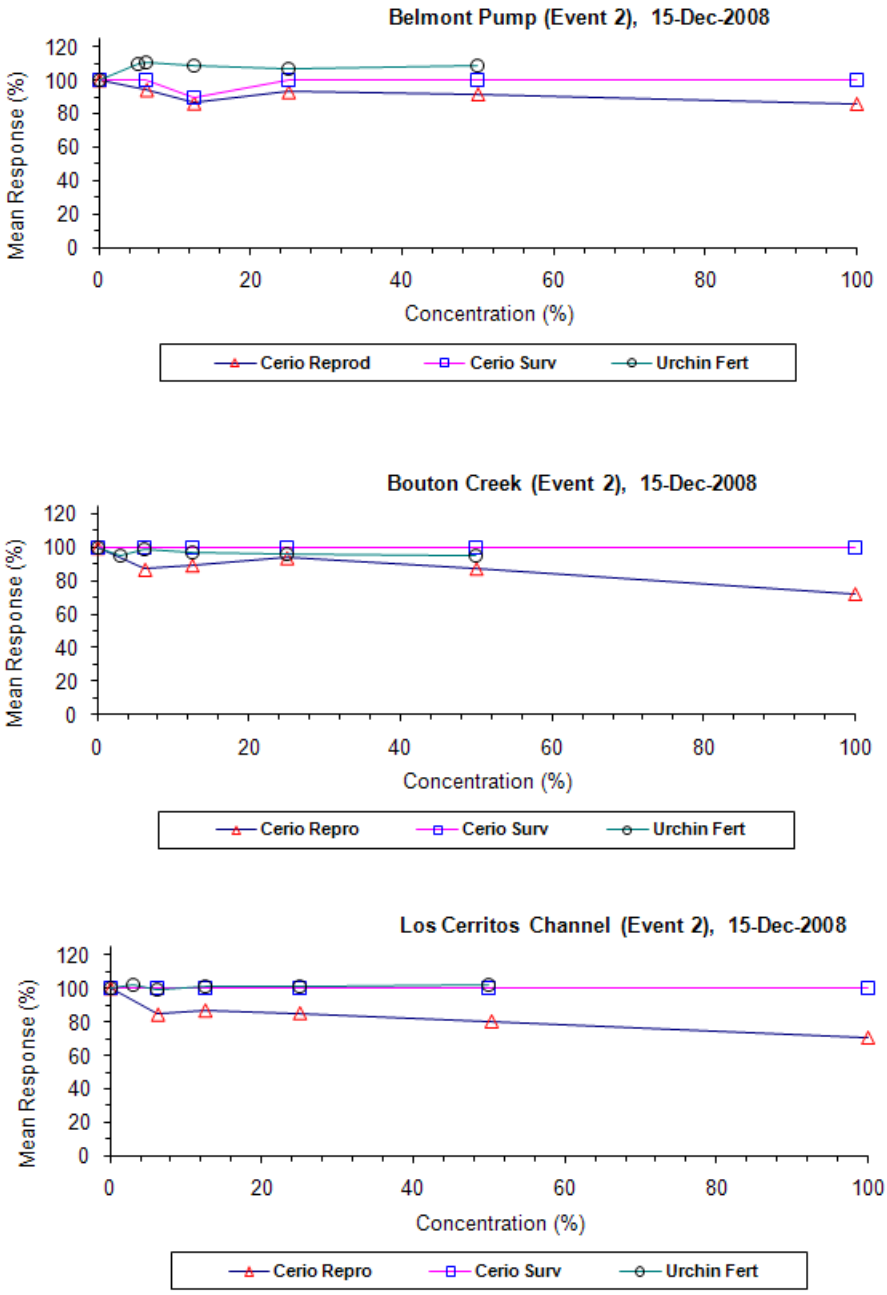


Figure 26. Toxicity Dose Response Plots for Stormwater Samples Collected during Event 2.

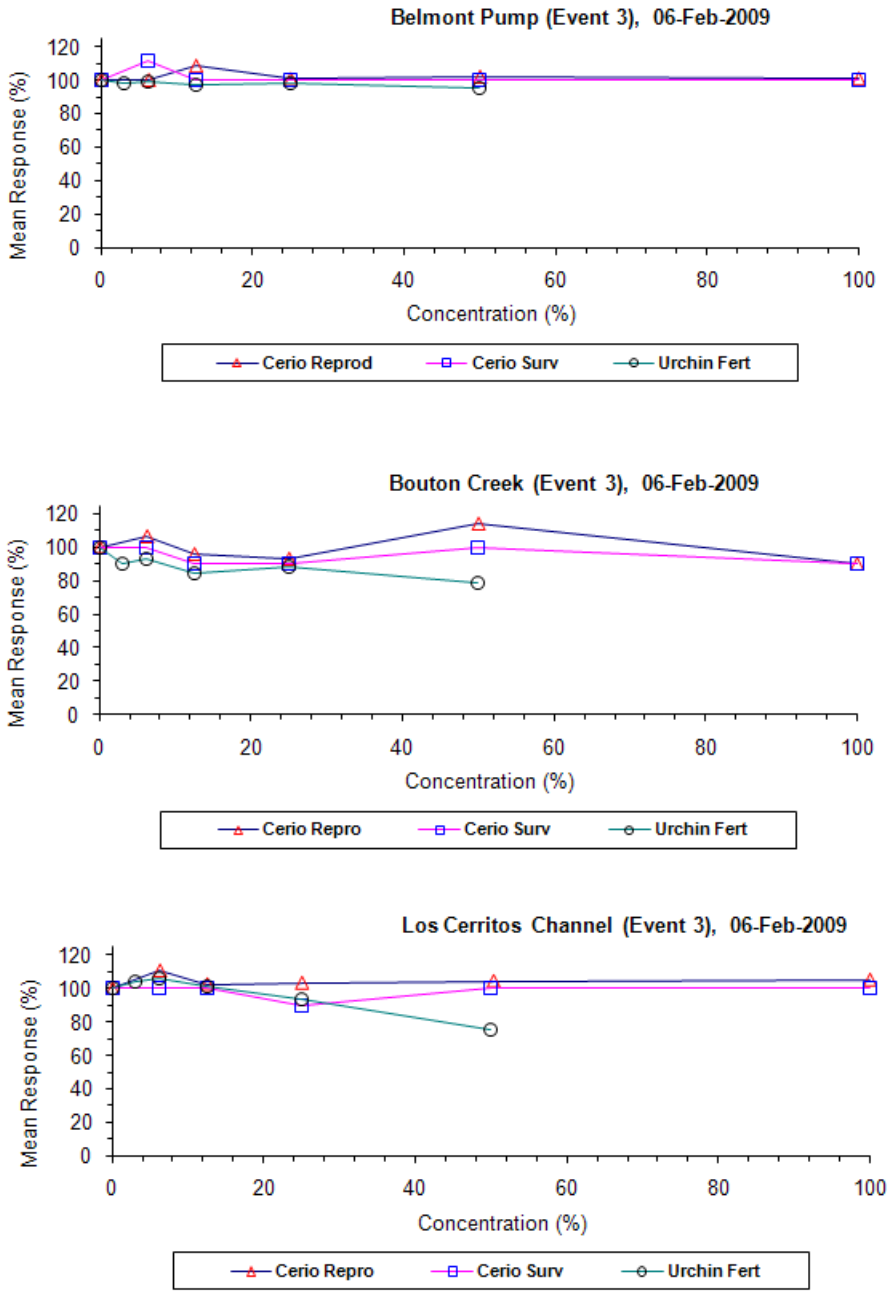


Figure 27. Toxicity Dose Response Plots for Stormwater Samples Collected during Event 3.

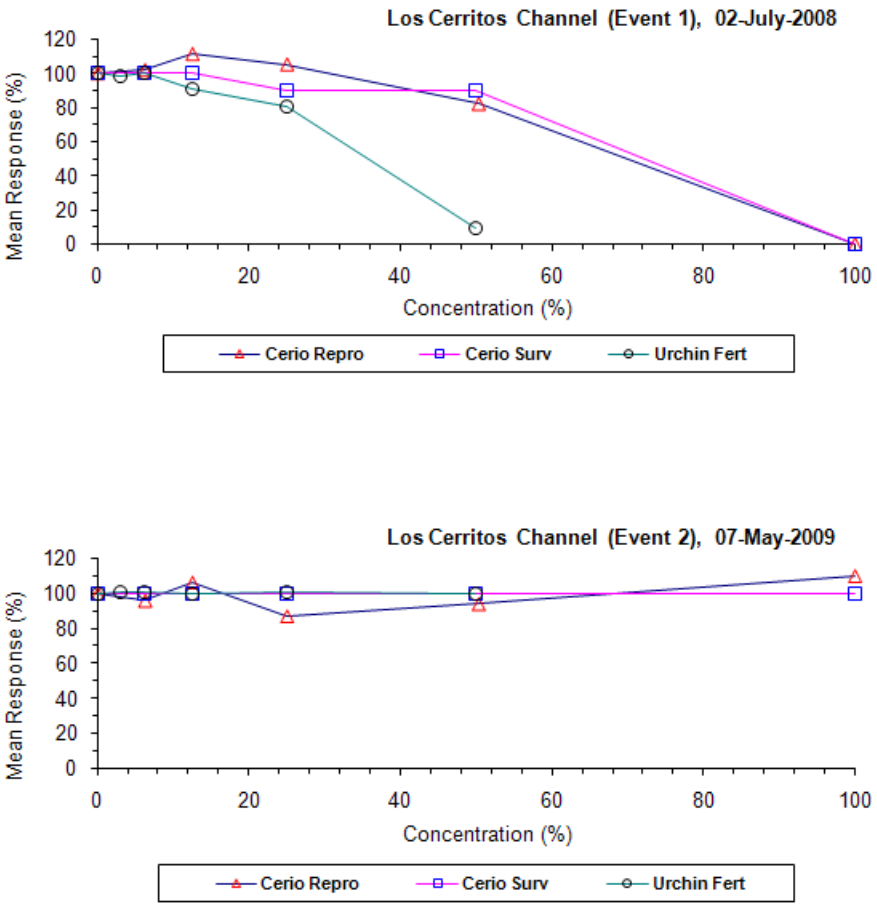


Figure 28. Toxicity Dose Response Plots for Dry Weather Samples Collected during Events 1 and 2.

Table 20. Toxicity of Wet Weather Samples Collected from the City of Long Beach Belmont Pump Station during the 2008/2009 Monitoring Season.

Test results indicating toxicity are shown in bold type.

Date	Test	Test Response (% sample)			TU_a[d]	TU_c[e]
		NOEC[a]	LOEC[b]	Median Response[c]		
11/26/08	Water Flea Survival	100	>100	>100	<1	1
11/26/08	**Water Flea Reproduction**	**50**	**100**	**>100**	**<1**	**2**
11/26/08	Sea Urchin Fertilization	50	>50	>50	<2	2
12/15/08	Water Flea Survival	100	>100	>100	<1	1
12/15/08	**Water Flea Reproduction**	**50**	**100**	**>100**	**<1**	**2**
12/15/08	Sea Urchin Fertilization	50	>50	>50	<2	2
2/6/09	Water Flea Survival	100	>100	>100	<1	1
2/6/09	Water Flea Reproduction	100	>100	>100	<1	1
2/6/09	Sea Urchin Fertilization	50	>50	>50	<2	2

[a] No Observed Effect Concentration: the highest concentration with a test response not significantly different from the control.

[b] Lowest Observed Effect concentration: the lowest concentration producing a test response that was significantly different from the control.

[c] Concentration causing 50% mortality to water fleas (LC_{50}), 50% inhibition in water flea reproduction (IC_{50}), or 50% reduction in sea urchin fertilization (EC_{50}).

[d] Acute toxicity units = $100/LC_{50}$ or EC_{50}.

[e] Chronic toxicity units = 100/NOEC.

Table 21. Toxicity of Wet Weather Samples Collected from the City of Long Beach Bouton Creek Station during the 2008/2009 Monitoring Season

Test results indicating toxicity are shown in bold type.

Date	Test	Test Response (% sample)			TU_a[d]	TU_c[e]
		NOEC[a]	LOEC[b]	Median Response[c]		
12/15/08	Water Flea Survival	100	>100	>100	<1	1
12/15/08	**Water Flea Reproduction**	**25**	**50**	**>100**	**<1**	**4**
12/15/08	**Sea Urchin Fertilization**	**12.5**	**25**	**>50**	**<2**	**8**
2/6/09	Water Flea Survival	100	>100	>100	<1	1
2/6/09	Water Flea Reproduction	100	>100	>100	<1	1
2/6/09	Sea Urchin Fertilization	50	>50	>50	<2	2

[a] No Observed Effect Concentration: the highest concentration with a test response not significantly different from the control.
[b] Lowest Observed Effect concentration: the lowest concentration producing a test response that was significantly different from the control.
[c] Concentration causing 50% mortality to water fleas (LC_{50}), 50% inhibition in water flea reproduction (IC_{50}), or 50% reduction in sea urchin fertilization (EC_{50}).
[d] Acute toxicity units = $100/LC_{50}$ or EC_{50}.
[e] Chronic toxicity units = 100/NOEC.

Table 22. Toxicity of Wet Weather Samples Collected from the City of Long Beach Los Cerritos Channel Station during the 2008/2009 Monitoring Season.

Test results indicating toxicity are shown in bold type.

Date	Test	Test Response (% sample)			TU_a[d]	TU_c[e]
		NOEC[a]	LOEC[b]	Median Response[c]		
12/15/08	Water Flea Survival	100	>100	>100	<1	1
12/15/08	**Water Flea Reproduction**	**<6.25**	**6.25**	**>100**	**<1**	**>16**
12/15/08	Sea Urchin Fertilization	50	>50	>50	<2	2
2/6/09	Water Flea Survival	100	>100	>100	<1	1
2/6/09	Water Flea Reproduction	100	>100	>100	<1	1
2/6/09	**Sea Urchin Fertilization**	**25**	**50**	**>50**	**<2**	**4**

[a] No Observed Effect Concentration: the highest concentration with a test response not significantly different from the control.

[b] Lowest Observed Effect concentration: the lowest concentration producing a test response that was significantly different from the control.

[c] Concentration causing 50% mortality to water fleas (LC_{50}), 50% inhibition in water flea reproduction (IC_{50}), or 50% reduction in sea urchin fertilization (EC_{50}).

[d] Acute toxicity units = $100/LC_{50}$ or EC_{50}.

[e] Chronic toxicity units = 100/NOEC.

Table 23. Toxicity of Dry Weather Samples from the City of Long Beach Los Cerritos Channel Station during the 2008/2009 Monitoring Season.

Test results indicating toxicity are shown in bold type.

Station	Date	Test	Test Response (% sample)			TU_a[d]	TU_c[e]
			NOEC[a]	LOEC[b]	Median Response[c]		
Los Cerritos	**7/2/08**	**Water Flea Survival**	**50**	**100**	**59**	**1.7**	**2**
Los Cerritos	**7/2/08**	**Water Flea Reproduction**	**50**	**100**	**68**	**1.5**	**2**
Los Cerritos	**7/2/08**	**Sea Urchin Fertilization**	**6.25**	**12.5**	**35.8**	**2.8**	**16**
Los Cerritos	5/7/09	Water Flea Survival	100	>100	>100	<1	1
Los Cerritos	5/7/09	Water Flea Reproduction	100	>100	>100	<1	1
Los Cerritos	5/7/09	Sea Urchin Fertilization	50	>50	>50	<2	2

[a] No Observed Effect Concentration: the highest concentration with a test response not significantly different from the control.

[b] Lowest Observed Effect concentration: the lowest concentration producing a test response that was significantly different from the control.

[c] Concentration causing 50% mortality to water fleas (LC_{50}), 50% inhibition in water flea reproduction (IC_{50}), or 50% reduction in sea urchin fertilization (EC_{50}).

[d] Acute toxicity units = $100/LC_{50}$ or EC_{50}.

[e] Chronic toxicity units = 100/NOEC.

Belmont Pump dry weather flows are now bypassed to the sanitary sewer, and were not tested.

Bouton Creek samples not collected due to low flow.

DISCUSSION

The following sections discuss the quality of stormwater and dry weather discharges from the mass emission monitoring sites. Concentrations of contaminants measured in both stormwater and dry weather discharges are compared with various receiving water quality criteria. Temporal trends over the past nine years are examined for principal contaminants of concern. Lastly, the toxicity of both stormwater and dry weather discharges is evaluated for the current year and general trends are examined over the duration of this permit.

COMPARISON TO WATER QUALITY CRITERIA

Numeric standards are not available for stormwater discharges. For the purpose of this report, water quality criteria or objectives were used to provide reference points for assessing the relative importance of various stormwater contaminants, though specific receiving water studies are necessary to quantify the presence and magnitude of any actual water quality impacts. Ultimately, specific beneficial uses of the receiving water body should be considered when selecting the appropriate benchmarks. Existing, potential and intermittent beneficial uses are provided in Table 24 for the receiving waters associated with each discharge point. Water quality criteria used as benchmarks are summarized in **Table 25**.

Wet Season Water Quality

Table 26 through Table 29 provide a comparison of Event Mean Concentrations (EMCs) for each measured constituent with various water quality criteria. The results summary tables (Table 13 and Table 14) also identify benchmarks that are exceeded for each storm event. These benchmarks are intended to serve as a tool for interpreting the stormwater quality data and assuring beneficial uses are not impacted. Exceedances of these receiving water quality benchmarks do not necessarily indicate impairment. Other factors such as dilution, duration and transformation in the receiving waters must also be considered.

For comparative purposes, an EMC was considered to be an exceedance if the value was higher than any of the reference or benchmark values. In using these benchmarks, it is important that the source of the specific criterion is considered. For instance, metals concentrations derived from California Toxics Rule (CTR) freshwater criteria for protection of aquatic life are based upon dissolved concentrations and are often a function of hardness. Values listed in **Table 25** are based upon a default hardness of 50 mg/L. Evaluation of any possible exceedance of hardness-dependant criterion is based upon the actual hardness EMC for that site and event. Saltwater objectives listed for metals under the CTR are also based upon dissolved concentrations while those listed under the California Ocean Plan are based upon total recoverable measurements. Although Ocean Plan numbers are used for comparative purposes, the marine and estuarine receiving waters in the vicinity of Long Beach would only be subject to the CTR saltwater values since Alamitos Bay and the coastal waters of Long Beach are considered enclosed bays and estuaries. Values provided for the Basin Plan are primarily based upon Title 22 drinking water standards. For two of the key organophosphate pesticides, the only available water quality criteria are those proposed by the California Department of Fish and Game (Siepmann and Finlayson, 2002). USEPA (2006) National Recommended Water Quality Criteria provide an additional reference for many of the nonpriority pollutants included in the monitoring program.

Both acute and chronic water quality criteria are used in this evaluation. Due to the limited period of discharge, the acute criteria are considered most applicable to stormwater. Dry weather discharges are most appropriately compared against chronic criteria.

As noted in previous years, the pH of stormwater runoff is typically slightly acidic. This is mostly due to dissolved carbon dioxide that the rain "scrubs" from the atmosphere. Other gases such as sulfur dioxide (SO_2) and nitrogen oxides (NO_x) can cause further acidification of the rainfall. The National Atmospheric Deposition Program (NADP, 2007) indicates that pH associated with rainfall is typically 5.1 around the Los Angeles County area. Over the past 30 years, the pH of rainfall has shown evidence of increasing throughout the United States although these increases have been most notable on the east coast. Rainfall in the northeastern portion of the United States is commonly much more acidic due to primarily due to use of coal. Average pH values for precipitation in the northeastern United States is typically 4.3 to 4.5, more than 1.2 units lower than the Los Angeles basin.

The water quality criteria for pH included in the Los Angeles Basin Plan (CRWQCB, Los Angeles, 1994) indicate that surface waters should be maintained in the range of 6.5 to 8.5. Due to the acidic nature of rainfall, low pH values are common but quite variable among years. Stormwater discharges with elevated pH values are less common but do occur in 2 to 5 percent of the storm events. This is often attributed to the low buffering capacity in most stormwater runoff from highly urbanized areas.

The pH of stormwater from all stations and events have met Basin Plan criteria for both the 2008/2009 (Table 13 and Table 14; Table 26 through Table 29) and 2007/2008 (Kinnetic Laboratories, Inc. 2008) monitoring seasons. In the earlier years of the program about 25% of the stormwater samples had measured pH values that were below the lower Basin Plan limits of 6.5. Due to the acid nature of rainfall, it is unusual to have stormwater with measured pH values greater than the upper Basin Plan limit of 8.5. This has only happened during two small volume storm events, one in 2005/2006 at the Belmont Pump Station and another during the 2006/2007 season at the Los Cerritos Channel station.

The total coliform, fecal coliform and enterococcus single sample criteria were exceeded during 100 percent of the sampling events. Grab samples taken for bacteria during storm events typically exceed Basin Plan water quality criteria but also have shown a tremendous degree of variability of time. This can be attributed to both extreme variability that can occur over the course of a storm event and even extreme short term variability that is common when taking field duplicates. Since bacteria analyses must be initiated within 6 hours of collection it is only practical to take a single grab during each storm event. Although periods of peak flow are targeted, this can often be impacted by the accuracy of weather forecasts used to determine the best time for grab sampling.

Benchmark reference values were commonly exceeded for five total recoverable metals including aluminum, copper, iron, lead and zinc. One of these five metals, iron, is only listed as National Non Priority Pollutant in freshwater. Criteria for total recoverable aluminum exist for drinking water (Basin Plan criteria) and aquatic life as a nonpriority pollutant (**Table 25**). Both total recoverable aluminum and iron exceeded in 100% of the samples (Table 26 through Table 29) mass emission sites. Both of these metals are abundant in soils and are often used to normalize other metals data to better evaluate enrichment from anthropogenic activities. Elevated levels of both iron and aluminum are normal during storm events with increased loads of sediment and are not typically considered to be a major concern.

This season, concentrations of both total recoverable copper and zinc measured in runoff from the mass emission sites exceeded Ocean Plan criteria 100% of the time. Total recoverable lead exceeded Ocean Plan criteria in 90% of the stormwater samples. None of the remaining total recoverable metals exceeded Ocean Plan criteria in the 10 station-events monitored during the 2008/2009 wet season.

Total recoverable concentrations of three metals (copper, lead and zinc) have frequently exceeded Ocean Plan criteria over the past nine years of the stormwater monitoring program. Historically, total recoverable concentrations of these metals have met the criteria only when TSS concentrations were also low.

In 1993 (USEPA, 1993) EPA recognized that, in most cases, measurement of metals in the dissolved form provided the most accurate assessment of potential stress to aquatic ecosystems. As a result water quality criteria promulgated by EPA as the "California Toxics Rule" (CTR; USEPA, 2000) were based upon the dissolved fraction for both freshwater and saltwater. In the case of freshwater, criteria for six of the eight metals included in the monitoring are functions of hardness. Low concentrations of hardness lead to low water quality criteria. With increasing hardness, toxicity decreases and the water quality criteria for these six metals increase. The saltwater criteria included in the CTR are applicable in bays and estuaries of California.

Dissolved copper exceeded both CTR freshwater criteria and CTR saltwater criteria in 100% of the stormwater samples this wet season. Concentrations of dissolved lead and zinc only exceeded the CTR freshwater criteria. Concentrations of dissolved lead exceeded the CTR freshwater criterion in 70% of the samples. Dissolved zinc exceeded the CTR freshwater criteria in 60% of the stormwater samples. Benchmark reference values have been often exceeded for dissolved forms of copper, lead and zinc throughout the life of the permit (Kinnetic Laboratories, Inc., 2007).

Chlorinated pesticides are uncommon in stormwater runoff from the mass emission sites. When detected, concentrations of detected compounds have typically been low (less than 10 times the reporting limit). Although largely banned or restricted throughout the industrialized nations, these legacy pesticides persist in the environment. Chlorinated pesticides are hydrophobic, lipophilic and very stable. Due to the hydrophobic nature of these compounds, chlorinated pesticides strongly associate with suspended solids which settle and accumulate in bottom sediments. Organochlorine pesticides most often detected in stormwater runoff have been DDT compounds, primarily 4,4'-DDE, and chlordane compounds.

Technical chlordane, another organochlorine compound, is a complex mixture of approximately 140 compounds but NOAA considers seven compounds as representative of the major components of technical chlordane. These include alpha-chlordane, gamma-chlordane, cis-nonachlor, trans-nonachlor, heptachlor, heptachlor epoxide and oxychlordane. During the 2008/2009 storm season, chlordane was detected in 70% of the stormwater composites including all three monitored events at the Belmont Pump Station. Despite being completely banned for over 20 years, the Event Mean Concentration (EMC) for chlordane during the first monitored event at the Belmont Pump Station was 0.336 µg/L. This is the highest concentration measured at any monitoring station since the program was initiated 10 years ago. Chlordane exceeded 0.1 µg/L during only two occasions at the Los Cerritos Channel site (0.13 µg/L in 2004 and 0.11 µg/L in 2007) and one other time at the Belmont Pump Station (0.13 µg/L in 2007). Due to the larger size of the Los Cerritos Channel watershed, total loads of chlordane from the Los Cerritos Channel were substantially higher than those from the Belmont Pump Station despite the similar concentrations (Table 15 and Table 16).

Toxaphene, another organochlorine pesticide, exceeded both the CTR freshwater and saltwater criteria however the presence of any toxaphene in the samples would constitute an exceedance since the reporting limits are well above the criteria. Toxaphene was detected at all monitoring stations during the December 15, 2008 event but the highest concentration (0.325 µg/L) was measured in stormwater from the Belmont Pump Station. Toxaphene, like chlordane, is a complex mixture of chemicals of nearly 180 different compounds. Such complex mixtures can often vary in different formulations making quantification difficult. The detection limits for toxaphene have improved

substantially over the life of the monitoring program making interpretation of long term trends somewhat difficult.

The banning of residential, nonprofessional use of diazinon and chlorpyrifos resulted in these contaminants no longer being measureable in any of the stormwater samples during the 2008/2009 season. In 2007/2008 diazinon was only detected in association with one storm event at both the Los Cerritos Channel and Dominguez Gap monitoring stations but concentrations remained well below the available criterion (0.08 µg/L; Siepmann and Finlayson, 2002). Chlorpyrifos was below detection limits at all sites in 2007/2008 as well. As will be discussed later, the absence of these pesticides in stormwater discharges has resulted in substantial decreases in toxicity to *Ceriodaphnia*.

Malathion, another organophosphate pesticide used as a residential pesticide, continues to be common in stormwater samples. Malathion is far less toxic to daphnids with reported LC_{50}s for ranging from 1.14 to 3.18 µg/L (TDC, 2003). During the 2008/2009 monitoring period 100% of the samples had measurable concentrations of malathion. This compared to 75% during the 2007/2008 wet season and 63% during the 2006/2007 wet season (Kinnetic Laboratories, Inc. 2008). Concentrations of malathion, however, only exceeded EPA Recommended Water Quality Criteria of 0.1 µg/L (freshwater and saltwater) in 7 out of the 10 stormwater samples. Malathion concentrations have been consistently highest during early season events with concentrations decreasing substantially later in the season. None of the reported concentrations were high enough to be expected to exert a toxic response in the *Ceriodaphnia* (waterflea) tests.

As noted last year, the triazine pesticides continue to be uncommon in stormwater runoff. In previous years, the only triazine pesticides detected in stormwater or dry weather discharges have been prometon, simazine and cyanazine. All three typically occur at levels of less than 10 times the detection limit. This year simazine was detected in only one of the ten stormwater samples. Simazine was reported at 0.0861 µg/L in the first monitored storm event in the Los Cerritos Channel. None of the other triazine pesticides were detected in the stormwater composites. Although simazine is frequently detected in stormwater, concentrations have consistently been well below levels that would exert measurable toxicity on aquatic life and even well below drinking water standards.

Dry Season Water Quality

With the exception of organophosphate pesticides, water quality of dry weather discharges has not changed substantially since the start of the program in early 2000. Dry season water quality has not tended to vary greatly between sites or sampling dates. The most significant changes continue to be decreases in the volume of dry weather discharges including the elimination of dry weather flow at the Belmont Pump Station. Dry weather discharges at the Bouton Creek site have been too low to conduct sampling for the past two years. Flows have continued to be insufficient to clear the saltwater from the channel to the degree that samples could be taken to characterize the dry weather flow. Combined with the current lack of dry weather discharges at the Dominguez Gap Pump Station, this has limited dry weather monitoring to two events at the Los Cerritos Channel site. By next summer, we anticipate that the Dominguez Gap Pump Station may be discharging during the summer but the water will largely originate from the Los Angeles River.

Discharges sampled during the July 2008 survey had a TSS concentration of 69 mg/L. Water sampled during the May 2009 dry weather survey had only 6.8 mg/L of TSS. This year, the higher TSS concentration measured at the Los Cerritos Channel site may have been impacted by tidal waters that extended to the site for a portion of the sampling effort. This is evident from the elevated conductivity/chloride content of the sample and a review of the recorded water level information. In general, the concentrations of suspended particulates and total recoverable metal concentrations are

low in dry weather runoff. TSS was always least at the Belmont Pump Station which averaged just 2.6 mg/L. The Los Cerritos Channel dry weather flows have always exhibited higher and more variable concentrations of solids. Dry weather flows at the Los Cerritos Channel monitoring site have averaged 37 mg/L of TSS since monitoring was first started. The high variability was evident in both surveys conducted during the 2008/2009 season

Trace metals associated with dry weather discharge have predominantly been in the dissolved form largely due to lower concentrations of suspended solids. Hardness is also consistently high which tends to mitigate the effects of the dissolved metals (Table 30). Hardness was measured at 140 and 150 mg/L in association with the two dry weather surveys at the Los Cerritos Channel site and 470 mg/L during the September 2007 dry weather survey in Bouton Creek. As a result, most trace metals were below CTR freshwater criteria during both dry weather sampling events.

As in all previous years, copper remains the primary constituent of concern in dry weather discharges although it has been uncommon for dissolved copper to exceed the CTR freshwater criterion at most stations due to the elevated hardness of dry weather discharges. Dissolved copper in dry weather discharges from the Los Cerritos Channel exceeded the CTR freshwater only during the May 2009 survey. Dissolved copper concentrations in dry weather flows from the Los Cerritos Channel mass emission site were 5.7 µg/L and 13 µg/L). Both of the dry weather measurements of total copper in the Los Cerritos Channel dry weather samples exceeded Ocean Plan criteria (12 µg/L) (Table 30).

This year simazine was the only triazine pesticide detected in association with one of the dry weather surveys. Simazine was measured at a concentration of 0.02 µg/L in the May 2009 dry weather sample from the Los Cerritos Channel. The reporting limit for simazine is 0.01 µg/L. The infrequent presence of these compounds in stormwater runoff and the low concentrations when they are detected suggests that this group of organic compounds should be considered for elimination from the analytical suite for both wet and dry weather monitoring.

TEMPORAL TRENDS OF STORMWATER POLLUTANTS

Temporal trends in concentrations of selected trace metals, three organophosphate pesticides, TSS and bacteria have been tracked since the first dry weather surveys conducted in 2000 (Figure 29 through Figure 45). The metals and organic compounds included in this assessment are those that are 1) often detected in both stormwater and dry weather discharges and/or 2) are suspected to be primary sources of toxicity. Time series are presented for total and dissolved concentrations of five trace metals including cadmium, copper, nickel, lead and zinc. Due to the typically large differences between total and dissolved lead concentrations, a separate graphic is included to detail changes in dissolved lead over time. The figures include all wet and dry weather data for the past nine years at each monitoring site. Periods of dry weather are indicated by the shaded areas or, in the case of indicator bacteria, by the color of the data point.

With the exception of diazinon and chlorpyrifos, visual review of the data shows no obvious increases or decreases in concentration over time (Figure 29 through Figure 45). Since residential use of diazinon and chlorpyrifos was phased out, these pesticides have rarely been detected. This past year, neither compound was detected in either stormwater or dry weather discharges. Chlorpyrifos has not been detected in runoff since November 2001. This is the first year that diazinon was not detected in stormwater from any event at all stations.

- Dissolved concentrations of cadmium, copper, and nickel do not vary substantially between wet and dry weather periods.

- Concentrations of dissolved zinc and lead are often higher during storm events than during dry weather sampling events.
- Concentrations of total copper, lead and zinc are consistently higher in association with storm flows.
- The decline in concentrations of chlorpyrifos and diazinon in stormwater at all sites remains one of the most significant temporal trends. Neither of these organophosphate compounds was detected in stormwater or dry weather discharges during the 2008/2009 monitoring year.
- Malathion, another organophosphate pesticide, continues to be commonly detected in stormwater at levels exceeding national nonpriority pollutant guidelines but has not been implicated as a source of significant toxicity.
- Historically, concentrations of total trace metals in stormwater from the Dominguez Gap Pump Station were notably lower than the other monitoring locations but over the past two years concentrations of total copper, lead and zinc are showing signs of increases to levels comparable to other sites. This is concurrent with increasing concentrations of suspended solids.
- Fecal indicator bacteria typically exceed Basin Plan water quality criteria during both wet and dry weather monitoring (Figure 42 through Figure 45) although dry weather monitoring was limited to the Los Cerritos Channel site this past year

Statistical methods are being considered for potential implementation in subsequent years to improve assessment of potential long-term trends that are not readily evident by examination of the graphical plots. We expect that we will be using the nonparametric Mann-Kendall Trends (Kendall, 1980) test to determine if there is an increasing or decreasing trend and Sen's method for estimation of slope or rate of change (Gilbert, 1987). This approach cannot be used without an initial and thorough assessment of the data set. One key assumption is that there is an underlying, monotonic trend. This may require addressing some of the functional relationships associated with stormwater that could either obscure long term trends or lead to misinterpretation of the trends.

Over the first nine years of the monitoring effort stormwater discharges at the Dominguez Gap Pump Station were uncommon and, when they occurred, concentrations of TSS and metals were among the lowest encountered at the four mass emission sites. Starting in April 2007, higher concentrations of TSS and metals have been encountered at this site. Since April 2007, eight of the nine TSS measurements rank as the highest concentrations measured at this location since the start of the program. Similar trends are evident for total recoverable trace metals such as lead, copper and zinc that would be strongly associated with suspended solids.

The apparent changes in quantity and quality of stormwater discharges at the Dominguez Gap Pump Station are likely associated with the soil disturbances that were associated with construction activities necessary to develop the wetland habitat as well as changes in the operation of the Pump Station to help establish and maintain the wetlands. The fact that wetland vegetation is now established should contribute to decreases in concentrations of TSS and trace metals. Improvement in the operation of the wetlands may also contribute to better water quality and fewer discharges. Increasing the capacity of the wetlands by closing down the diversion from the Los Angeles River to the wetlands at an earlier time and allowing more time for infiltration could substantially reduce discharges. This would also decrease the bias in water quality and pollutant load measurements causing by Los Angeles River water mixing with City of Long Beach stormwater runoff. If operational constraints for wetland maintenance continue to result in significant quantities of water from the Los Angeles River being incorporated into stormwater discharges at the Dominguez Gap Pump Station, an alternative mass emission monitoring site may need to be located that more effectively monitors stormwater from the City of Long Beach.

TOXICITY

The following sections address toxicity as expressed during both dry and wet weather periods, examine long-term (between years) and short-term (within seasons) trends, provide a comparison with toxicity in other Southern California areas, and examine sources of toxicity.

Stormwater Toxicity

Three wet weather samples from the Belmont Pump station and two samples from Bouton Creek and the Los Cerritos Channel were analyzed for toxicity during the monitoring period. All seven of those samples were tested with water fleas and sea urchins (14 total bioassays). The three storm events were sampled over a period of four months. The first storm was occurred in November, 2008, the second in December, 2008 and the third in February, 2009.

The Belmont Pump samples from all three storms showed no measurable water flea mortality (NOEC=100%, LC_{50}>100%). The first two Belmont storms (November 26 2008 and 15 December 2008) produced minor reproductive toxicity NOEC=50%, EC_{50}>100%) to *Ceriodaphnia*. Neither mortality nor decreased reproduction was measureable in the third Belmont Pump sample (February 6 2009). Sea urchin toxicity was measurable only in the second Belmont Pump sample of the year, collected February 6, 2009, where slight (NOEC=25%, EC_{50} >50%) chronic toxicity was observed.

The Bouton Creek sample from the December 2008 storm showed no measurable water flea mortality (NOEC=100%) but slight (NOEC=25%) reproductive toxicity. The LC_{50} and EC_{50} were both >100%. The February 6, 2009 Bouton Creek sample did not produce any measurable toxicity (NOEC=100%, LC_{50}>100%). Moderate chronic toxicity (NOEC=12.5%) to sea urchins was detected in the December 15 2008 storm, but there was no decreased fertilization (NOEC=50%) measured in the last storm (on February 6 2008). EC_{50}s were >50% in both samples.

The Los Cerritos Channel station showed no measurable *Ceriodaphnia* mortality in samples from either storm (NOECs=100%) There was significantly decreased reproduction in the 15 December 2008 sample (NOEC=6.25%), but the EC_{50} was >100%). This very low NOEC value was largely due to very similar numbers of neonates among the replicate exposures at all test concentrations, resulting in low standard deviations and very sensitive statistical discriminations. The apparently high chronic toxicity (>16 TU_c) in this test was more apparent than real. No water flea toxicity was measured in the February 6, 2009 sample. Chronic toxicity to sea urchins was not detected in the 15 December 2008 storm (NOEC=50%) but was detected in the sample collected on 6 February 2009 (NOEC=25%).

Chronic toxicity of the wet weather samples to *Ceriodaphnia* reproduction was observed in the first storm at the only station tested, in the second storm at all three stations and not at all in the third storm. There was no lethal toxicity measured in any wet weather sample from any station. This pattern of little to no mortality throughout the monitoring period and minor reproductive inhibition only in the early storms is similar to that seen in the previous three project years.

Dry Weather Toxicity

Dry weather toxicity tests were only performed at the Los Cerritos Channel mass emission site. Discharges from the Belmont Pump station were being bypassed to the sanitary system and Bouton Creek flows were again too low to provide sufficient volumes for testing in either the July 2008 or the May 2009 sampling periods.

The July 2008 dry weather sample from Los Cerritos Channel produced moderate lethal toxicity (LC_{50} = 59%) and reproductive inhibition (EC_{50} = 68%). NOECs for both endpoints were 50%. Thus there was

measurable chronic toxicity (2 TU_c) and acute toxicity (1.6 to 1.8 TU_a) but no TIEs were triggered. The May 2009 dry weather sample did not show measurable toxicity to water flea survival or reproduction.

There was substantial sea urchin toxicity in the Los Cerritos Channel dry weather sample in July 2008 (NOEC=6.25% - 16 TU_c and EC_{50}=35.8% - 2.8 TU_a) but acute toxicity was not sufficient to trigger a TIE. No toxicity was measured in the May 2009 Los Cerritos Channel sample.

Historical Toxicity Trend

Figure 49 and Figure 47 summarize chronic toxicity of stormwater to water flea reproduction and sea urchin fertilization, respectively, throughout the nine years of the City's monitoring program. Figure 48 and Figure 46 provide similar summaries of dry weather chronic toxicity for water fleas and urchins, respectively.

Figure 49 shows a virtual absence of wet weather water flea toxicity after the 2002/2003 storm season at all three stations, except for the first storm of 2004/2005 where 4 to 8 TU_c were measured. In the current program, however, the December storm produced 4 TU_c at Bouton Creek and 16 TU_c at the Los Cerritos Channel station. As noted above, the within-test variability of the daphnid bioassays during those tests was very low with PMSDs ranging from 10 to 12%, whereas PMSDs of up 47% are considered acceptable in this test method. The high precision of these data allows the statistical tests to reliably identify smaller differences among sample groups as significantly different from one another. In the Los Cerritos Channel data set, for example, significantly fewer neonates were produced in all sample concentrations, making the NOEC <6.25%, equivalent to >16 TU_c. In our professional judgment this elevated chronic toxicity should be viewed as unrealistically high. We suggest that the pattern of low daphnid toxicity has continued through this 2008/2009 season.

Substantial chronic sea urchin toxicity has been documented at all three stations during wet weather in each monitoring season since 2000/2001 (Figure 47). One or more of the three stations have measured 16 TU_c or more at least once during each season. Such relatively high levels of toxicity have occurred with almost equal frequency at each of the three stations, but not always consistently among stations. For example, the first storm tested during 2006/2007 showed very high urchin toxicity (32 TU_c) at the Belmont Pump Station and the Los Cerritos Channel but much lower toxicity (2-4 TU_c) at the Bouton Creek site. Such differences among stations are the rule rather than the exception. During the current monitoring program the maximum urchin stormwater toxicity was 8 TU_c in the December Bouton Creek sample. Here again however, within-test variability was extremely low (PMSD=4%), producing "statistically significantly reduced" fertilization at the two highest sample concentrations in which fertilization rates were 94.5% and 93.6%, respectively. We judge the 8 TU_c number to be unrealistically high for this sample.

Until the 2005/2006 monitoring program, 41% of water flea samples have demonstrated substantial chronic toxicity (>8 TU_c) in dry weather samples at the Bouton and Los Cerritos Channel stations (Figure 48), in contrast to the usual non-toxic results in wet weather samples (Figure 49). In most years the elevated water flea toxicity was seen in dry weather samples taken in the fall, just prior to the storm season, with toxicity much reduced in the spring dry weather samples. Over the last three years there has been very little evidence of dry weather toxicity to *Ceriodaphnia.* In the 2008/2009 program there was 2 TU_c at the Los Cerritos Channel site in the fall and 1 TU_c in the spring. Since the 2000/2001 monitoring program there has been negligible chronic toxicity at the Belmont Pump station.

Figure 46 shows the pattern of chronic dry weather toxicity in sea urchins. Again, the Belmont Pump samples have shown little toxicity. At the Bouton Creek station, 20% of samples have produced

>8TU_c of chronic toxicity, and 47% of the Los Cerritos Channel station samples produced chronic toxicity at levels of >8 TU_c. These have been equally split between those collected in spring and fall.

In summary, sea urchins have shown more instances of moderate to high (>8 TU_c) wet weather toxicity than have water fleas. Episodes of high urchin toxicity have occurred with approximately equal frequency at all three stations, beginning with the 2000/2001 monitoring program and continuing through 2007/2008. No such episodes occurred during the 2008/2009 monitoring program.

In contrast, water fleas showed elevated toxicity 8-16 TU_c in the early years (2000/2002) of the study at the Belmont Pump and Cerritos Channel stations, but have only once before (in 2004/2005 at Los Cerritos Channel) demonstrated such effects since that time. The 16 TU_c at Los Cerritos Channel in the current year's program is considered anomalous due to atypical test sensitivity.

Dry weather samples were negligibly toxic to both species in water collected from Belmont Pump in all study years. With the exception of the 2000/2001 and2002/2003 programs, sea urchin fertilization tests have also shown little dry weather toxicity at Bouton Creek and Los Cerritos Channel. The fall Los Cerritos Channel samples of the 2007/2008 and 2008/2009 programs, however, were very toxic to urchins.

Water fleas have been more frequently toxic in dry weather than in wet weather samples from Bouton and Los Cerritos Channel, though neither station produced much dry weather toxicity during 2006/2007, 2007/2008 and 2008/2009. Some of the *Ceriodaphnia* toxicity observed in Bouton Creek dry weather samples in 2003-2005 can probably be attributed to elevated sample salinity.

Temporal Toxicity Patterns

There was some suggestion in the toxicity data from early monitoring periods that seasonal flushing may have been a factor affecting the variability in stormwater toxicity. Early years of the program suggested that *Ceriodaphnia* toxicity was usually somewhat elevated in early vs late storms. Water flea data between the 2005/2006 and 2007/2008 monitoring periods, however, tend not to support that thesis since there was only very minor water flea toxicity in any of the 10 storms monitored during that time span at any of the three stations. The little toxicity (2 TU_c) that did occur, however, was seen in the first-of-the year storms at Belmont and Cerritos (2005/2006) and at Belmont and Bouton (2007/2008). The toxicity seen in the mid-season storm at Bouton and Los Cerritos Channel in 2008/2009 is viewed as anomalous due to elevated test sensitivity (Figure 49).

Toxicity to sea urchins has varied widely over the storm seasons at each of the three stations, often with little agreement among them. In 2007/2008, for example, Belmont Pump Station samples showed high urchin toxicity in the last storm sampled and no toxicity in the first three storms. Bouton Creek samples were moderately toxic in the second and third storms and non-toxic in the first and last storms. In 2008/2009, however, neither early nor late storms produced substantial urchin toxicity. There has been a similar lack of pattern in the timing of stormwater toxicity to sea urchins over several storm seasons. Careful examination of Figure 47, shows that in six of nine monitoring periods at least one early storm has shown urchin toxicity of 16 TU_c or more, while in five of the nine we have seen such substantial toxicity in late storms. It seems that early storms have been more likely to produce sea urchin toxicity at any given station, but later storms can also frequently produce highly toxic samples.

Thus the idea that seasonal flushing is significantly affecting stormwater toxicity is not strongly supported by recent water flea test data. That idea was supported in a limited way by sea urchin data prior to 2007/2008, but not supported over the last two monitoring periods. This may be attributable to not being able to successfully sample the first storm of the season at all sites.

Comparative Sensitivity of Test Species

Seven wet weather samples were tested for toxicity with both water fleas and sea urchins during the 2008/2009 program. Toxicity was detected by water fleas in four (57%) of those samples, while the urchin fertilization bioassay detected toxicity in two of seven samples (29%). Three of the four samples that produced minor toxicity to water flea reproduction did not produce measurable toxicity to sea urchin fertilization. One sample produced toxicity to both species and one sample was toxic to urchins but not to water fleas. In contrast to previous years, the water flea test was a slightly more "sensitive" test method. It should be noted, however, that the current year's samples showed little acute toxicity (no TIEs were triggered) and that the chronic toxicity observed in *Ceriodaphnia* was either minor (2-4 TU_c) or probably overestimated by the statistical methods employed. Program history suggests that the sea urchin probably remains the more sensitive species.

There were two dry weather discharge samples tested with both water fleas and sea urchins, both collected from Cerritos Channel. The July 2008 showed substantial toxicity to sea urchins and minor effects on water flea survival and reproduction. The May 2009 sample did not produce measurable toxicity to either test species. Thus dry weather toxicity to urchins was more substantial than toxicity to water fleas.

This pattern of sensitivity (sea urchin>water flea) in storm waters was observed during all eight previous monitoring programs and in a study of urban stormwater toxicity in San Diego (Southern California Coastal Water Research Project 1999).

The 2008/2009 data suggest that species sensitivity to Cerritos Channel dry weather discharge samples was similar to that observed in 2000/2001 through 2002/2003 and 2007-2008 where there appeared to be greater sensitivity of urchins to dry weather samples. However, the dry weather species sensitivity has varied over the course of the monitoring program. In 2003/2004, 2004/2005 and 2005/2006 water fleas were generally the more sensitive species in dry weather samples, while in 2006/2007 the two species showed approximately equal sensitivities to dry weather discharge**.**

Relative Toxicity of Stormwater

Table 31 compares the frequency and magnitude of stormwater toxicity from the Long Beach stations in 2008/2009 with that of stormwater samples from Long Beach in previous years and with toxicity in other southern California watersheds (Los Angeles and San Gabriel Rivers, Ballona and Cholla Creeks). The data suggest a decrease from the previous three monitoring periods in both frequency and magnitude of Long Beach stormwater toxicity to sea urchins.

The frequency of toxicity to water fleas in 2008/2009 was higher than that seen in recent years, continuing the trend towards higher frequency that began in the 2007/2008 monitoring year. With the exception of the December sample from Cerritos Channel, the magnitude of toxic response was low continuing the trend toward reduction in magnitude seen in the previous six monitoring periods.

We might expect results from Chollas Creek and Ballona Creek to be similar to Long Beach results, as these samples were obtained from smaller highly urbanized watersheds, relative to the samples from the Los Angeles and San Gabriel Rivers. The Chollas/Ballona Creek data, which show frequency of sea urchin toxicity ranging from 85-100%, suggest comparability for Long Beach samples from the first two monitoring periods. Table 31, however, indicates a decreased frequency of urchin toxicity during the 2002/2003, 2003/2004, 2004/2005, 2007/2008 monitoring periods. In 2005/2006 and 2006/2007 the frequency of urchin toxicity returned to pre-2002 levels but obviously decreased again in the past two monitoring programs.

Toxicity Characterization

Because of low acute toxicity in both wet and dry weather samples during this monitoring period, no TIEs were triggered and no direct evidence of possible toxicants was obtained.

Correlation analysis of the toxicity and chemistry data provides an additional test of the association between stormwater toxicity and chemical contamination. The data from all storms in all monitoring periods from 2001/2002 through 2008/2009 were pooled for the correlation analyses. The correlation analyses generally confirm the conclusion from the previous study years, that the toxic responses measured in this study are related to the chemical composition of the stormwater samples. The toxic responses of sea urchins and/or water fleas were significantly correlated with increased concentrations of several stormwater constituents, including dissolved metals, hardness, TSS, TDS and TOC (Table 32). Dissolved copper and nickel were significantly correlated with toxicity to both species, while dissolved cadmium, lead, and zinc were correlated with water flea toxicity (Table 32). Previous annual reports have included organophosphate pesticides in the correlation analysis, but in recent years these compounds, including diazinon, have not been detected in stormwaters. As a result of the increasing numbers of non-detects, these analytes were removed from the analysis.

Over the past two years, dissolved copper has been most strongly correlated with sea urchin toxicity, closely followed by nickel. In the 2006/2007 report, zinc showed a lower though significant correlation while this year there was no significant correlation with zinc. Reports from 2004/2005, 2003/2004 and 2002/2003 showed significant correlations with copper, nickel, lead and zinc. Monitoring data from earlier study years showed significant correlations only with dissolved copper and zinc.

A sufficient number of data points have been measured over the nine program years to allow similar correlation analyses to be performed at the three individual stormwater stations. The results are presented in Table 33. There are significant correlations between “conventional” pollutants, including hardness, TSS, TDS and TOC, and water flea acute toxicity in samples from Bouton Creek and the Los Cerritos Channel but not in Belmont Pump samples. Acute survival and/or reproductive chronic toxicity in water fleas is significantly correlated with dissolved cadmium, copper, lead, nickel and zinc at Bouton Creek and/or the Los Cerritos Channel but only with cadmium, nickel and lead in Belmont Pump Station samples. These results suggest that the toxicity of stormwater discharge at Belmont Pump is quite different from that associated with the Bouton Creek and Los Cerritos Channel monitoring stations. The significant correlations of combined site data with conventionals , dissolved copper, nickel and zinc (Table 32) are driven by Bouton and Los Cerritos Channel data.

It is also of interest that the only significant correlations with urchin acute toxicity data in Table 33 are with copper and nickel at the Los Cerritos Channel station and that urchin toxicity in the combined data set is also significantly correlated with copper and nickel. This suggests that the Los Cerritos Channel data are of primary importance in the combined correlations.

A third method, comparing the measured and predicted toxic units of the samples was used to assess the importance of zinc and copper as a cause of the toxicity of Long Beach stormwater. The predicted acute toxicity of the sample was calculated from the measured concentrations of the chemical constituents and their corresponding EC_{50} or LC_{50}. Results of these comparisons for storms in the 2008/2009 program are graphically presented in Figure 50 through Figure 51. Toxic unit comparisons were not particularly useful this year due to the lack of substantial toxicity during the 2008/2009 season. Nevertheless, the lack of toxicity corresponded with low predicted toxicity based upon concentrations of zinc, chlorpyrifos and diazinon in the samples.

Due to pre-test sample dilution the detection limit for toxicity in sea urchin bioassays is 2 TU_a. As shown in Figure 51, the predicted toxicity contribution from zinc and copper in six of the seven tests during 2008-09 is at or just above 2 TU_a. In the December test, predicted toxicity is about 1 TU_a. All seven bioassays measured acute toxicity at <2TU_a, suggesting that observed toxicity was reasonably close to that predicted from the concentrations of zinc and copper.

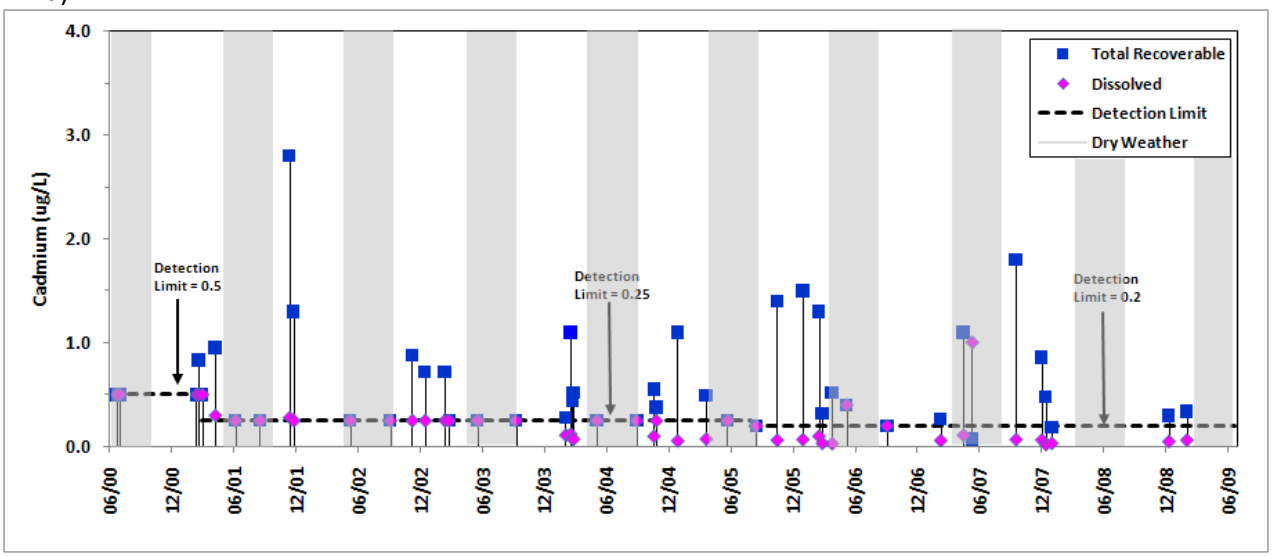
For water fleas (Figure 50 and Figure 52) all seven samples showed observed acute toxicity below the 1 TU_a limit of detection, and for all of those the predicted toxicity from zinc was also <1 TU_a. Thus there was good agreement between observed and predicted toxicity. Note that neither diazinon nor chlorpyrifos were detected in these 2008/2009 stormwater samples.

Figure 52 and Figure 53 compare observed acute toxicity with predicted toxicity from zinc and copper (for urchins) or from zinc and organophosphates (for water fleas) in selected toxic samples from program years 2001/2002 through 2006/2007. Only samples that showed initial (acute) toxicity of 3 TU_a are included in these summary figures. Note that these figures remain unchanged from the 2007/2008 annual report, since we observed no toxicity exceeding 3 TU_a during 2008/2009.

Of the fourteen selected sea urchin samples, five exhibited very high initial toxicity (10-40 TU_a). Of these, predicted toxicity from zinc and copper accounted for well under 10% of observed toxicity (except in April 2001 when zinc and copper accounted for about 50% of observed toxicity). The remaining nine samples showed initial observed toxicities of between 3 and 4 TU_a and in most of those zinc and copper accounted for about half of that toxicity. In two of those nine samples the predicted (zinc + copper) toxicity exceeded the observed toxicity by a factor of two.

There were seven water flea samples that showed initial toxicity of >3 TU_a, and six of those were collected during the 2001/2002 storm season. Two of those samples exhibited very high initial toxicity (10-25 TU_a), and chemical analysis was able to account for about 30% of initial toxicity mostly due to diazinon and chlorpyrifos content. The remaining five samples showed initial toxicity of 3-5.5 TU_a. In one sample, predicted toxicity exceeded observed toxicity by a factor of three; in three samples zinc and pesticide toxicity accounted for between 50% and 80% of observed toxicity, while in the fifth sample the measured contaminants could account for only 10% of the observed toxicity.

a)



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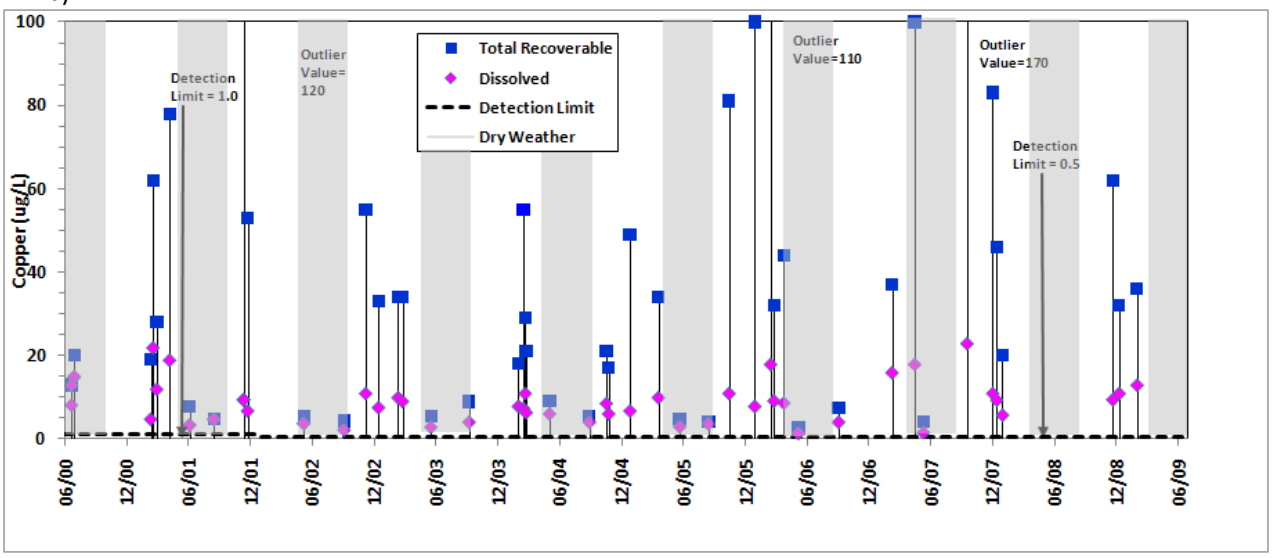

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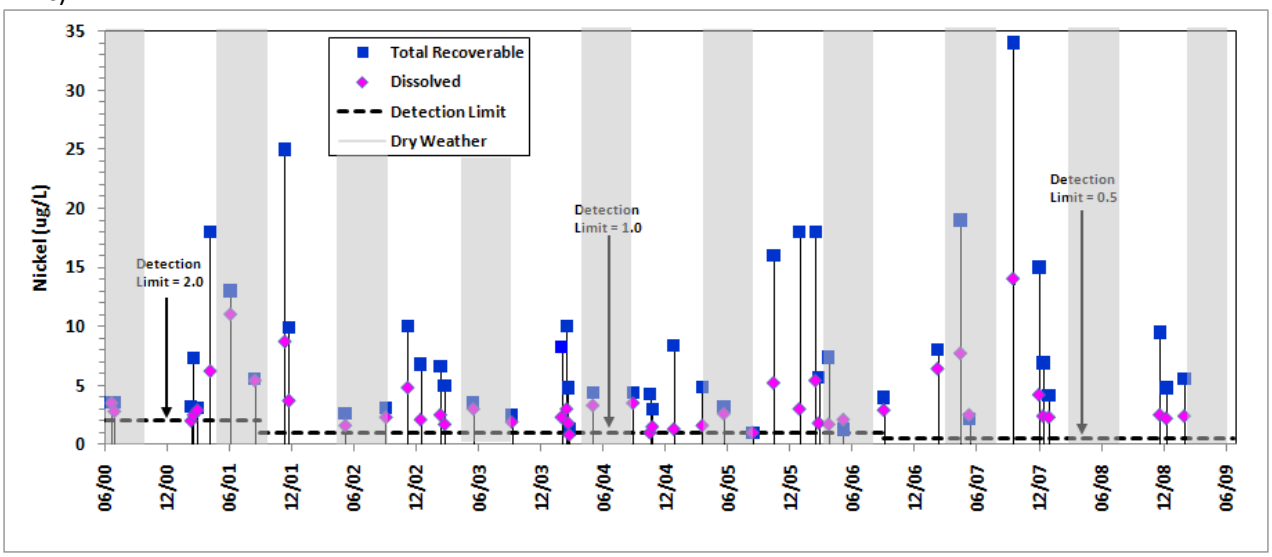
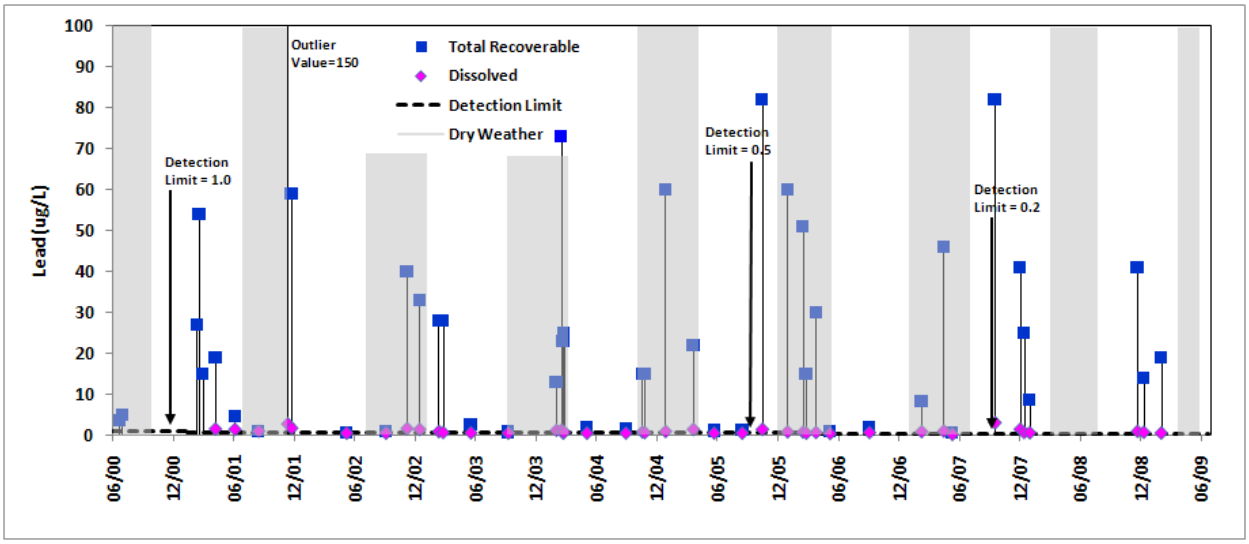


Figure 29. Belmont Pump Station Chemistry Results: a) Cadmium; b) Copper; c) Nickel

a)



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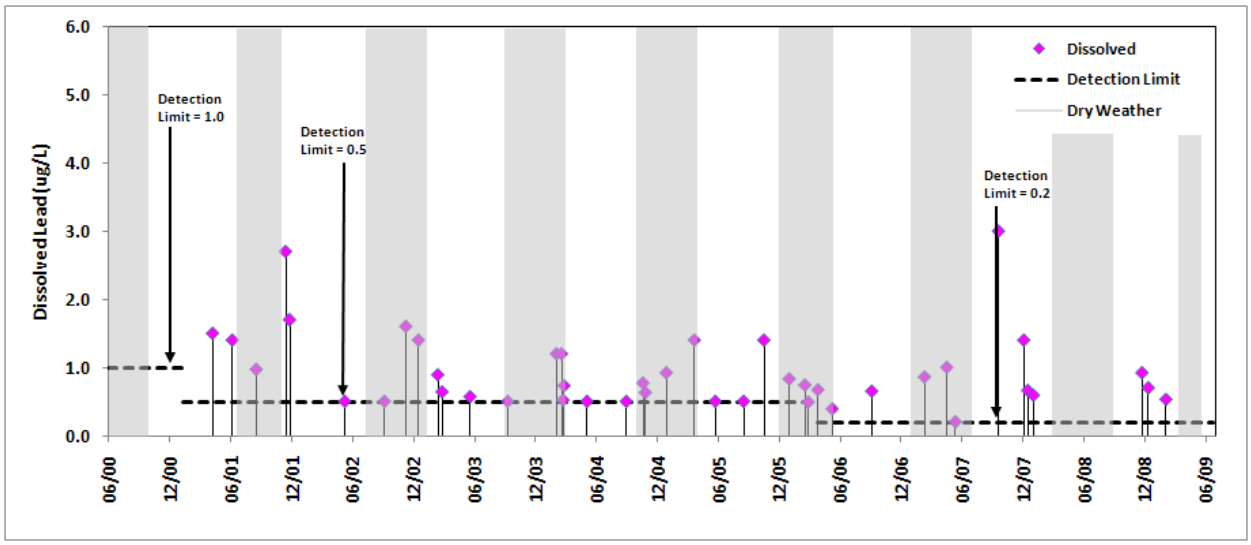

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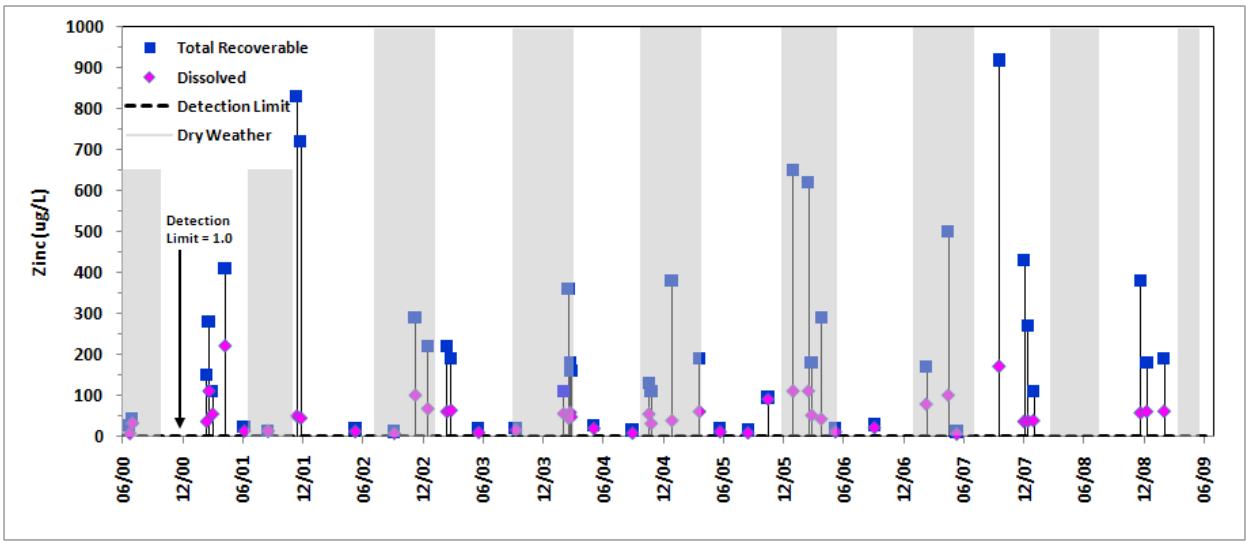
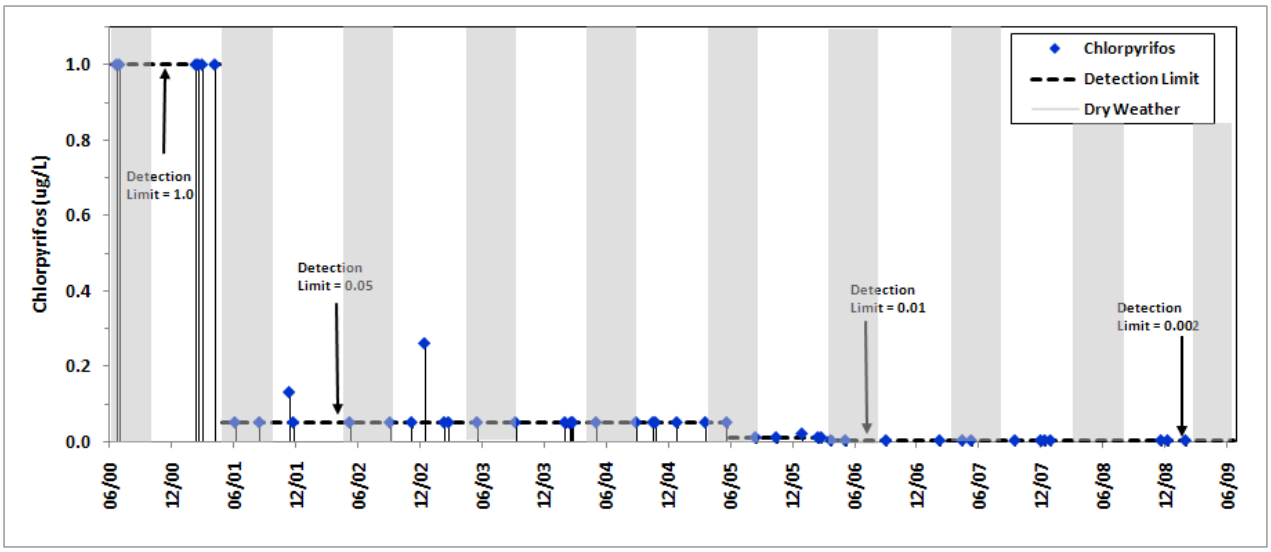


Figure 30. Belmont Pump Station Chemistry Results: a) Lead (total and dissolved); b) Lead (dissolved only); c) Zinc

a)



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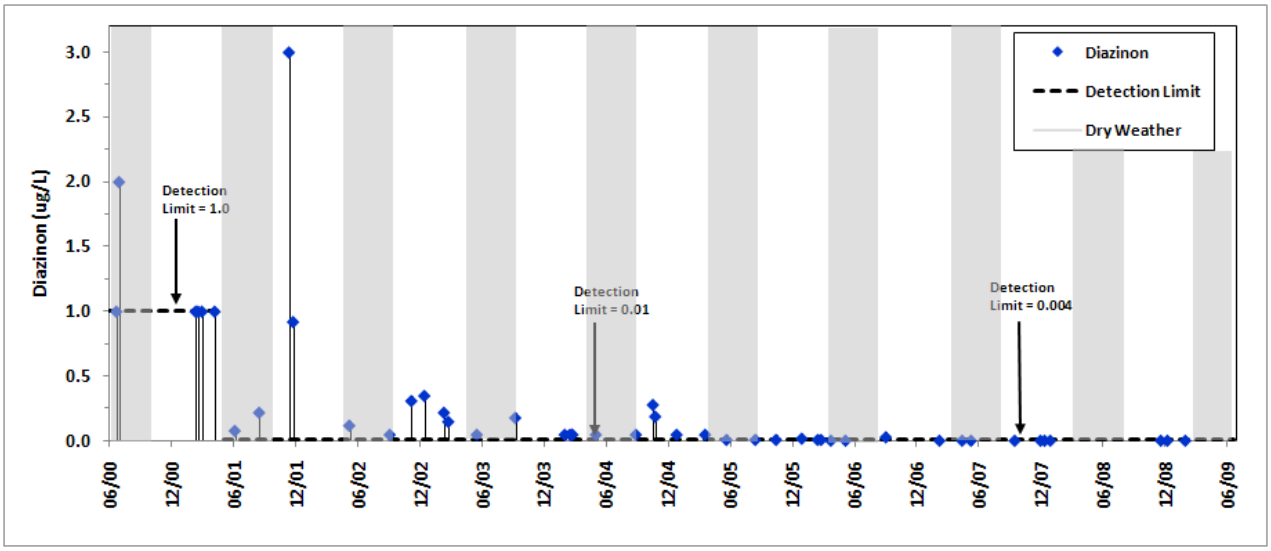

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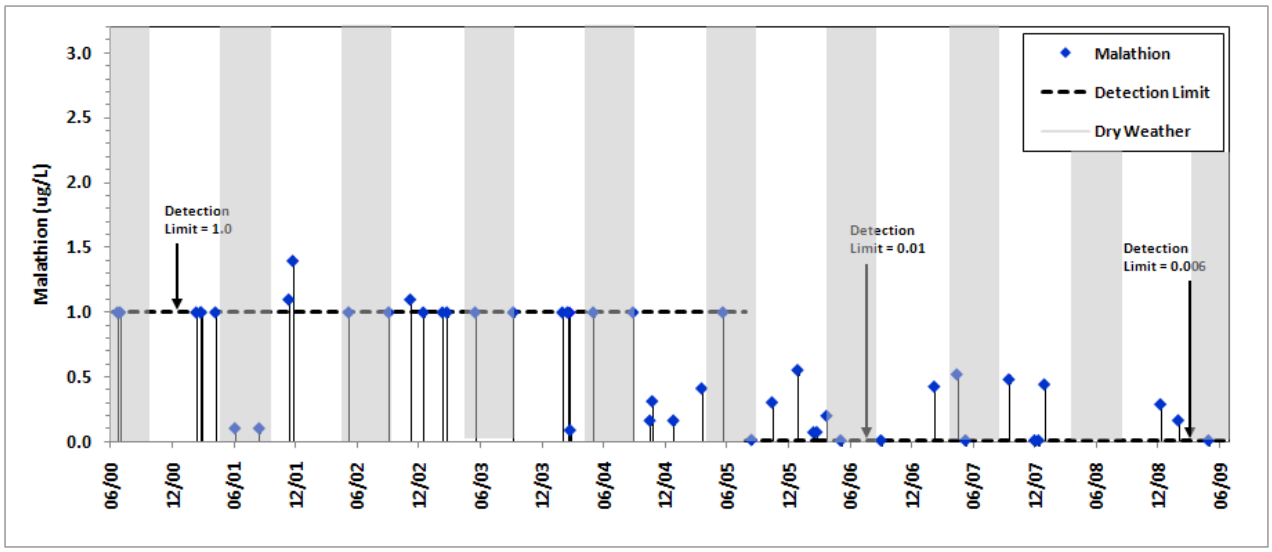
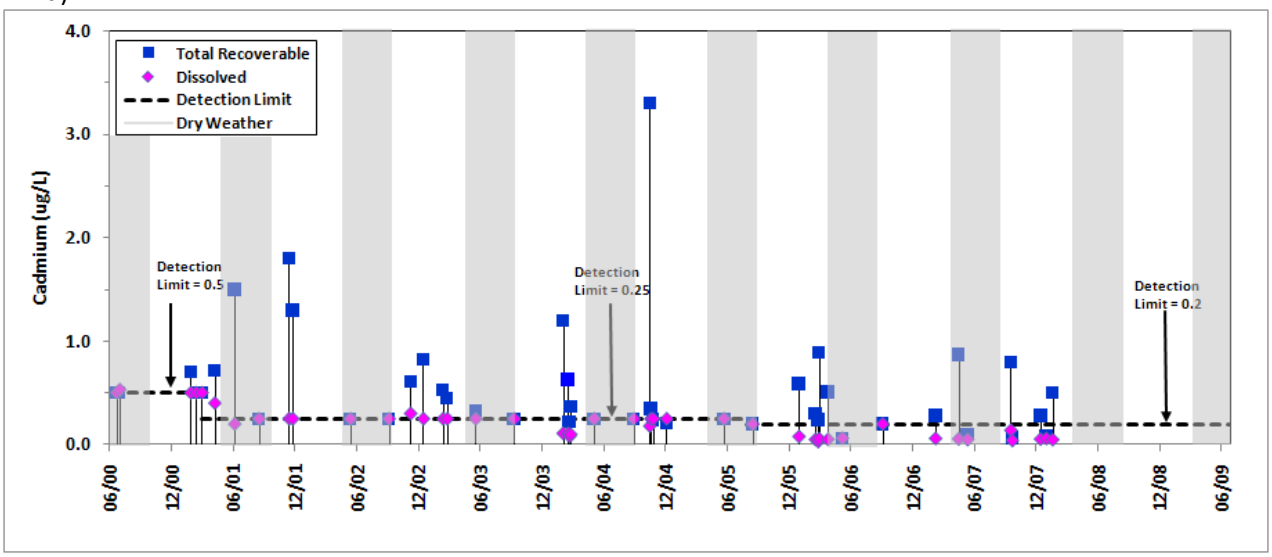


Figure 31. Belmont Pump Station Chemistry Results: a) Chlorpyrifos; b) Diazinon; c) Malathion

a)



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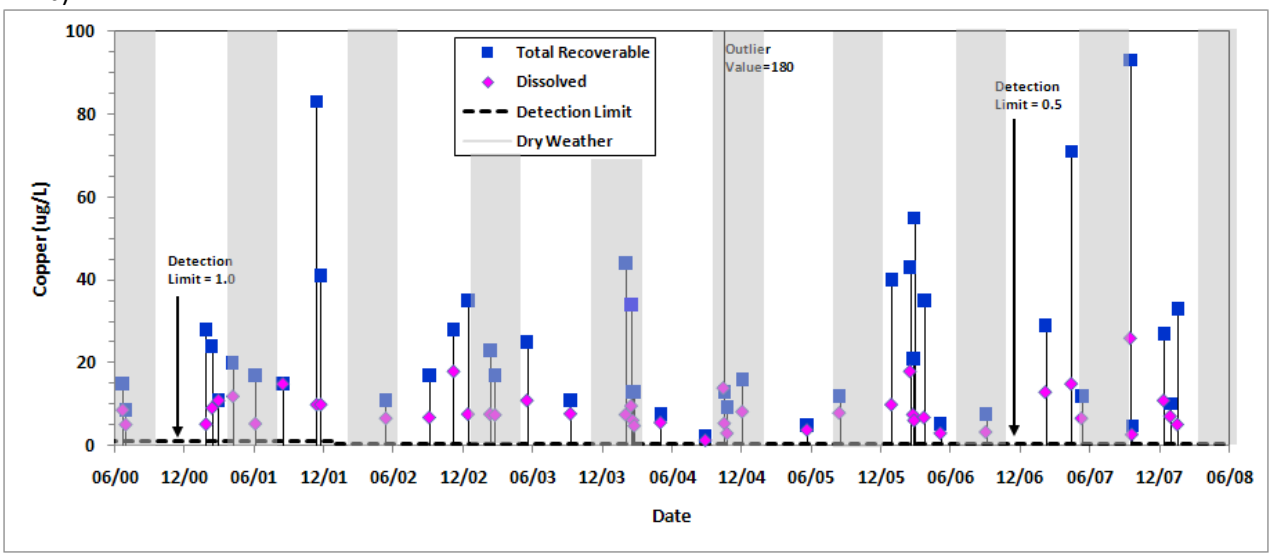

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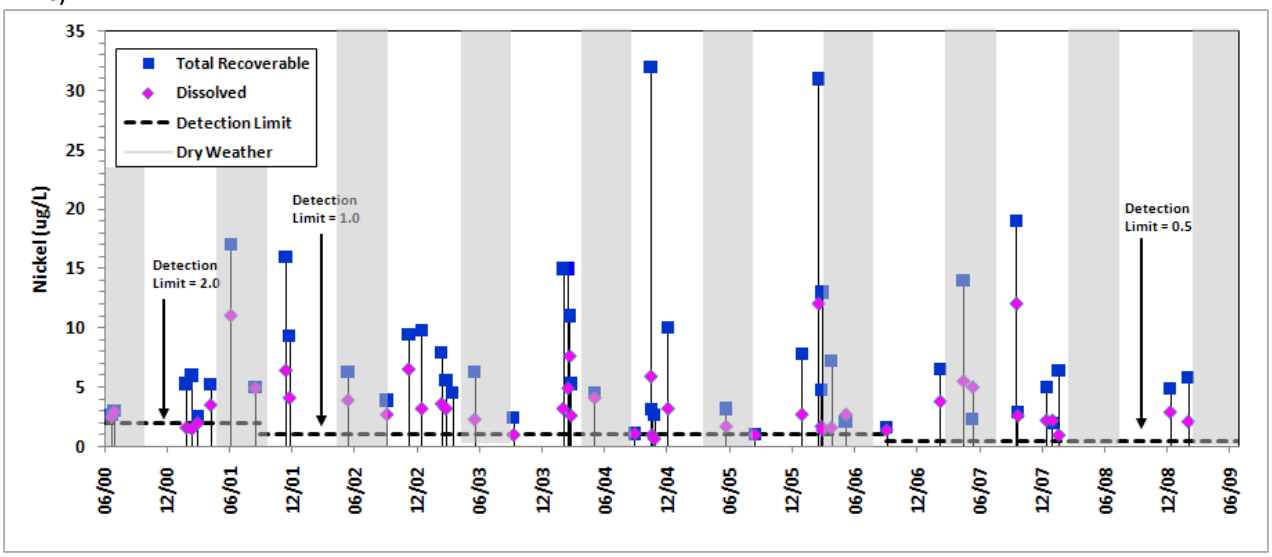
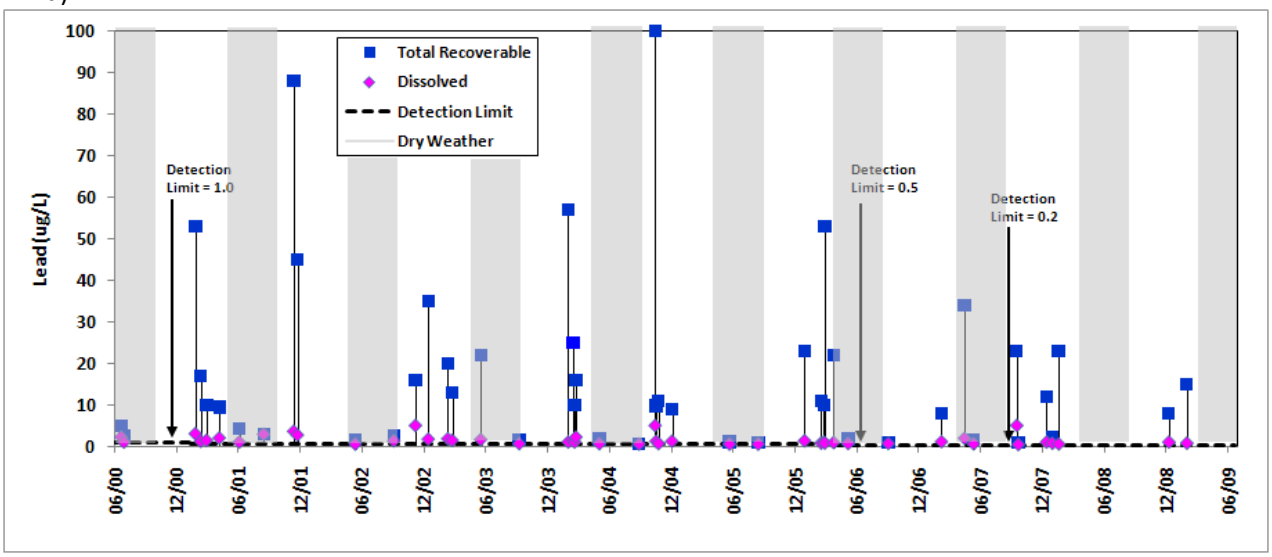


Figure 32. Bouton Creek Chemistry Results: a) Cadmium; b) Copper; c) Nickel

a)



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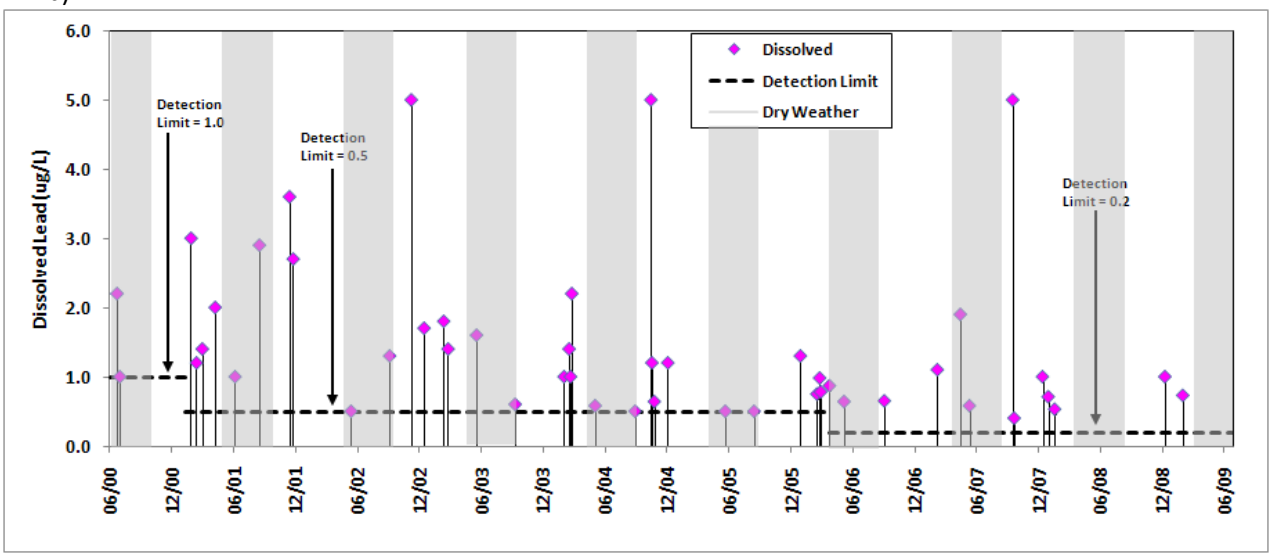

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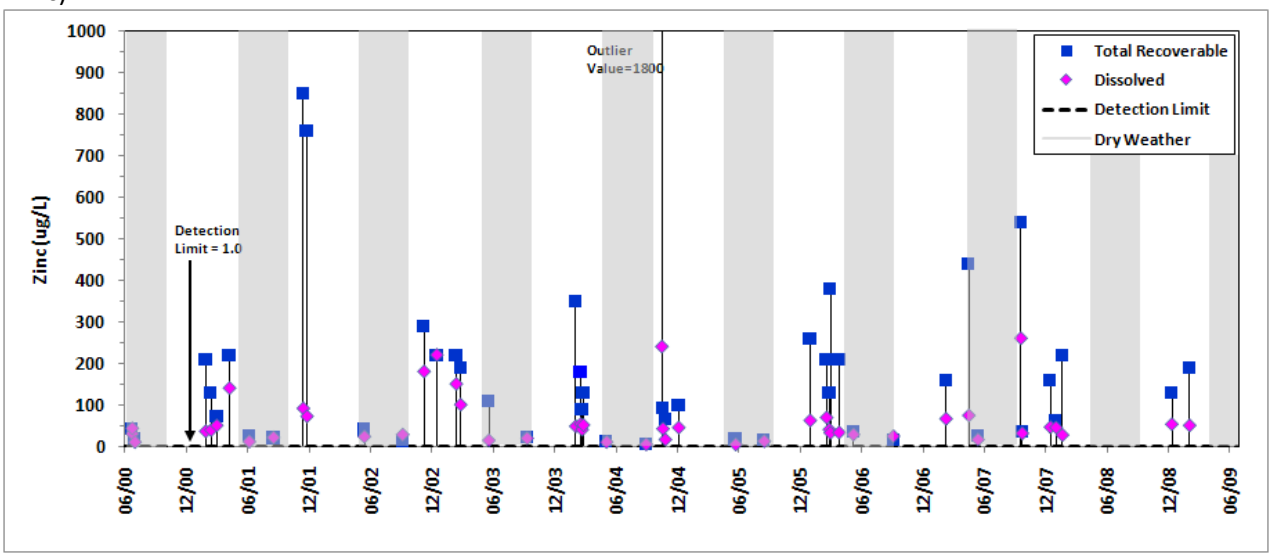
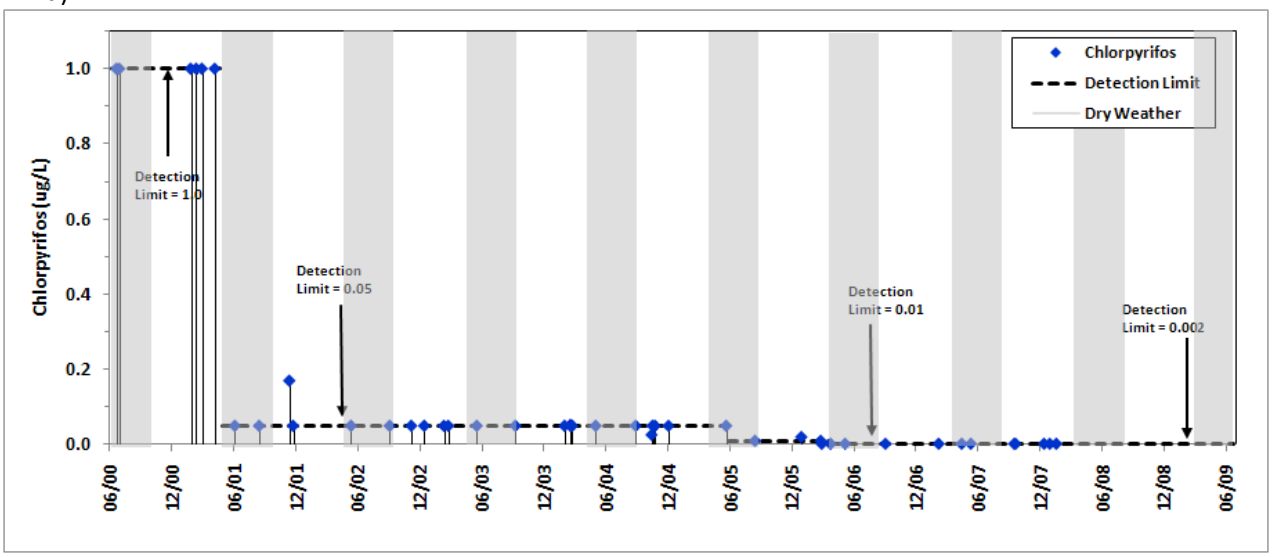


Figure 33. Bouton Creek Chemistry Results: a) Lead (total and dissolved); b) Lead (dissolved only); c) Zinc

a)



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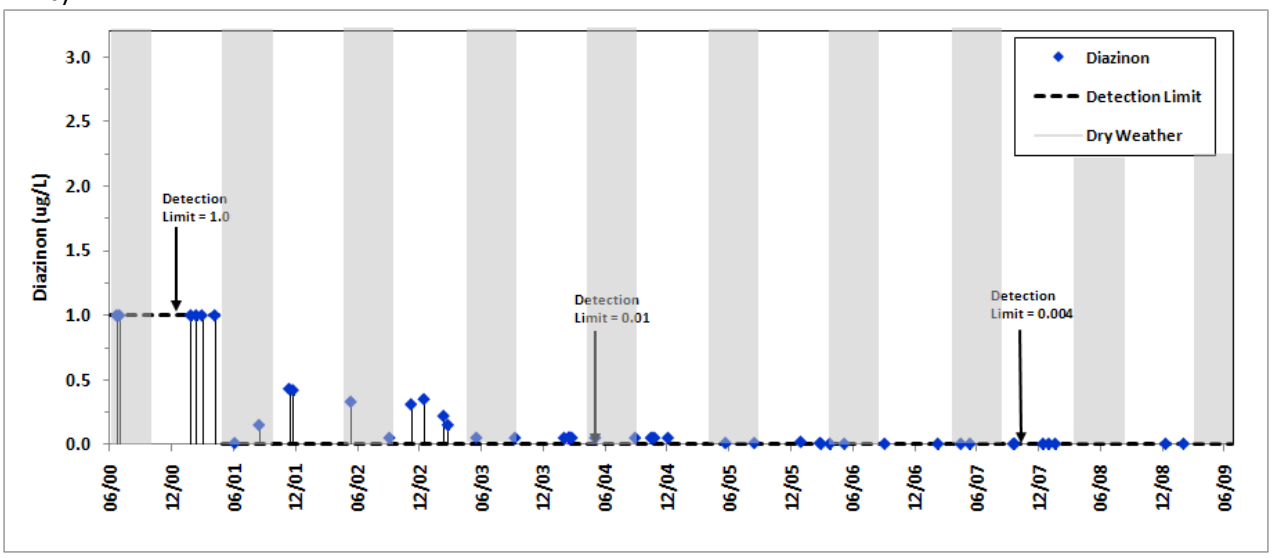

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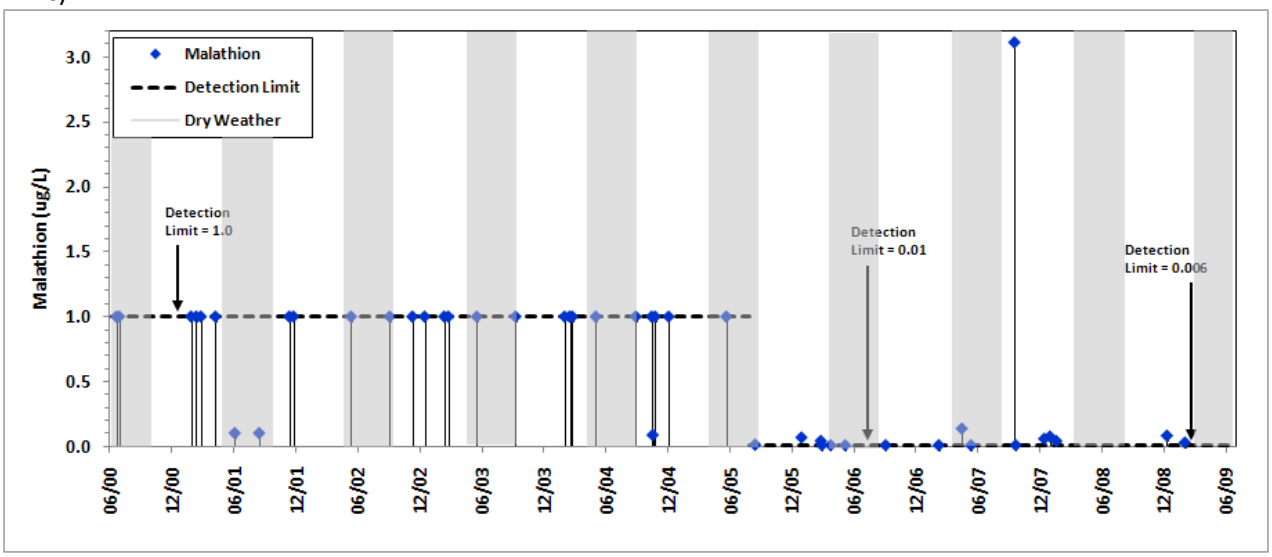
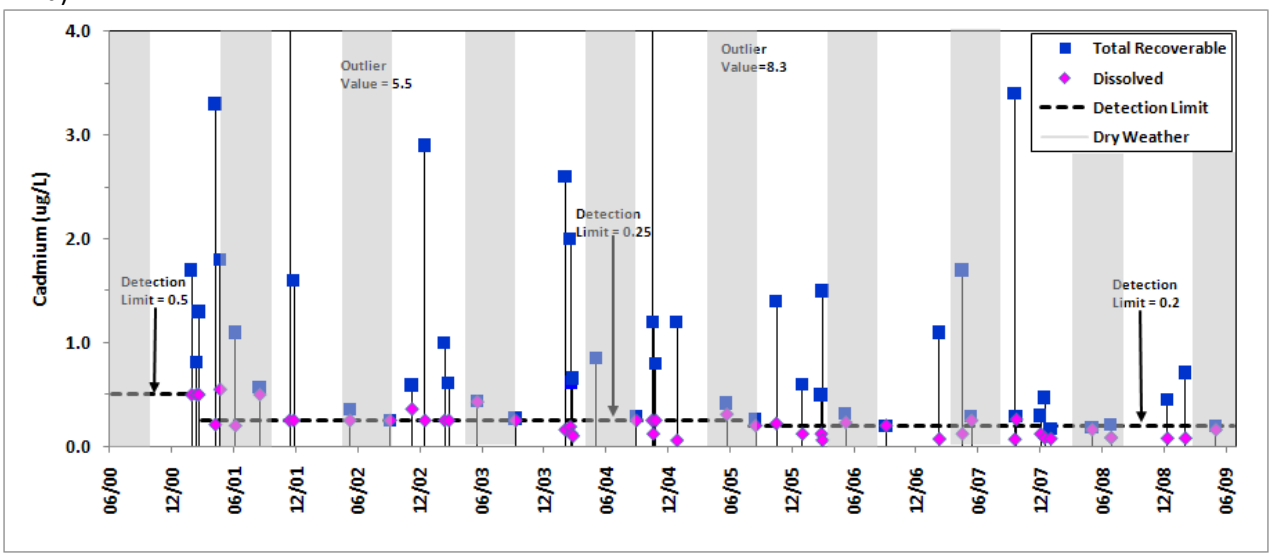


Figure 34. Bouton Creek Chemistry Results: a) Chlorpyrifos; b) Diazinon; c) Malathion

a)



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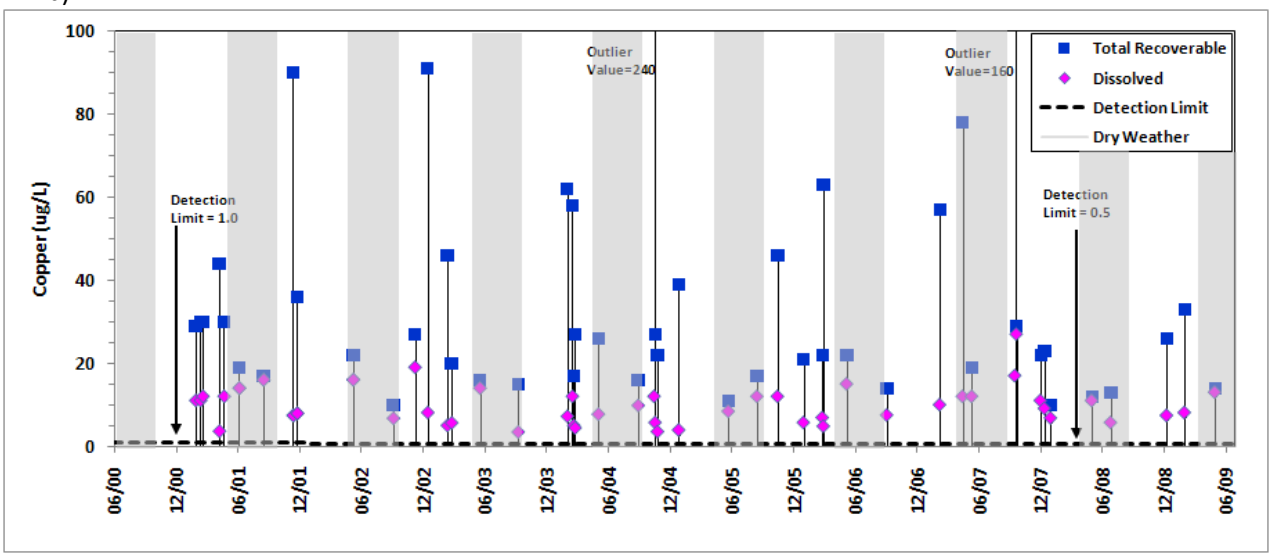

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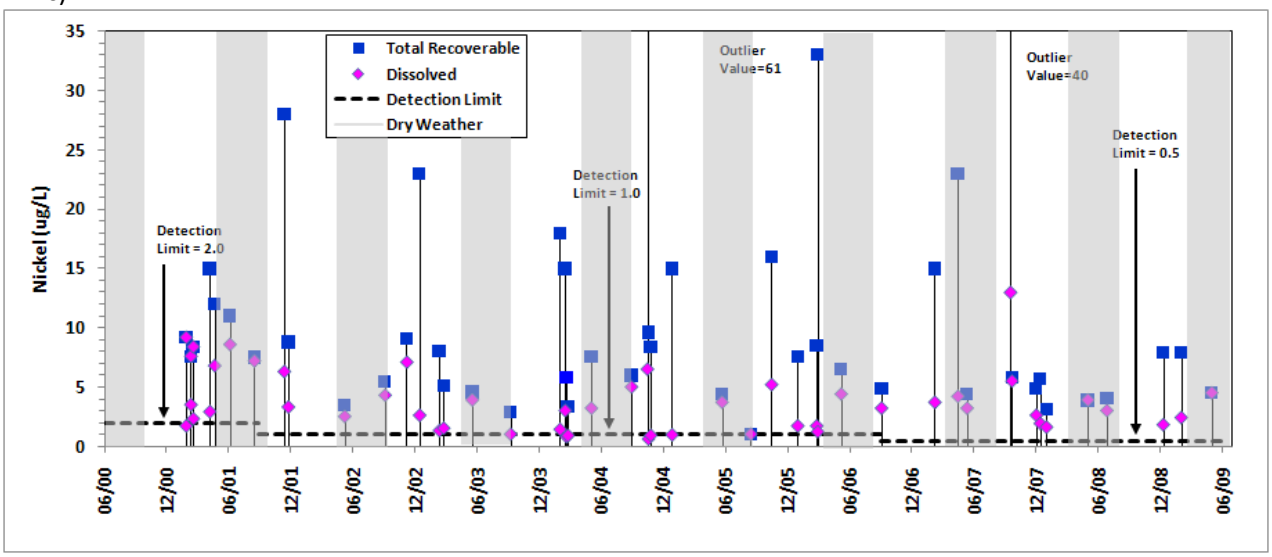
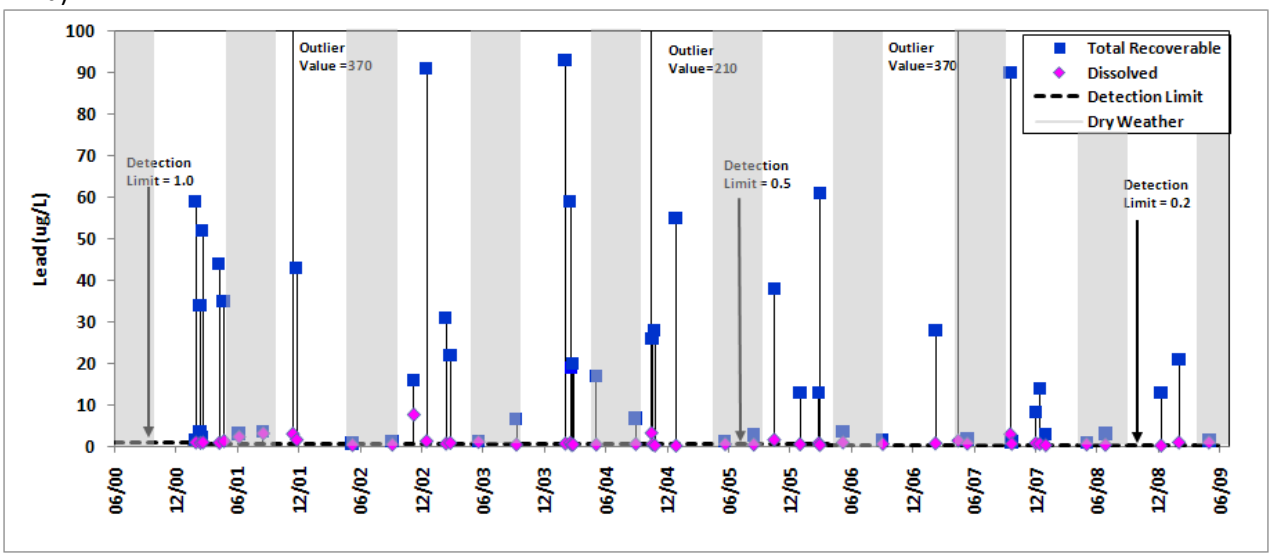


Figure 35. Los Cerritos Channel Chemistry Results: a) Cadmium; b) Copper; c) Nickel

a)



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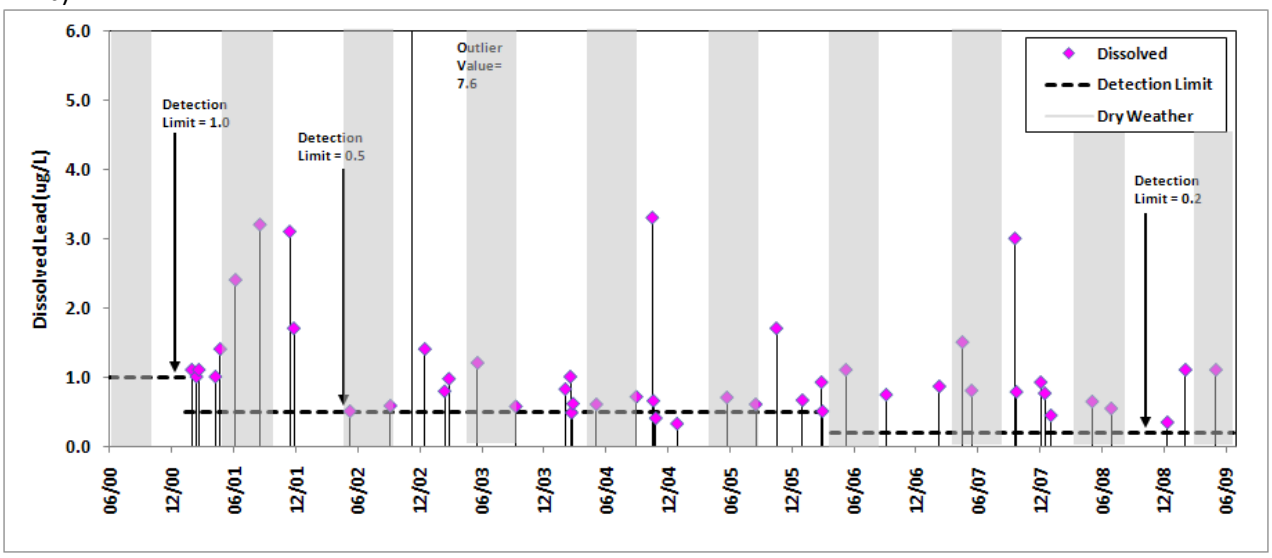

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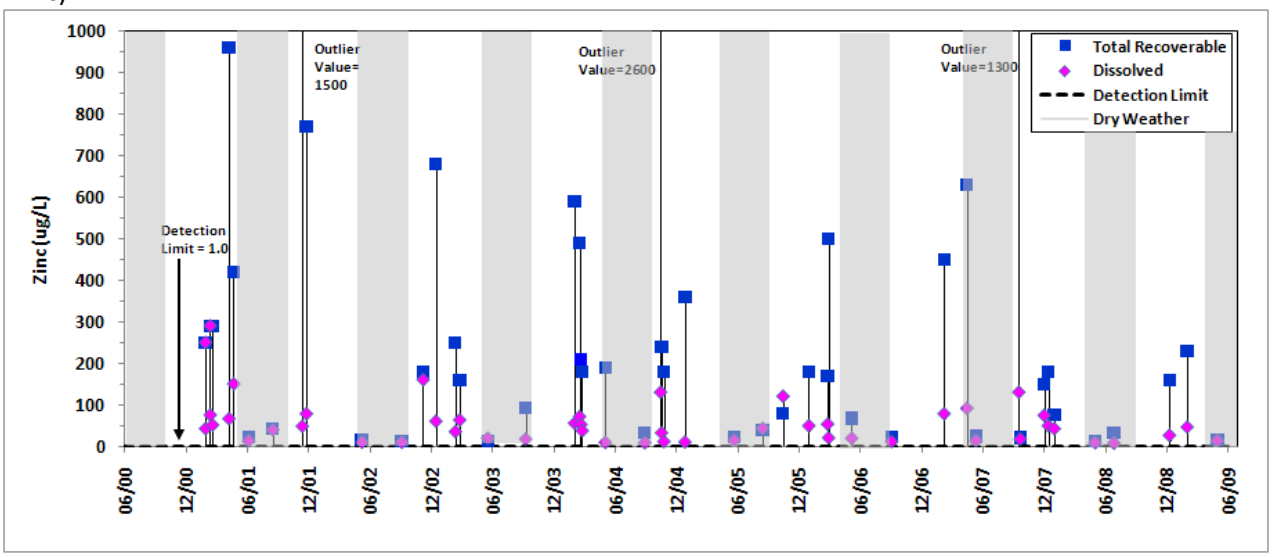
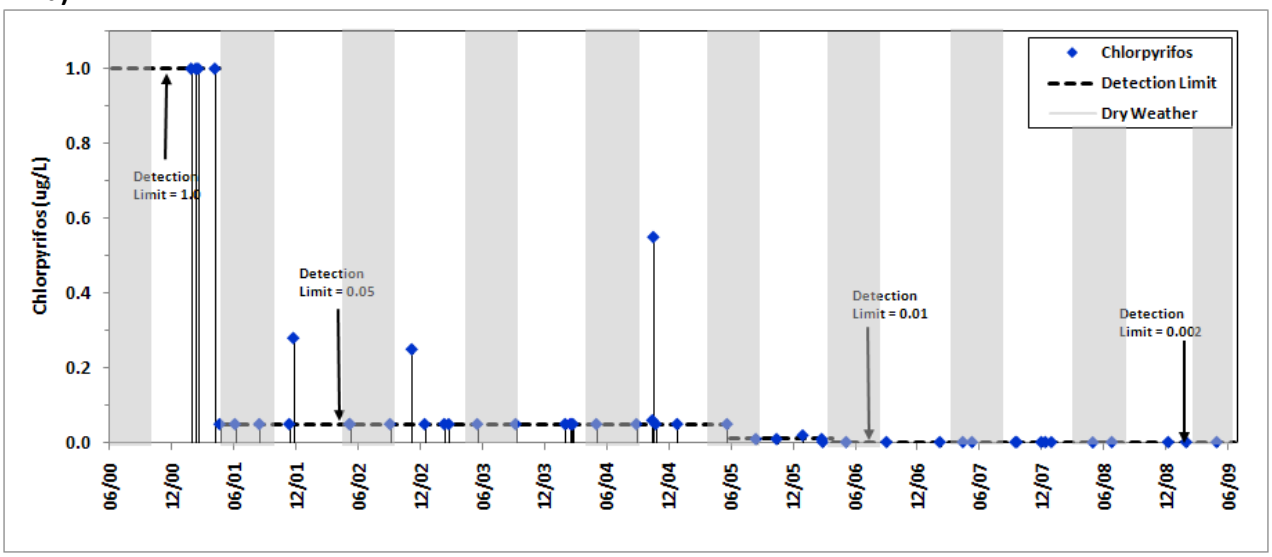


Figure 36. **Los Cerritos Channel Chemistry Results: a) Lead (total and dissolved); b) Lead (dissolved only); c) Zinc**

a)



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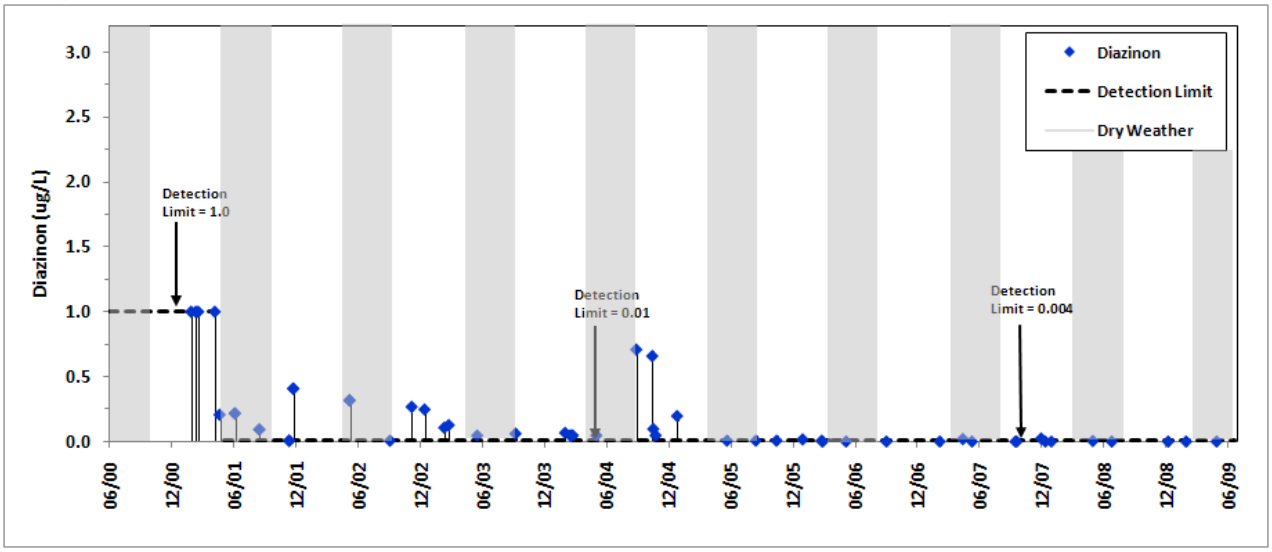

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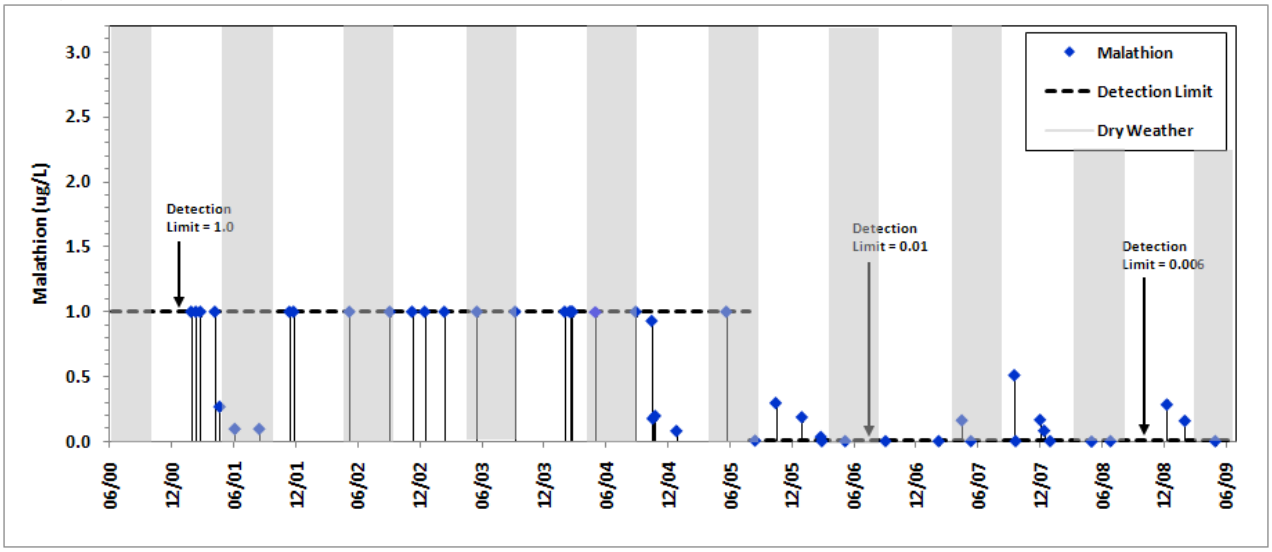


Figure 37. Los Cerritos Channel Chemistry Results: a) Chlorpyrifos; b) Diazinon; c) Malathion

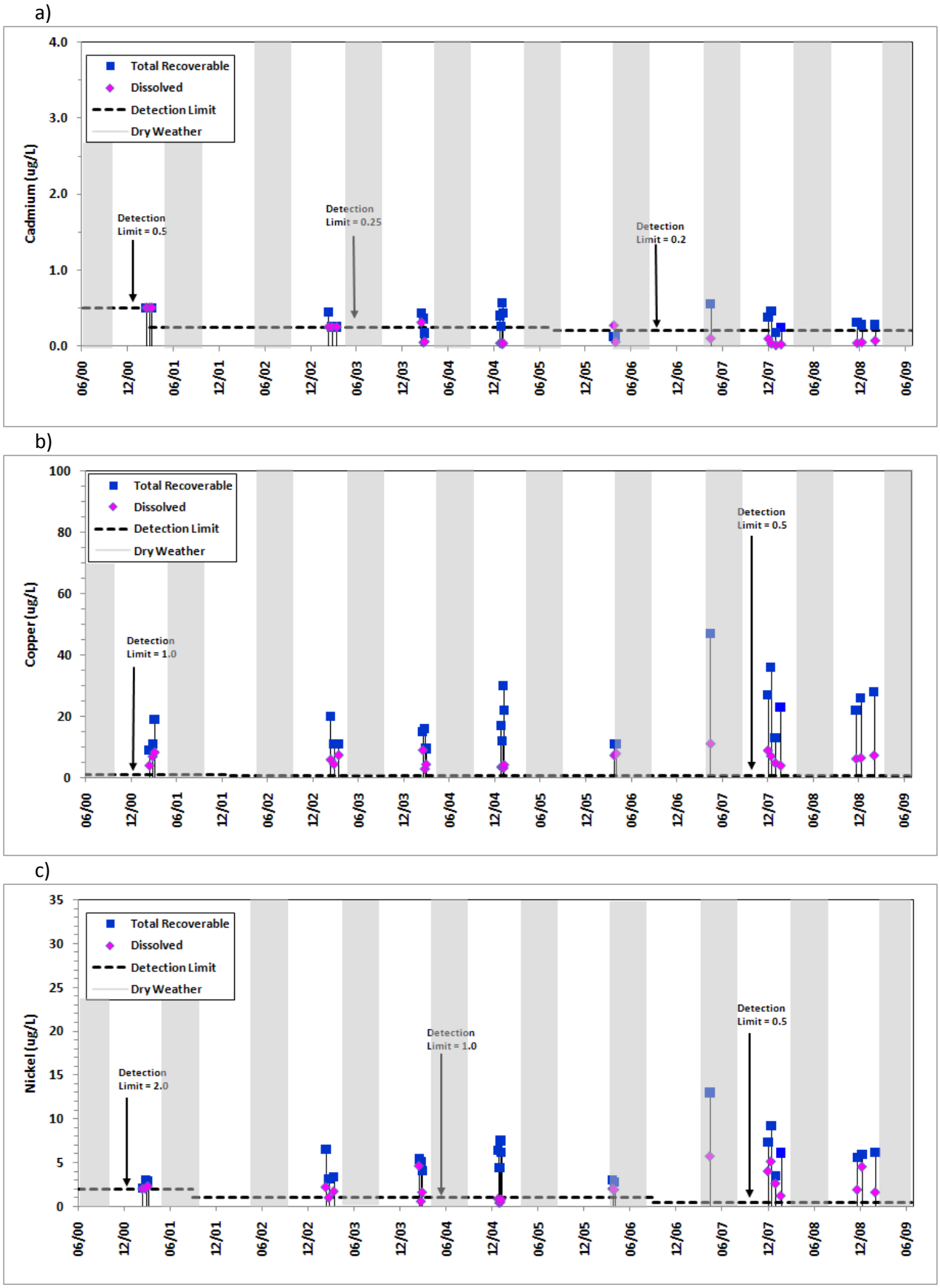
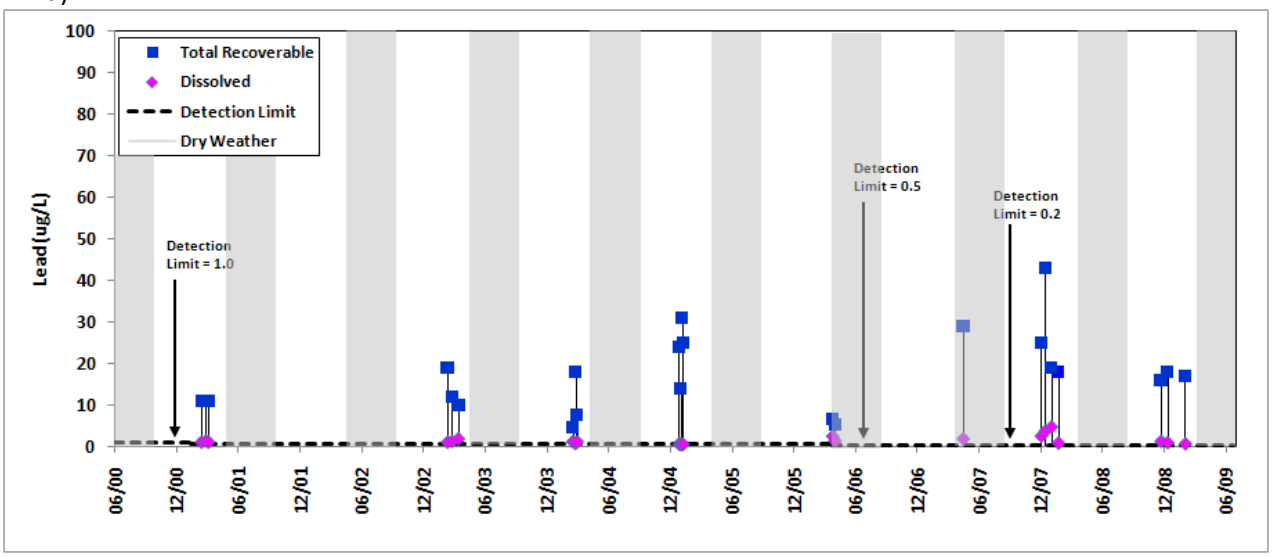


Figure 38. Dominquez Gap Chemistry Results: a) Cadmium; b) Copper; c) Nickel

a)



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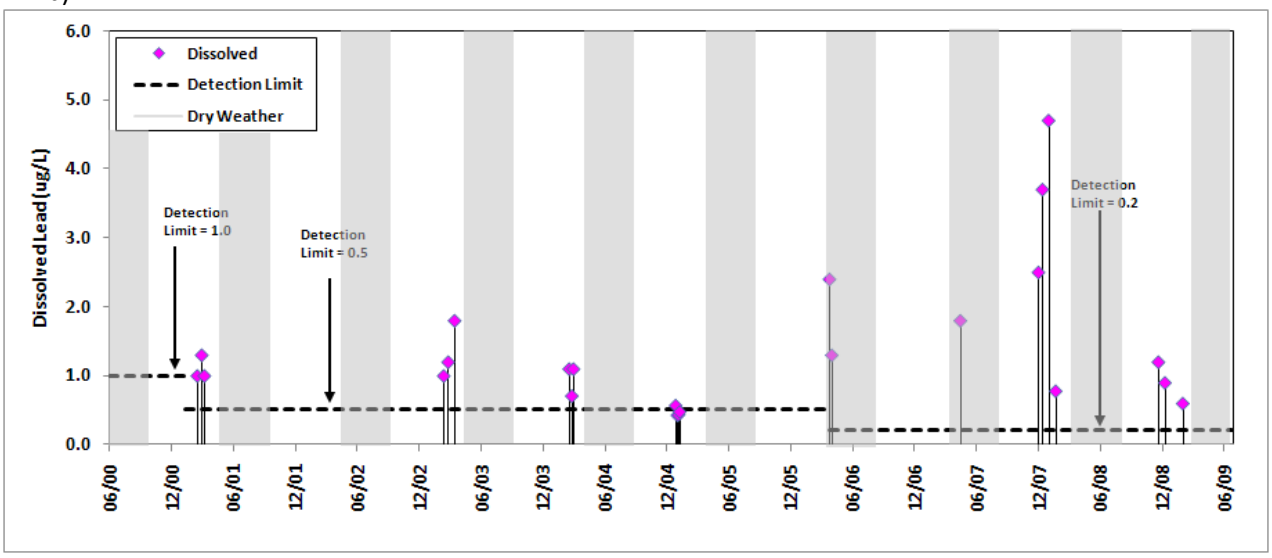


c)

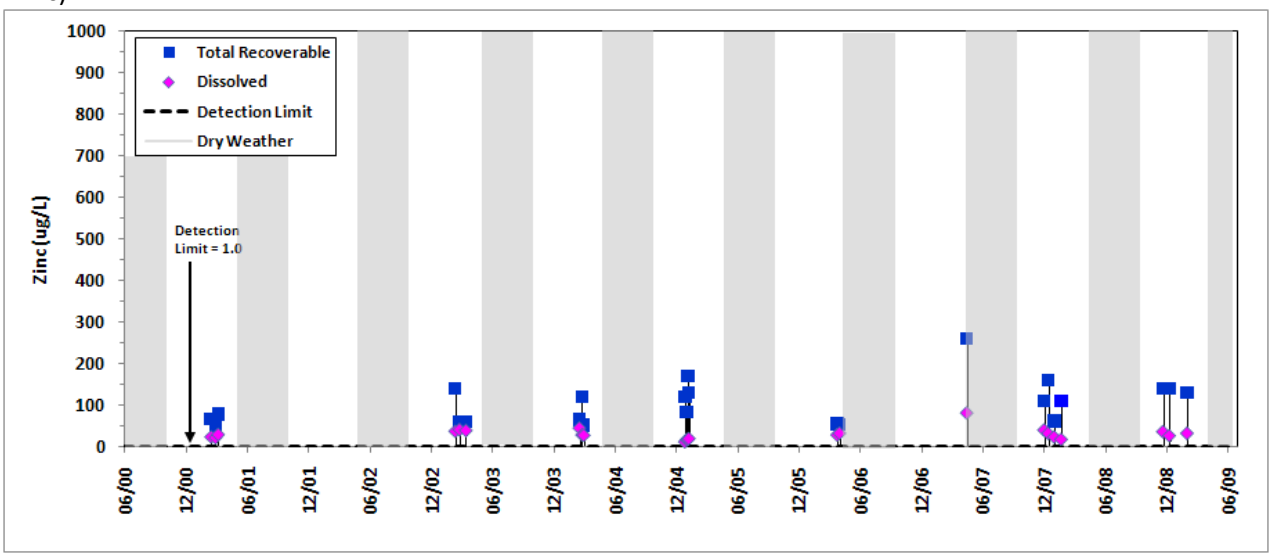
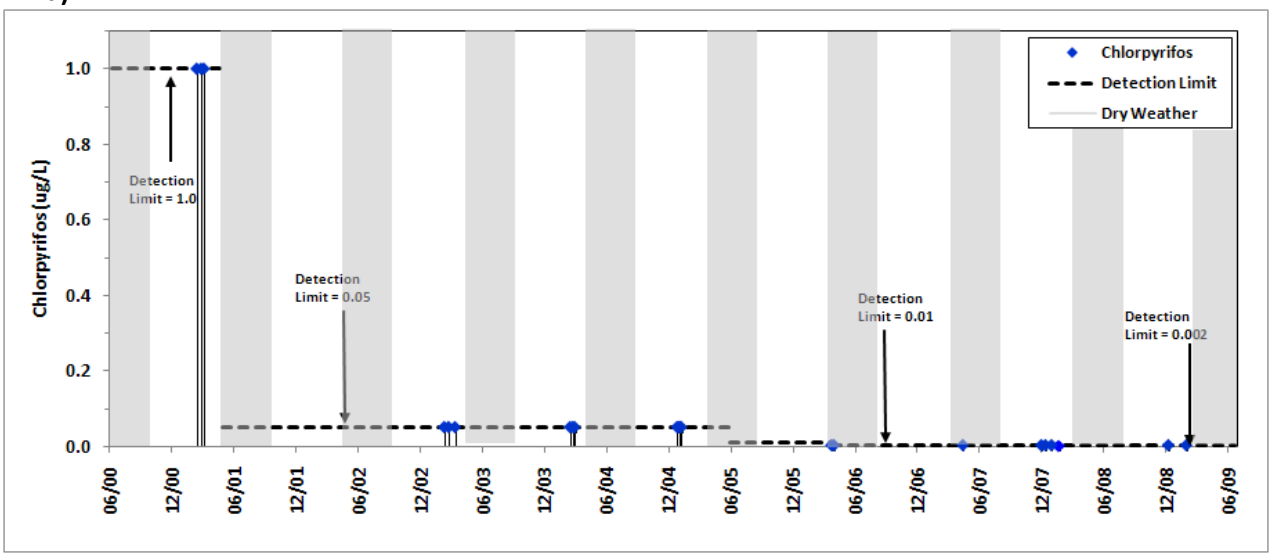
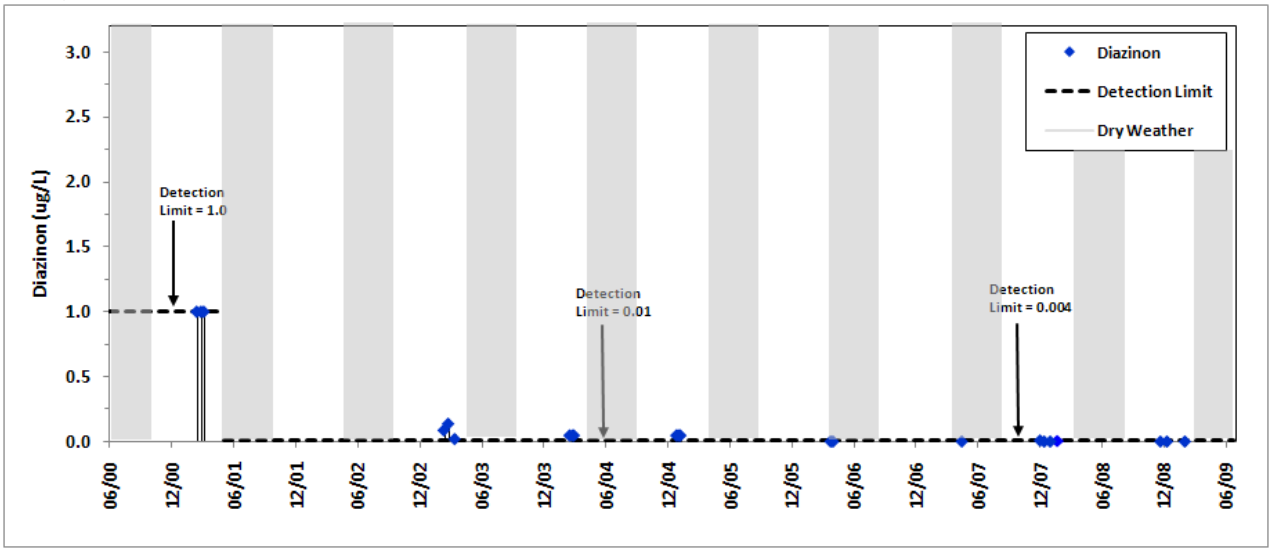


Figure 39. Dominquez Gap Chemistry Results: a) Lead (total and dissolved); b) Lead (dissolved only); c) Zinc

a)



b)



c)

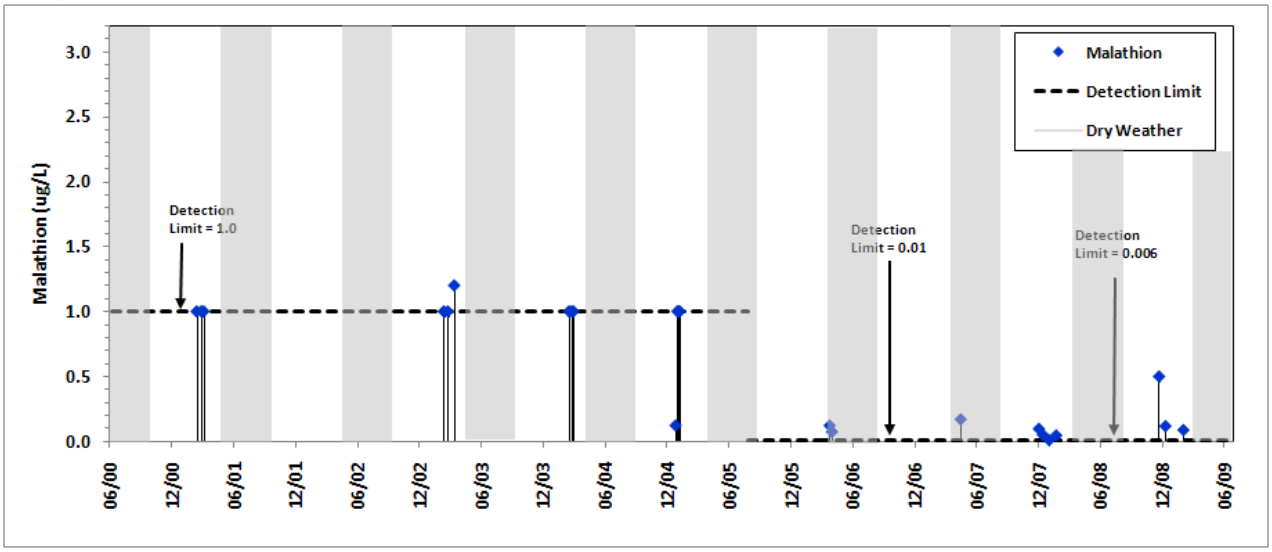
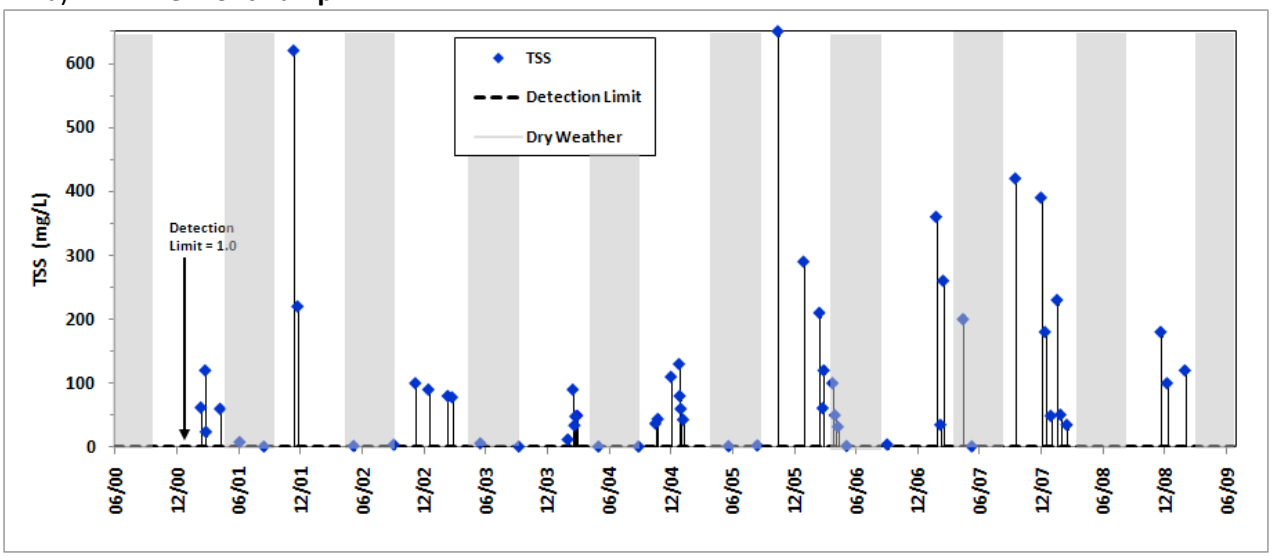
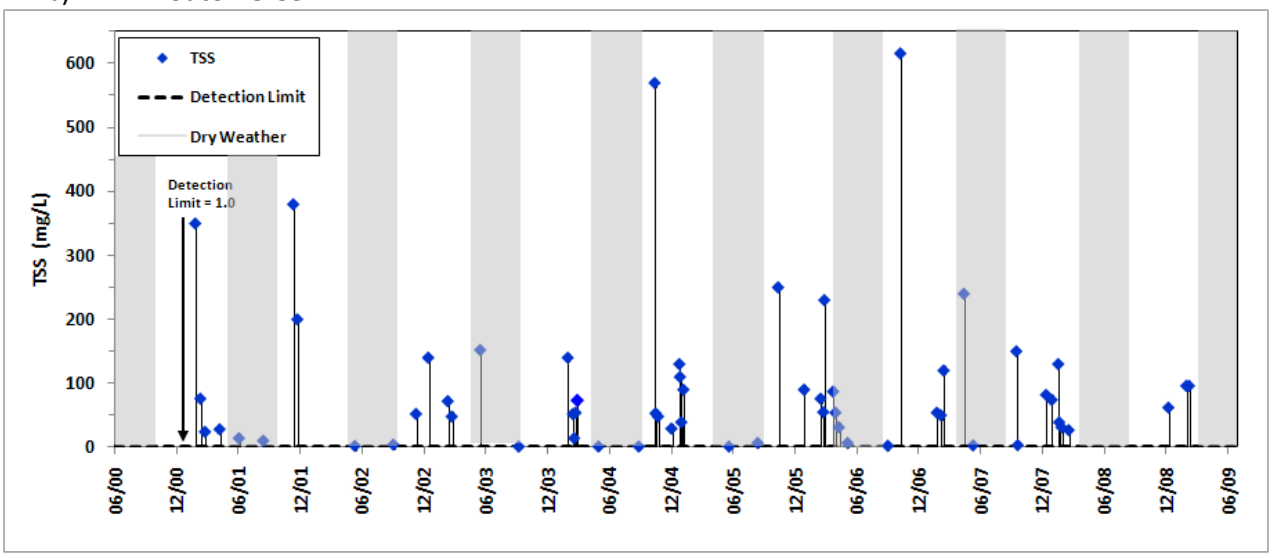


Figure 40. Dominquez Gap Chemistry Results: a) Chlorpyrifos; b) Diazinon; c) Malathion

a) **Belmont Pump**



b) **Bouton Creek**



c) **Los Cerritos Channel**

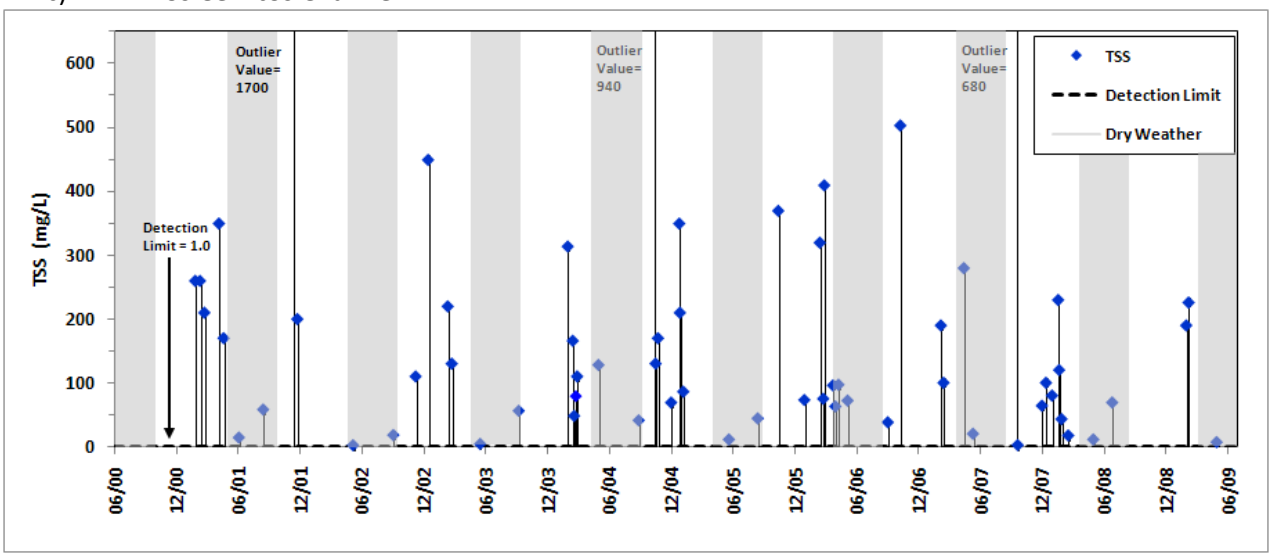


Figure 41. TSS Concentrations at all Monitoring Sites.

d) **Dominguez Gap**

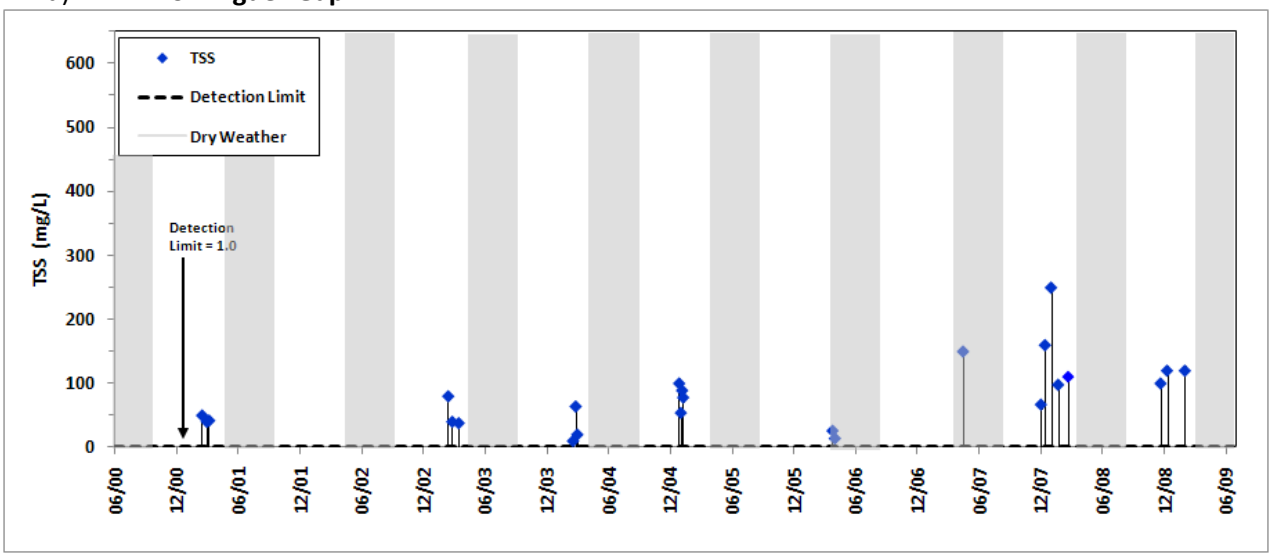


Figure 41. TSS Concentrations at all Monitoring Sites (continued)

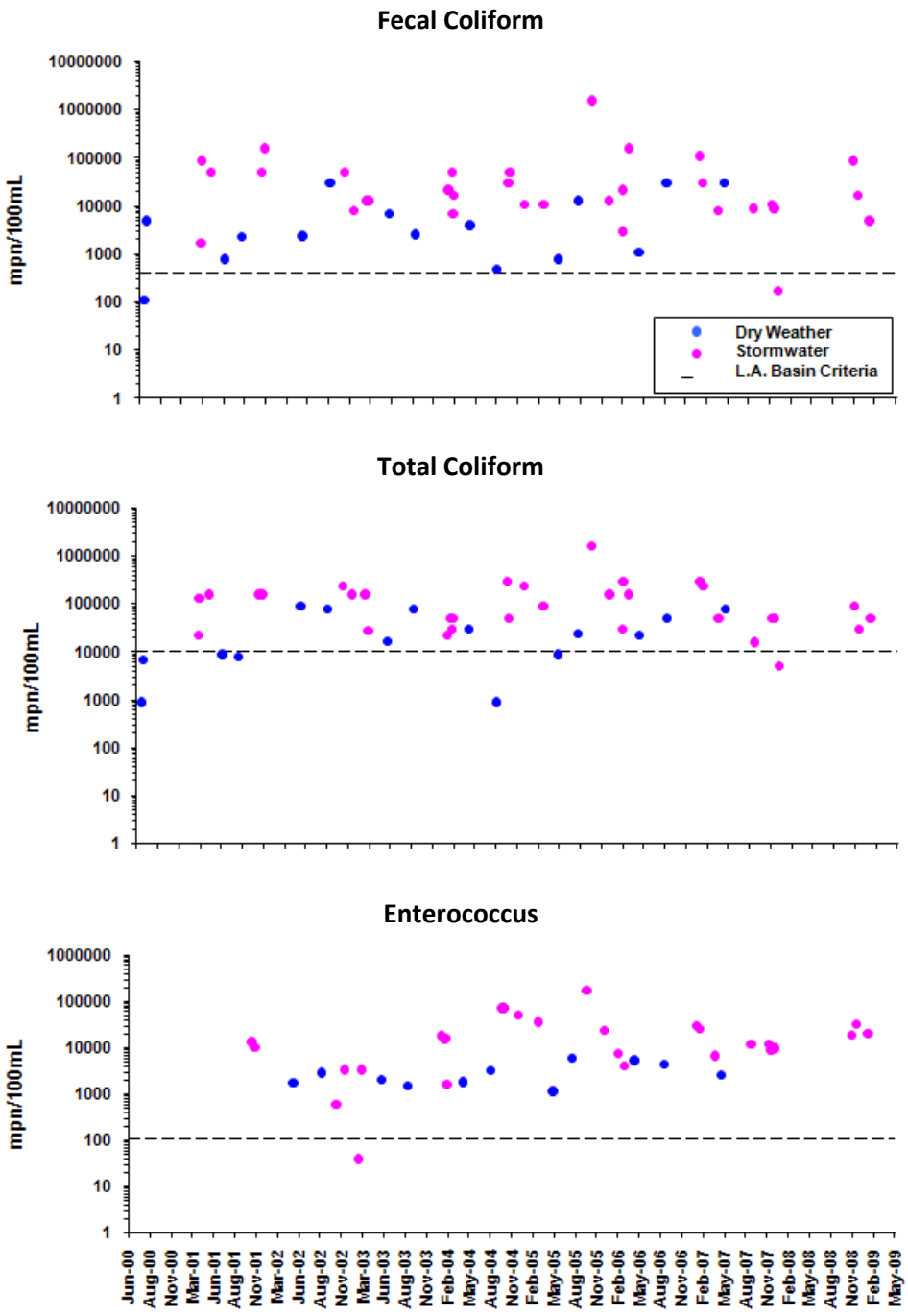


Figure 42. Belmont Pump Station Bacteria Concentrations for 2000 through 2009.

The dashed lines indicate the species-specific sample criteria based upon the Los Angeles Basin Plan

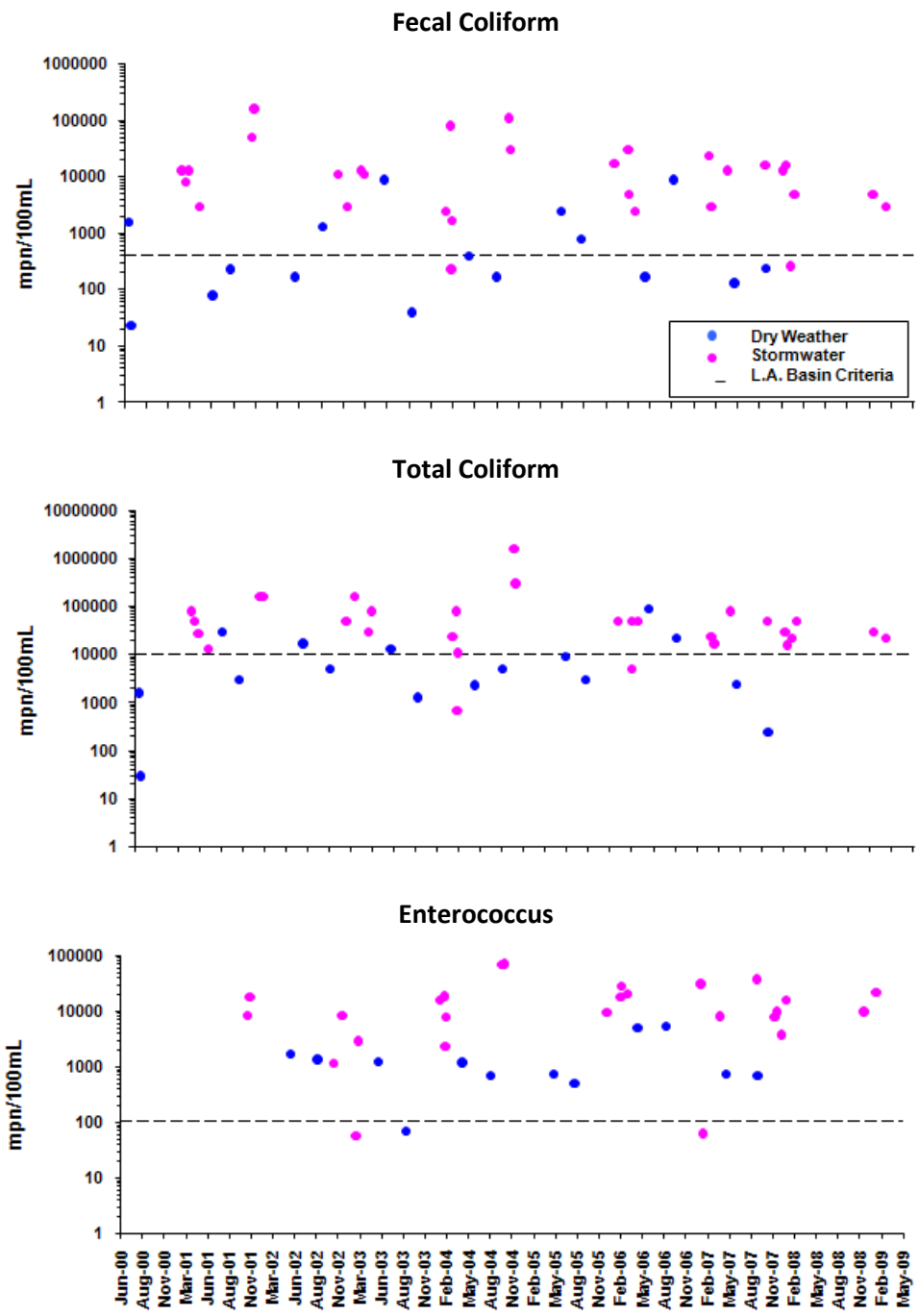


Figure 43. Bouton Creek Bacteria Concentrations for 2000 through 2009.

The dashed lines indicate the species-specific sample criteria based upon the Los Angeles Basin Plan

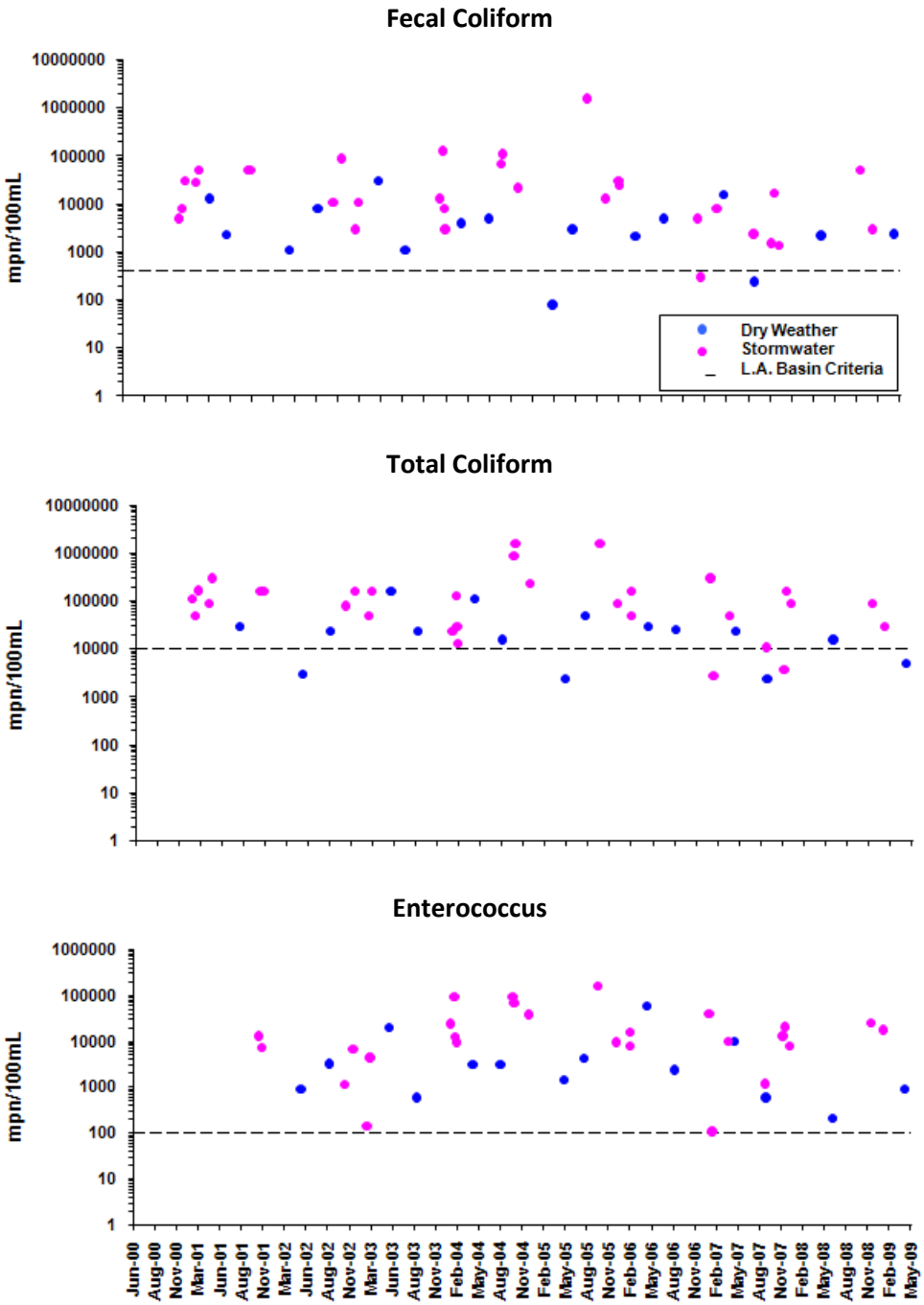


Figure 44. Los Cerritos Channel Bacteria Concentrations for 2000 through 2009.

The dashed lines indicate the species-specific sample criteria based upon the Los Angeles Basin Plan

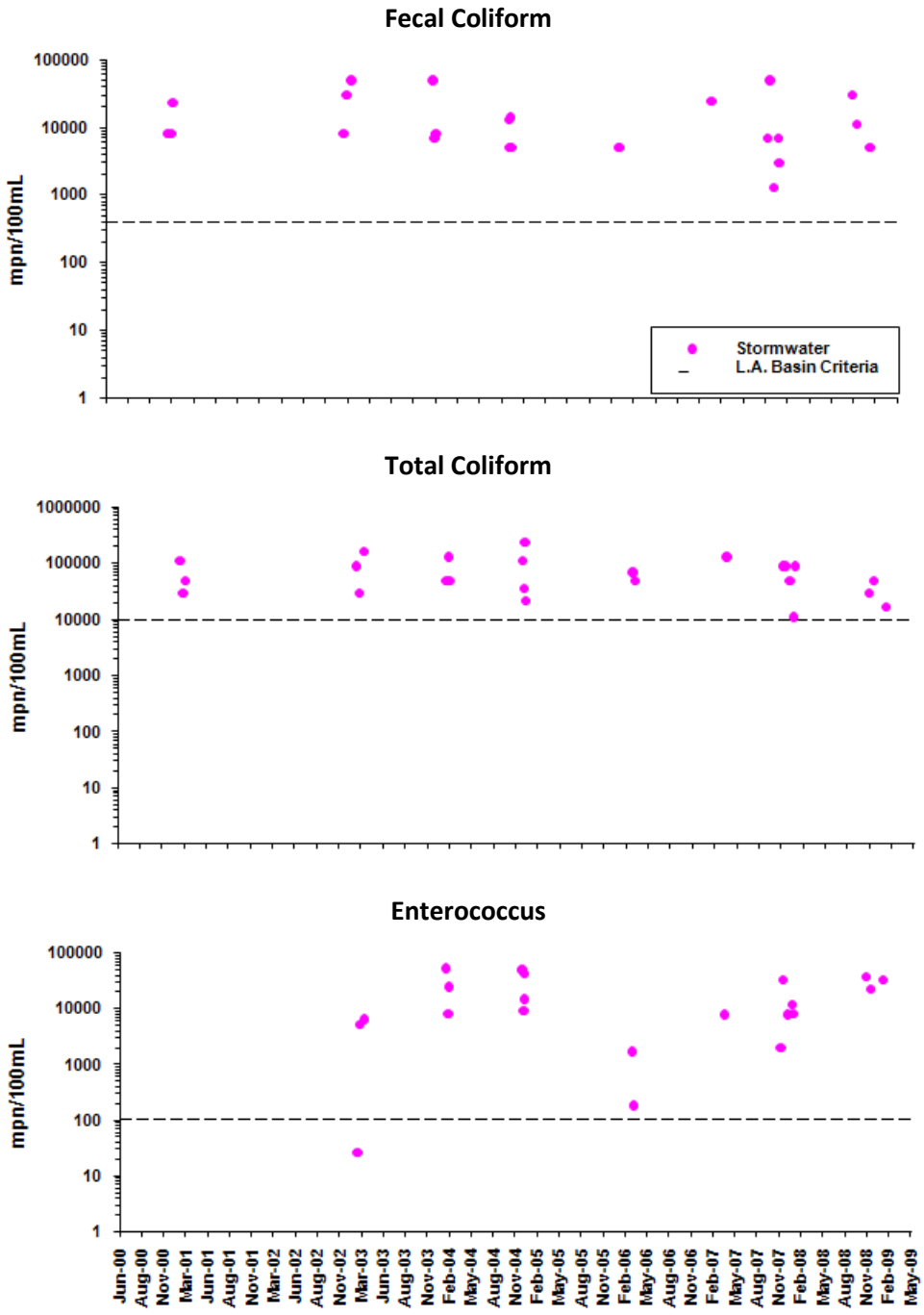


Figure 45. Dominguez Gap Bacteria Concentrations for 2000 through 2009.

The dashed lines indicate the species-specific sample criteria based upon the Los Angeles Basin Plan

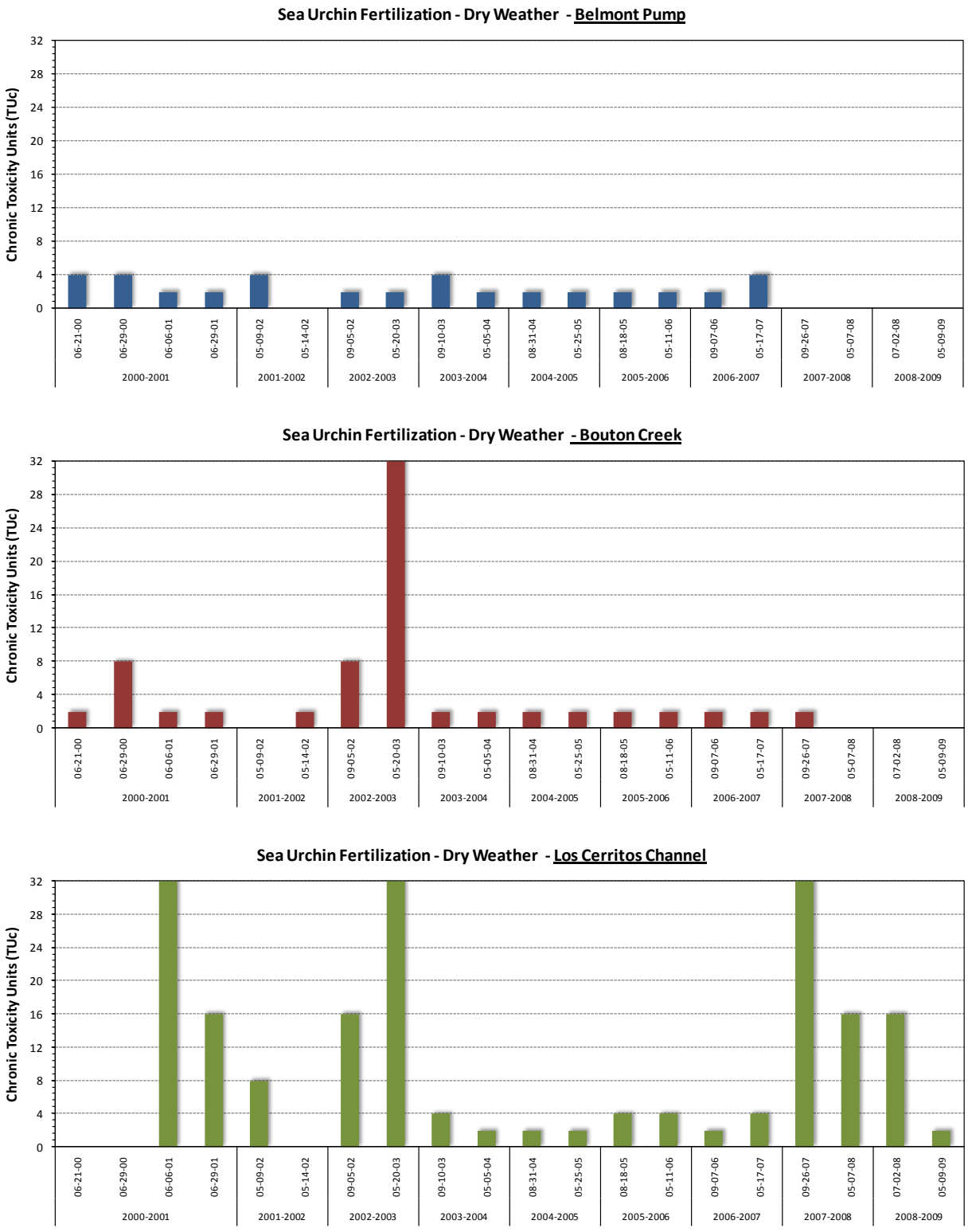


Figure 46. Chronic Toxicity of Dry Weather Discharge to Sea Urchins – 2000/2001 through 2008/2009

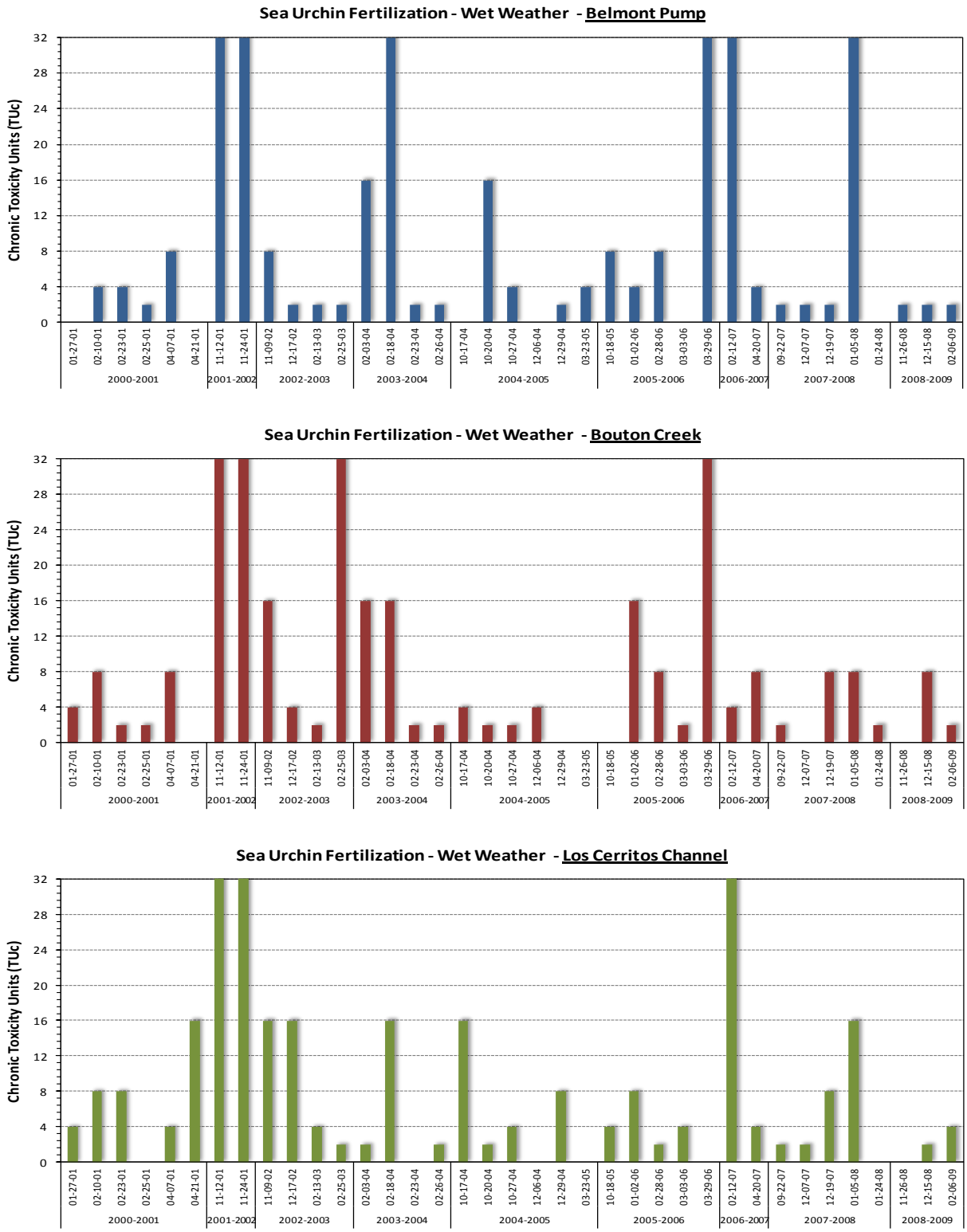


Figure 47. Chronic Toxicity of Stormwater to Sea Urchins – 2000/2001 through 2008/2009.

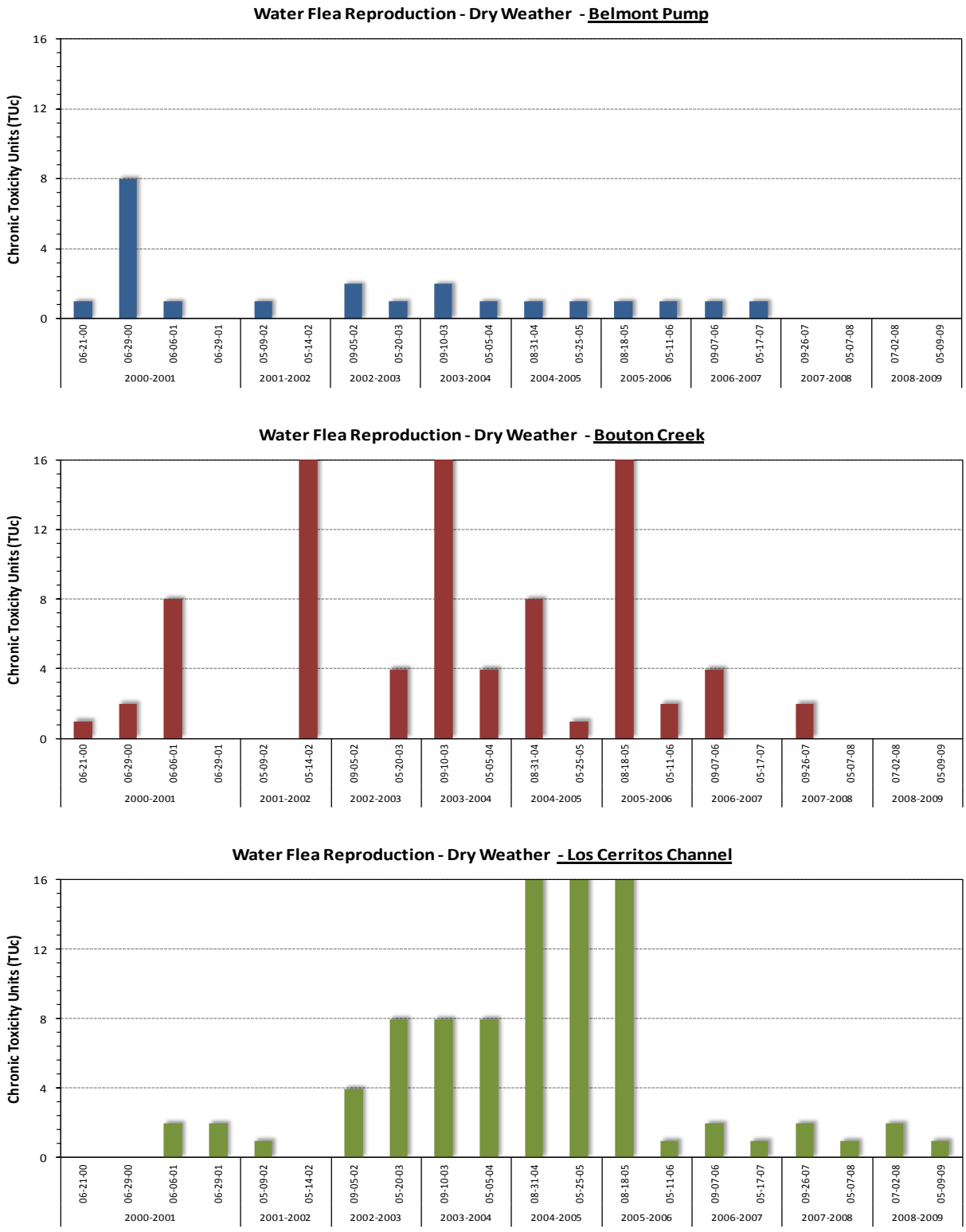


Figure 48. Chronic Toxicity of Dry Weather Discharge to Water Fleas – 2000/2001 through 2008/2009.

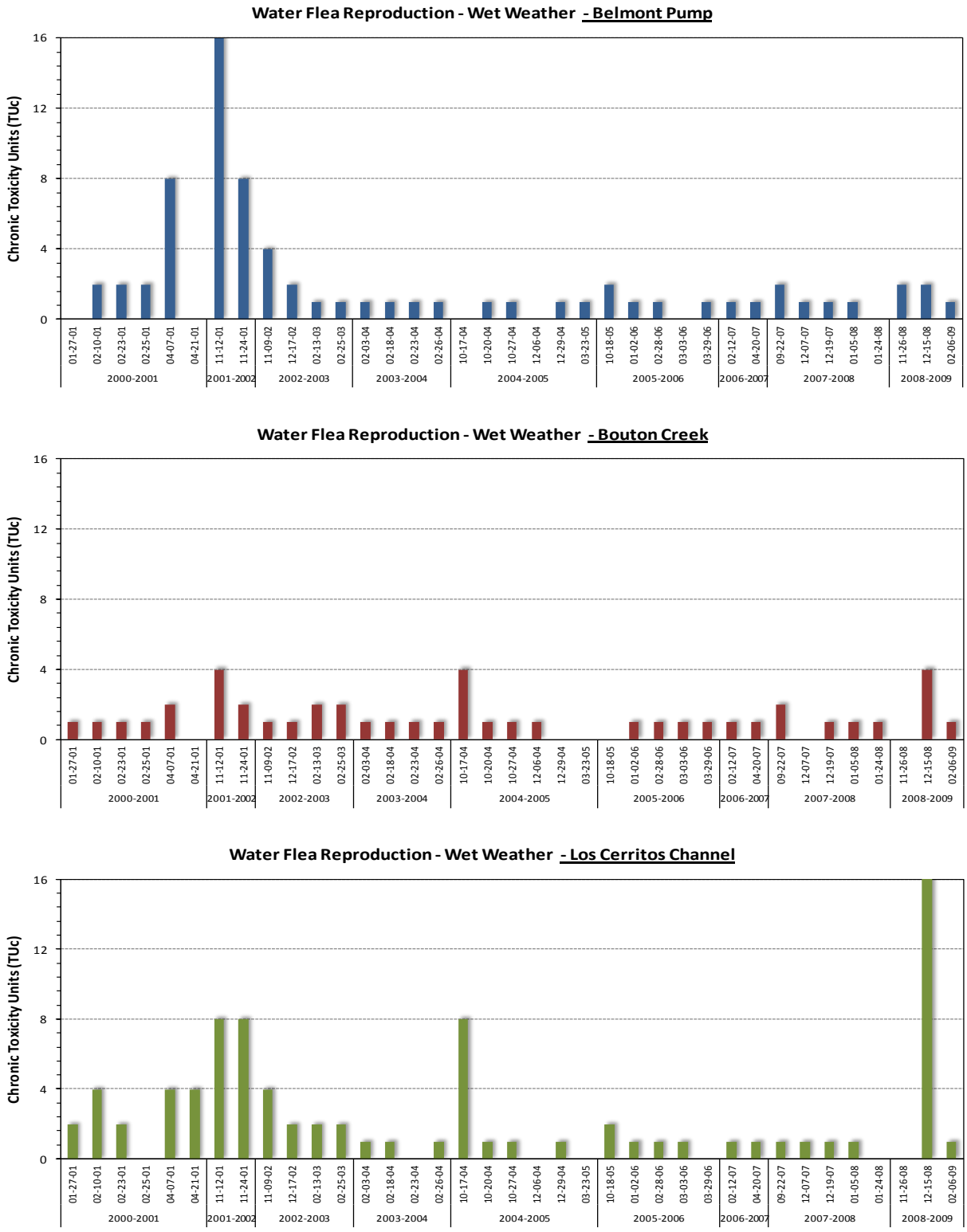


Figure 49. Chronic Toxicity of Stormwater to Water Fleas – 2000/2001 through 2008/2009.

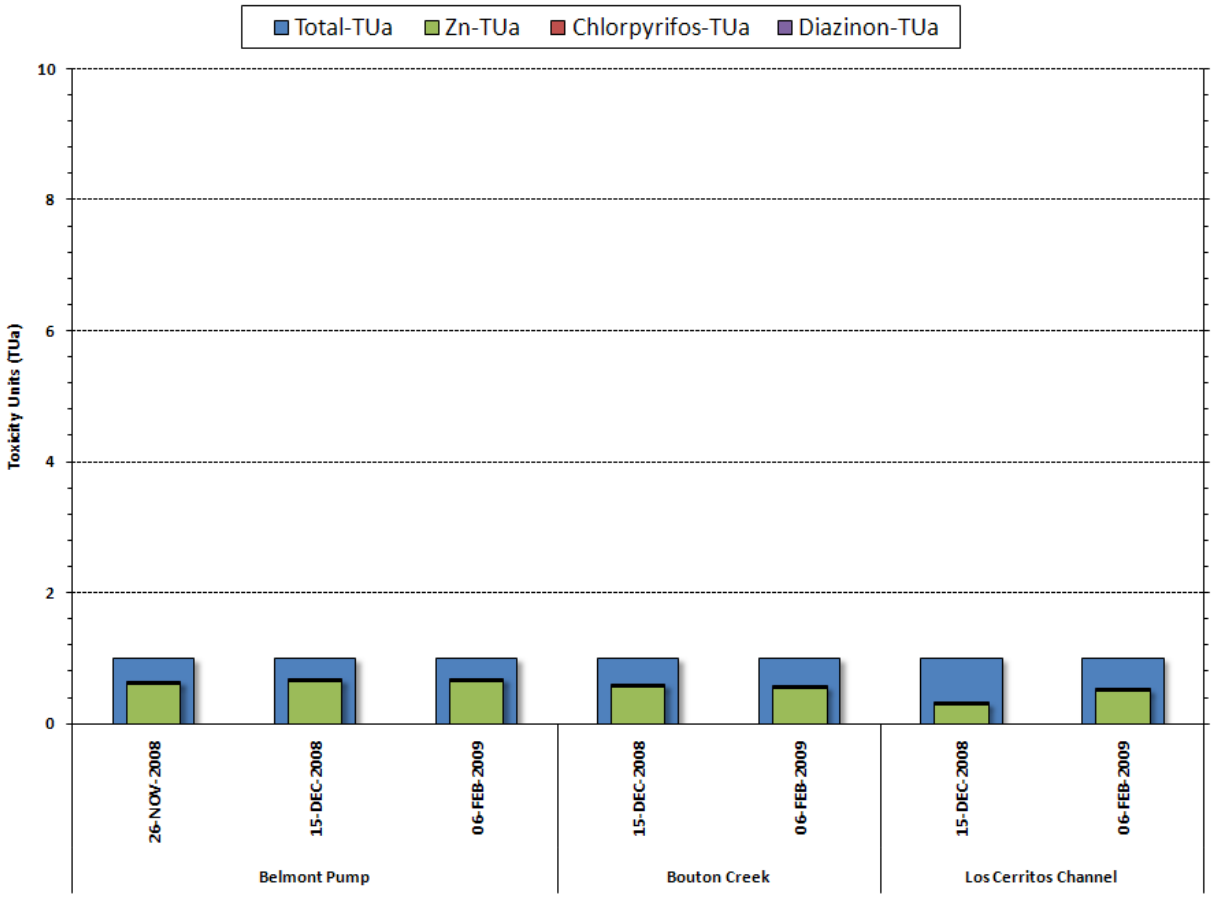


Figure 50. Measured Acute Toxicity to *Ceriodaphnia dubia* versus Predicted Toxicity due to Zinc, Chlorpyrifos and Diazinon, 2008/2009.

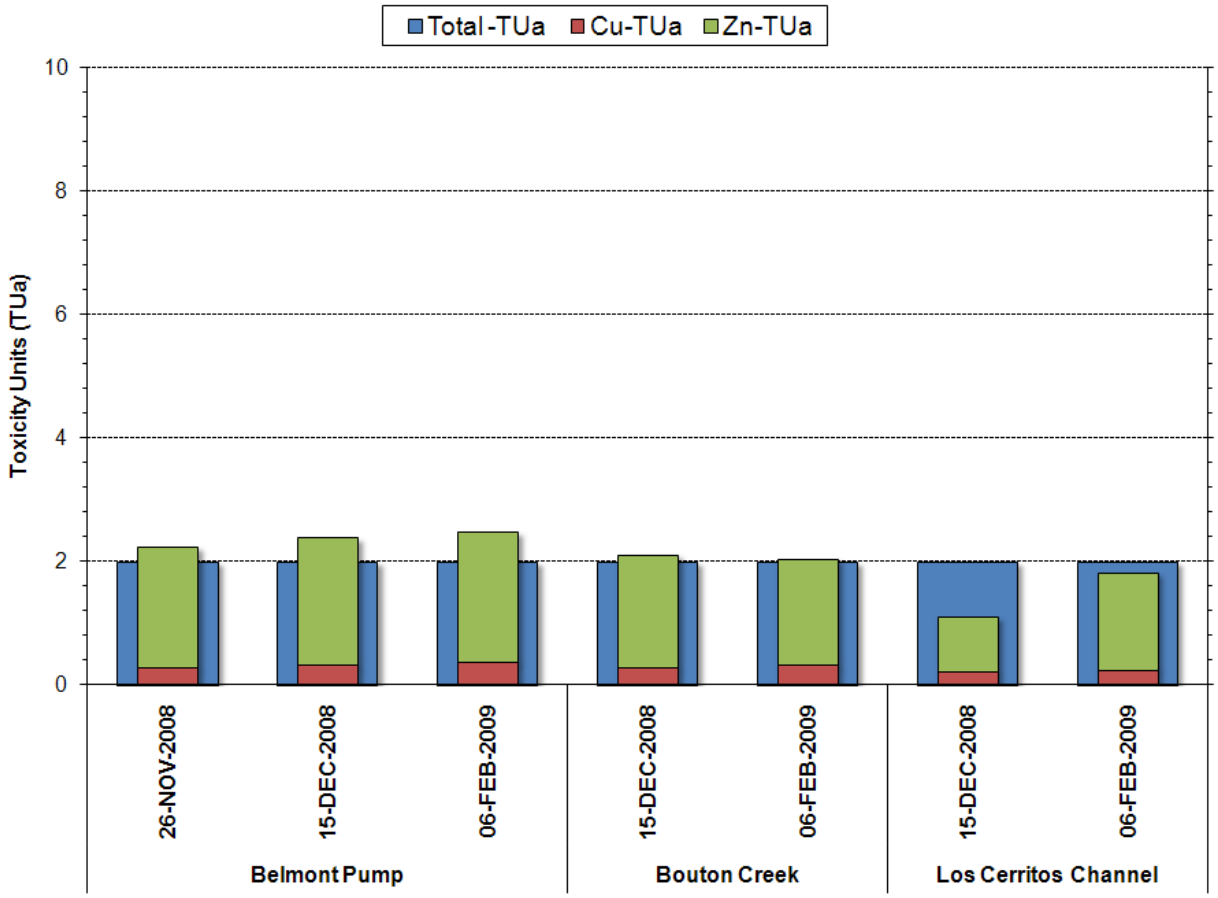


Figure 51. Measured Acute Toxicity to *Strongylocentrotus purpuratus* versus Predicted Toxicity due to Zinc and Copper, 2008/2009.

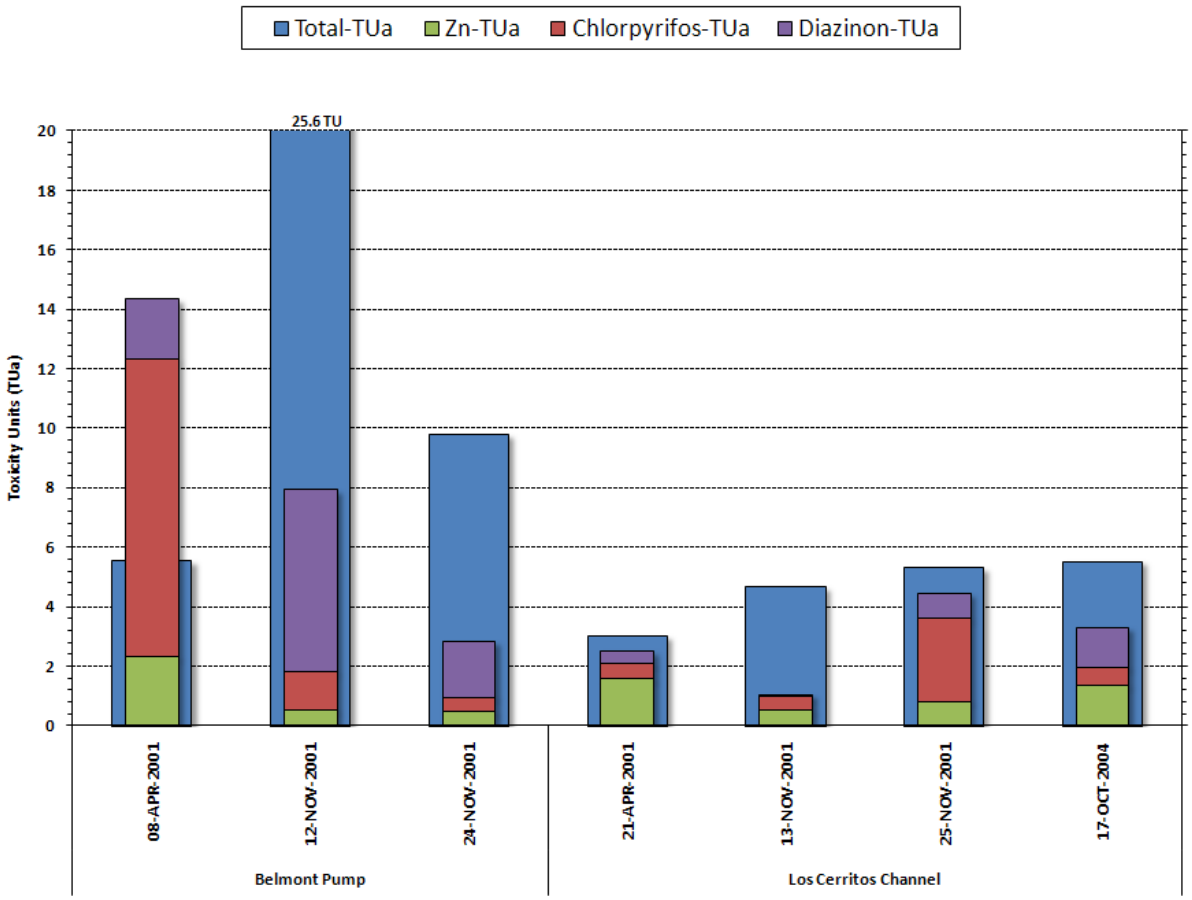


Figure 52. Measured Acute Toxicity (≥3 TU_a) to *Ceriodaphnia dubia* versus Predicted Toxicity due to Zinc, Chlorpyrifos and Diazinon, 2001-2009.

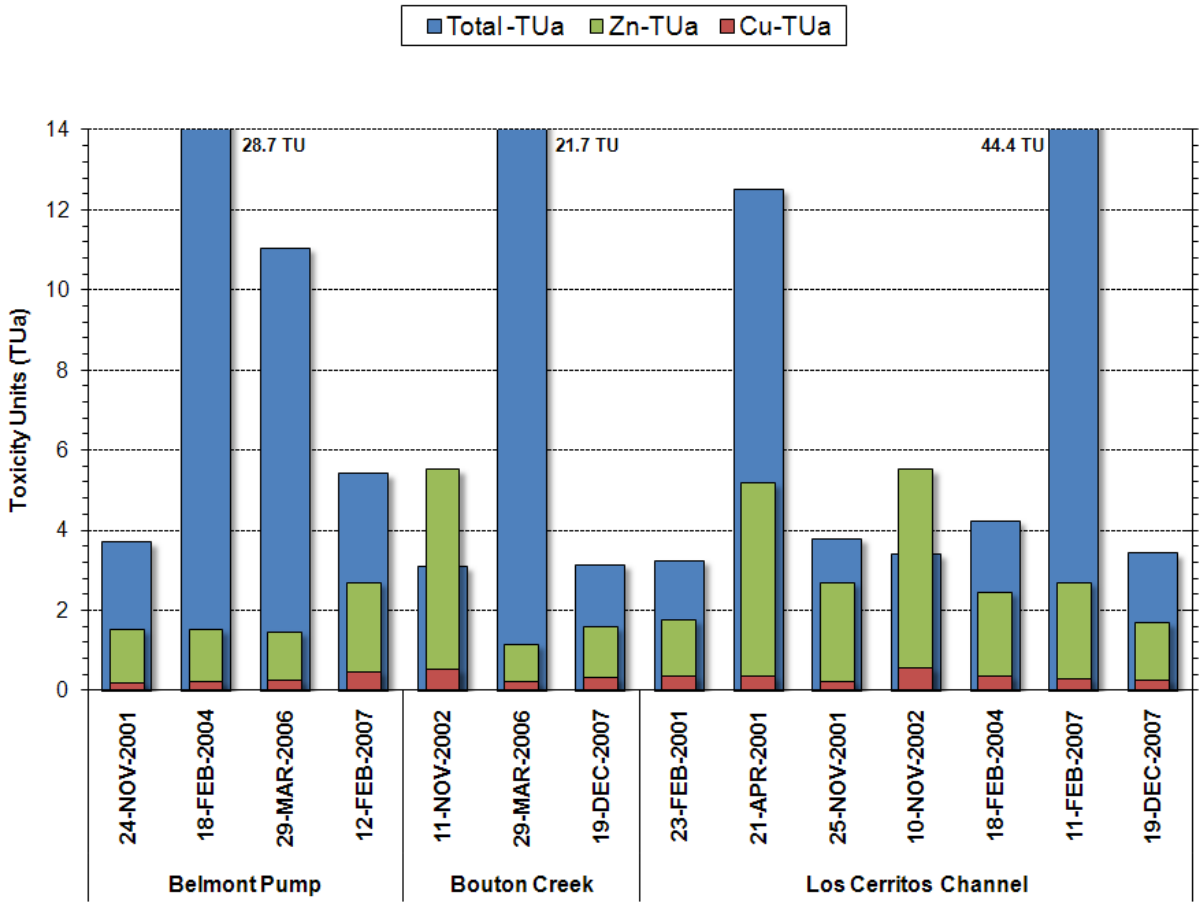


Figure 53. **Measured Acute Toxicity (≥3 TU_a) to *Strongylocentrotus purpuratus* versus Predicted Toxicity due to Zinc and Copper, 2001-2009.**

Table 24. Summary of Beneficial Uses for Receiving Water Bodies Associated with each Monitoring Location[1].

DISCHARGE LOCATION	HYDRO. UNIT	COMM	EST	GWR	IND	MAR	MUN	NAV	RARE	REC1	REC2	SHELL	WARM	WET	WILD
Bouton Creek	405.15						P			P	I		I		E
Los Cerritos Channel	405.15						P			P	I		I		E
Dominguez Gap Pump Sta.	405. 15			E	P		P			E	E		E		P
Belmont Pump Sta./Alamitos Bay	405.12	E	E		E	E		E	E	E	E	E		E	E

1. Source: California Regional Water Quality Control Board, Los Angeles Region. 1994. Water Quality Control Plan, Los Angeles Region, Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties. P=Potential, E=Existing, and I=Intermittent

Commercial and Sport Fishing (COMM): Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.

Estuarine Habitat (EST): Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).

Ground Water Recharge (GWR): Uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.

Industrial Service Supply (IND): Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well re-pressurization.

Marine Habitat (MAR): Uses of water that support marine ecosystems including, but not limited to, preservation or enhancement of marine habitats, vegetation, such as kelp, fish, shellfish, or wildlife (e.g., marine mammals, shorebirds).

Municipal and Domestic Supply (MUN): Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water.

Navigation (NAV): Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.

Rare, Threatened, or Endangered Species (RARE): Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened, or endangered.

Water Contact Recreation (REC-1): Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.

Non-contact Water Recreation (REC-2): Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sun bathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.

Shellfish Harvesting (SHELL): Uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sports purposes.

Warm Freshwater Habitat (WARM): Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Wetland Habitat (WET): Uses if water that support wetland ecosystems including, but not limited to, preservation or enhancement of wetland habitats, vegetation, fish, shellfish, or wildlife, and other unique wetland functions which enhance water quality, such as providing flood and erosion control, stream bank stabilization, and filtration and purification of naturally occurring contaminants.

Wildlife Habitat (WILD): Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., Mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.

Table 25. Available Benchmarks and Guidelines used to Evaluate Quality of Wet and Dry Season Discharges from the Mass Emission Sites.

Analyte Name	Long Beach 2008-2009 ML	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Conventionals (mg/L unless noted)									
pH (pH Units)	0.1		<[6.5-8.5]<						
MBAS	0.025		0.5						
Nitrate (as N)	0.1		10						
Nitrite (as N)	0.1		1						
Total Ammonia (as N)	0.1		19.9						
Dissolved Metals (µg/L)									
Arsenic	0.5			150	36				
Cadmium	0.2			1.3	9.3				
Copper	0.5			5	3.1				
Lead	0.2			1.2	8.1				
Nickel	0.5			29	8.2				
Selenium	1				71				
Silver	0.2			1.1	1.9				
Zinc	1			66	81				
Total Metals (µg/L)									
Aluminum	25		1000					87	
Arsenic	0.5	32	50						
Cadmium	0.2	4	5						
Copper	0.5	12							
Iron	25							1000	
Lead	0.2	8							
Nickel	0.5	20	100						
Selenium	1	60	50	5					
Silver	0.2	2.8							
Zinc	1	80							

Table 25. Available Benchmarks and Guidelines used to Evaluate Quality of Wet and Dry Season Discharges from the Mass Emission Sites. (continued)

Analyte Name	Long Beach 2008-2009 ML	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Bacteria (MPN/100 ml)									
Enterococcus	10	104	104						
Fecal Coliform	20	400	400						
Total Coliform	20	10000	10000						
Ratio of Fecal to Total Coliform	-	FC/TC≥0.1 & TC>1000	FC/TC≥0.1 & TC>1000						
Aroclors (µg/L)									
Aroclor 1016	0.02		0.5						
Aroclor 1221	0.02		0.5						
Aroclor 1232	0.02		0.5						
Aroclor 1242	0.02		0.5						
Aroclor 1248	0.02		0.5						
Aroclor 1254	0.02		0.5						
Aroclor 1260	0.02		0.5						
Chlorinated Pesticides (µg/L)									
4,4'-DDT	0.005			0.001	0.001				
Aldrin	0.005	0.000022		3	1.3				
Dieldrin	0.005	0.00004		0.056	0.0019				
Endrin	0.005	0.004	2	0.036	0.023				
gamma-BHC (Lindane)	0.005		0.2	0.95	0.16				
Endosulfan I	0.005			0.056	0.0087				
Endosulfan II	0.005			0.056	0.0087				
Heptachlor	0.005	0.00005	0.01	0.0038	0.0036				
Heptachlor epoxide	0.005	0.00002	0.01	0.0038	0.0036				
Total Chlordane	0.005		0.1	0.0043	0.004				
Methoxychlor	0.005		40					0.03	0.03
Mirex	0.005							0.001	0.001
Toxaphene	0.05	0.00021	2	0.0002	0.0002				

Table 25. Available Benchmarks and Guidelines used to Evaluate Quality of Wet and Dry Season Discharges from the Mass Emission Sites. (continued)

Analyte Name	Long Beach 2008-2009 ML	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Organophosphates (µg/L)									
Chlorpyrifos	0.002					0.02	0.02	0.041	0.0056
Demeton	0.002							0.1	0.1
Diazinon	0.004					0.08		0.17	0.82
Malathion	0.006							0.1	0.1
Triazines (µg/L)									
Atrazine	0.01		3						
Simazine	0.01		4						

Notes to Table 25:

General

- Minimum Level (ML) is the concentration at which the entire analytical system must give a recognizable signal and acceptable calibration point. The ML is the concentration in a sample that is equivalent to the concentration of the lowest calibration standard analyzed by a specific method. analytical procedure, assuming that all the method specified sample weights, volumes, and processing steps have been followed.
- Criteria continuous concentration (CCC) equals the highest concentration of pollutant to which aquatic life can be exposed for an extended period of time without deleterious effects.
- Criteria maximum concentration (CMC) equals the highest concentration of pollutant to which aquatic life can be exposed for a short period of time with deleterious effects.

California Toxics Rule

- CTR freshwater dissolved metals are hardness dependant. The values listed here are computed for a hardness of 50 mg/L.
- CTR freshwater dissolved cadmium and lead conversion coefficients for total to dissolved are also hardness dependent.
- CTR freshwater and saltwater dissolved metal criteria are "CCC" except for Silver which are "CMC".
- CTR freshwater and saltwater organics are "CCC" except for aldrin and gamma-BHC which are "CMC".

Ocean Plan and LA Basin Plan

- Bacteria are instantaneous or single sample criteria.
- LA Basin Plan contains Title 22 Drinking Water standards
- Ammonia listed is Acute 1-hour average objective for waters not designated COLD and/or MIGR and is pH dependent. The value listed is for a pH of 7.5. Chronic criteria are applied to Dry Weather results and are pH and temperature dependent

California Fish and Game

- All values are "CMC" criteria. CMCs are considered acute criteria.

National Recommended Water Quality Criteria

- All values CCCs

Table 26. Belmont Pump Station: Comparison of Stormwater Chemistry with Benchmarks and Guidelines.

Belmont Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Conventionals										
pH	3	3		0						
MBAS	3	3		0						
Nitrate (as N)	3	3		0						
Nitrite (as N)	3	3		0						
Total Ammonia (as N)	3	3								
Dissolved Metals										
Arsenic	3	3			0	0				
Cadmium	3	3			0	0				
Copper	3	3			3	3				
Lead	3	3			2	0				
Nickel	3	3			0	0				
Selenium	3	0				0				
Silver	3	2			0	0				
Zinc	3	3			3	0				
Total Metals										
Aluminum	3	3		2					3	
Arsenic	3	3	0	0						
Cadmium	3	3	0	0						
Chromium	3	3		0						
Copper	3	3	3							
Iron	3	3							3	
Lead	3	3	3							
Nickel	3	3	0	0						
Selenium	3	0	0	0	0					
Silver	3	3	0							
Zinc	3	3	3							

Table 26. Belmont Pump Station : Comparison of Storm Chemistry with Benchmarks and Guidelines. (Continued)

Belmont Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Bacteria										
Enterococcus	3	3	3	3						
Fecal Coliform	3	3	3	3						
Total Coliform	3	3	3	3						
Ratio of Fecal to Total Coliform	3	-	2	2						
Aroclors										
Aroclor 1016	3	0		0						
Aroclor 1221	3	0		0						
Aroclor 1232	3	0		0						
Aroclor 1242	3	0		0						
Aroclor 1248	3	0		0						
Aroclor 1254	3	0		0						
Aroclor 1260	3	0		0						
Chlorinated Pesticides										
4,4'-DDT	3	0			0	0				
Aldrin	3	0	0		0	0				
Dieldrin	3	0	0		0	0				
Endrin	3	0	0	0	0	0				
gamma-BHC (Lindane)	3	0								
Endosulfan I	3	0								
Endosulfan II	3	0								
Heptachlor	3	0	0	0	0	0				
Heptachlor epoxide	3	0	0	0	0	0				
Total Chlordane	3	3		1	3	3				
Methoxychlor	3	0		0					0	0
Mirex	3	0							0	0
Toxaphene	3	2	2	0	2	2				

Table 26. Belmont Pump Station : Comparison of Storm Chemistry with Benchmarks and Guidelines. (Continued)

Belmont Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Organophosphates										
Chlorpyrifos	3	0					0	0	0	0
Demeton	3	0							0	0
Diazinon	3	0						0	0	0
Malathion	3	3							3	3
Triazine										
Atrazine	**3**	**0**		**0**						
Simazine	3	0		0						

Table 27. Bouton Creek: Comparison of Stormwater Chemistry with Benchmarks and Guidelines.

Bouton Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Conventionals										
pH	2	2		0						
MBAS	2	2		0						
Nitrate (as N)	2	2		0						
Nitrite (as N)	2	2		0						
Total Ammonia (as N)	2	2		0						
Dissolved Metals										
Arsenic	2	2			0	0				
Cadmium	2	2			0	0				
Copper	2	2			2	2				
Lead	2	2			2	0				
Nickel	2	2			0	0				
Selenium	2	0				0				
Silver	2	2			0	0				
Zinc	2	2			2	0				
Total Metals										
Aluminum	2	2		1					2	
Arsenic	2	2	0	0						
Cadmium	2	2	0	0						
Chromium	2	2		0						
Copper	2	2	2							
Iron	2	2							2	
Lead	2	2	1							
Nickel	2	2	0	0						
Selenium	2	0	0	0	0					
Silver	2	2	0							
Zinc	2	2	2							

Table 27. Bouton Creek: Comparison of Stormwater Chemistry with Benchmarks and Guidelines. (Continued)

Bouton Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Bacteria										
Enterococcus	2	2	2	2						
Fecal Coliform	2	2	2	2						
Total Coliform	2	2	2	2						
Ratio of Fecal to Total Coliform	2	-	2	2						
Aroclors										
Aroclor 1016	2	0		0						
Aroclor 1221	2	0		0						
Aroclor 1232	2	0		0						
Aroclor 1242	2	0		0						
Aroclor 1248	2	0		0						
Aroclor 1254	2	0		0						
Aroclor 1260	2	0		0						
Chlorinated Pesticides										
4,4'-DDT	2	0			0	0				
Aldrin	2	0	0		0	0				
Dieldrin	2	0	0		0	0				
Endrin	2	0	0	0	0	0				
gamma-BHC (Lindane)	2	0								
Endosulfan I	2	0								
Endosulfan II	2	0								
Heptachlor	2	0	0	0	0	0				
Heptachlor epoxide	2	0	0	0	0	0				
Total Chlordane	2	1		0	1	1				
Methoxychlor	2	0		0					0	0
Mirex	2	0							0	0
Toxaphene	2	0	0	0	0	0				

Table 27. Bouton Creek : Comparison of Stormwater Chemistry with Benchmarks and Guidelines. (Continued)

Bouton Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Organophosphates										
Chlorpyrifos	2	0					0	0	0	0
Demeton	2	0							0	0
Diazinon	2	0						0	0	0
Malathion	2	2							0	0
Triazine										
Atrazine	2	0		0						
Simazine	2	0		0						

Table 28. Los Cerritos Channel: Comparison of Stormwater Chemistry with Benchmarks and Guidelines.

Los Cerritos Channel Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Conventionals										
pH	2	2		0						
MBAS	2	2		0						
Nitrate (as N)	2	2		0						
Nitrite (as N)	2	1		0						
Total Ammonia (as N)	2	2		0						
Dissolved Metals										
Arsenic	2	2			0	0				
Cadmium	2	2			0	0				
Copper	2	2			2	2				
Lead	2	2			1	0				
Nickel	2	2			0	0				
Selenium	2	0				0				
Silver	2	1			0	0				
Zinc	2	2			1	0				
Total Metals										
Aluminum	2	2		2					2	
Arsenic	2	2	0	0						
Cadmium	2	2	0	0						
Chromium	2	2		0						
Copper	2	2	2							
Iron	2	2							2	
Lead	2	2	2							
Nickel	2	2	0	0						
Selenium	2	0	0	0	0					
Silver	2	2	0							
Zinc	2	2	2							

Table 28. Los Cerritos Channel: Comparison of Stormwater Chemistry with Benchmarks and Guidelines. (Continued)

Los Cerritos Channel Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Bacteria										
Enterococcus	2	2	2	2						
Fecal Coliform	2	2	2	2						
Total Coliform	2	2	2	2						
Ratio of Fecal to Total Coliform	2	-	1	1						
Aroclors										
Aroclor 1016	2	0		0						
Aroclor 1221	2	0		0						
Aroclor 1232	2	0		0						
Aroclor 1242	2	0		0						
Aroclor 1248	2	0		0						
Aroclor 1254	2	0		0						
Aroclor 1260	2	0		0						
Chlorinated Pesticides										
4,4'-DDT	2	0			0	0				
Aldrin	2	0	0		0	0				
Dieldrin	2	0	0		0	0				
Endrin	2	0	0	0	0	0				
gamma-BHC (Lindane)	2	0								
Endosulfan I	2	0								
Endosulfan II	2	0								
Heptachlor	2	0	0	0	0	0				
Heptachlor epoxide	2	0	0	0	0	0				
Total Chlordane	2	1		0	1	1				
Methoxychlor	2	0		0					0	0
Mirex	2	0							0	0
Toxaphene	2	1	1	0	1	1				

Table 28. Los Cerritos Channel: Comparison of Stormwater Chemistry with Benchmarks and Guidelines. (Continued)

Los Cerritos Channel Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Organophosphates										
Chlorpyrifos	2	0					0	0	0	0
Demeton	2	0							0	0
Diazinon	2	0						0	0	0
Malathion	2	2							2	2
Triazine										
Atrazine	2	0		0						
Simazine	2	1		0						

Table 29. Dominguez Gap Pump Station: Comparison of Stormwater Chemistry with Benchmarks and Guidelines.

ominguez Gap Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Conventionals										
pH	3	3		0						
MBAS	3	3		0						
Nitrate (as N)	3	3		0						
Nitrite (as N)	3	2		0						
Total Ammonia (as N)	3	3		0						
Dissolved Metals										
Arsenic	3	3			0	0				
Cadmium	3	3			0	0				
Copper	3	3			3	3				
Lead	3	3			2	0				
Nickel	3	3			0	0				
Selenium	3	0				0				
Silver	3	2			0	0				
Zinc	3	3			0	0				
Total Metals										
Aluminum	3	3		3					3	
Arsenic	3	3	0	0						
Cadmium	3	3	0	0						
Chromium	3	3		0						
Copper	3	3	3							
Iron	3	3							3	
Lead	3	3	3							
Nickel	3	3	0	0						
Selenium	3	0	0	0	0					
Silver	3	3	0							
Zinc	3	3	3							

Table 29. Dominguez Gap Pump Station: Comparison of Stormwater Chemistry with Benchmarks and Guidelines. (Continued)

Dominguez Gap Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Bacteria										
Enterococcus	3	3	3	3						
Fecal Coliform	3	3	3	3						
Total Coliform	3	3	3	3						
Ratio of Fecal to Total Coliform	3	-	3	3						
Aroclors										
Aroclor 1016	3	0		0						
Aroclor 1221	3	0		0						
Aroclor 1232	3	0		0						
Aroclor 1242	3	0		0						
Aroclor 1248	3	0		0						
Aroclor 1254	3	0		0						
Aroclor 1260	3	0		0						
Chlorinated Pesticides										
4,4'-DDT	3	0			0	0				
Aldrin	3	0	0		0	0				
Dieldrin	3	0	0		0	0				
Endrin	3	0	0	0	0	0				
gamma-BHC (Lindane)	3	0								
Endosulfan I	3	0								
Endosulfan II	3	0								
Heptachlor	3	0	0	0	0	0				
Heptachlor epoxide	3	0	0	0	0	0				
Total Chlordane	3	2		0	2	2				
Methoxychlor	3	0		0					0	0
Mirex	3	0							0	0
Toxaphene	3	1	1	0	1	1				

Table 29. Dominguez Gap Pump Station: Comparison of Stormwater Chemistry with Benchmarks and Guidelines. (Continued)

Dominguez Gap Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Organophosphates										
Chlorpyrifos	3	0					0	0	0	0
Demeton	3	0							0	0
Diazinon	3	0						0	0	0
Malathion	3	3							2	2
Triazine										
Atrazine	3	0		0						
Simazine	3	0		0						

Table 30. Los Cerritos Channel: Comparison of Dry Weather Chemistry with Benchmarks and Guidelines.

Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Conventionals										
pH	2	2		1						
MBAS	2	1		0						
Nitrate (as N)	2	0		0						
Nitrite (as N)	2	0		0						
Total Ammonia (as N)	2	1		0						
Dissolved Metals										
Arsenic	2	2			0	0				
Cadmium	2	2			0	0				
Copper	2	2			1	2				
Lead	2	2			0	0				
Nickel	2	2			0	0				
Selenium	2	1				0				
Silver	2	2			0	0				
Zinc	2	2			0	0				
Total Metals										
Aluminum	2	2		0					1	
Arsenic	2	2	0	0						
Cadmium	2	2	0	0						
Chromium	2	2		0						
Copper	2	2	2							
Iron	2	2							0	
Lead	2	2	0							
Nickel	2	2	0	0						
Selenium	2	1	0	0	0					
Silver	2	2	0							
Zinc	2	2	0							

Table 30. Los Cerritos Channel: Comparison of Dry Weather Chemistry with Benchmarks and Guidelines. (continued)

Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Bacteria										
Enterococcus	2	2	2	2						
Fecal Coliform	2	2	2	2						
Total Coliform	2	2	1	1						
Ratio of Fecal to Total Coliform	2	-	2	2						
Aroclors										
Aroclor 1016	2	0		0						
Aroclor 1221	2	0		0						
Aroclor 1232	2	0		0						
Aroclor 1242	2	0		0						
Aroclor 1248	2	0		0						
Aroclor 1254	2	0		0						
Aroclor 1260	2	0		0						
Chlorinated Pesticides										
4,4'-DDT	2	0			0	0				
Aldrin	2	0	0		0	0				
Dieldrin	2	0	0		0	0				
Endrin	2	0	0	0	0	0				
gamma-BHC (Lindane)	2	0								
Endosulfan I	2	0								
Endosulfan II	2	0								
Heptachlor	2	0	0	0	0	0				
Heptachlor epoxide	2	0	0	0	0	0				
Total Chlordane	2	0		0	0	0				
Methoxychlor	2	0		0					0	0
Mirex	2	0							0	0
Toxaphene	2	0	0	0	0	0				

Table 30. Los Cerritos Channel: Comparison of Dry Weather Chemistry with Benchmarks and Guidelines. (continued)

Analyte	Samples	Hits	Ocean Plan	LA Basin Plan	California Toxics Rule Freshwater	California Toxics Rule Saltwater	California Fish and Game Freshwater	California Fish and Game Saltwater	National Non Priority Pollutant Freshwater	National Non Priority Pollutant Saltwater
Organophosphates										
Chlorpyrifos	2	0					0	0	0	0
Demeton	2	0							0	0
Diazinon	2	0						0	0	0
Malathion	2	0							0	0
Triazine										
Atrazine	2	0		0						
Simazine	2	1		0						

Table 31. Summary of Toxicity Characteristics of Stormwater from Various Southern California Watersheds.

Test Types: SF = sea urchin fertilization, MS = mysid survival/growth, DS = daphnid survival/reproduction.

Location	Date	Test Type	Number of Samples	%Toxic	TU_c
Long Beach	2008-2009	SF	7	29	2-8
	2008-2009	DS	7	57	1->16
Long Beach	2007-2008	SF	12	42	2-32
	2007-2008	DS	12	33	1-2
Long Beach	2006-2007	SF	6	100	4->32
	2006-2007	DS	6	0	1
Long Beach	2005-2006	SF	12	83	2->32
	2005-2006	DS	2	17	1-2
Long Beach	2004-2005	SF	12	58	2-16
	2004-2005	DS	12	25	1-8
Long Beach	2003-2004	SF	11	45	<2-32
	2003-2004	DS	11	9	1-2
Long Beach	2002-2003	SF	13	46	≤2-32
	2002-2003	DS	13	31	1-4
Long Beach	2000-2002	SF	22	86	≤2-32
	2000-2002	MS	20	55	1-16
	2000-2002	DS	22	77	1->16
Los Angeles River	1997-1999	SF	4	100	4-8
San Gabriel River	1997-1999	SF	4	50	≤2-4
Ballona Creek	1996-1997	SF	13	85	≤4-32
Chollas Creek	2000-2001	DS	40	35[1]	Not reported
	1999-2000	SF	5	100	8-32
	1999	MS	3	0	1
	1999	DS	3	67	1-2
	1994-1998	DS	11	100	2-8

1. Percent toxic based only on daphnid survival LC_{50}.

Table 32. Spearman Rank Correlation Coefficients (r_s) for Toxicity and Chemical Data from Eight Wet Weather Seasons from 2001 to 2009.

The nonparametric tests show the relationship between paired chemical concentrations and toxic units (TU) for either acute or chronic bioassay toxicity tests. Toxic units are based on either the median response (EC_{50} or LC_{50}, acute TU_a) or the NOEC (chronic TU_c) concentration. Values of r_s in **bold** text are significant at $p \leq 0.05$ and indicate that each significant ranked pair series approach the same positive or negative order and are statistically different from an order that is random. For all constituents n=89.

	Sea Urchin	Water Flea	
	Fertilization	Survival	Reproduction
Constituent	**TU_a**	**TU_a**	**TU_c**
Conventional			
Hardness	0.198	**0.410**	**0.229**
TSS	-0.030	**0.346**	**0.374**
TDS	0.132	**0.281**	0.193
TOC	0.198	**0.369**	**0.313**
Dissolved Metals			
Cadmium	0.097	**0.576**	**0.489**
Chromium	0.143	0.095	0.048
Copper	**0.296**	**0.305**	**0.220**
Lead	0.192	**0.542**	**0.476**
Nickel	**0.277**	**0.438**	**0.416**
Zinc	0.194	**0.405**	**0.368**

bold **Black** - significant values at the level of significance of α = 0.050 (two-tailed test).
In bold **Red** - significant values at the level of significance of α = 0.010 (two-tailed test).

Table 33. Spearman Rank Correlation Coefficients (r_s) for Station Toxicity and Chemical Data from Eight Wet Weather Seasons (2001 to 2009).

The nonparametric tests show the relationship between paired chemical concentrations and toxic units (TU) for either acute or chronic bioassay toxicity tests. Toxic units are based on either the median response (EC_{50} or LC_{50}, acute TU_a) or the NOEC (chronic TU_c) concentration. Values of r_s in **bold** text are significant at $p \leq 0.05$ and indicate that each significant ranked pair series approach the same positive or negative order and are statistically different from an order that is random.

	Sea Urchin	Water Flea	
	Fertilization	Survival	Reproduction
Constituent	TU_a	TU_a	TU_c
Bouton Creek (*n*=30)			
Conventional			
Hardness	0.285	**0.547**	0.258
TSS	0.030	0.079	0.210
TDS	0.292	**0.513**	0.287
TOC	0.186	**0.367**	**0.384**
Dissolved Metals			
Cadmium	-0.162	**0.377**	0.308
Chromium	0.144	-0.062	0.056
Copper	0.221	**0.409**	0.349
Lead	0.055	**0.467**	**0.490**
Nickel	0.139	0.342	**0.480**
Zinc	0.130	**0.475**	**0.570**
Belmont Pump (*n*=30)			
Conventional			
Hardness	0.194	0.281	0.203
TSS	0.101	0.211	0.348
TDS	0.127	0.147	0.108
TOC	0.107	0.102	0.209
Dissolved Metals			
Cadmium	0.110	**0.651**	**0.462**
Chromium	0.095	0.183	0.142
Copper	0.144	0.073	0.231
Lead	0.246	**0.664**	**0.699**
Nickel	0.286	0.331	**0.434**
Zinc	0.103	0.156	0.270
Los Cerritos (*n*=29)			
Conventional			
Hardness	0.181	**0.579**	0.319
TSS	-0.231	**0.493**	**0.374**
TDS	0.036	**0.544**	**0.387**
TOC	0.228	**0.612**	**0.370**
Dissolved Metals			
Cadmium	0.219	**0.670**	**0.630**
Chromium	0.174	0.300	0.076
Copper	**0.499**	**0.488**	0.193
Lead	0.209	**0.758**	**0.476**
Nickel	**0.400**	**0.678**	**0.436**
Zinc	0.367	**0.545**	0.269

In bold **black** - significant values at the level of significance of $\alpha = 0.050$ (two-tailed test).
In bold **Red** - significant values at the level of significance of $\alpha = 0.010$ (two-tailed test).

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CONCLUSIONS

The City of Long Beach's water quality monitoring program for stormwater and dry weather discharges through the City's municipal separate storm sewer system (MS4) began in the 1999/2000 wet weather season under terms of Order No. 99-060 National Pollutant Discharge Elimination Systems Municipal Permit No. CAS004003 (CI 8052). Since that time, 112 wet weather monitoring events have been conducted at the four Long Beach mass emission stations for the full set of analytes, along with 72 dry weather inspections/monitoring events. In addition 57 wet weather events have been monitored to develop Event Mean Concentrations (EMCs) for total suspended solids only.

The Long Beach stormwater monitoring program has emphasized an approach of paired chemical analysis and toxicity testing of discharges of municipal stormwater. The purpose of this approach was to first identify the constituents in the City of Long Beaches stormwater discharges that exhibited potential water quality impacts. This requires that the chemical analyses and toxicity tests be conducted on the same composite water samples. This approach has successfully led to identification of impacts of organophosphate pesticides as problems early in the program.

The 2008/2009 wet season marked the fourth season in a row with below normal precipitation. The last storm season with above normal precipitation was 2004/2005 when rainfall was approximately twice the seasonal averages. Normal precipitation for September through April at the Long Beach Airport is 12.51 inches. This season, a total of 9.29 inches of rainfall was recorded at the airport. Compared to normal precipitation at this site, there was a 3.22 inch deficit for the season or 74% of normal. The prior wet season, 2007/2008, was similar with just 72% of normal seasonal rainfall.

The results continue to support the many common trends identified over the previous eight years of the program. Concentrations of dissolved cadmium, copper and nickel do not vary substantially between wet and dry periods. High hardness concentrations during periods of dry weather generally reduce or mitigate exceedences of water quality criteria that are used as benchmarks for the data evaluations. Concentrations of total copper, lead and zinc are consistently higher in association with storm flows and, based on previous analyses, are significantly impacted by concentrations of suspended solids. Diazinon and chlorpyrifos, two organophosphate pesticides banned for residential use, were absent in all samples after showing dramatic decreases in concentrations soon after being pulled off the market. Malathion, an organophosphate pesticide not included in the ban, has continued to be detected in stormwater runoff but not at levels that elicit a toxic response in the bioassays.

Changes in the stormwater quality and the frequency of stormwater discharges from the Dominguez Gap Pump Station remain a concern. These changes started in 2007 and have been attributed to construction activities and the general reconfiguration of the site to develop a constructed wetland habitat and provide recreational benefits in terms of hiking, biking and horseback trails. Although the wetlands appear to have become fully developed this last season, the system is still not being operated as intended due to issues with the electric pump that was intended to control flow through the system. The County has indicated that they expected the problem with the electric pump to be resolved by August, 2009. The interim operation of the wetlands has had distinct effects on the quantity and quality of stormwater discharges from this site. The frequency of wet weather discharges appears to be increasing since discharges can occur with much lower rainfall and concentrations of suspended solids and total recoverable metals, particularly copper, lead and zinc, have increased in recent years.

Under current conditions, it is clear that this site is not producing data that reflect stormwater contributions from the City of Long Beach even though the system provides regional benefits by infiltrating and treating dry weather flow from the Los Angeles River, providing enhanced wildlife habitat and recreational opportunities. As the wetland vegetation matures and operational procedures are refined at the pump station, we anticipate that management of this facility will allow better characterization of water quality and loads from the City of Long Beach. This will only occur if the diversion of Los Angeles River water into the wetlands is shut down for a sufficient time prior to incoming storms to provide improved capacity for stormwater from the City of Long Beach and to reduce commingling with Los Angeles River water. The timing of this activity could have a substantial impact on the quality and quantity of stormwater that is ultimately discharged to the Los Angeles River. In the future, an alternative site may need to be investigated if the operation of the wetlands remains inconsistent with the objective of quantifying stormwater quality and quantity from the City of Long Beach.

Stormwater discharges have consistently shown toxicity to freshwater and marine species. Early years of the program typically showed more frequent toxic samples from storms early in the year. This pattern has become less obvious for water fleas over more recent program years, primarily because of the decreased frequency and magnitude of samples toxic to *Ceriodaphnia*. This 2008/2009 program showed elevated chronic daphnid toxicity in a single mid-season storm. This high toxicity is viewed as anomalous, and is attributed to very low variability among test replicates and consequent increased test sensitivity. Ignoring these anomalous results, water flea toxicity remained low. There was overall decreased frequency of stormwater samples toxic to sea urchins in the 2009/2009 monitoring season and the magnitude of urchin toxicity was generally low. Due to a lack of sufficient acute toxicity to both test species in both wet and dry weather samples, no TIEs were done in the 2008/2009 program.

Three approaches to toxicity characterization are currently used. These included TIEs, correlations of chemical data with toxicity results and comparison of observed versus predicted toxicity. The very low acute toxicity observed in all storm and dry weather samples this season made the latter analysis less useful. Despite the limited applicability of this analysis, it was useful with regard to the fact that the concentrations of the key contaminants of concern did not suggest that toxic responses would be expected. Analyses correlating chronic toxicity with chemical data at each individual station suggested that much of the observed water flea toxicity originates in the Los Cerritos Channel and Bouton Creek samples. Given the complexities of the chemistry-toxicity relationship, however, it is important to continue the current multi-phased approach to the problem of identifying and managing critical toxicants.

Several minor adjustments to the NPDES monitoring program are recommended based upon the results of the 2008/2009 monitoring period as well as work conducted over the past ten years. Two of these recommendations were also suggested last year but, lacking official authorization, these changes were not incorporated into the 2008/2009 monitoring year. These minor adjustments include elimination of 1) analysis of the triazine pesticides and 2) dry weather monitoring at the Dominguez Gap Pump Station. It is recommended that wet weather monitoring be continued at the Dominguez Gap Pump Station at least until the effects of operating the system as designed are better understood. If significant quantities of diverted water from the Los Angeles River continue to commingle with stormwater runoff from the City of Long Beach's Dominguez Gap watershed (Basin 14), an alternative site will need to be evaluated. In addition, we recommend establishing a new upstream sampling location for the Bouton Creek watershed that would enable successful quantification and sampling of the lower dry weather flows now being experienced in this watershed.

REFERENCES CITED

APHA [American Public Health Association]. 1995. Standard Methods for the Examination of Water and Waste Water. (19th edition) Eaton, A.D., L.S. Clesceri, and A.E. Greenberg (Eds.). American Public Health Association, Washington, D.C.

Bay, S., B.H. Jones, and K. Schiff. 1999. Study of the Impact of Stormwater Discharge on Santa Monica Bay. Executive Summary. Sea Grant Program, University of Southern California. Los Angeles.

CRWQCB, Los Angeles [California Regional Water Quality Control Board, Los Angeles Region]. 1994. Water Quality Control Plan, Los Angeles Region, Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties.

CRWQCB, Los Angeles [California Regional Water Quality Control Board, Los Angeles Region]. 1999. Waste Discharge Requirements for Municipal Stormwater and Urban Runoff Discharges within the City of Long Beach. Order No. 99-060 National Pollutant Discharge Elimination Systems Municipal Permit No. CAS004003 (CI 8052), June 30, 1999.

CRWQCB, Los Angeles [California Regional Water Quality Control Board, Los Angeles Region]. 2006. Region 4, 303(d) List.

City of Long Beach, 2000. City of Long Beach GIS Database. Dept. of Technology, Long Beach.

Gilbert, R.O. 1987. *Statistical Methods for Environmental Pollution Monitoring*. van Nostrand Rienhold Company, Inc., New York.

Kinnetic Laboratories, Inc. 2000. City of Long Beach Storm Water Monitoring Report 1999-2000. NPDES Permit No. CAS0040003 (CI 8052), July, 2000.

Kinnetic Laboratories, Inc. and Southern California Coastal Water Research Project. 2001. City of Long Beach Storm Water Monitoring Report 2000-2001. NPDES Permit No. CAS004003 (CI 8052), July, 2001.

Kinnetic Laboratories, Inc. and Southern California Coastal Water Research Project. 2002. City of Long Beach Storm Water Monitoring Report 2001-2002. NPDES Permit No. CAS004003 (CI 8052), July, 2002.

Kinnetic Laboratories, Inc. 2003. City of Long Beach Stormwater Monitoring Report 2002-2003. NPDES Permit No. CAS0040003 (CI 8052), July, 2003.

Kinnetic Laboratories, Inc. 2004. City of Long Beach Stormwater Monitoring Report 2003-2004. NPDES Permit No. CAS0040003 (CI 8052), July, 2004.

Kinnetic Laboratories, Inc. 2005. City of Long Beach Stormwater Monitoring Report 2004-2005. NPDES Permit No. CAS0040003 (CI 8052), July, 2005.

Kinnetic Laboratories, Inc. 2006. City of Long Beach Stormwater Monitoring Report 2005-2006 NPDES Permit No. CAS0040003 (CI 8052), July, 2006

Kinnetic Laboratories, Inc. 2007. City of Long Beach Stormwater Monitoring Report 2006-2007 NPDES Permit No. CAS0040003 (CI 8052), July, 2007

Kinnetic Laboratories, Inc. 2008. City of Long Beach Stormwater Monitoring Report 2007-2008 NPDES Permit No. CAS0040003 (CI 8052), July, 2007

Mann, H.B. (1945), Nonparametric tests against trend, Econometrica, 13, 245-259.

Miles, S.R. and C.B. Goudey. 1998. Ecological Subregions of California. Internet number R5-EM-TP-005 NET. Available at: http://www.r5.pswfs.gov/ecoregions. [Access Date June 6, 2001]

National Atmospheric Deposition Program. 2007. 30 Years of the NADP: 2007 Summary of the National Atmospheric Deposition Program. Illinois State Water Survey, Champaign, IL.

NCDC/NOAA. 2004. Climatography of the United States, No. 81. http://lwf.ncdc.noaa.gov/oa/climate/normals/usnormalsprods.html#CLIM81.

Phillips, B.M., B.S. Anderson and J.W. Hunt. 1998 Spatial and temporal variation in results of purple urchin (*Strongylocentrotus purpuratus*) toxicity tests with zinc.

Phillips, B.M., P.A. Nicely, J.W. Hunt, B.S. Anderson, R.S. Tjeerdema, S.E. Palmer, F.H. Palmer and H.M Puckett. 2003. Toxicity of cadmium-copper-nickel-zinc mixtures to larval purple sea urchins (*Strongylocentrotus purpuratus*). Bull. Environ. Contam. Toxicol. 70: 592-599.

Schiff, K.C., S.M. Bay and D.W. Diehl. 2001. Stormwater Toxicity in Chollas Creek and San Diego Bay. SCCWRP Technical Report 340

Sharma, S.S., H. Schat, R. Vooijs and L.M. Van Heerwaarden. 1999. Combination toxicology of copper, zinc, and cadmium in binary mixtures: concentrations-dependent antagonistic, nonadditive, and synergistic effects on root growth in *Silene vulgaris*. Environ. Toxicol. Chem. 18: 348-355.

Siepmann, S. and B. Finlayson. 2002. Water Quality Criteria for Diazinon and Chlorpyrifos. California Department of Fish and Game Office of Spill Prevention and Response, Administrative Report 00-3, 2000.

Southern California Coastal Water Research Project. 1999. Characterization of stormwater toxicity from Chollas Creek, San Diego. Southern California Coastal Water Research. Westminster, CA

Storm Water Panel. 2006. Stormwater Panel Recommendations to the State Water Resources Control Board: The Feasibility of Numeric Effluent Limits Applicable to Discharges of Storm Water Associated with Municipal, Industrial and Construction Activities. June 19, 2006 (Panelists include B.Currier, G. Minton, R. Pitt, L. Roesner, K. Schiff, M. Stenstrom, E. Strassler and E. Strecker)

State of California, Department of Finance, E-4 Population Estimates for Cities, Counties and the State, 2001–2009, with 2000 Benchmark. Sacramento, California, May 2009.

SWRCB [State Water Resources Control Board]. 2006. Water Quality Control Plan, Ocean Waters of California, California Ocean Plan 2005.

TDC Environmental. 2003. Insecticide Market Trends and Potential Water Quality Implications. Prepared for the San Francisco Estuary Project. April.

USEPA [U.S. Environmental Protection Agency]. 1983. Methods for the chemical analyses of water and wastes. EPA-600/4-79/020. Revised March 1983.

USEPA [U.S. Environmental Protection Agency]. 1991. Methods for Aquatic Toxicity Identification Evaluations. Phase I, Toxicity Characterization Procedures. (2nd Ed.). EPA/600/6-91/003. Office of Research and Development

USEPA [U.S. Environmental Protection Agency]. 1993. Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria. Memorandum from Martha Prothro, Acting Assistant Administrator for Water.

USEPA [U.S. Environmental Protection Agency]. 2000. Federal Register, Part III. "California Toxics Rule: Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule."

USEPA [U.S. Environmental Protection Agency]. 2001. USEPA Functional Guidelines for Low Level Concentration Organic Data Review. EPA540-R-00-006

USEPA [U.S. Environmental Protection Agency]. 2002. USEPA Functional Guidelines for Inorganic Data Review. EPA 540-R-01-008.

USEPA [U.S. Environmental Protection Agency]. 2006. National Recommended Water Quality Criteria.