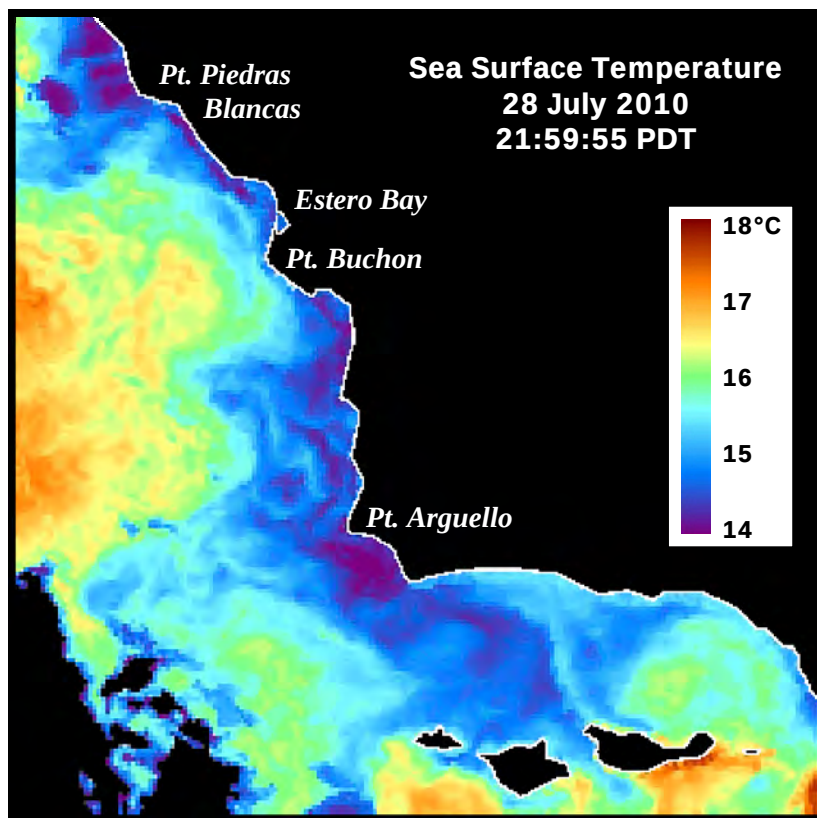


**City of Morro Bay and
Cayucos Sanitary District**

OFFSHORE MONITORING AND REPORTING PROGRAM

2010 ANNUAL REPORT



Marine Research Specialists

**3140 Telegraph Rd., Suite A
Ventura, California 93003**

**Report to the
City of Morro Bay and
Cayucos Sanitary District**

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Morro Bay, California 93442
(805) 772-6272

**OFFSHORE MONITORING
AND REPORTING PROGRAM**

2010 ANNUAL REPORT

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March 2011

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Mr. Bruce Keogh
Wastewater Division Manager
City of Morro Bay
955 Shasta Avenue
Morro Bay, CA 93442

31 March 2011

Reference: 2010 Annual Monitoring Report

Dear Mr. Keogh:

Enclosed is the referenced report. It documents the continued effectiveness of the treatment process, the absence of marine impacts, and compliance with the discharge limitations and reporting requirements specified in the NPDES discharge permit.

Please contact the undersigned if you have any questions regarding this report.

Sincerely,

Bonnie Luke
Project Manager

Enclosures (4 Reports)

I certify under penalty of law that this document and all attachments were prepared under my direction 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 fine and imprisonment for knowing violations.

Mr. Rob Livick
Acting Director of Public Services
City of Morro Bay

Date

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LIST OF ACRONYMS AND DEFINITIONS

ACOE	U.S. Army Corps of Engineers
Anomaly	An anomaly is a deviation or departure from ambient (mean) conditions in one of the six measured seawater properties: salinity, temperature, density, dissolved oxygen, alkalinity, or transmissivity. The amplitude of the anomaly is quantified as the difference between the measured seawater property at a given station and the mean of that property measured at all other stations at the same depth level or distance above the bottom.
Anthropogenic	Changes to the environment induced by human activities
ASP	Amnesic Shellfish Poisoning
BCCE	Brown and Caldwell Consulting Engineers
BEHP	Bis 2-Ethyl Hexyl Phthalate is a compound that leaches out of plastics and is ubiquitous in the environment.
BIP	A Balanced Indigenous Population is as an ecological community that exhibits characteristics similar to those of nearby, healthy communities existing under comparable but unpolluted environmental conditions.
BBL	A benthic boundary layer is often synonymous with a bottom nepheloid layer (<i>see below</i> BNL) and is associated with increased turbulence and mixing caused by the decrease in current flow immediately above the seafloor that is required to meet the zero-velocity boundary condition at the seafloor.
BNL	The bottom nepheloid layer is a common phenomenon on continental shelves where increased turbidity near the seafloor is caused by the presence of naturally occurring particulates formed from light-weight flocs of detritus. Oscillatory bottom currents generated by passing surface gravity waves easily suspend these flocs.
BOD₅	Five-day biochemical oxygen demand
BTEX	Benzene, toluene, ethyl benzene, and xylene
Cal/OSHA	California Department of Industrial Relations, Division of Occupational Safety and Health
CAM-17	CAM is the California Administrative Manual and CAM-17 refers to the list of 17 heavy metals identified in the California Code of Regulations (CCR 2003), Title 22, Chapter 11: Identification and Listing of Hazardous Waste.
CCLEAN	<u>Central Coast Long-term Environmental Assessment Network</u>
CEQA	California Environmental Quality Act
CCR	California Code of Regulations (CCR 2003)
CDFG	California Department of Fish and Game
Coordinate Datum	All coordinates cited in this report are referenced to the WGS84 datum

LIST OF ACRONYMS AND DEFINITIONS

(Continued)

COP	The California Ocean Plan (SWRCB 1997), which has been revised but the 1997 edition was in force when the current NPDES discharge permit was issued to MBCSD.
CTD	CTD is an instrument package that continuously records conductivity, temperature, and depth, in addition to a number of other physical oceanographic parameters in the water column.
CV	A coefficient of variation is used to compare the relative amounts of variation in populations having different means. It is the standard deviation expressed as a percentage of the mean.
DDT	Dichloro Diphenyl Trichloroethane, a chlorinated pesticide
DEHP	Di(2-ethylhexyl) phthalate synonymous with Bis(2-ethylhexyl) phthalate
dEIR	Draft Environmental Impact Report
DHS	California Department of Health Services
DMR-QA	Discharge Monitoring Report Quality Assurance (DMR-QA) Study administered by the United States Environmental Protection Agency
DO	Dissolved Oxygen
EIR	Environmental Impact Report
ELAP	California Department of Health Services, Environmental Laboratory Accreditation Program
EQ	Exceptional Quality is a standard for compost that meets the Federal and State requirements for beneficial reuse as a soil amendment in the local community.
ERL	Effects Range Low is a sediment toxicity concentration below which adverse biological effects are not expected to occur.
ERM	Effects Range Median is a sediment toxicity concentration above which adverse biological effects are expected to occur.
GPM	Gallons per Minute
HAB	Harmful Algal Bloom
Hazwopper	Hazardous Waste Operations and Emergency Response
HCl	Hydrochloric Acid
HCH	Isomers of hexachlorocyclohexane including alpha, beta, gamma (lindane), and delta
I&I	Inflow and Infiltration
Isopycnal	A surface of constant seawater density
Leachate	A solution formed by leaching, especially a solution containing contaminants picked up through the leaching of soil
LC₅₀	Lethal 50% Concentration is a toxicity endpoint where 50% of the specimens will die after a 96-hour exposure period.

LIST OF ACRONYMS AND DEFINITIONS

(Continued)

LOE	Line of Evidence used to evaluate whether a receiving-water measurement complied with permit limits
MANOVA	Multivariate Analysis of Variance
MBCSD	The City of Morro Bay and Cayucos Sanitary District
MTBE	Methyl Tertiary Butyl Ether is an additive to gasoline that boosts octane to reduce air emissions but has contaminated groundwater in many regions after accidentally leaking from underground storage tanks.
MDL	Method Detection Limit is the lowest concentration that can be reported under ideal conditions where the sample contains only the compound of interest with a concentration in an optimal calibration range and in a medium that does not interfere with the performance of the analytical instrument.
MGD	Million Gallons per Day
mg/Kg	Milligrams per Kilogram = $\mu\text{g/g}$ dry weight = parts per million
mg/L	Milligrams per Liter = aqueous parts per million
Mixed liquor	A mixture of activated sludge, wastewater, and oxygen where organic sewage constituents are biologically assimilated
ML	The Minimum Level is the method-specific minimum concentration of a substance that can be quantitatively measured in a sample given the current analytical performance used by most certified laboratories within California, as specified in the 2005 Ocean Plan.
MLLW	Mean Lower Low Water
MMS	Minerals Management Service
MPN	Most Probable Number
MRS	Marine Research Specialists
MT	Metric Ton = 1,000 kg
MWH	Montgomery, Watson, Harza is the engineering firm selected for the design of the MBCSD treatment-plant upgrade.
NEP	National Estuary Program
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOEC	No Observable Effect Concentration
NORM	Naturally Occurring Radioactive Material
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Units
O&G	Oil and Grease
O&M	Operations and Maintenance

LIST OF ACRONYMS AND DEFINITIONS

(Continued)

OIT	Operator-in-Training
PAH	Polynuclear Aromatic Hydrocarbons
PCA	Principal Component Analysis is a multivariate technique that arranges samples along an axis based on species composition. This arrangement is conducted independently along a number of dimensions (usually 2 or 3) that approximate some pattern of response of the intertidal community to underlying environmental gradients. PCA condenses the complex species-abundance database to a few factors responsible for observed variability within the intertidal community structure, while retaining ecologically meaningful biological information.
PCB	Polychlorinated Biphenyl
PCi/L	Pico-Curies per liter is a measure of aqueous radioactivity.
Perturbation	A perturbation is a small but detectable variation (anomaly) in one or more seawater properties caused by the presence of dilute effluent within the receiving waters. Individual Perturbations identified in this report are designated P1 through P12.
PG&E	Pacific Gas and Electric
POTW	Publicly Owned Treatment Works
Power (1-β)	The probability correctly rejecting the null hypothesis depending on the significance criterion, the variability of the sample results, and the size of the impact
ppm	Parts per million = mg/L in solution , or mg/Kg = μg/g dry weight
PQL	Practical Quantification Limit is the lowest concentration that can be measured with statistical reliability given the sample size and analytical method.
PSDWF	Peak seasonal dry-weather flow
PSP	Paralytic Shellfish Poisoning
<i>p</i>-value	Low <i>p</i>-values (<0.05) indicate a high degree of confidence that the computed quantity is statistically significant.
PWWF	Peak wet-weather flow
Pycnocline	A region of rapid vertical change in the density field of the seawater column
QA/QC	Quality Assurance and Quality Control
RAS	Return Activated Sludge is continuously returned to the aeration tank to provide a seed of developed bacteria for rapid digestion of incoming wastewater. Some sludge is wasted (WAS) to prevent excessive solids buildup.
RPA	The Reasonable Potential Analysis procedures in Appendix IV of the California Ocean Plan provide a quantitative methodology for statistically analyzing historical effluent data to determine the likelihood of exceeding permit limits in the future, and thus, whether continued monitoring is warranted.

LIST OF ACRONYMS AND DEFINITIONS

(Continued)

RWQCB	State of California Regional Water Quality Control Board - Central Coast Region
SAIC	Science Applications International Corporation
SBE	Sea-Bird Electronics, Inc.
SCBPPFCT	Southern California Bight Pilot Project Field Coordination Team
SCCWRP	Southern California Coastal Water Research Project
SEP	Supplemental Environmental Project
Sigma-T	σ_t units are a measure of the density of water equal to the 1000 times the specific gravity minus one.
SJCF	San Joaquin Composting Facility located in Kern County California and owned by McCarthy Family Farms, Inc.
STLC	Soluble Threshold Limit Concentration applies to the measured concentration in the liquid extract from a biosolid sample, as determined by a Waste Extraction Test. The State of California classified biosolids with leachate concentrations exceeding the STLC as hazardous.
SWRCB	State Water Resources Control Board
Thermocline	A region of rapid vertical change in the temperature field of the seawater column
TIC	Tentatively Identified Compound is a compound that can be seen by the analytical testing method, but its identity and concentration cannot be confirmed without further analytical investigation. Many analytical methods can report TICs but the analysis is not targeted specifically for their detection.
TKN	Total Kjeldahl Nitrogen
TRC	Total Residual Chlorine in effluent is determined from grab samples collected beyond the chlorine contact chamber.
TSS	Total Suspended Solids
TTLC	Total Threshold Limit Concentration applies to the total wet-weight concentration of a contaminant within a bulk biosolid sample consisting of the entire millable solid matrix rather than just the leachate. Biosolids are designated as hazardous wastes in the State of California if measured bulk concentrations exceed the TTLC.
TUa	Acute Toxicity Units
TUc	Chronic Toxicity Units
TVS	Total Volatile Solids
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGPO	United States Government Printing Office

LIST OF ACRONYMS AND DEFINITIONS

(Continued)

USMMS	United States Minerals Management Service
VFD	Variable-Frequency Drives are electronic-motor-speed controllers used at the MBCSD WWTP to precisely control the influent pumping rate at the plant headworks by adjusting the frequency of electrical power sent to the pump motors.
WAS	Waste Activated Sludge is removed from the treatment process to prevent excessive solids buildup.
WERF	The Water Environment Research Foundation is a nonprofit organization that helps utilities and corporations manage water resources.
WET	Waste Extraction Tests measure the soluble leachate or the extractable amount of a substance contained within a bulk sample of biosolids. A WET is indicated if the bulk wet-weight concentration of a contaminant in a biosolids sample exceeds ten times the STLC.
WWTP	City of Morro Bay-Cayucos Sanitary District Waste Water Treatment Plant
ZID	The Zone of Initial Dilution is a limited volume of water surrounding the outfall where wastewater rapidly mixes with receiving waters. Most receiving-water objectives of the Ocean Plan do not apply within the ZID.

EXECUTIVE SUMMARY

The City of Morro Bay and the Cayucos Sanitary District (MBCSD) jointly own the wastewater treatment plant operated by the City of Morro Bay. The treatment plant discharges effluent to the open ocean environment of northern Estero Bay under the authority of National Pollutant Discharge Elimination System (NPDES) permit No. CA0047881. The current permit was issued in January 2009. The permit allows discharge of blended primary- and secondary-treated wastewater, although the vast majority of the wastewater receives secondary treatment. The discharge permit requires a monitoring and reporting program that evaluates short- and long-term effects of the effluent discharge on receiving waters, benthic sediments, and infaunal communities. This 2010 Annual Report partially satisfies those reporting requirements.

This document presents a comprehensive analysis of the extensive monitoring data collected over the last 25 years. Virtually every aspect of the treatment process, receiving waters, and seafloor sediments is monitored. An exhaustive quantitative analysis of all measured parameters demonstrates that the effluent discharge consistently meets the discharge requirements and has no discernible effect on the ocean environment. A comparison of the properties of the influent and effluent affirms the treatment plant's proficiency at removing contaminants and reducing organic loads within the wastewater stream. All offshore water-quality measurements indicate that the effluent plume was primarily restricted to a narrow 15-m zone of initial dilution (ZID) around the outfall. Measurements within the effluent plume collected a few feet from a diffuser port quantified the plume's rapid dispersion, and demonstrated that the structure was operating better than predicted by modeling. Finally, the absence of adverse discharge-related impacts to the physics, chemistry, and biology of benthic sediments verified the effectiveness of the treatment process, the high dilution of effluent within receiving waters, and the low toxicity of the discharged effluent. The additional data presented in this report are consistent with conclusions based on historical data insofar as the treatment plant's continued low emission of contaminants, low toxicity of the effluent stream, and absence of impacts to the marine environment.

The plant operates under a 301(h)-permit that modifies the general NPDES requirements on suspended-solid and biochemical oxygen demand (BOD) emissions. All other NPDES limits, including restrictions on the discharge of toxic substances, apply to the MBCSD discharge without exception. Regardless, the partial-secondary treatment currently performed by the plant routinely achieves reductions in suspended solids and BOD that are close to, and often exceed, secondary treatment requirements. In fact, the effluent usually consists entirely of wastewater that has received secondary treatment.

Effluent monitoring during 2010 documented another year of exceptionally high operational performance by the treatment plant. Major effluent constituents, including suspended solids (TSS), BOD, and oil and grease (O&G), all had much lower concentrations and mass emissions than the permitted maximums, as has consistently been the case throughout the history of the monitoring program. The plant performed remarkably well in 2010 in spite of an increase in the flow compared to recent years. The flow increase resulted from 27 inches of rain that fell within the collection area during 2010; an amount double the average amount of precipitation measured at the plant over the last decade. The high rainfall generated greater inflow and infiltration (I&I) into the collection system, thereby increasing plant throughput and increasing mass-emission estimates. Nevertheless, effluent parameters remained comparable to those of the recent past when the plant performed at record levels.

Although the treatment process efficiently removed major organic wastewater constituents such as suspended solids, BOD, O&G, and coliform bacteria, the general lack of other chemical contaminants within effluent was largely due to their absence within the influent stream. Like most publicly owned treatment works, the MBCSD plant is not designed to extract heavy metals and synthetic organic

compounds from wastewater. Instead, the MBCSD effluent's low toxicity is primarily due to the lack of heavy industry within its service area. The few businesses that discharge to the sewer system produce wastewater that is similar to that of domestic sources, only on a larger scale. A comprehensive industrial waste survey, maintained and periodically updated by collections system personnel, documents these sources. In addition, an ongoing public-outreach program and the convenience of an onsite household hazardous waste recycling facility further reduced the introduction of pollutants into the waste stream.

Throughout the more than two decades of operation, the treatment plant has consistently outperformed expectations for wastewater treatment based on regulatory standards. During this time, there has been no indication of deterioration in plant performance, and effluent quality has consistently exceeded the performance criteria anticipated in the original design. On rare occasions where exceptions to standards or criteria have occurred, they have been the direct result of unforeseen external events, or the brief, unavoidable mechanical failure of a treatment-system component. In light of their diligent adherence to a program of preventative maintenance, the main challenge for plant personnel has been to respond quickly to unanticipated failures in system components or unforeseeable events.

Among the thousands of samples and measurements collected as part of the monitoring program during 2010, there were no exceptions to the waste-discharge requirements specified in the NPDES permit. This level of compliance is laudable and represents the culmination of many years of hard work by dedicated and experienced MBCSD personnel. Their knowledge and experience regularly enables them to enact appropriate proactive measures that ensure the smooth operation of this facility.

Quarterly offshore water-column surveys evaluated receiving-water quality. The high-precision measurements collected during the surveys were capable of resolving minute changes in ambient water properties. These measurements detected and delineated effluent as it mixed with receiving waters upon discharge from the diffuser. Slight anomalies in water properties associated with the presence of dilute effluent were observed very close to the diffuser structure within the ZID. These highly localized anomalies were still within the limits specified in the NPDES permit, even those collected well within the ZID, where such limits do not apply. The high degree of effluent dilution observed close to a diffuser port attested to the continued effectiveness of the diffuser structure in rapidly mixing the wastewater within receiving waters.

The physics, chemistry, and biology of benthic sediments around the outfall have also been monitored for 25 years. As has been the case throughout the two and a half decades of monitoring, all measurements fully complied with requirements of the discharge permit and the objectives of the California Ocean Plan. Benthic environments are important indicators of the presence of marine pollution because they act as a major reservoir for most contaminants that enter the ocean. The lack of perceptible impacts to the benthic environment around the diffuser structure during 2010 confirmed that the treatment process effectively removed contaminants from the influent stream and that the diffuser structure efficiently diluted wastewater upon its discharge into receiving waters.

Three sediment-chemistry analyses document the absence of discharge-related benthic impacts. First, chemical concentrations measured within Estero Bay sediments during 2010, and in prior years of monitoring, were below thresholds identified as toxic to marine organisms. This includes samples collected close to the diffuser structure, as well as those collected more than 1 km away. In fact, measured concentrations were comparable to those found in benthic sediments collected throughout the region, but they were generally much less than those found within the Southern California Bight. Second, benthic samples collected during 2010 did not exhibit significant gradients of increasing contaminant concentration with increasing proximity to the outfall. Finally, there is no evidence of a buildup of

wastewater constituents near the outfall over time, based on a comparison of the long record of measurements collected near and far from the discharge.

Infauna residing within seafloor sediments also serve as indicators of marine contamination because of their limited mobility and well-defined responses to pollution. Numbers of species, abundance, biomass and other parameters describing infaunal communities can indicate the presence of contaminant-induced stresses if, for example, gradients extending from a pollutant source to distant, unaffected areas are observed. More than 236,000 infaunal organisms have been collected and examined since the beginning of the benthic monitoring program 25 years ago. Throughout the monitoring program, there has never been any indication of outfall-related impacts to benthic biota. Instead, the data have revealed a consistently healthy indigenous infaunal community, with uniformly high diversity that does not decline with proximity to the diffuser. These observations hold true despite widespread and significant temporal variation in the abundance of individual organisms. The analyses continue to demonstrate that the sediments surrounding the outfall support an extraordinarily healthy marine community dominated by suspension-feeding organisms living in clean sediments.

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1.0 INTRODUCTION

The City of Morro Bay and the Cayucos Sanitary District (MBCSD) jointly own the wastewater treatment plant operated by the City of Morro Bay. A 301(h)-modified National Pollutant Discharge Elimination System (NPDES) permit was originally issued to the MBCSD in March 1985 (Permit Number CA0047881). Region IX of the U.S. Environmental Protection Agency (USEPA) and the Central Coast California Regional Water Quality Control Board (RWQCB) jointly issued the permit. Following extensive evaluation processes, the USEPA and the RWQCB reissued the permit three times: March 1993 (RWQCB-USEPA 1993ab), December 1998 (RWQCB-USEPA 1998ab), and January 2009 (RWQCB-USEPA 2009ab). This report addresses compliance with the provisions of the most recent permit.

Marine Research Specialists began conducting the Offshore Monitoring and Reporting Program for the MBCSD in July 1993. Since then, the treatment plant staff, Marine Research Specialists, and subcontracted laboratories, which include BC Laboratories and Aquatic Testing Laboratories, have collected and analyzed samples as part of the monitoring program.

1.1 REPORT ORGANIZATION

This 2010 annual report summarizes results from the four major monitoring components that analyze the treatment plant, receiving waters, marine sediments, and benthic biota. The organization of this document is similar to that of previous annual reports for continuity with these four reporting aspects of the monitoring program. Other than this brief introductory chapter, the major sections include the following:

Chapter 2	Treatment Plant Performance
Chapter 3	Receiving Water Quality
Chapter 4	Bottom Sediments and Biota
Chapter 5	Conclusions and Recommendations

Chapter 2 details all aspects of the onshore portion of the monitoring program, including the operation and performance of the treatment plant and the disposition of biosolids during 2010. Chapter 3 documents the four offshore surveys that were conducted during 2010 to assess the quality of ocean waters where the effluent is discharged. Chapter 4 documents the analysis of sediment samples collected during an offshore survey in October 2010. It places the chemical and biological measurements in historical context by incorporating time-series analyses of the entire 25-year database. Finally, Chapter 5 reiterates the major conclusions of this report, and presents recommendations for future actions concerning the monitoring program.

In addition to these chapters, a large set of appendices provides detailed supporting documentation for the analyses in the body of this report. Appendix A lists the design specifications of the wastewater treatment plant. Appendix B details the biological analysis of the offshore sediment samples and contains information about the taxonomists who performed the species-level identification of the specimens. Appendix C contains sample descriptions, including the location, depth, and grain-size characteristics of sediment samples. Appendix D contains the annual outfall inspection report. The original benthic chemistry report and quality assessment and quality control (QA/QC) analyses performed by BC Laboratories are provided in Appendix E, which is included on the compact disk (CD) attached to the cover of this report. QA/QC procedures for the analytical laboratories are provided in Appendix F, which is also on the CD. It also contains a summary of the analytical methods used by BC Laboratories in their chemical analyses of the samples.

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CHAPTER 2

Treatment Plant Performance

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2.0 TREATMENT PLANT PERFORMANCE

During 2010, the treatment plant efficiently removed nearly all organics and other solids from the wastewater stream. Analyses of key diagnostic constituents, including suspended solids, biochemical oxygen demand (BOD), and oil and grease (O&G), demonstrated the high operational performance of the plant. Similarly, periodic analyses of effluent for trace metals, pesticides, priority pollutants, and toxicity demonstrated the benign environmental character of the effluent. A proactive operation and maintenance program ensured that there were no avoidable exceptions to the limits specified in the NPDES discharge permit during 2010. The sections below use these analyses to evaluate regulatory compliance through a comparison of measured wastewater characteristics with limits cited in the NPDES discharge permit issued to the City of Morro Bay and Cayucos Sanitary District in January 2009 (RWQCB-USEPA 2009).

Data collected during 2010 augment 24 years of prior monitoring information, chronicling the consistently high level of performance achieved by the treatment process over the last two decades. As in previous years, removal of suspended solids and oxygen-demanding materials during 2010 consistently and substantially exceeded permit-required minimum limits. In fact, the treatment plant's performance routinely approached and exceeded the requirements for full secondary treatment.

Despite processing a large volume of sewage during 2010, the plant discharged only 21% of the allowed solids, while still attaining removal rates 17% higher than the permitted minimum. Throughout the year, the treatment plant removed solids at a rate significantly exceeding the 85% requirement for full secondary treatment. Additionally, the average effluent suspended solids concentrations during 10 months of the year remained below or met the 30-mg/L criterion for full secondary treatment. The annual average effluent suspended-solids concentration (27 mg/L) was less than half of the permitted maximum (70 mg/L), and the total solids emission (42 MT¹) was only 21% of the allowed (199 MT).

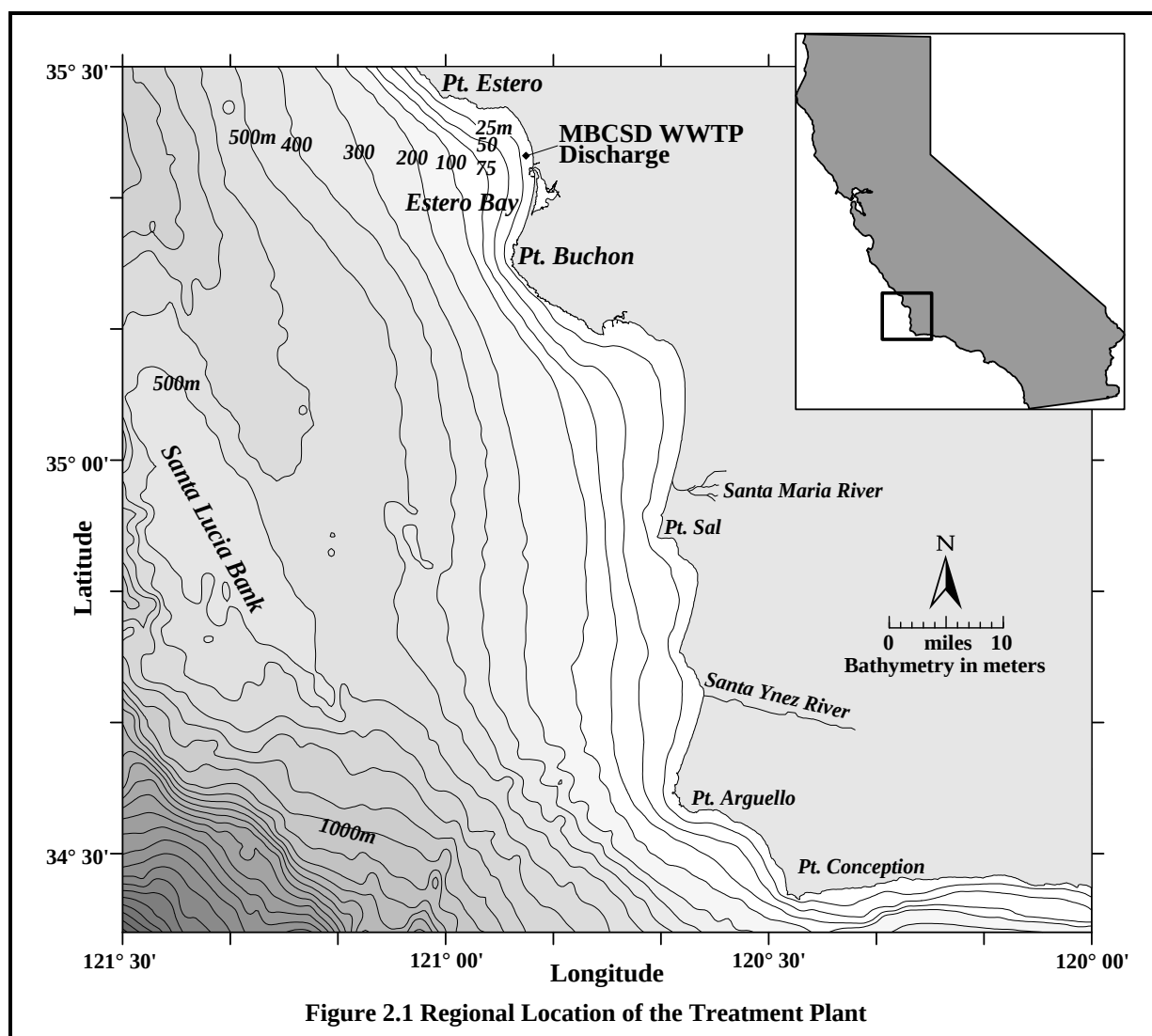
During 2010, the treatment plant also removed the vast majority (85%) of oxygen-demanding material from the influent stream. The average BOD removal rate exceeded the 85% monthly standard for full secondary treatment during 6 months of the year, while the lowest monthly removal rate of 80.0% was still two and a half times greater than the minimum permitted rate of 30%. Because oxygen depletion is of little concern in the open ocean, technology-based requirements on BOD are generally unimportant for marine discharges (National Academy of Sciences 1993), so the MBCSD discharge was effectively meeting secondary treatment requirements for all of 2010. The annual average effluent BOD concentration (49 mg/L) was well less than half of the permitted maximum (120 mg/L), and the total mass emission (85 MT) was only about one-fourth of the allowed BOD discharge (342 MT).

The general absence of industrial contaminants in the wastestream attests to the benign nature of the influent, which is almost entirely generated by nonindustrial residential sources. Chemical analyses for 78 chemical compounds quantified low-level concentrations of only six common wastewater constituents and four naturally occurring trace minerals. All measured concentrations were well below permit limitations. Chronic bioassays conducted on effluent samples that were collected during 2010 determined that discharge had a very low toxicity to marine organisms, results that were consistent with the prior 17-year record of testing.

¹ Metric tons or 1,000 Kg (1.1 short tons)

2.1 WASTEWATER TREATMENT PLANT

The Morro Bay/Cayucos Wastewater Treatment Plant (WWTP) is publicly owned and operated by the City of Morro Bay and the Cayucos Sanitary District (MBCSD). The WWTP is located in the City of Morro Bay, within San Luis Obispo County along the central coast of California (Figure 2.1). The plant serves the Morro Bay and Cayucos communities, which, according to the 2000 census, have a combined population of approximately 13,293 (10,350 in Morro Bay and 2,943 in Cayucos). The WWTP discharged, on average, 1.19 million gallons per day (MGD) during 2010. The plant was designed to accommodate an average dry-weather flow of 2.06 MGD, a peak seasonal dry-weather flow (PSDWF) of 2.36 MGD, and a peak wet-weather flow (PWWF) of 6.64 MGD. The plant's flow did not approach any of these design limits during 2010.



2.1.1 Operations

During 2010, eight trained personnel operated the WWTP (Table 2.1). Bruce Keogh served as both the Wastewater Division Manager and the Laboratory Director; Les Girvin continued to serve as WWTP Supervisor.

The WWTP personnel provided laboratory workspace to the National Estuary Program (NEP), which is dedicated to protecting and restoring the natural resources of Morro Bay and its watershed. NEP volunteers used the WWTP laboratory to analyze bacterial samples collected throughout the Morro Bay watershed.

WWTP personnel attended a number of workshops, seminars, and continuing education classes throughout 2010. Course topics included CPR and first aid, emergency operations center (EOC) operations, confined space entry and safety, lock out/tag out procedures, basic electrical safety, fire safety, environmental safety, proper volt-ohm meter usage, stormwater training and nonpoint-source pollution reduction in the workplace, first responder training for power line and gas line emergencies, CIWQS electronic reporting methods, and Grade IV & V operator certification review. Additionally, WWTP personnel attended a California Water Environment Association Tri Counties Workshop and Training Seminar and toured the following wastewater treatment plants: Ojai, South Coast Sanitation (Oceano), Santa Paula, and Mountain House.

WWTP personnel also conducted plant tours for the public, other public agencies (including the California Integrated Waste Management Board staff, the California Joint Powers Authority Insurance Agency, and Air Pollution Control District staff), equipment suppliers, and Central-Coast Regional Water Quality Control Board (RWQCB) staff.

In addition to performing the periodic effluent analyses required by the NPDES Permit, during 2010 the laboratories involved in the analyses of the MBCSD WWTP samples participated in laboratory performance evaluations intended to evaluate the accuracy of effluent measurements and assure the overall quality of the monitoring reports. The WWTP laboratory analyzes effluent parameters reported on a daily and weekly basis, including residual chlorine, suspended solids, turbidity, coliform, pH, and biochemical oxygen demand. Aquatic Testing Laboratories evaluates the toxicity of effluent to marine organisms with semiannual bioassay tests. BC Laboratories, Weck Laboratories, and Monterey Bay Analytical Services (MBAS) determine the concentrations of a wide range of chemical compounds within effluent with semiannual chemical analyses. BC Laboratories also performs the annual analysis of biosolid samples and performs the chemical analyses of benthic sediments described in Chapter 4 of this report. Each laboratory's quality assurance and control plan is included in Appendix F of this report.

Several State and Federal laboratory performance evaluations were successfully completed during 2010. The regulatory agencies found the results from all of these studies to be within acceptable ranges. These included:

- The United States Environmental Protection Agency's (USEPA) Discharge Monitoring Report-Quality Assurance Study #30 (DMR-QA-30), which assessed analytical chemistry capabilities, and
- The USEPA DMR-QA Whole Effluent Toxicity Test (WETT) determination of the accuracy of bioassay capabilities.

Table 2.1 Morro Bay/Cayucos WWTP Personnel During 2010

Name	Grade and Certification No.
Bruce Keogh	IV – 8978
Les Girvin	III – 8499
Steven Aschenbrenner	II – 7548
David Williams	II – 9601
John Gunderlock	III – 10500
Steve Sibley	I – 8005
George Helms	I – 28158
David Bierman	I – 28745

In recent years, both the City of Morro Bay and the Cayucos Sanitary District have actively sought to identify and eliminate sources of inflow (rainwater runoff) and infiltration (of groundwater), known as I&I, within their respective collection systems. Reducing the volume of groundwater infiltration entering the collection system minimizes the amount of non-wastewater throughput processed by the WWTP.

Meanwhile, at the WWTP, personnel maintain a diligent, proactive preventative maintenance program that includes major preemptive repairs of various components of the treatment process. The WWTP documented these activities during 2010 in monthly operations summaries submitted to the RWQCB (MBCSD 2010a-l). To assist WWTP staff in the operation and maintenance (O&M) of major plant components, an O&M manual, dated November 1987, was completed following the plant upgrade in 1986. The O&M manual includes standard operating procedures as well as preventative and contingency plans for controlling and minimizing the affects of accidental discharges. The manual is reviewed and updated as new major equipment is placed on-line or when procedures are updated.

Recent revisions to the O&M manual include updates to the Laboratory Quality Assurance and Quality Control Manual (April 2010) and procedures relating to the operation of the main influent sluice gate (October 2010). Updates were also made to various safety programs including the Emergency Evacuation and Fire Prevention Program (April 2010), the Electrical Lockout/Tagout Procedures (April 2010), and Confined Space Entry Procedures (June 2010).

In addition to the updates to the O&M manual in 2010, staff worked with CAL/OSHA on a review of required programs related to the specific needs of the wastewater treatment plant and a hazard survey of the job site. As a result of that program, in July 2010, CAL/OSHA presented the plant with a “Golden Gate Partnership Recognition” certificate to recognize the plant for its commitment to workplace safety and health, and its efforts in implementing and maintaining an effective Injury and Illness Prevention Program.

As part of routine maintenance procedures, SCUBA divers inspect the ocean outfall’s exterior and the diffuser structure for signs of damage annually. On 20 September 2010 the outfall was found to be in good condition, with no broken or plugged diffuser ports. The divers noted the presence of starfish, anemones, and small fish around the diffuser structure. The divers conducting the inspection removed the spar buoys and associated ground tackle for inspection and recommended that the buoys and ground tackle be replaced. New buoys and ground tackle were installed on 11 October 2010. The annual outfall inspection report is included herein as Appendix D.

Figure 2.2 is a photograph of a diffuser port taken during a previous outfall inspection. It shows a dense cover of marine epifaunal organisms thriving on the outer surface of the diffuser port. A large colony of club-tipped anemones (*Corynactis californica*), bright pinkish-red in color, covers the top surface of the port. The continued presence of these filter-feeding organisms attests to the benign nature of the effluent discharge, and to the outfall’s value as an artificial reef. Quantitative biological surveys conducted within the region found that these anemones are only occasionally observed on high-relief rock surfaces within Estero Bay, and then only in deeper water (>85 m) (Morro Group, Inc. 1999). Ostensibly, their susceptibility to elevated suspended-sediment loads explains their rarity on nearshore, lower-relief rocks. The preponderance of anemones on the diffuser confirms the minimal negative impact of the outfall’s particulate discharge on marine organisms.

Other routine maintenance and minor repairs were regularly conducted on various treatment-plant components. For example, the emergency standby generator was regularly tested under full load. Every quarter, the standby generator was inspected, and a certified contractor performed scheduled maintenance. Annual inspections were also performed on the Plant’s cathodic protection system and back-flow prevention devices.

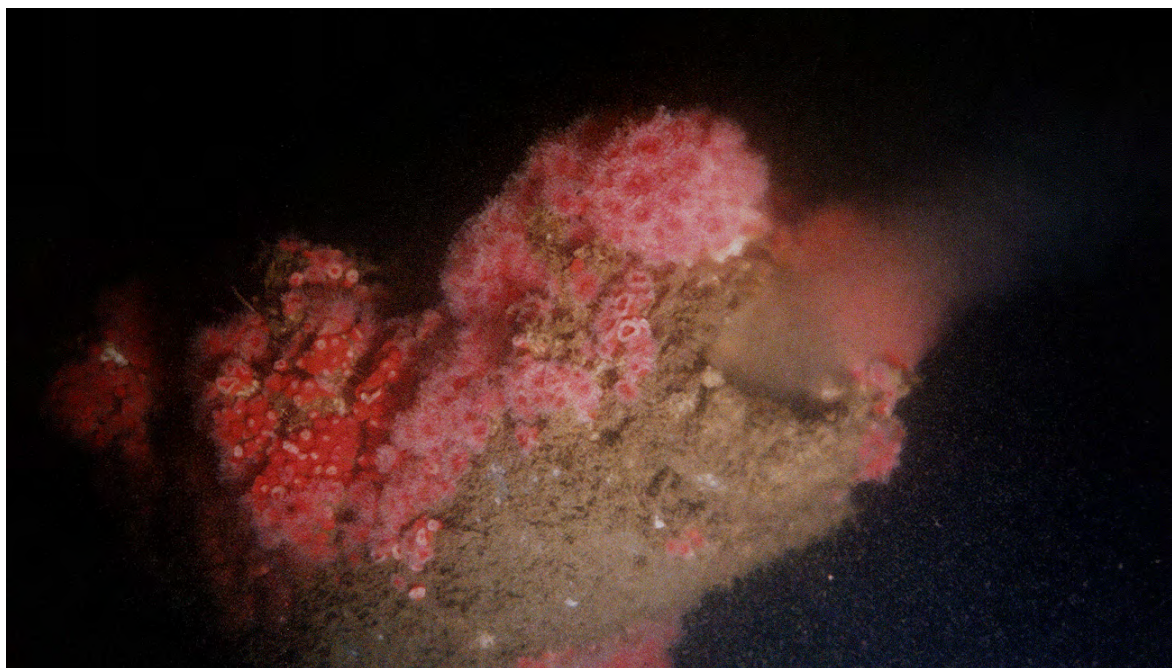


Figure 2.2 Photograph of a Diffuser Port Discharging Effluent

In addition, the WWTP staff instituted several major repairs and preventative-maintenance measures during 2010. For example, staff conducted substantial repairs to main influent pump #2 in June. The pump was taken offline on the first of June and was placed back in service on 30 June 2010. In the interim, a new epoxy coating was placed on the volute and impeller to increase pumping efficiency. In addition, the pump was rebuilt, including machining and sleeving of the bearing housing, installation of new bearings and seals, and the rewinding of the pump motor. These repairs improved the pumping efficiency and resulted in a significant reduction in pump run times over a twenty-four hour period.

The second major maintenance event took place beginning on 31 October 2010 when inconsistencies in the incoming power load from PG&E resulted in operational issues for the main influent pumps. Voltage spikes of up to 500 volts triggered an overload of the pump motor for main influent pump #3 that caused the variable frequency drive (VFD) to shut down. At the same time, influent pumps #2 and #3 were found to have unacceptable levels of vibration, and both the grinder unit on the muffin monster and the composite effluent sampler became disabled.

Staff were quickly able to get influent pumps #2 and #3 and the grinder unit back on-line, and placed a spare sampler on-line for collecting twenty-four hour composite effluent samples until repairs could be made to the primary composite sampler. Staff then proceeded to trace the source of the incident, working with various contractors and staff at PG&E through the month of November to both determine the initial cause of the incident and to implement changes that would protect plant operations in the event of a repeat occurrence. The steps they took included:

- Filing a claim with PG&E for reimbursement of costs associated with assessment and repair of equipment that was impacted by the event.
- Installing a data logger on the incoming power supply to the VFDs that control the main influent pumps. The data logger monitors both voltage and current draw, and will assist in determining if influent power to the VFDs is within the appropriate operational range.

- Installing input line reactors on all three of the VFDs used to control the main influent pumps. The line reactors are designed to protect the VFDs in the event there is a power surge.
- Switching the level control device in the main influent channel from an ultrasonic level controller to a bubbler system. The bubbler level control system provides a faster response time on the level of the influent channel thus causing the pumps to have a smoother response curve resulting in fewer starts and stops on the pump motors.
- Modifying controller programming for the VFDs in an attempt to fine tune the VFD's response to the control signal from the level controller.

In conjunction with these major maintenance efforts, WWTP staff performed the following more routine maintenance actions in 2010:

- Replaced the hose in the sample head of the 24-hour composite influent sampler and reprogrammed the 24-hour composite effluent sampler (January);
- Performed minor adjustments to the dosing pumps and calibrated the chlorine residual analyzers following triggering of the high residual chlorine alarm during several large rainfall events (January);
- Installed a reconditioned spare motor-control-center main breaker and new pressure gauges on the primary sludge pumps (February);
- Installed a new 24-hour composite sampler at the air relief structure and a new hot water recirculation pump and motor on the outside hot water loop for Digester #3 (February);
- Performed a confined-space entry to replace the 1-inch drain valve on the expansion tank located in the gas vault next to digester #1 (March);
- Replaced the cutter cartridge assembly on the muffin monster in the influent channel and installed new vacuum and pressure relief valves on all three digesters (April);
- Replaced the drive belt and the adjuster plate for the motor on digester sludge circulation pump #3 as well as the tubing on sodium hypochlorite dosing pumps #1 and #3 (April);
- Installed a rebuilt American Sigma SD 900 composite sampler at the headworks used to collect twenty-four-hour-composite influent samples (May);
- Installed a new three-inch digester-gas feed line from the drain vault outside the maintenance shop to the boilers (June);
- Performed major repairs to the two grit bins used to collect grit prior to hauling grit to the landfill. Staff removed badly corroded sections of the bins and welded on replacement plates and gussets (June);
- Installed new three-inch piping for the air manifold supplying air to the diffusers in the grit aeration basin, and replaced the air manifolds in both the east and west chambers. The existing piping had been cracked and filled with grit (June-July);
- Adjusted the impeller clearance on main influent pump #2 in response to excess vibration (July);
- Installed a new section of digester gas piping on digester #2 to replace a section that was severely corroded (August);
- Replaced the sodium bisulfite storage tank, and mounted and installed earthquake hold-downs for the sodium hypochlorite storage tank (August);
- Rebuilt sludge pump #2 following discovery of a two-inch tear in the diaphragm of the pump. The rebuild included replacement of the o-rings on the shaft, new face gaskets, new balls and seats, and new diaphragms (September);

- Replaced the supply piping to the chemical dosing pump used to transfer ferrous chloride to the headworks (September);
- Installed a new motor on biofilter pump M4502 and new biofilter distributor arms on biofilter #1 (October);
- Performed repairs to the discharge piping for the grit pumps located at the aerated grit chamber and installed earthquake straps on the ferrous chloride and sodium bisulfite chemical storage tanks (October);
- Installed a new motor, motor stand, sheaves, and belts on the digester sludge recirculation pump for digester #3 (October);
- Drained primary clarifier #2 for inspection and maintenance. While the clarifier was drained and off-line, plant staff inspected the tanks and the components in the clarifiers, removing approximately two cubic yards of rags from the clarifier (November);
- Installed a new compressor head on air compressor #2 and replaced a burned wire in the local remote switch on primary collector drive #1 (November);
- Installed new contactors and switches in the Muffin Monster Control Box, replaced a faulty motor on the bar screen located at the influent channel and inspected and performed maintenance on the backflow preventers throughout the plant (December); and
- Drained primary clarifier #2 for the purpose of facilitating a video-inspection of the first 350 feet of the outfall beginning at the air relief structure. While the clarifier was drained and off-line, plant staff also inspected the tanks and the components in the clarifiers; no problems were noted (December).

2.1.2 Plant History

The original WWTP, built in 1954, had a nominal capacity of 0.7 MGD and a 1-MGD maximum throughput. The original plant included a headworks structure, primary and secondary clarifiers, a biofilter, a single-stage digester, chlorination facilities, biosolids drying beds, and a short ocean outfall.

In 1964 the plant upgraded to a nominal capacity of 1 MGD and a 1.3-MGD maximum throughput to meet the demands of the growing coastal community. This upgrade added a pump station, a splitter box, a primary clarifier, a secondary clarifier, a biofilter, chlorination facilities, biosolids beds, and another primary digester, which allowed conversion of the existing digester to a secondary capacity. A new office and laboratory were also constructed during this upgrade.

During the 1970s, the City of Morro Bay developed a plan for additional upgrades to the WWTP facilities intended to further augment the plant's capacity. In 1980, the City began designing these planned improvements, including construction of a new outfall to better protect the marine environment, and a facilities upgrade providing full secondary treatment.

Following a yearlong study of oceanographic conditions within Estero Bay, design of the new outfall was completed in April 1981. The new outfall and diffuser system extended the discharge from the surfzone to a point far off shore. The deeper discharge increased dilution of wastewater within the open-ocean environment. The new outfall was completed and placed in service in June 1982.

The design of the facility improvements, completed in September 1981, called for a final effluent suspended-solids concentration of 30 mg/L and an equivalent limit on BOD. However, aid from state or federal agencies to finance the construction to meet these full-secondary treatment levels was not available. Since discharge through the new outfall was not causing any apparent adverse environmental impact and the projected future throughput was low, the State determined that additional financial aid for upgrading the MBCSD WWTP to full secondary was not warranted. Instead, the City modified the design

to provide secondary treatment to a majority (1 MGD) of the projected flow to comply with the state water-quality standards, set forth in the California Ocean Plan (COP) (SWRCB 1990). State officials agreed with this level of treatment, provided that the USEPA approved a 301(h)-modified NPDES discharge permit that adjusted secondary-treatment requirements on suspended-solid and BOD emissions.

In a 16 March 1983 letter, the staff of the RWQCB determined that the proposed discharge would comply with applicable state laws, including water-quality standards, and would not require additional treatment, pollution control, or other requirements on any other point or nonpoint source. This tentative determination was pursuant to Title 40 of the Code of Federal Regulations, Section 125.60(b)(2) [40 CFR 125.60(b)(2)] (USGPO 1982a) and 40 CFR 125.63(b) of the 301(h) regulations dated November 1982 (USGPO 1982b).

The treatment-plant upgrades between 1983 and 1985 increased the plant capacity to a 2.06-MGD average dry-weather flow and a peak flow of 6.6 MGD. The plant now includes primary treatment of all influent by screening, grit removal, and primary sedimentation. Depending on the hydraulic conditions within the plant, most of the flow (up to 1 MGD) can be diverted through a secondary treatment process of trickling filters, clarifiers, and a solids contact chamber. Although most wastewater receives secondary treatment, blending of primary- and secondary-treated wastewater is occasionally necessary during periods of particularly high flow, such as during severe rainstorms. During 2010, more than 27 inches of rain fell at the treatment plant. This amount is more than double the annual average (13 inches) measured at the plant over the last decade and greatly influenced flow rates through the plant. Nevertheless, the blending valve was open only about 10% of the time.

The secondary-treatment process utilizes two trickling filters, an aerated solids contact channel, and a secondary sedimentation tank. The original 1954 sedimentation tank was converted into a chlorination system where the primary and secondary effluents are mixed and disinfected prior to dechlorination and discharge through the ocean outfall.

On 29 March 1985, an NPDES permit based on the previously approved Section-301(h) modification established water-quality standards for the MBCSD WWTP. The permit required the treatment plant achieve a suspended solids content of no more than 70 mg/L (75% removal) and a maximum BOD of 120 mg/L (30% removal). The permit also required an extensive monitoring program to assure maintenance of environmental quality. The permit was valid for five years and expired on 8 March 1990. After an evaluation process, the permit was reissued in December 1992. During this period, improvements to the treatment facilities included the installation of a sludge removal system in the mixing chamber of the chlorine contact tank.

The MBCSD again applied for renewal of the permit in May 1997, supporting its application with an extensive technical review of more than ten years of monitoring data (MRS 1997a). An administrative extension until 11 December 1998 allowed regulatory agencies additional time to review and issue the new permit (RWQCB 1998). In July 1998, RWQCB staff determined that the discharge described in the MBCSD application “*would comply with applicable state laws, including water quality standards, and would not result in additional treatment, pollution control, or other requirements on any other point or nonpoint source.*” This permit was finalized and issued by USEPA on 26 January 1999, with an effective date of 1 March 1999.

Based on discussions between RWQCB, USEPA, and MBCSD staff and their consultants, the following revisions were also implemented in the 1999 permit:

- A 12.7% reduction in the allowed mass emission of suspended solids, BOD, and O&G;
- More extensive reporting requirements for biosolids;

- Elimination of shellfish monitoring;
- A revised benthic sampling pattern eliminating seasonal sampling and increasing the number of stations close to the diffuser structure;
- A revised receiving-water sampling program eliminating bottle casts and doubling the number of CTD casts close to the diffuser structure; and
- Specification of mass emission goals for toxic chemicals.

Based on the historical absence of perceptible impacts and continued projected high effluent quality, on 3 July 2003, the MBCSD again applied for a renewal of the discharge permit (MBCSD 2003). As with the previous permits, the application requested a continued discharge under the 301(h) provision with minor modifications of BOD and suspended solids requirements. On 4 February 2004, the RWQCB (2004) administratively extended the existing permit to allow time for further review. On 10 September 2005, the USEPA Region IX (2005) issued a tentative decision concurring with the issuance of a permit to the MBCSD in accordance with Section 301(h) of the Clean Water Act. On 6 April 2006, the USEPA and RWQCB staff issued a joint notice for a proposed action to reissue the 301(h) modified NPDES discharge permit to the MBCSD. However, on 11 May 2006, the RWQCB and the USEPA conducted a joint public hearing on reissuing the MBCSD permit wherein the RWQCB voted to continue the hearing pursuant to the issuance of a biological evaluation by the USEPA (2007).

In 2008, the USEPA issued an Endangered Species Act (ESA) biological evaluation of continued discharge under a 301(h) modified discharge permit wherein they determined:

that the continued wastewater discharge from the Morro Bay/Cayucos facility is not likely to adversely affect the brown pelican or southern sea otter, both of which occur in the vicinity of the subject discharge. EPA finds that any potential direct or indirect effects of the continued wastewater discharge would be insignificant to the brown pelican and southern sea otter.

Pursuant to Section 7 of the ESA, the proposed action of the USEPA required consultation with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS), which protect federally listed endangered species and designate critical habitat that may be affected by the proposed action. On 21 December 2007, the USFWS concurred with the USEPA “*determination that the proposed project is not likely to adversely affect the brown pelican or southern sea otter.*”

Nevertheless, the USEPA incorporated three conservation measures into the new NPDES discharge permit to address concerns about potential contributions to otter morbidity by cat litter and domoic acid poisoning. First, the MBCSD would implement a public outreach program to minimize the input of cat litter-box waste into the municipal sewer system. Second, the MBCSD would regularly monitor nutrient loading from the WWTP. Third, the facility would upgrade to at least full secondary treatment levels by 2014.

Based on the foregoing findings and the incorporated conservation measures, the RWQCB unanimously adopted the new discharge permit on 4 December 2008. Subsequently, on 9 January 2009, the California Coastal Commission unanimously determined that the new discharge permit complied with the California Coastal Zone Management Act. On 14 January 2009, the USEPA issued the new NPDES permit, effective 1 March 2009. In addition to the conservation measures noted above, the following revisions were also implemented in the 2009 permit:

- Elimination of acute toxicity testing;
- Implementation of triggered shoreline coliform monitoring;

- Revision of benthic sampling pattern eliminating cross-shore stations and shifting from grab- to composite-sediment chemistry samples;
- Revision of receiving-water sampling program reducing the number of vertical CTD casts, and implementing a tow-survey component; and

Although the current NPDES permit was not finalized until January 2009, the MBCSD had actually begun to implement several of the proposed conservation measures years before. For example, in April 2006, the MBCSD, working to address the concerns of the USEPA and RWQCB, adopted an eight-year time schedule to rehabilitate and upgrade the treatment plant to tertiary treatment, including onsite composting, as the preferred alternative for upgrading the WWTP by 2014. The MBCSD subsequently adopted a draft facilities master plan that outlined the facilities necessary for a tertiary treatment capacity of 1.5 MGD in September 2007. Meanwhile, in August 2007, the City of Morro Bay and CSD individually adopted revenue programs that identified the sewer-rate fees required for each community to finance the proposed plant upgrade and to provide revenue for needed sewer-system capital improvement projects. In July 2008, the City of Morro Bay implemented new residential and commercial water-use rates that increased the existing fees by 50%. Subsequent annual increases of 5% for residents and 7.25% for non-residents and commercial businesses will continue through 2014.

During 2009, following completion of a flood hazard analysis, the City and District voted to relocate the treatment plant site to an elevated area adjacent to the existing treatment plant. In October 2009, the MBCSD public noticed an RFP for Engineering Design Services for the upgrade, and the City of Morro Bay released a Revised Notice of Preparation (NOP) for the project, reflecting changes to the project description involving construction of treatment-plant components in the new location, and the demolition of the existing plant after the relocated treatment-plant components were constructed and brought on-line. Based on the proposals received, the City and District awarded a contract to Montgomery, Watson, Harza (MWH) at the February 2010 JPA meeting. The design process was expected to take fifteen months.

Throughout 2010, the City of Morro Bay and District staff continued work with both MWH on the design process for the plant upgrade, and with staff from Environmental Science Associates on the environmental review process for the proposed upgrade. As part of these efforts, treatment plant staff conducted an influent sampling program designed to verify influent loading parameters to the plant during high loading periods. The sampling program was conducted on a weekly basis from Memorial Day weekend through the Labor Day weekend.

In June 2010, the City and District also voted to consider a separate proposal from PERC Water Corporation to design, build, operate and finance an alternative treatment plant project. A Construction Design Report (CDR) from PERC Water Corporation containing design criteria and project costs for alternative treatment technologies, and project delivery methods for the proposed plant upgrade, was to be delivered in September 2010. After the receipt of a complete CDR, an objective third party would perform a peer review of the current project being designed by MWH and the proposed PERC Water project. However, the CDR that PERC Water presented to City and District staff in September 2010 was found to be incomplete. Although PERC staff initially stated they would provide the missing construction and project cost estimates at the following JPA meeting, PERC Water withdrew from the process in early October, notifying the City and District that they would no longer continue their efforts on the wastewater upgrade project.

Meanwhile, in September 2010, a draft Environmental Impact Report (dEIR) for the upgrade project was released for review and public comment. A series of public meetings were held on 4, 14, and 28 October to receive public comments regarding the scope, content, and analysis provided in the dEIR. The

comment period for this document closed in November 2010, and the final EIR was released in December 2010.

On 11 January 2011 the Morro Bay City Council certified the EIR and approved the Conditional Use Permit and Coastal Development Permit (CDP) for the upgrade project. The decision to issue the CDP was subsequently appealed to the California Coastal Commission, and the design process is currently on hold pending resolution of the Commission's process in regard to this matter.

2.1.3 Regulatory Setting

The 1972 Federal Clean Water Act and its 1977 amendments established national water-quality goals and created a national permit system (NPDES) of minimum standards for the quality of discharged waters (USGPO 1997a). Pursuant to the new system, states established standards specific to water bodies and designated the types of pollutants to be regulated. Since 1973, the California State Water Resources Control Board and its nine Regional Water Quality Control Boards have been delegated the responsibility for administering permitted discharges into the coastal marine waters of California. The State Board prepares and adopts the COP, which incorporates the state water-quality standards that apply to all NPDES permits. The RWQCB established a Water Quality Control Plan for the basin containing San Luis Obispo County waters (RWQCB 1994). The basin standards incorporate the applicable portions of the COP and specifically address the beneficial uses of marine waters adjacent to the outfall site. Water-quality objectives and toxic material limitations in the basin plan are designed to protect the beneficial uses of ocean waters within specific coastal areas. The basin plan identifies the following existing beneficial uses for the waters of Estero Bay:

- **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, and fishing.
- **Noncontact 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, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, and aesthetic enjoyment in conjunction with the above activities.
- **Industrial Service Supply (IND).** Uses of water for industrial activities that do not depend primarily on water quality, including, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.
- **Navigation (NAV).** Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels. The RWQCB interprets NAV as being present within any natural body of water that has sufficient capacity to float watercraft for the purposes of commerce, trade, transportation, and pleasure.
- **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 such as marine mammals and shorebirds.

- **Shellfish Harvesting (SHELL).** Uses of water that support habitats suitable for the collection of filter-feeding shellfish such as clams, oysters, and mussels, for human consumption, commercial, or sport purposes. This includes waters that have in the past, or may in the future, contain significant shellfisheries.
- **Ocean Commercial and Sport Fishing (COMM).** Uses of water for commercial or recreational collection of fish, shellfish, or other organisms, including uses involving organisms intended for human consumption or bait purposes.
- **Preservation of 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.
- **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.

Section 301(b) of the Clean Water Act requires publicly owned treatment works to meet effluent limitations based on secondary treatment, which is defined in terms of limits on three technology-based effluent parameters (40 CFR 133; USGPO 1997a). These limitations are:

- Total suspended solids (TSS) concentrations not exceeding 30 mg/L as a 30-day average and removal rates not less than 85%;
- BOD concentrations not exceeding 30 mg/L as a 30-day average and removal rates not less than 85%; and
- Hydrogen-ion concentration (pH) between 6.0 and 9.0.

Section 301(h) of the Act allows an NPDES permit to modify some or all of these full secondary treatment requirements, if certain conditions are met. The MBCSD WWTP is a combined primary and secondary treatment facility that has operated under a Section 301(h)-modified NPDES permit (number CA0047881) since March 1985. The modifications in this NPDES permit apply only to the TSS and BOD requirements, so all other NPDES limitations apply without exception, including those for wastewater pH and toxic compounds. The modification was issued only after the MBCSD satisfied the following additional conditions.

- Demonstrate the existence of a water-quality standard specific to the pollutant for which the modification is requested (40 CFR 125.61; USGPO 1997a). The COP specifies limits on TSS and DO depression (SWRCB 2005). In January 1999, the California Coastal Commission determined that the discharge complies with the State Coastal Zone Program that incorporates COP standards.
- Demonstrate that the discharge does not adversely impact public water supplies or interfere with the protection and propagation of balanced, indigenous biological populations (40 CFR 125.62). The USFWS (1998 2007) and the NMFS (1998 2004) determined that the discharge will not adversely impact threatened or endangered species, or critical habitats, pursuant to the ESA.

- Conduct a monitoring and reporting program capable of evaluating the effects of the discharge (40 CFR 125.63). The monitoring program described in this report satisfies this requirement.
- Demonstrate that the discharge will not result in any additional treatment requirements on any other point or nonpoint source (40 CFR 125.64). The footprint of the MBCSD discharge does not overlap other discharges.
- Determine whether the WWTP is subject to pretreatment requirements. Since there are no known sources of toxic pollutants or pesticides in the influent, the WWTP is exempt from general pretreatment requirements in lieu of a pollution prevention program. And since the discharge is considered small, it is also exempt from the urban pretreatment requirement (40 CFR 125.65).
- Demonstrate whether the pollution-prevention program meets the requirement for a nonindustrial source control program (40 CFR 125.66). The MBCSD pollution prevention program implements public education and source reduction programs to limit the entrance of toxic pollutants or pesticides into the treatment plant.
- Demonstrate that there will be no new, substantially increased discharges of BOD and TSS beyond those specified in the permit (40 CFR 125.67). The historically high performance of the plant process and the limited projected growth in population and industry within the service area, and the analyses provided in this report demonstrate this.
- Ensure that the WWTP exceeds the minimum requirements for primary treatment (40 CFR 125.60). The WWTP performs “*treatment by screening, sedimentation, and skimming adequate to remove at least 30 percent of the biochemical oxygen demanding material and of the suspended solids in the treatment works influent, and disinfection, where appropriate*” (40 CFR 125.58(r); USGPO 1997a).

The MBCSD WWTP is categorized as a Class III wastewater treatment facility by the Office of Operator Certification within the California State Water Resources Control Board. The Board reclassified the facility in 2001 from a Class-IV facility based on the advanced treatment process and low volume of flow through the plant. A typical Class-IV facility treats more than 20 MGD in the primary process, while the MBCSD plant processes a total flow of approximately 1.1 MGD with partial-secondary treatment. The change in classification acknowledges the exceptionally small volume of flow handled by the plant and reduces the operator grades required by personnel running the plant.

2.1.4 Description of the Treatment and Outfall System

The WWTP operating characteristics are listed in Appendix A. All wastewater is treated through a primary treatment process, which includes screening, grit removal, and primary sedimentation, as shown in Figure 2.3. Typically, the vast majority of the flow (often more than 1 MGD) is diverted for an additional secondary treatment process using biofilters, a solids-contact chamber, and a secondary clarifier. The secondary process consists of parallel single-stage, high-rate, trickling filters whose combined outflow goes to a solids contact channel and then to a secondary sedimentation tank. When flows exceed 1 MGD, secondary-treated effluent can be subsequently blended with primary-treated effluent, before the entire blend is chlorinated for disinfection and then dechlorinated. The disinfected and dechlorinated effluent is discharged into Estero Bay through a 4400-ft (1341-m) outfall terminating in a multi-port diffuser system. Waste biosolids are anaerobically digested, dried, composted and used as soil conditioner and fertilizer. A schematic of the biosolid process is shown in Figure 2.15 on Page 2-36.

The location of the Morro Bay-Cayucos WWTP and outfall within Estero Bay is shown in Figure 2.4. The discharge is released into unstressed, open-ocean waters at 35°23'11"N latitude and 120°52'29"W longitude. Treated effluent flows through a 27-in (0.69-m) diameter outfall that extends approximately 4,400 ft (1,341 m) in a northwesterly direction. The outfall terminates in a multi-port diffuser approximately 2,700 ft (827 m) from shore. The 170-ft (51.8 m) long diffuser lies in 50 ft (15.2 m) of water, referenced to mean lower low water. Twenty-eight of the 34 available diffuser ports are currently open. The remaining six ports can be made operational if the sustained discharge exceeds 6.60 MGD.

Because of its location, the MBCSD discharge does not interfere with maintenance of water quality and designated beneficial uses within Estero Bay (listed in Section 2.1.3 on Page 2-11). The discharge occurs in well-flushed, open coastal waters where re-entrainment or accumulation of effluent will not violate applicable water-quality standards, even if combined with pollutants from other sources. Intakes and outfalls from other publicly owned treatment works are distant from the MBCSD outfall. For example, water intake for the desalinization plant is from saltwater wells and not from the ocean environment where the MBCSD discharges. Similarly, surface discharge of water from the Dynegy plant, when it does occur, is far south of the MBCSD discharge point and does not add chemical loads to the ocean environment.

2.1.5 Pollution Prevention Program

The MBCSD continued to advance its Pollution Prevention Program along several fronts during 2010. The program's purpose is to minimize the introduction of pollutants and pesticides into the treatment process. The NPDES permit requires an annual status report detailing efforts to comply with the requirements for a Pollution Prevention Program. This section serves as that report. Additionally, the current permit includes a specific requirement to document educational and outreach efforts regarding proper cat waste disposal.

As in previous years, three aspects of pollution prevention were emphasized during 2010: public outreach, industrial waste source control and identification, and diligent monitoring of influent and effluent for industrial contaminants.

Industrial Waste Survey

The local economy within the MBCSD service area relies on tourism and commercial fishing, with no heavy industry or manufacturing of any environmental significance. Accordingly, slightly more than 50 restaurants are found in the service area during any given year.

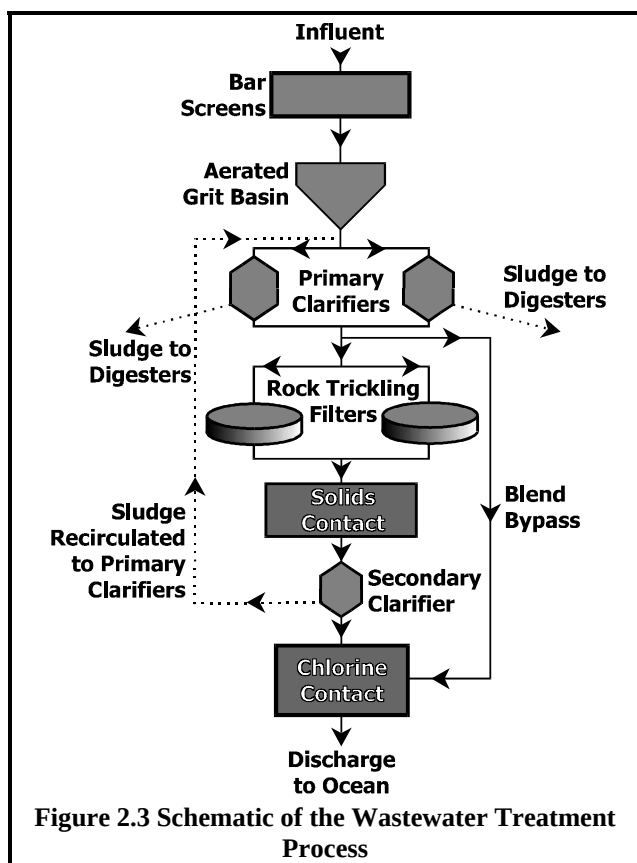


Figure 2.3 Schematic of the Wastewater Treatment Process

Comprehensive monitoring for more than 25 years indicates that effluent discharged from the treatment plant consists primarily of benign constituents. Industrial waste surveys conducted during 2010 and prior years support these findings; they quantify a comparatively low volume of influent from light industrial sources containing nontoxic constituents typical of wastewater from domestic sources. During 2010, the absence of significantly elevated levels of industrial pollutants within the wastewater stream confirmed the continuous lack of substantive industrial input.

The industrial-waste survey activities rely heavily on a digital database originally developed by MBCSD plant staff in 1999. The database includes business names, addresses, contacts, telephone numbers, inventories of chemicals, discharge volumes, and other pertinent information for all potential industrial users in the service area. As businesses turnover, the database is updated with new information. Using this database expedites quantitative assessments of industrial usage and annual updates of contact information.



The master list of businesses in the database is adapted from business license applications filed with the City of Morro Bay and input provided by the CSD. The master list is subdivided into businesses with no potential for industrial discharges, such as offices and retail stores, and those with the potential for industrial waste discharge. All businesses with potential industrial discharges are either interviewed in person or asked to complete a Commercial User Questionnaire.

Based on the detailed information provided in the questionnaire, some businesses are excluded from classification as industrial dischargers because they either do not generate wastewater at all, or they discharge only domestic wastewater. These businesses included theaters, beauty shops, barbershops, and various retail firms. For the remaining industries, waste discharge volumes are estimated proportionate to water usage history from City Water Department billing records. Follow-up activities for these businesses include scheduled return visits, surprise onsite inspections, and formal tours of the facilities. Based on this phase of the survey, certain industrial dischargers are identified for continued close monitoring with scheduled, annual future site visits. These include commercial laundries, car washes, dry cleaners, print shops, and the oil-water separator maintained by the City of Morro Bay. A series of businesses were also targeted with unannounced inspections in 2010.

Overall water use within the communities has changed little between 1999 and 2010. Although domestic sources contributed the majority of the wastewater processed by the plant in 2010, commercial businesses and government agencies contributed approximately 0.31 MGD, or about 26% of the influent. However, a substantial portion of the water use attributed to the City of Morro Bay, Morro Bay High School, the San Luis Coastal School District (Del Mar Elementary School), and the State Department of Parks (Morro Bay State Park) is utilized for the irrigation of landscaping, sports fields and agricultural uses, and would not be expected to flow into the collection system. Additionally, the compounds added to the wastestream by the large commercial and government users are not particularly toxic to humans or aquatic organisms, and do not generally interfere with the treatment process.

Mission Linen is the most industrial of the large dischargers in the service district. This commercial laundry uses several industrial-grade detergents, bleaches, surfactants, and brighteners that can potentially harm the bacteria within the secondary treatment system. In addition, solvents, oils, and other substances removed from soiled laundry have the potential to release contaminants into the wastestream. Although Mission Linen's discharge constitutes only a small percentage (1.1%, or 0.013 MGD in 2010) of the wastewater processed by the treatment plant, MBCSD staff actively work with this discharger to minimize potential risks from their wastestream. For example, in 2002 Mission Linen installed a pretreatment system that includes pH buffering with phosphoric acid to neutralize excessive increases in wastewater alkalinity that can potentially interfere with the plant's treatment process.

Other light industrial users with smaller discharges include car washes. Car wash discharge is considered industrial in nature because of the volume of solids, oils, and greases washed from vehicles. As mitigation, the car washes pretreat their wastewater with grease separators before discharging it into the collection system. The sewer-use ordinance of the City of Morro Bay municipal code prohibits smaller contributors, like gas stations and repair garages, from disposing known contaminants into the collection system. Similarly, the municipal code requires restaurants and self-service car washes to install and maintain grease traps within sewer line connections.

In addition to chemicals from the industrial sources that contributed to the influent, the WWTP intentionally introduces three chemicals, ferrous chloride, sodium hypochlorite, and sodium bisulfate into the treatment process. Ferrous chloride is used primarily to control odor in the collection system, although it also reduces hydrogen sulfide emissions during flaring of digester gas and heating of the digesters at the WWTP, as required by the Air Pollution Control Board. Wastewater facilities commonly disinfect effluent prior to discharge with some form of chlorine; the WWTP uses sodium hypochlorite. Because residual chlorine can react with organic matter in the wastewater, and even low concentrations of residual chlorine can be hazardous to aquatic life, the MBCSD treatment plant utilizes sodium bisulfite to remove excess free and combined chlorine ions once disinfection is complete.

Not surprisingly, the sodium bisulfate added to the MBCSD treatment process for dechlorination generally tracks the monthly sodium hypochlorite dose used by the plant. For example, both hypochlorite (2,657 gallons) and bisulfate (1,846 gallons) usage were lowest during the month of October. In contrast, the highest monthly dosage of hypochlorite occurred during July 2010 when organic loading and bacterial densities within the wastestream were largest. During that time, the monthly hypochlorite (3,975 gallons) dosage increased by nearly 50%.

Public Outreach

The MBCSD's public outreach program seeks to educate consumers and local business about the organization and operation of the treatment plant, best management practices for the proper disposal techniques for a variety of household wastes, including pharmaceuticals, fats, oils, and grease.

Additionally, the program strives to keep consumers up to date on current topics of interest, including *T. gondii* and cat litter disposal, and the pending treatment plant upgrade.

The MBCSD reaches out to the public through online and written literature, direct communication through presentations, talks, and tours, and resource availability, such as implementation and oversight of the on-site household hazardous-waste disposal facility and onsite biosolids composting program. For example, the City's website includes a series of pages devoted to an overview of the wastewater treatment plant and the collection system operations. The pages contain links to pertinent information on: collection system dos and don'ts, the availability of composted biosolids as a soil amendment, the household hazardous waste facility, and the ongoing treatment plant upgrade. Also available are searchable copies of all of the treatment plant's self-monitoring reports from 2005 onward, as well as a copy of the current NPDES permit.

The website also provides information on specific disposal concerns, like the appropriate disposal methods for pharmaceuticals and personal care products, biomedical wastes, oils and grease, explosives, and pet wastes, as well as links to the USEPA website and other outside sources of information on these and other relevant topics. Pursuant to the conservation measures recommended by the USEPA (2007) in the biological evaluation they conducted in preparation for issuance of the current NPDES discharge permit, the City's website incorporates updated information on best management practices for cat litter disposal to avoid introduction of cat litter into the collection system. During the permit renewal process, USEPA staff had postulated that minimizing the input of cat litter-box waste into the municipal sewer system would help reduce the introduction of the parasite *T. gondii* into the marine environment, thereby mitigating a known disease vector affecting southern sea otters. RWQCB staff incorporated the USEPA's concerns into a special provision within the plant's final NPDES permit requiring the creation of a cat litter public outreach program.

Shortly following the finalization of the permit, on 21 January 2009 however, Johnson et al. (2009) published the results of a detailed field study of southern sea otter exposure to *Toxoplasma gondii* which essentially refuted the claims that the MBCSD discharge was responsible for observed impacts on otter morbidity from *Toxoplasma gondii* infection through the incidental disposal of cat litter to the collection system. The authors of the 2009 study not only confirmed that the epicenter of *T. gondii* exposure in otters was not located within Estero Bay as erroneously asserted by NRDC (2006), but also hypothesized that, based in part on the new epicenter location, instead of housecats "*a more important source of infection might be bobcats and mountain lions.*" In fact, the world's largest reported outbreak of human toxoplasmosis was linked to a municipal drinking-water reservoir in British Columbia that had been contaminated by cougar feces (Bowie et al. 1997; Aramini et al. 1998).

Nevertheless, during 2010, MBCSD staff continued existing public outreach and education efforts on the proper disposal of cat litter. The MBCSD cat litter outreach program incorporated the distribution of newsletters to water users in both April and September 2010, circulation of "flush the mush" postcards in June 2010, presentations at various realtor groups, presentations at televised City Council and JPA board meetings, and discussions of best management practices during numerous tours at the treatment plant. In addition, MBCSD continued to provide "*don't flush the mush*" posters to interested parties, including the Central Coast Partners for Water Quality, an inter-agency coalition that **works together to prevent storm water pollution in San Luis Obispo County** and provides storm water public education and outreach.

MBCSD does not anticipate any changes to the cat litter public outreach program in the coming year. They will continue to use "*don't flush the mush*" mailers, newsletters, public outreach presentations, and plant tours to communicate with the general public on the topic of cat litter and waste disposal. In

addition, MBCSD staff will continue to make periodic visits to specific commercial and professional establishments to encourage them to establish and implement appropriate policies and procedures to properly dispose of cat waste.

Among its other public outreach endeavors, in August 2000 the MBCSD partnered with the Integrated Waste Management Authority to establish a permanent household hazardous-waste collection facility at the treatment plant. The WWTP offers free waste disposal to all residents of San Luis Obispo County every Saturday from 11:00 AM to 3:00 PM, except holiday weekends.

Over the last decade, this household hazardous-waste disposal facility has been one of the top sites in the county in terms of the volume of material collected. On average, between 20 and 50 individuals dispose of household hazardous waste at the facility each weekend. Between July 2009 and June 2010, the WWTP disposal facility processed more than 125 tons (249,472 pounds) of household hazardous waste; a large portion of that waste was recycled. Just under half (124,600 pounds) of the collected material, by weight, was comprised of electronic wastes (e-waste), including video display devices such as television and computer monitors, which the facility started accepting in 2004. Cathode ray tubes (CRT), the picture tubes used in many older computer monitors and television screens, contain large quantities of five known toxic chemicals: cadmium, mercury, chromium, lead, and phosphorous. In fact, the USEPA estimates that discarded CRTs contribute at least 40% of the known lead in U.S. landfills. Flat panel monitors, cell phones, digital cameras, and computer hardware also contain hazardous wastes.

Additional materials collected at the facility during 2010 included more than 41,100 pounds of oil-based paint; 32,750 pounds of latex paint; 5,100 pounds of flammable liquids and solids; 2,300 pounds of aerosol containers; 5,500 pounds of antifreeze; 5,135 pounds of car batteries; 4,975 pounds of motor oil products; 4,200 pounds of poisons; 1,000 pounds of acids and bases; 6,075 pounds of light bulbs and lamps, 5,530 pounds of rechargeable and other batteries, and 6,500 pounds of compressed gas cylinders. Without the permanent hazardous waste facility, much of this material would have gone to a landfill or would have passed through the treatment plant.

During 2010, the MBCSD broadened their partnership with the Integrated Waste Management Authority and local law enforcement agencies by participating in the development and implementation of Operation Medicine Cabinet, a county-wide pharmaceutical take-back program. This program allows the public to drop off unused pharmaceuticals and medications in a secure drop boxes located at ten different police and Sheriff Stations throughout the county, including one in the lobby of the Morro Bay Police Station. The program officially kicked off on 25 September 2010 in conjunction with the federal Drug Enforcement Agency's national "One Day Take Back" program. During the inaugural one-day event, approximately 20 pounds of unwanted or expired medications were collected from Morro Bay. Under Operation Medicine Cabinet, however, the public will continue to be able to drop off unwanted medications 24 hours a day, seven days a week. As of February 2011, over 130 pounds of unused medications have been collected at the Morro Bay drop box. Encouraging awareness and utilization of the drop box rather than storing unwanted and unused prescription and over-the-counter medicines or disposing of them in the garbage or down the drain not only prevents abuse of these compounds, but also keeps them from winding up in landfills or being passed through the treatment plant and discharged into the ocean.

Source Identification

Although measures have been implemented to reduce the introduction of incompatible contaminants into the wastestream, elevated contaminant concentrations have been found in the periodic chemical analysis of effluent on rare occasions. When this occurs, MBCSD personnel trace the contaminants to the source

and work with the source owner to eliminate the contamination. However, in 2006 the State Water Resources Control Board adopted new statewide waste discharge requirements for sanitary sewer systems. These new requirements transferred responsibility for managing the introduction of fats, oils, grease, and other components from the WWTP to the Collections Department under the City of Morro Bay's Sewage System Management Plan². Although no unusual contaminants were detected within the wastestream during 2010, WWTP personnel identified and tracked occasional excursions of influent properties with the established source-detection program.

Ongoing source identification and resolution efforts conducted by the City in 2010 included a grease-trap inspection program. Originally begun in 2002, this program manages the potentially damaging input of fats, oils, and grease into the WWTP. In 2002, 68 businesses in the City of Morro Bay were subject to grease-trap requirements. This number has fluctuated over the years with approximately 44 to 55 businesses subject to the requirements in 2010. The MBCSD conducted spot checks at many of these establishments during the year; but did not find anything of concern.

2.2 WASTEWATER CHARACTERIZATION

Monthly wastewater characterizations documented a number of different aspects of the treatment plant's performance in 2010 (Table 2.2). Removal rates quantified the plant's ability to reduce major organic constituents within the wastestream. Effluent concentrations characterized the overall quality of effluent discharged through the ocean outfall, while mass emissions quantified the cumulative load of wastewater constituents introduced into the marine environment.

Table 2.2 Monthly Averages of Influent and Effluent Parameters

Month	Flow (MGD)	Suspended Solids				Biochemical Oxygen Demand			
		Influent (mg/L)	Effluent (mg/L)	Removal (percent)	Emission (kg/day)	Influent (mg/L)	Effluent (mg/L)	Removal (percent)	Emission (kg/day)
January	1.357	347	29	89.4	140	325	53	82.8	290
February	1.265	317	24	93.0	116	289	46	83.8	222
March	1.168	298	21	91.4	93	292	36	87.5	164
April	1.149	404	25	92.3	109	361	49	85.3	235
May	1.101	327	27	91.0	108	334	63	80.9	258
June	1.118	306	30	90.5	126	292	52	82.2	231
July	1.278	387	35	92.0	164	368	61	83.6	320
August	1.223	427	26	93.6	119	372	48	87.0	231
September	1.066	516	25	94.4	97	401	38	89.5	149
October	1.037	369	16	94.6	62	361	36	90.0	146
November	1.050	475	25	94.6	99	447	40	90.8	148
December	1.432	365	35	89.0	153	307	62	80.0	329
Average	1.187	383	27	92.2	116	350	49	85.2	232
Monthly Limitation	≤2.36¹		≤70	≥75.0	≤546		≤120	≥30.0	≤936
Annual Total (MT)					42				85
Nominal Annual (MT/year)					≤199				≤342

² City of Morro Bay Sewer System Management Plan, approved June, 2009. City of Morro Bay Public Services Department, Wastewater Collections Division

Table 2.2 (continued) Monthly Averages of Influent and Effluent Parameters

Month	pH		Turbidity (NTU)	Settleable Solids (ml/L)	Median ² Total Coliform (MPN/100ml)	Oil and Grease		
	Influent	Effluent				Influent (mg/L)	Effluent (mg/L)	Emission (kg/day)
January	7.9	7.5	36	<0.1 ³	2	73	≈4.0 ⁴	21
February	7.9	7.5	30	<0.1	<2	32	≈4.4	19
March	7.8	7.5	23	<0.1	<2	67	≈3.3	15
April	7.8	7.6	27	<0.1	<2	32	≈4.1	18
May	7.8	7.6	32	<0.1	<2	35	5.1	20
June	7.8	7.6	32	<0.1	<2	190	≈4.8	31
July	7.8	7.6	41	<0.1	<2	65	5.4	26
August	7.8	7.6	31	<0.1	<2	66	≈4.0	20
September	7.7	7.6	29	<0.1	<2	77	≈4.9	21
October	7.8	7.5	27	<0.1	<2	130	≈4.3	37
November	7.9	7.6	27	<0.1	<2	85	≈4.7	14
December	7.7	7.5	38	<0.1	<2	65	9.6	38
Average	7.8	7.6	31	<0.1	<2	76	≈4.7	23
Monthly Limitation		6-9	≤75	≤1.0	≤23		≤25.0	≤195

¹ Peak Seasonal Dry-Weather Flow (PSDWF)

² Computed from samples collected in the 30 days prior to the last day of the month (MBCSD 1997a)

³ The “less-than” symbol (<) indicates that the substance was not detected at a concentration above the method detection limit (MDL), which is listed after the “<” symbol.

⁴ Monthly medians are reported because O&G concentrations in most effluent samples were below the 5-mg/L practical quantification limit (PQL), as shown by the light-gray shading in Figure 2.9c on Page 2-25. COP compliance determination for multiple samples within a sampling period is based on the median value, rather than the average, when one or more concentrations are below minimum reporting level (ML) (SWRCB 2005). The “approximation” symbol (≈) indicates that the median concentration for the month was too low to be reliably quantified, namely, it was below the PQL or ML.

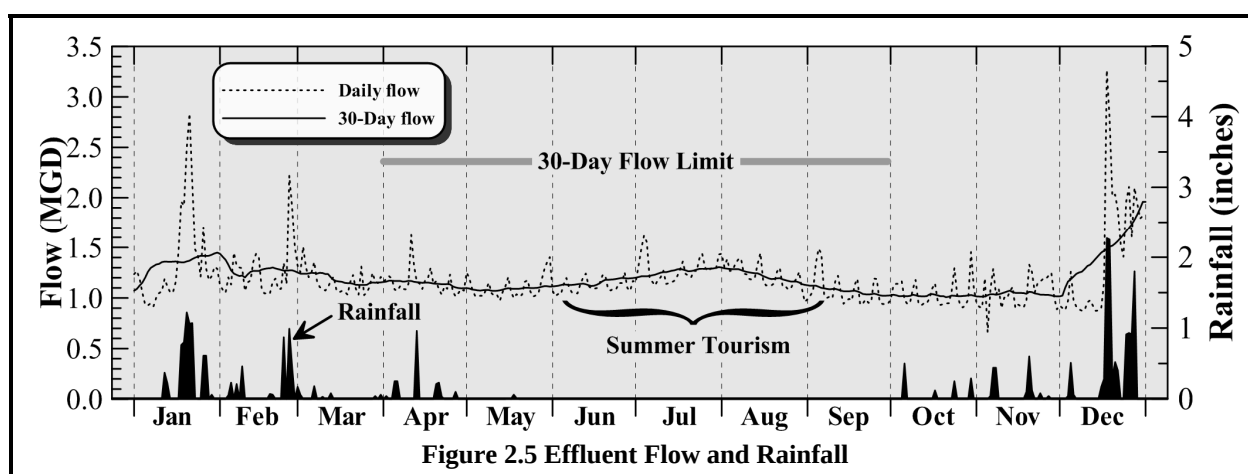
Treatment-plant personnel collected and analyzed samples throughout 2010; those samples were then used to compute the monthly averages of the principal influent and effluent characteristics listed in Table 2.2. WWTP personnel regularly determined the principal physicochemical properties of the effluent, including suspended solids, BOD, pH, total residual chlorine (TRC), turbidity, settleable solids, and total coliform bacteria. The frequency and the duration of individual samples varied among the parameters. For example, average reductions in suspended solids and BOD were determined from 24-hour composite samples of influent and effluent collected and analyzed at least weekly. Analyses for the concentration of most of the remaining constituents were conducted only on effluent samples. Discrete effluent grab samples were analyzed for pH, TRC, temperature, turbidity, and settleable solids on a daily basis. Effluent grab samples were also analyzed for total coliform five times per week, whereas O&G concentrations were determined weekly. Effluent ammonia was determined from monthly grab samples.

Detailed analyses of these measurements has repeatedly concluded that the plant consistently outperformed wastewater treatment expectations based on regulatory standards. Over the long plant history, there has never been an indication of deteriorating plant performance, and effluent quality has consistently exceeded expectations based on the original design criteria. Rare exceptions to standards or criteria have been direct results of brief, unavoidable mechanical failures of a treatment-system component or the external introduction of a contaminant within the influent stream. As a byproduct of a diligent preventative maintenance program, the plant operates at a high level of efficiency with little equipment down time. The primary challenge for plant personnel is to quickly respond to unanticipated failures in system components and to external events that impact the treatment process.

2.2.1 Flow Rate

Flow through the plant in 2010 was far less than the plant's design capacity and the limit in the NPDES discharge permit. The waste discharge requirements (RWQCB-USEPA 2009) state that the "*peak seasonal dry weather flow shall not exceed a monthly average of 2.36 MGD.*" Plant throughput never approached this flow limitation during 2010 (Table 2.2), not even during winter when the limitation does not apply due to increased flows from precipitation events.

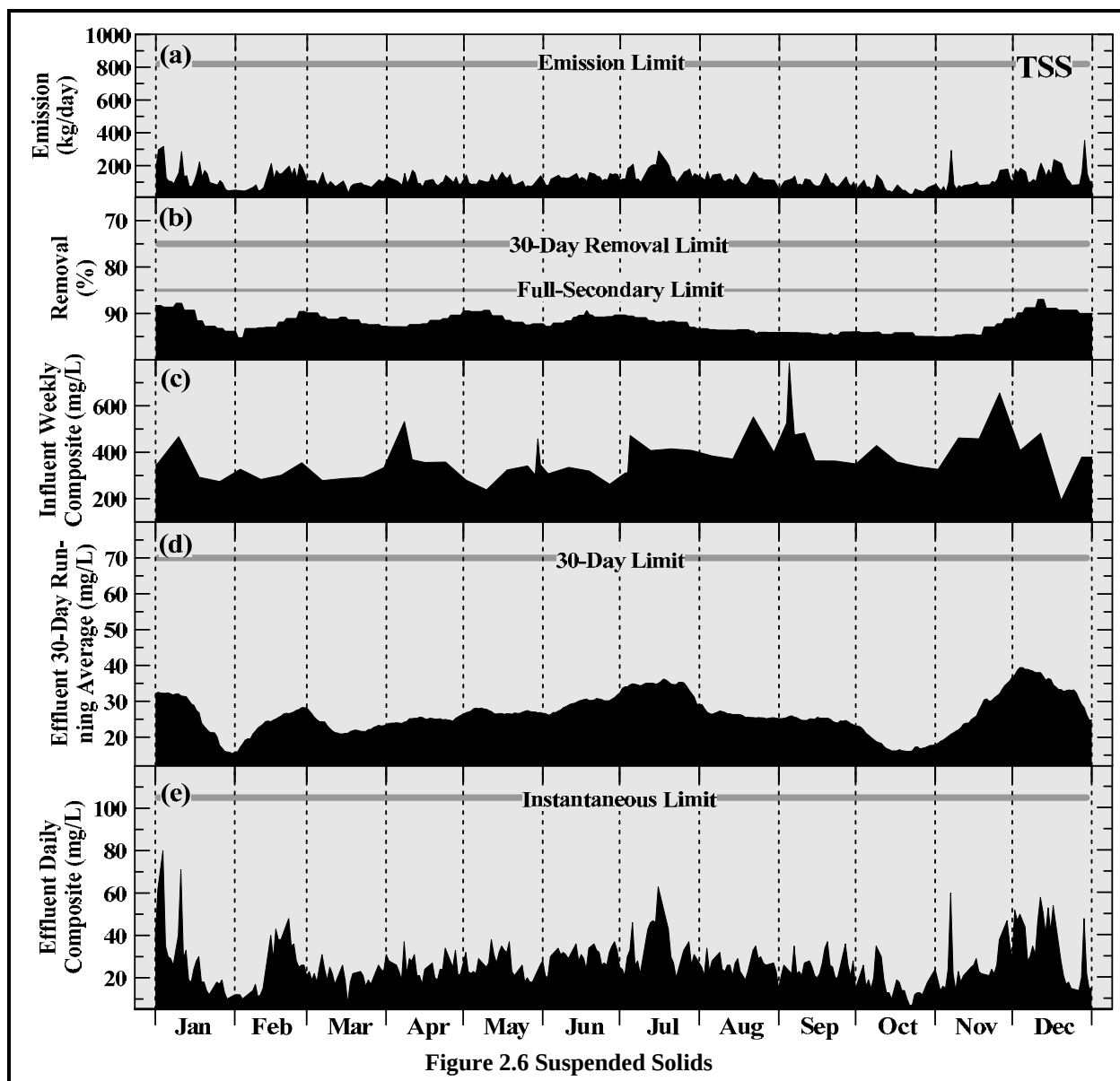
The highest average monthly flow (1.432 MGD) of 2010 occurred in the month of December. It was associated with a series of rainstorms that brought more than 11 inches of rain to the area, and produced a succession of daily flow volumes in excess of 2 MGD. Similar, though less dramatic peaks in daily flow coincided with significant rainfall events in the months of January, February, and April (Figure 2.5). Overall, more than 27 inches of rain fell at the treatment plant during 2010. For comparison, this is double the average amount of precipitation (13.7 inches) measured at the plant over the last decade.



The influence of summer tourism is also apparent in Figure as a slight increase in the 30-day running average flow between mid-June and September (solid line in Figure 2.5). However, at 1.30 MGD, the end-of-July peak of this 30-day running average flow still represented only 55% of the monthly permit limit for peak dry-season flow, which is indicated by the thick shaded line that spans the 'dry' season (April through September) in Figure 2.5. Smaller peaks can also be observed in the figure that coincide with key holiday weekends throughout the year. The most prominent of these are associated with the Memorial Day (May 31st), Independence Day (July 4th) and Labor Day (September 6th) weekends.

2.2.2 Suspended Solids, Turbidity, and Settleable Solids

Suspended solids, turbidity, and settleable solids measure the particulate load within the wastewater stream. One of the primary functions of the treatment process is to remove organic particulates from the wastestream. The treatment plant's removal of nearly all (92%) of solids from influent (Figure 2.6; Table 2.2 on Page 2-19) indicates an exceptionally high overall performance during 2010. As such, the plant's solids removal rate far exceeded the minimum required by the NPDES permit, which specifies removal of only 75% of the suspended solids on a monthly basis. In fact, during every month in 2010, the plant's removal rate was well in excess of the rate (85%) established for full secondary treatment.



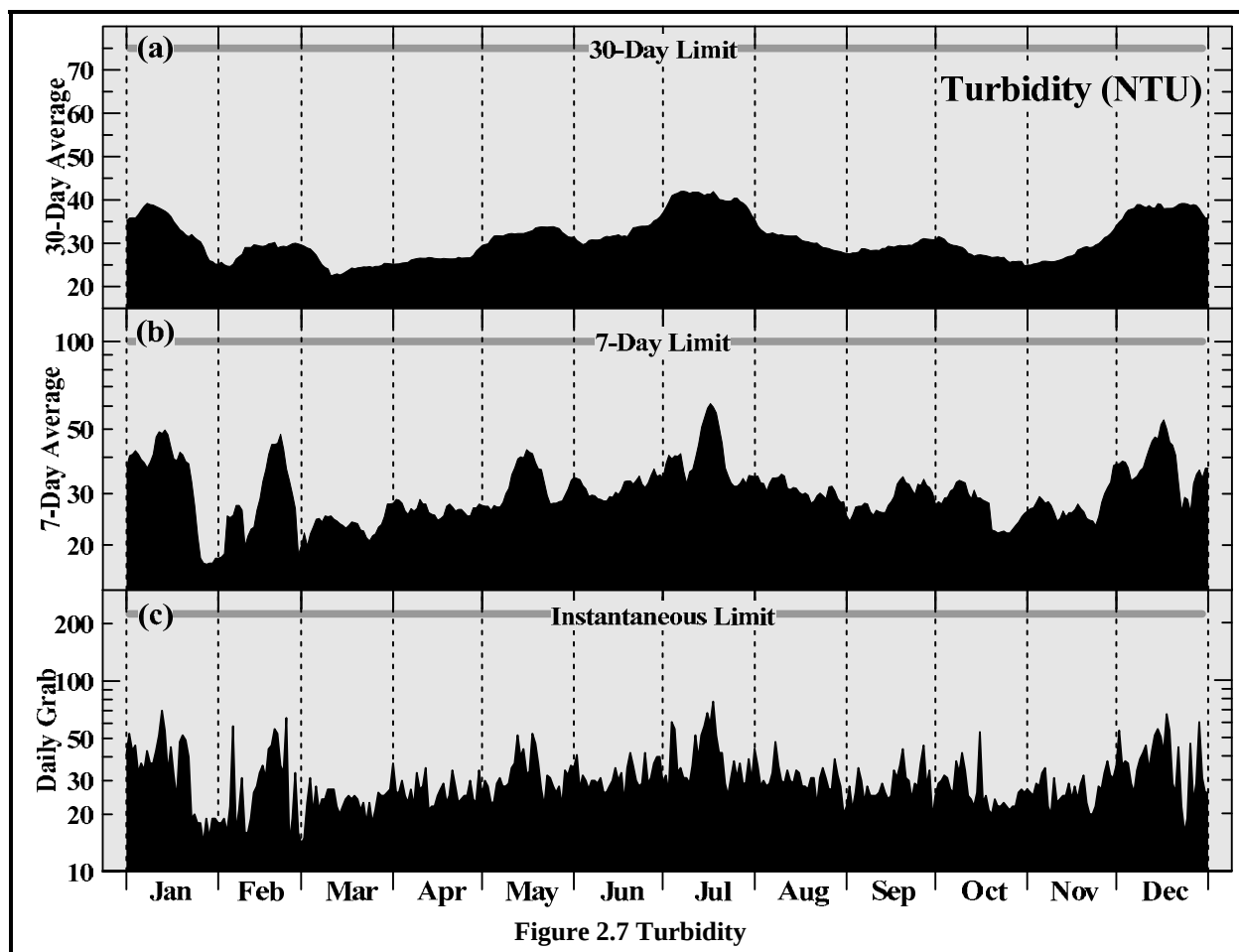
All of the TSS data collected in 2010 demonstrate that the treatment plant's routine performance levels exceed secondary treatment standards. The low average TSS concentration (27 mg/L) within the effluent discharged in 2010 measured less than half of the monthly permit limit of 70 mg/L, and was a direct consequence of the plant's high solids removal rate. Benchmark monthly TSS concentrations during ten months of the year were also at or below the 30-mg/L maximum concentration required to meet full-secondary standards even though the average influent TSS concentration was 383 mg/L.

Regardless of the high influent solids load, the effluent TSS concentrations were so low in 2010 that the permit-required removal rate did not even apply. Regulators recognize that high removal rates are unnecessary when effluent already has low TSS concentrations. Consequently, the NPDES discharge permit imposes the 75% monthly removal rate only when effluent TSS concentrations exceed 60 mg/L (RWQCB-USEPA 2009, SWRCB 2005). Monthly effluent concentrations at the WWTP remained at or

below 35 mg/L throughout 2010, yet the treatment process still exceeded the performance expectations by removing an additional 17% of the influent TSS above the 75% removal rate.

The diffuse particulate cloud in the photograph of the diffuser in Figure 2.2 on Page 2-5 reflects the light sediment loads in discharged wastewater and its low turbidity (Figure 2.7). Over the entire year, the WWTP discharged approximately 42 metric tons of suspended solids to the ocean. This mass emission is only 21% of the projected 199 metric tons that would have been discharged if effluent had contained the permitted TSS concentration of 70 mg/L and the throughput reached the nominal average dry-weather flow of 2.06 MGD.

The consistently low monthly averages for TSS, turbidity, and settleable solids demonstrate the overall effectiveness of the treatment plant's screening, grit removal, sedimentation, filtration, and clarifying processes (Table 2.2). The monthly averages all remained well below the permitted limits, and despite a low detection limit of 0.1 ml/L, not one of the 365 daily effluent samples contained a detectable amount of settleable solids.



2.2.3 Biochemical Oxygen Demand

BOD measures organic loading within the wastewater stream (Figure 2.8). Organic loading is indirectly determined from the amount of oxygen required for aerobic bacteria to decompose organic matter in a sample of wastewater. Organic material, which supports bacterial degradation and demands oxygen, can harm the environment if organic decomposition severely depleats DO within receiving waters. However, such occurrences are only of concern in semi-enclosed water bodies such as bays and estuaries. Their environments are vastly different from the highly oxygenated open-coastal marine environment of Estero Bay, where the MBCSD discharge is located. Because of higher oxygen-replenishment capabilities, an evaluation by the National Academy of Sciences (1993) questioned the environmental benefits of imposing pure technology-based BOD limits on open-ocean dischargers, namely, requiring secondary treatment standards for BOD.

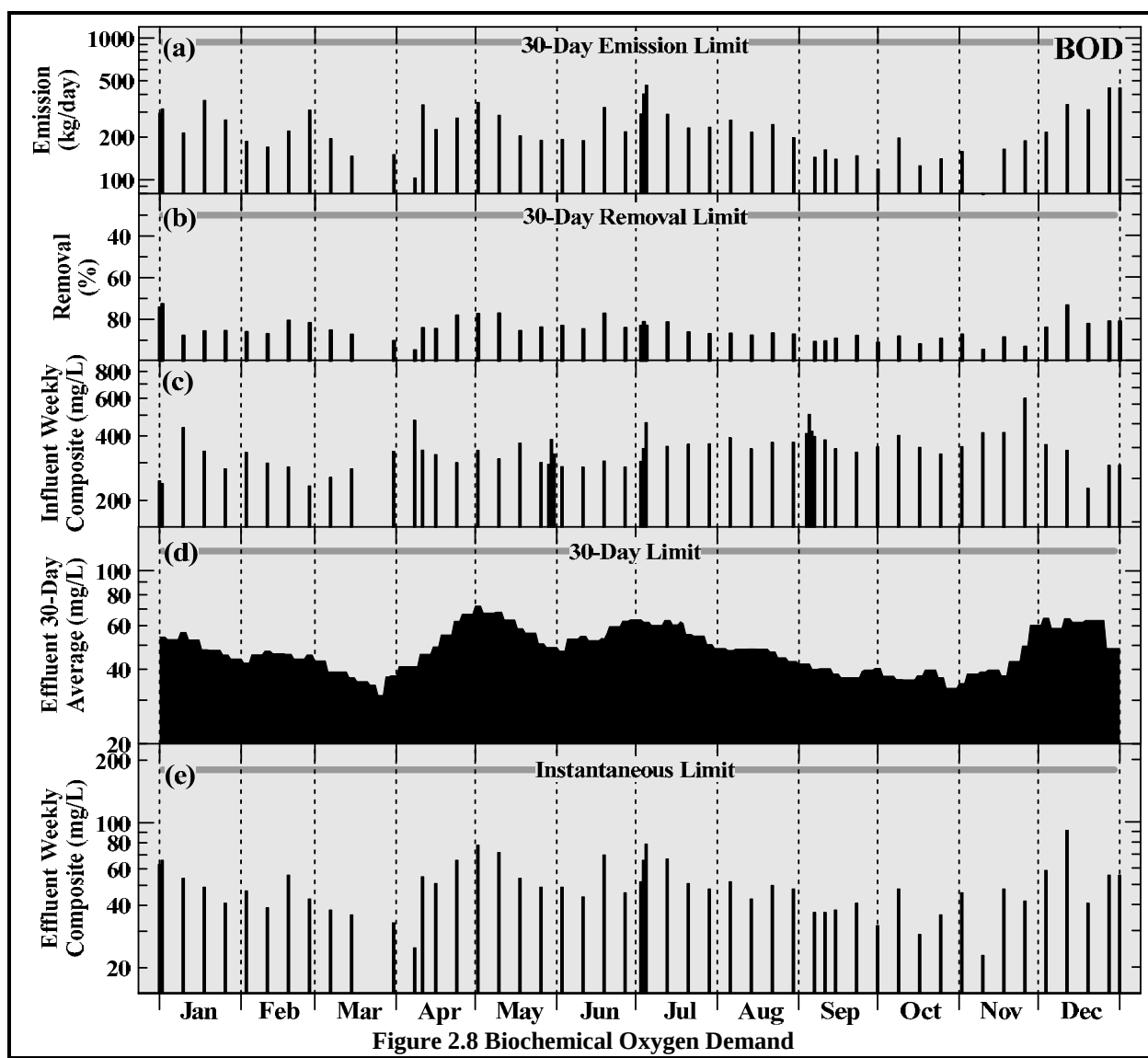


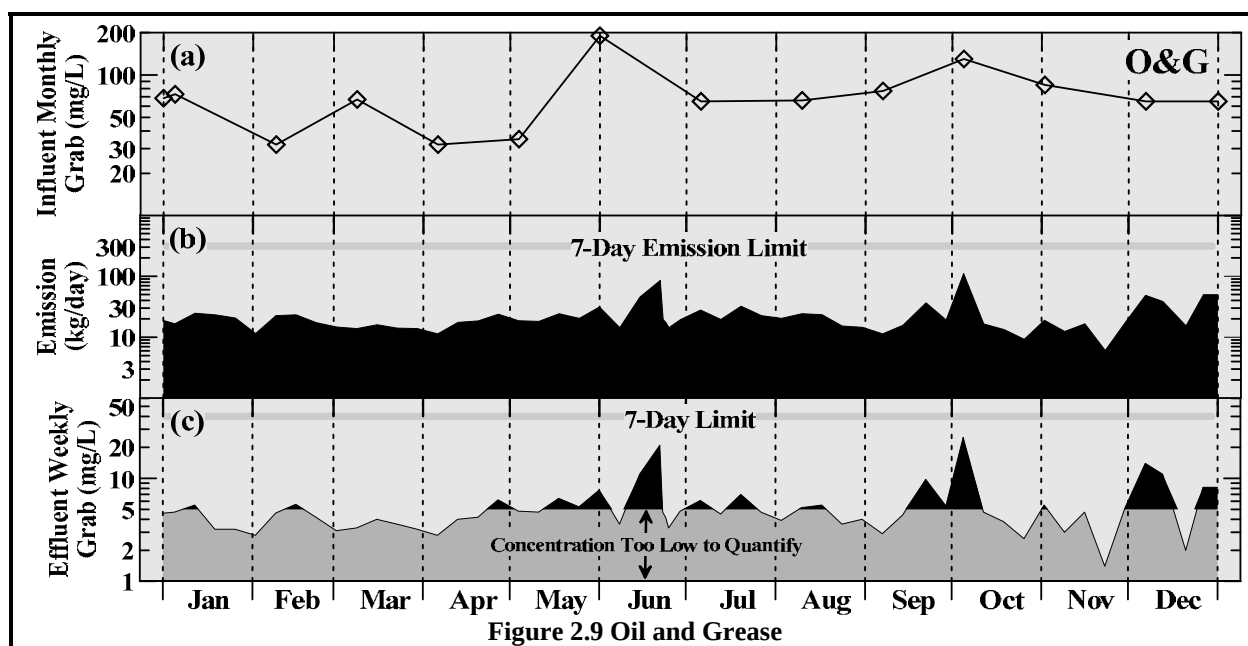
Figure 2.8 Biochemical Oxygen Demand

Nevertheless, during 2010, the treatment process reduced influent organics by more than 85%, as determined by the weekly composite samples analyzed for BOD (Figure 2.8; Table 2.2 on Page 2-19). Thus, the WWTP removed nearly three times the minimum amount organic material that is required for removal by the NPDES discharge permit. The permit requirement for only a 30% reduction in BOD was based on primary treatment standards (USGPO 1997a). Not only was the annual average BOD removal far higher than the required minimum, monthly removal rates exceeded the 85% removal rate requirement for full secondary treatment during six months of the year and achieved rates of 80.0% or higher during the other six months. Because of the high removal rates, the 85 MT of oxygen-demanding organic material discharged during 2010 was only one-quarter of the 342 MT allowed by the discharge permit.

Thus, the treatment plant routinely performed at secondary-treatment levels with respect to its removal of oxygen-demanding organics from the wastestream. Throughout 2010, the treatment process also maintained monthly effluent BOD concentrations at or below 63 mg/L. BOD concentrations in the effluent never exceeded, or even approached, the 30-day limit of 120 mg/L (Figure 2.8d), much less the permitted instantaneous maximum of 180 mg/L (Figure 2.8e). As with TSS removal, regulators recognize that high BOD removal rates are not necessary when effluent has a low BOD concentration. Consequently, the NPDES discharge permit imposes the 30% minimum monthly removal rate only when effluent BOD levels exceed 60 mg/L. Nonetheless, although the plant was only subject to the 30% removal requirement for three months during 2010, it consistently achieved far higher rates of BOD removal throughout the year.

2.2.4 Oil and Grease

During 2010, the treatment process reduced average O&G concentrations within the influent stream by a factor of over 16 (Table 2.2). As a result, individual weekly effluent O&G concentrations remained low throughout most of the year and the associated emissions were only a fraction of the permitted maximum emission of 585 kg/day (Figure 2.9c).



On one occasion, in June 2010, sample contamination resulted in the reporting of single elevated daily effluent concentration. An anomalously high concentration of 42 mg/L was reported on the effluent sample collected on 22 June 2010. Subsequent analyses were conducted on the archived split of this sample as well as three additional samples that had been collected and archived from the three following days. The results of these additional analyses were all within the normal historical range however, and were, in fact, below the PQL of 5 mg/L.

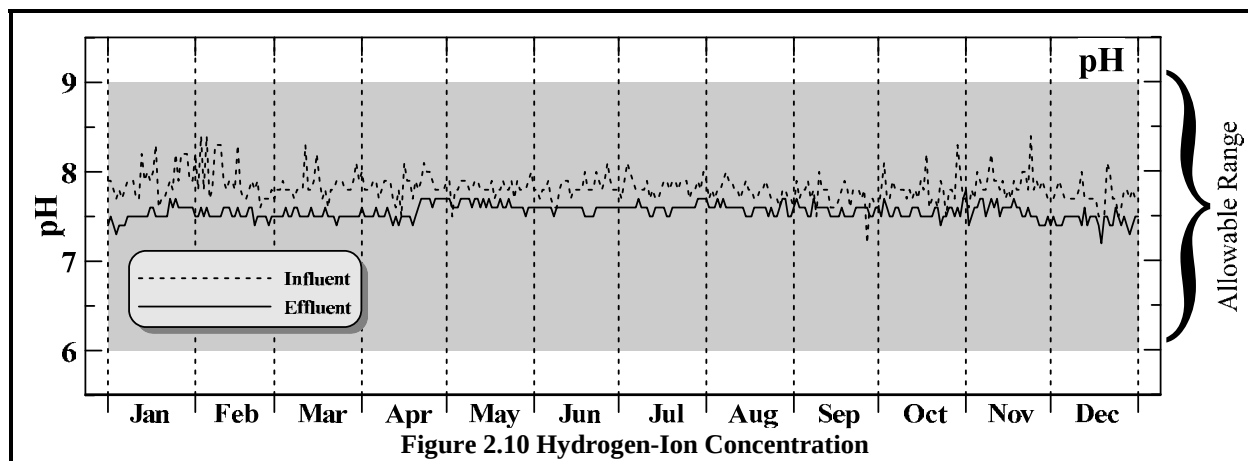
Although it is likely that lab, field, or container contamination was responsible for the anomalously high concentration measured during the initial analysis, the laboratory was unable to confirm the exact cause of the 14-fold discrepancy between the results of the split samples. Therefore, an average of the two results (21 mg/L) was reported. Even with the inclusion of the suspect value, however, the final results for all the analyses were within the acceptable limits of the MBCSD discharge permit.

Regardless, the majority (91%) of O&G in the MBCSD influent was found to be comprised of polar hydrocarbons. Hydrocarbon composition can help indicate whether the source of an O&G sample is industrial in nature, and therefore represents a new or potentially hazardous discharge for the treatment process. For example, polar hydrocarbons are associated with animal and vegetable-based O&G, such as that used in restaurant cooking, while non-polar hydrocarbons are usually associated with more industrial sources, specifically fuels and motor oils. The predominately polar composition of the MBCSD influent O&G is a testament to the region's tourism-based economy and the lack of heavy industry within the MBCSD service area.

2.2.5 pH

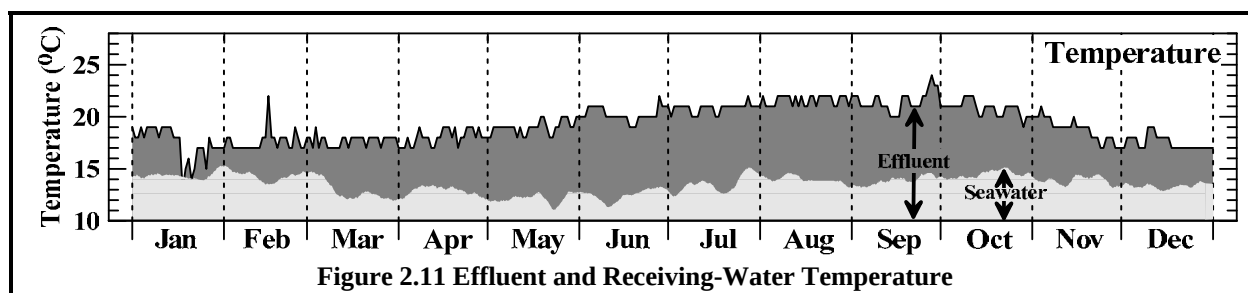
The MBCSD discharge permit requires that the hydrogen-ion concentration (pH) of the effluent remain within 6 to 9 at all times. Section 301(h) of the Clean Water Act allows an NPDES discharge permit to be issued that exceeds these pH limitations. However, because the plant's partial secondary treatment can routinely treat wastewater to comply with the pH standards for full secondary treatment, the MBCSD discharge permit does not allow this exception. Moreover, the general absence of heavy industrial input into the collection system creates an influent stream with a nominal pH that would meet the discharge requirement even without secondary treatment.

Because influent pH (dashed line in Figure 2.10) remained within the discharge limits (shaded area), effluent pH measurements also remained within the allowable range by default (solid line). Comparison of the two time histories demonstrates that the treatment process significantly moderated short-term pH fluctuations within the influent.



2.2.6 Temperature

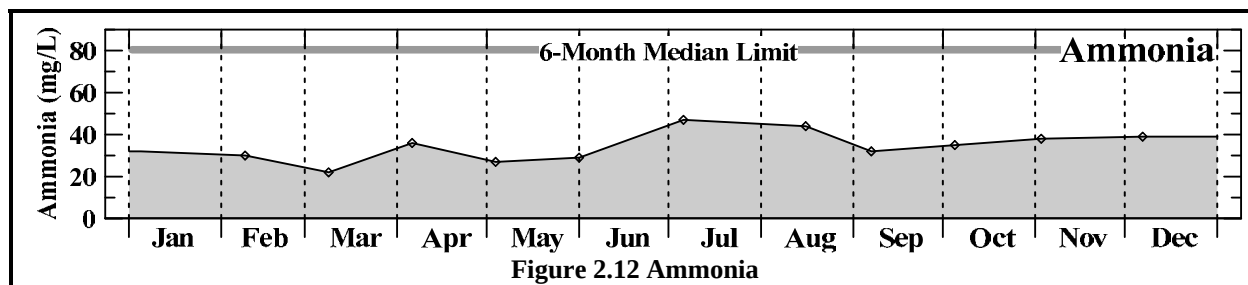
Although the NPDES permit does not limit effluent temperature, it is an important physical property to document because the difference between effluent and receiving-water temperature dictates the amount of mixing that occurs shortly after the wastewater is discharged into the ocean. The warmer the effluent compared to seawater, the greater the buoyancy of the plume and the more turbulence generated by its rise within the water column. Effluent temperature, shown by the dark shading in Figure 2.11, exhibits a distinct semi-annual cycle that tracks seasonal insolation, as does air temperature. Effluent temperatures begin gradually increasing in spring (mid-May), peak in mid-to-late summer (July through September), and then decline during the fall (October through December).



Because of the strong and sustained influence of upwelling in 2010, seawater temperatures, shown by the light shading, did not track trends in effluent that were due to seasonal insolation. In response to intense southeastward winds, a sharp drop in seawater temperature occurred in mid-March and extended into June (see Chapter 3). The resulting low seawater temperatures in March through June provided a greater thermal contrast with effluent than occurred in late fall and winter (November and December). Upwelling winds continued throughout the summer of 2010, and depressed seawater temperatures relative to the steadily increasing effluent temperatures. As a result, a large thermal contrast between seawater and effluent persisted throughout the period between March and October. Although this large thermal contrast would normally enhance buoyancy-induced dispersion of the effluent plume, the stratification of the water-column caused by upwelling limits vertical motion, largely offsetting the dispersion benefits of the thermal contrast during upwelling season.

2.2.7 Ammonia

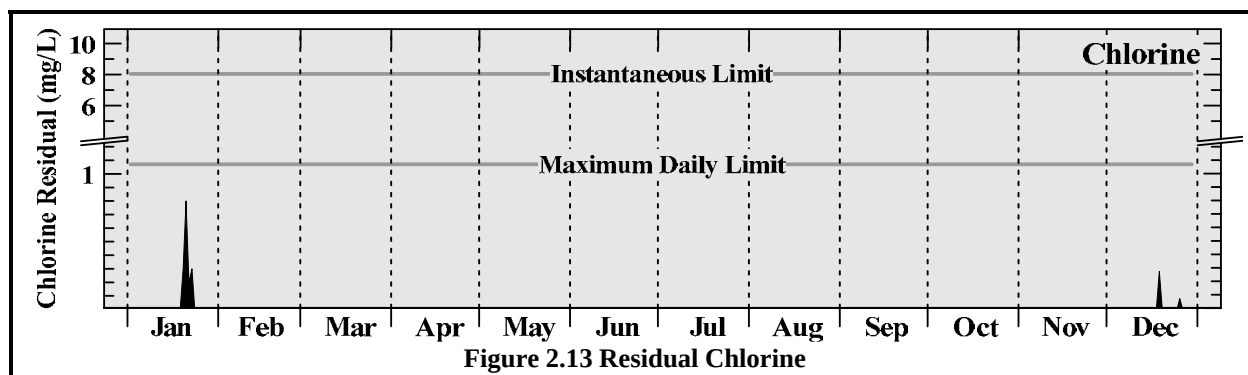
The concentration of ammonia as nitrogen ($\text{NH}_3\text{-N}$) was uniformly low throughout 2010. Grab samples analyzed for ammonia on a monthly basis had concentrations at or below 47 mg/L, which is only slightly more than half of the 6-month median limit of 80.4 mg/L (Figure 2.12). This peak concentration was also approximately 17 times lower than the permitted instantaneous limit of 804 mg/L, which is imposed to protect marine aquatic life.



2.2.8 Residual Chlorine

Total residual chlorine (TRC) measures chlorine remaining in the effluent after disinfection with sodium hypochlorite and subsequent dechlorination or buffering with sodium bisulfite. Daily grab samples for residual chlorine were collected when concentrations of effluent constituents are expected to be at their highest levels, during peak flow periods. Balancing chlorination and dechlorination to obtain adequate disinfection (coliform reduction) without dosing the marine environment with high levels of chlorine can be challenging, because the chlorine demand is constantly changing due to continuous variations in flow and organic loading within the wastestream. Consequently, the disinfection process occasionally requires direct operator intervention. If sodium hypochlorite beyond what is needed to meet the coliform demand is added, then dechlorination may be complicated and TRC levels in the effluent may increase.

Throughout 2010, treatment plant personnel maintained careful control over the disinfection and dechlorination processes. As a result, only 6 of the 365 grab samples had detectable concentrations of TRC (Figure 2.13). Each of the detects was associated with a significant rainfall event where substantial variations in flow rates complicated the disinfection process. TRC in the remaining samples never exceeded the 0.05-mg/L detection limit, which is five-times lower than the 6-month median limit of 0.27 mg/L specified in the discharge permit.

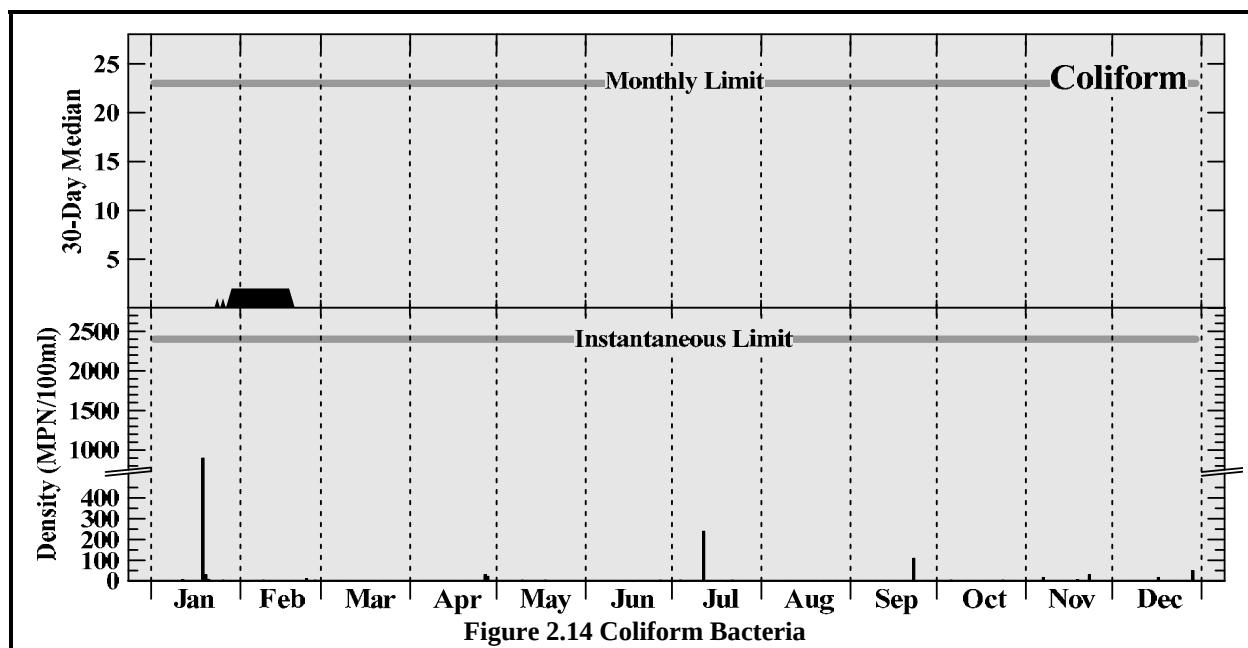


Four of the detects, including the highest measurement of the year, occurred during a six-day storm event that deposited 4.92 inches of rain at the plant in mid-January. Nevertheless, the highest measured concentration (0.8 mg/L) remained well below the permitted instantaneous limit (8.04 mg/L), nor did the plant approach the 6-month median specified in the permit.

Similarly, the two measurable TRC concentrations on 19 and 26 December were likewise associated with significant rainfall events. Back-to-back storms combined to deposit an excess of 11 inches of rain at the plant and resulted in almost daily surcharging of the influent flow meter. The first storm, lasting from 16 December through 22 December, deposited approximately 6.17 inches of rain. The second storm, beginning on 25 December and lasting four days, dropped an additional 4.55 inches of rain in Morro Bay.

2.2.9 Coliform Bacteria

Effluent samples collected on five consecutive days each week were analyzed for the most probable number of total coliform organisms per 100 ml (MPN/100ml). Figure 2.14 shows that the highest measured daily coliform density (900 MPN/100ml) was less than half of the permitted instantaneous maximum of 2400 MPN/100ml; all other measured daily coliform densities were one tenth or less of the permitted limit. In fact, more than two-thirds of the 284 effluent samples analyzed in 2010 had no measurable coliform density. As a result, the highest monthly median coliform density (Table 2.2) was



approximately one-tenth of the 30-day median limit of 23 MPN/100ml specified in the NPDES permit. For the most part, increased coliform densities were randomly scattered throughout the year Figure 2.14.

2.2.10 Toxicity

In 2010, effluent samples were tested semiannually, in January and July (Table 2.3), for toxicity using chronic bioassays³ of composite effluent samples. The chronic bioassays found consistently low effluent toxicity, with levels much less than the discharge permit limits.

Toxic screening studies conducted in 1993 indicated that giant kelp (*Macrocystis pyrifera*) was more sensitive to MBCSD effluent than other species typically used in bioassays at that time, such as the larvae of the inland silverside (*Menidia beryllina*) and the bay mussel (*Mytilus edulis*) (MRS 1994). Chronic bioassays conducted on kelp since that time have repeatedly demonstrated that giant kelp was only minimally affected by exposure to treatment plant effluent.

Table 2.3 Comparison of Measured Toxicity Levels with Permit Limitations

Sample Date	Bioassay Test	End Point (%)	Concentration (TU)	Limit (TU)
12 January	Chronic: Giant Kelp (<i>Macrocystis pyrifera</i>)			
	Germination	10.0	10.0	134
	Growth	18.0	5.6	134
12 January	Chronic: Red Abalone (<i>Haliotis Rufescens</i>)	10.0	10.0	134
13 July	Chronic: Red Abalone (<i>Haliotis Rufescens</i>)	5.6	17.9	134

³ Acute bioassay testing requirements were eliminated in the current MBCSD discharge permit, in accordance with previous updates to the California Ocean Plan.

The chronic toxicity tests in January 2010 measured spore germination and growth response in giant kelp (*M. pyrifera*) after exposure to a range of effluent dilutions.⁴ The results of the 2010 kelp bioassays confirm the effluent's continued low chronic toxicity. All chronic-toxicity endpoints were more than seven-times lower than the applicable permit limitation of 134 chronic toxic units (TUC) for the daily maximum toxicity. The reported TUC were based on a "*No Observable Effects Concentration*" (NOEC), which is the highest effluent concentration that does not cause an adverse effect statistically different from a control sample. They indicate that the chronic bioassays did not find adverse effects when kelp was exposed to effluent concentrations as high as 10%, whereas the permit allows adverse effects in concentrations as low as 0.75%.

As required by the current discharge permit, a new screening study was conducted on the July 2009 and January 2010 effluent samples that included an assessment of the effluent's effect on the development of larval red abalone (*Haliotis rufescens*) in addition to giant kelp (*Macrocystis pyrifera*). The bioassays indicated larval abalone were somewhat more sensitive to effluent than kelp zoospores. Therefore, future bioassays will be conducted on larval red abalone. Nevertheless, adverse effects in larval abalone were not observed after exposure to effluent that was seven times more concentrated than allowed by the discharge permit.

2.2.11 Nutrients

The current discharge permit's receiving-water limitations on chemical constituents state that "*Wastewater constituents within the discharge shall not cause objectionable aquatic growths or degradation of indigenous biota resulting from the discharge of nutrients.*" Measurements collected in 2010 demonstrate that nutrient concentrations within the MBCSD effluent, and mass loading to the marine environment from its discharge, are small compared to other central-coast dischargers, and compared to the contribution from regional streams and rivers. There is no evidence that these other much-larger nutrient sources materially contribute to the harmful or objectionable growth of marine algae along the central coast, so it is highly unlikely that the MBCSD nutrient discharge is of environmental concern.

Nevertheless, this concern was raised during the review process for the current MBCSD discharge permit (USEPA 2007) because the relative contribution of nutrients discharged to the ocean by coastal treatment plants, such as the MBCSD WWTP, was largely unknown, as was their potential role in promoting harmful algal blooms. Therefore, the USEPA proposed a conservation measure for "*Regular monitoring of nutrient loading from the [MBCSD] facility's ocean outfall*" in their biological evaluation and request for concurrence with their finding of "*no likely adverse effects*" from the USFWS.

In response, MRS (2008b) designed a nutrient-monitoring requirement for the MBCSD effluent monitoring program that included semiannual analysis of nitrate, urea, ortho-phosphate, and dissolved silica concentrations. Open-ocean dischargers, such as the MBCSD treatment plant, are not normally required to monitor for these bio-stimulatory nutrients because energetic, well-flushed marine environments rapidly dilute and disperse discharged nutrients, preventing their accumulation to deleterious levels. For this reason, there are no numerical objectives for nutrient compounds (except ammonia) within receiving waters that are promulgated in the COP.

Nevertheless, to estimate relative nutrient contribution from the MBCSD WWTP, analyses of these four compounds were added to the monitoring program. These particular compounds were selected because they represent limiting macronutrients for phytoplankton growth within the euphotic zone of the ocean.

⁴ The semiannual effluent reports contain raw test data, pertinent quality assurance/quality control (QA/QC) data, and chains of custody for the chronic bioassays (MRS 2009gh).

The ocean bio-stimulatory nutrients, in order of decreasing importance, are nitrogen, phosphorus, and silica. Ammonia [NH₃], nitrate [NO₃⁻], and urea [CO(NH₂)₂] are nitrogen compounds found in measurable concentrations within wastewater, and have been associated with the stimulation of phytoplankton growth (Kudela and Cochlan 2000). Ammonia concentrations have always been regularly measured as part of the compliance evaluation within the MBCSD discharge permit's waste discharge requirements, so the other two nitrogen forms were added to the new monitoring requirement. Similarly, dissolved phosphorus [ortho-phosphate, (PO₄)³⁻] and dissolved silica [SiO₂] are the principal bioavailable forms of these two nutrients in seawater, and measurement of the concentrations of these analytes within effluent were also included as part of the nutrient-monitoring component.

A nutrient assay of MBCSD effluent was conducted on a grab sample collected in July 2010 as part of the new annual monitoring requirement. It demonstrates that the contribution of nutrients from the MBCSD WWTP is insignificant compared to that of other central-coast WWTPs, and its loading to the marine environment is miniscule compared to nutrient mass contained within streams and rivers in the region (Table 2.4). Concentrations of nitrates and silica within MBCSD effluent were substantially lower than those of the three large central-coast WWTPs to the north, while concentrations of phosphates and urea were comparable to the other dischargers. With concentrations at or below the 0.1-mg/L detection limit, the MBCSD nitrate levels, in particular, were at least an order of magnitude lower than those of the other WWTPs within the central-coast region. Although nitrate and silica concentrations within MBCSD effluent were also less than average concentrations within central-coast rivers and streams, urea and phosphate concentrations were higher, as was the case for the other central-coast WWTPs.

Table 2.4 Nutrient Concentrations and Loading from Central-Coast Ocean Discharges

Source		Concentration (mg/L)				Mass Emission (kg)			
		Nitrate	Urea	Phosphate	Silica	Nitrate	Urea	Phosphate	Silica
MBCSD	January	<0.10	0.098	3.6	12.1	<164.	144.	5,740.	20,600.
	July	<0.10	0.078	3.4	13.0				
Santa Cruz		9.52	0.087	7.7	30.2	139,000.	1,360.	117,000.	489,000.
Watsonville		10.52	0.110	13.6	35.6	105,000.	1,250.	154,000.	364,000.
Monterey		4.82	0.084	3.4	41.0	85,600.	1,100.	30,300.	488,000.
Streams and Rivers ¹		3.58	0.021	0.14	25.6	1,660,000.	33,500.	340,000.	25,200,000.

¹ Average concentrations and total emissions from fourteen streams and rivers discharging to the northern central coast from July 2005 and June 2006 (CClean 2007)

Notwithstanding the slightly higher urea and phosphate concentrations within effluent, potential environmental effects from nutrient discharge are dictated by the total mass contributed by the various sources (Table 2.4). When the relatively small volume of the MBCSD is considered, its total nutrient loading to the marine environment is one- to three-orders-of-magnitude less than the individual large WWTPs to the north, and up to four-orders-of-magnitude (10,000-times) less than the contribution of runoff from the central-coast region. Additionally, of the dischargers listed in Table 2.4, the MBCSD treatment plant is the only plant that does not discharge into the waters of the Monterey Bay National Marine Sanctuary.

While it is unlikely that any of the central-coast WWTPs materially contribute to nutrient levels within the marine environment along the central coast, the occurrence of harmful algal blooms (HABs) within coastal waters throughout the world has become a growing concern. HABs occur when periodic explosions of growth in the naturally occurring algae, which normally form the base of the marine food web, result in extensive monocultures, or blooms, of particular species that are harmful to humans or other life. HABs can cause harm through the production of toxins, or simply by their accumulated

biomass. Both types of impacts affect co-occurring marine organisms and can dramatically alter food-web dynamics. Documented impacts from HABs include the devastation of coastal habitats, loss of economically and culturally vital shellfish resources, illness and death in populations of protected marine species, and serious threats to human health posed by exposure or ingestion of algal toxins.

Offshore central California, impacts from HABs are mainly caused by recurring blooms of two genera of algae (*Alexandrium* and *Pseudo-nitzschia*). Both *Alexandrium* and *Pseudo-nitzschia* algae produce potent neurotoxins that accumulate in fish and shellfish, and can cause paralytic shellfish poisoning (PSP) and amnesic shellfish poisoning (ASP), respectively. ASP is also commonly known as domoic acid poisoning. The exceptionally high potency of the saxotoxin produced by *Alexandrium* species means that even low density populations can cause severe problems; thus, these blooms generally do not discolor the water and may not be visible on the water surface.

Pseudo-nitzschia is a genera of naturally occurring diatoms common along the west coast of the United States. *Pseudo-nitzschia* species produce domoic acid, which, when ingested, can cause neurological damage, including dizziness, headache, seizures, disorientation, difficulty breathing, and coma. Domoic acid poisoning has been documented in a wide variety of marine mammals and seabirds.

Considerable research has been conducted in an effort to understand the environmental factors that promote HABs. Through these studies, processes such as coastal upwelling and river runoff have been implicated as factors that may create physical and chemical conditions (e.g., high nutrient concentrations) conducive to the development of phytoplankton blooms (Trainer et al. 2002, Kudela et al. 2004). Upwelling conditions along the central California coastline, which are discussed in Chapter 3 of this report, have been particularly implicated in the generation of HABs within the region that includes the MBCSD discharge (Trainer et al. 2000, Kudela et al. 2005). In addition to these natural processes, increased human activity and pollution are also thought to be contributing factors to the recent observed higher frequency and intensity of HABs.

2.2.12 Chemical Compounds

In addition to the effluent properties and bioassay results described above, there are 78 chemical properties that are regulated by the COP, and whose effluent concentrations are limited in the discharge permit. Effluent composite samples were analyzed in January and July 2010 for the presence of these chemical compounds, which include trace metals, chlorinated and nonchlorinated phenolic compounds, volatile organic compounds, organochlorine pesticides, PCBs, cyanide, base-neutral compounds, and radionuclides. The COP regulates the discharge of these compounds for the protection of marine life and the protection of human health from exposure to both carcinogenic and non-carcinogenic substances.

As has been the case in the historical record of 2,884 chemical assays spanning 18 years of MBCSD effluent monitoring, the 2010 analyses detected concentrations of only a few ubiquitous compounds at levels well below the regulatory limits (Table 2.5). Those detected compounds are discussed below, while detailed discussion of effluent chemistry, along with the corresponding concentration limits, minimum reporting levels, laboratory data sheets, pertinent QA/QC data, and chains of custody for all the chemical constituents was provided in semiannual self-monitoring reports (MRS 2010gh).

The chemical assays found only 10 of the 78 chemical compounds present in quantifiable amounts within the 2010 effluent samples.⁵ The measured concentrations for all 10 compounds were well less than the permitted limits. Annual mass emissions of these compounds also met the goals in the discharge permit reporting provisions. The compounds with quantifiable concentrations included three trace metals

⁵ Quantifiable concentrations of the 10 compounds are listed in bold typeface in Table 2.5.

Table 2.5 Chemical Compounds Detected within Effluent Samples

Compound	Concentration (µg/L)			Mass Emission (kg/yr)	
	Limit	January	July	Goal	Measured
Protection of Marine Aquatic Life					
Arsenic	670.	≈1.3 ¹	≈1.4	17.	≈2.22
Chromium VI	270.	<0.8 ²	≈1.6	93.	<1.97
Copper	140.	22.	12.	690.	27.9
Lead	270.	≈0.99	1.5	465.	≈2.04
Nickel	670.	≈3.7	≈2.7	142.	≈5.25
Selenium	2,010.	≈1.0	2.7	65.	≈3.04
Zinc	1,620.	59.	50.	244.	89.4
Cyanide	130.	5.7	5.1	71.	8.86
Phenolics (Non-Cl ₂)	4,020.	— ³	3.3	—	5.42
Radionuclides (pCi/L)	α	15.	—	<0.065	—
	β	50.	—	19.	—
Protection of Human Health (Non-Carcinogens)					
Chromium III	25,500,000.	<0.8	≈1.6	—	<1.97
Toluene	11,400,000.	—	≈0.16	4.	≈0.263
Protection of Human Health (Carcinogens)					
Bis(2-ethylhexyl)phthalate	469.	—	8.2	320.	13.5
Beryllium	4.42	—	≈1.2	28.	≈1.97
Chloroform	17,400.	—	0.61	5.	1.00
Dioxin (pg/L)	0.52	—	0.18	1.48 mg	0.30 mg

¹ The “approximation” symbol (≈) indicates detected concentration was too low to be reliably quantified, namely, it was below the PQL or Minimum Reporting Level. Consequently, the number listed after the symbol represents an estimated concentration. Accurately quantified concentrations are indicated by bold typeface.

² The “less-than” symbol (<) indicates that the compound was not detected at a concentration above the method detection limit (MDL), which is listed after the “<” symbol.

³ The “dash” symbol (—) indicates that analysis of the compound was not required as part of the monitoring program, or a mass-emission goal was not specified in the discharge permit.

(copper, lead, and zinc), a radionuclide, a common phthalate compound (bis 2-ethylhexyl phthalate), cyanide, chloroform, selenium, a non-chlorinated phenolic compound (3,4 methylphenol), and low-level congeners of dioxin.

The analyses also detected five additional compounds in the semiannual effluent samples, but at concentrations that were too low for reliable quantification. Specifically, the concentrations of these compounds were more than the method detection limit (MDL)⁶ but less than the practical quantification limit (PQL)⁷ or minimum reporting level (ML). Reporting of these detected-but-not-quantified concentrations is required under the current NPDES discharge permit, although they are not compared to effluent limitations for compliance assessments.

⁶ The method detection limit is the lowest concentration that can be reported under ideal conditions, when the sample contains only the compound of interest in a concentration within an optimal calibration range and within a medium that does not interfere with the performance of the analytical instrument.

⁷ The practical quantification limit is the lowest concentration that can be measured with statistical reliability given the sample size and analytical method.

Trace Metals

Three of the quantifiable concentrations were associated with commonly occurring metals: copper, lead, and zinc. Unlike synthetic organic compounds, trace metals occur naturally within the mineralogy of sediments along the central California coast and are ubiquitous in the local sedimentary environment. All three of the metals were detected in quantifiable amounts within seafloor sediment samples collected during the benthic survey (see Chapter 4). These metals enter the wastewater collection system through erosion of natural mineral deposits along the central California coast, and through corrosion of household plumbing systems. Regardless of their source, the effluent metal concentrations were only one-sixth of levels deemed deleterious to marine organisms. When combined with small volume of effluent discharged in 2010, the highest metal mass emission was still more than 2.5 times lower than the emission goal recommended in the discharge permit based on historical concentrations and maximum allowed flow rates.

These three metals have been detected at quantifiable levels in over half of the effluent samples collected during the last 18 years, and therefore, do not represent a new or increased source of contaminants entering the collection system. Moreover, the long monitoring history unequivocally demonstrates that there is no reasonable potential for these metal concentrations to exceed the discharge permit limits in the future (Refer to the recommendation concerning reductions in monitoring frequency in Chapter 5).

Bis(2-ethylhexyl) phthalate (DEHP)

Bis(2-ethylhexyl) phthalate (DEHP) is a organic compound with good plasticizing properties. On average, most plastics are comprised of anywhere from 1% to 40% of DEHP. As such, DEHP is pervasive in the environment due to the massive scale on which it is produced, in addition to its mobility and high vapor pressure. Consequently, it has been routinely detected at quantifiable levels in over half of the MBCSD effluent samples collected during the last 18 years. However, all detects have been at concentrations well below the permit limit established for the protection of human health. As with trace metals and other effluent constituents, the long history of measured DEHP concentrations demonstrates that there is no reasonable potential for continued discharge to exceed the DEHP permit limit. At 13.5 kg, its annual emission in 2010 was 23 times smaller than the goal recommended in the discharge permit.

Radionuclides

As with the chemical compounds described above, the presence of measurable radioactivity within the 2010 effluent sample was not unusual. Radioactivity has always been measured within MBCSD effluent samples, largely because naturally occurring radioactive material (NORM) is present throughout the earth's crust, and because radioactive decay can be quantified at extraordinarily low levels. Consequently, the permit limits specified for radionuclides are not derived in the same manner as for other chemical constituents, which are based on potential impacts after discharge. Specifically, the maximum radioactivity limits in effluent do not account for 133-fold minimum dilution that occurs immediately after discharge, and instead, are the same as those established for drinking water pursuant to the California Code of Regulations, Title 22, §64441 and §64443. Nevertheless, the radionuclide activities measured within the July 2010 effluent sample were well below those drinking-water standards.

The very low beta (β) decay levels measured within the July 2010 effluent samples were typical of most prior effluent samples, and of naturally occurring sediments of the region. Beta particle activity arises from radioactive decay in both natural and man-made materials, while alpha particle activity arises from natural mineral deposits that enter the collection system through erosion. Except for an erroneous measurement of a slightly elevated β radioactivity in January 1994, an RPA of radioactivity within

effluent samples collected over the past decade and a half demonstrates that there is no potential for radionuclide concentrations to exceed the drinking-water limits.

Phenolic Compounds

3- & 4- methylphenol (p-cresol) is a nonchlorinated phenolic compound that is a natural product in many foods as well as in crude oil and tar. It is also detected in animal and human urine. In addition to its industrial uses, p-cresol is also used as an antiseptic and disinfectant because of its bactericidal and fungicidal properties. As a metabolite of toluene, p-cresol is a known toxin; however, the combined concentrations of all non-chlorinated phenolic compounds in the July 2010 grab sample would have to be more than three orders of magnitude higher than those measured to be of concern to marine organisms.

Chloroform

Chloroform is part of a group of compounds known as halomethanes. These compounds are common by-products of wastewater and drinking water chlorination which form during the chlorine disinfection process when organic substances are present. Chloroform has been detected in approximately half of the effluent samples collected over the last decade and a half. However, at the low concentrations normally detected, it is not clear whether the presence of chloroform derives from wastewater disinfection within the treatment plant, or is the result of drinking-water chlorination. Although halomethanes, including chloroform, can negatively affect human health, the concentration of chloroform detected in July 2010 was more than four orders of magnitude below the permitted limit.

Cyanide

Cyanide was detected at low concentrations in both the January and July 2010 effluent samples. As with the other detected compounds, cyanide's measured concentration was low compared to its permit limitation and therefore, not of ecological concern. Cyanide has been detected at quantifiable levels within approximately 20% of the effluent samples collected over the past decade and a half.

Although cyanide occurs naturally, it can also form in the treatment process as a byproduct of the disinfection process. Additionally, it is frequently used in pigments and can be introduced into the collection system during photo processing, newspaper printing, jewelry making, chemicals used to develop photographs, electroplating, and metal cleaning. Cyanide is also a component in many insecticides.

Dioxin

Dioxin was the only other chemical compound quantified in the 2010 effluent samples. The toxic-equivalent concentration of the combined concentrations of dioxin congeners was only about one-third of the level considered a potential threat to human health. Similarly, the dioxin mass emission in 2010 was well below the goal identified in the discharge permit. Low concentrations of dioxin congeners have been detected in nearly all of the MBCSD effluent samples collected during the last decade, although the toxic-equivalent rarely approach the permitted limit. Dioxin is pervasive in the modern environment because it was introduced historically by incineration of municipal and chemical wastes, exhaust from automobiles using leaded gasoline, and improper disposal of chlorinated chemical wastes. Dioxins do not readily decompose and once introduced into the environment, they persist for long periods. Although relic dioxin introduced in the past accounts for much of the concentrations currently measured within the environment, extremely small concentrations of various dioxin congeners can also be formed during chlorination of municipal drinking water and wastewater effluent.

2.3 BIOSOLIDS

The monitoring and reporting requirements of the NPDES permit (RWQCB-USEPA 2009) stipulate characterization of biosolids in accordance with 40 CFR 503 (USGPO 1997b). To that end, this section describes the disposition of biosolids generated by the WWTP during 2010. Part of this discussion also addresses the major compounds within the sludge produced by the plant, because they determine the suitability of biosolids for future composting and land application. The complete biosolids report⁸ was submitted to USEPA, RWQCB, and San Luis County Environmental Health Services on February 16, 2011 and is incorporated herein by reference.

In 2010 the WWTP produced approximately 223 dry metric tons of biosolids. Approximately 130.3 dry metric tons, 58% of the 2010 production, was transported to McCarthy Family Farm's San Joaquin Composting facility on 3 and 5 December 2010. The treatment plant composted the remaining 92.7 dry metric tons. There were no biosolids in storage at the WWTP at the time of this report.

Solids removed by the primary clarifiers (Figure 2.3 on Page 2-14) are processed as shown in the schematic of Figure 2.15. Sludge is stabilized using two mixed-primary digesters heated to 97°F (36°C). Heated sludge is transferred to a secondary digester with heat exchange from the primary digesters. Solids settle in the secondary digester and the supernate is returned to the wastewater treatment process. The primary digester's capacities are 192,000 gallons and 170,544 gallons, and the secondary digester's capacity is 166,000 gallons, giving a total capacity of 528,000 gallons (2 megaL). The clarifiers pump an average of 9,250 gallons of sludge per day to the primary digesters. Average detention times are 57 days. Digester temperature and flow are recorded daily.

Stabilized sludge drawn from the secondary digester is transferred to one of 12 sludge-drying beds, each with a capacity of 5,200 ft² (483 m²).

Each of these beds has an under-drain and decanting system that recirculates runoff through the treatment process. Twelve to 14 inches (33 cm) of sludge is applied to the beds. Drying times typically range from two to four months depending on the weather conditions. Once dried, the biosolids are removed from the beds and stored in a concrete containment area that also drains rainfall runoff through the treatment system. Biosolids are stored in this area until they are removed from the WWTP for composting and eventual use as a soil amendment. Biosolids storage times are generally less than one year.

In the past six years, treatment-plant personnel developed a beneficial-reuse program for biosolids. The program's goal was to implement a cost-effective technique for producing compost that meets the Federal and State Class-A standards for metals, pathogen reduction, and vector-attraction reduction. As a result of their efforts, the plant regularly produces exceptional-quality (EQ) compost. The EQ compost is now

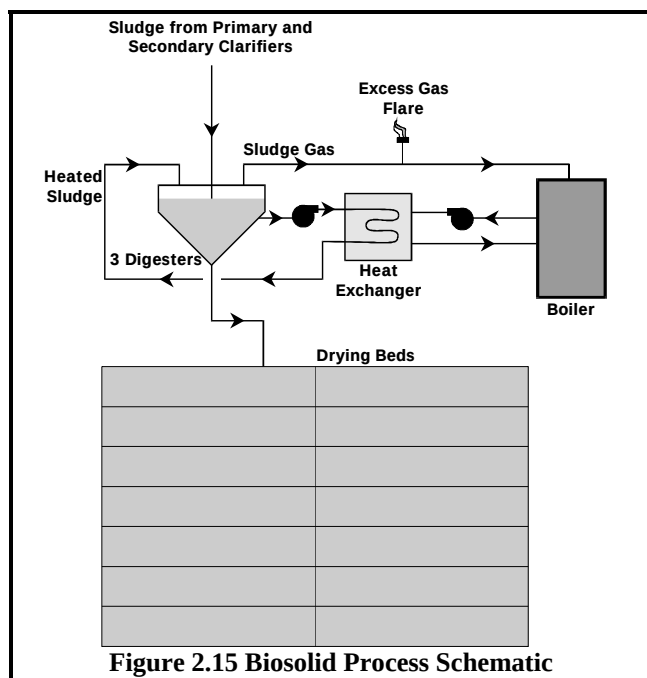


Figure 2.15 Biosolid Process Schematic

⁸ Morro Bay/ Cayucos Wastewater Treatment Plant 2010 Annual Sewage Sludge Report, February 2011.

available to the public for use as a high-quality soil amendment. The composting program utilizes windrow composting similar to that of McCarthy Family Farms.

Biosolids removed from the WWTP in December 2010 were composted at the 162-acre San Joaquin Composting Facility (SJCF) owned by McCarthy Family Farms, Inc. The SJCF is located in Kern County, California, and operates under Solid Waste Facility Permit No. 15-AA-0287 (Permit Resolution No. 1999-96 adopted by the California Integrated Waste Management Board). The SJCF uses windrow and aerated static pile composting to further reduce pathogens and limit vector attraction. Windrows are divided into three temperature-recording stations. A windrow passes the high-temperature phase after all three stations maintain a temperature of 55°C for 15 days and the windrow has been turned at least five times. Six temperature stations are monitored for aerated static pile composting. All six stations must maintain a temperature of 55°C for three days before pathogen reduction is considered complete. After maintaining 40°C for 14 days, reduction of vector attraction is also considered complete.

On 3 and 5 December 2010, the treatment plant sent a portion of the stored, dried biosolids to the composting facility. Prior to shipping, the MBCSD provided a Class-B biosolid certification statement based on chemical analyses performed on biosolid samples collected at the treatment plant. Chemical analyses were conducted on a composite sample collected on 14 September 2010 from the biosolids that were ready for shipment from the treatment plant at the time. Complying with the Monitoring and Reporting Program, the analyses were conducted on a composite of biosolid samples collected from the drying beds. The full laboratory results, including chains of custody, instrument calibration reports, and analyses of method blanks and spikes, were reported by MRS (2010b). They are compared with regulatory limits in Table 2.6.

The data in the tables show that biosolid contaminant concentrations were significantly less than regulatory criteria that would designate them as hazardous, or limit their use for land application or composting. The analyses tested for the presence of more than 150 potential contaminants and measured seven other properties and nutrients within the biosolid sample. Nevertheless, only a few compounds were detected, primarily naturally occurring trace metals.

All trace-metal concentrations were below the total threshold limit concentrations (TTLC) that would designate the biosolids as hazardous. One metal, copper, had a bulk wet-weight concentration that exceeded ten-times the soluble threshold limit concentration (STLC). Accordingly, a waste extraction test (WET) assessed its water solubility. This elutriate test demonstrated that the copper within the biosolids sample had very low solubility with a 9.3-mg/L dissolved concentration that was two and a half times lower than the 25-mg/L STLC level where leaching into groundwater may be of concern. The low solubility shows that the copper was tightly bound into a mineral matrix, with little bioavailability.

The insolubility of copper is further confirmed by the low concentrations found in effluent samples (22 µg/L and 12 µg/L in Table 2.5), which are comparable to the biosolids WET concentration. Copper occurs naturally in the mineralogy of ambient sediments in the coast region and, as a result, its presence in biosolids is not unexpected. Although not required, a WET was also conducted for lead in 2010. This test found a 0.38-mg/L soluble lead concentration that was a full order of magnitude below its respective STLC of 5-mg/L. In any regard, the dry-weight concentrations for all detected metals in the biosolid sample were well below the federally mandated limits, including the monthly limit for materials suitable for agricultural land application (three right-most columns of Table 2.6).

In addition to trace metals, cyanide and four synthetic organic contaminants: ethylbenzene, toluene, xylene, and DEHP, were also detected at quantifiable concentrations within the biosolids sample. Although, cyanide is not typically present in significant amounts in wastewater influent, it can form as a byproduct of the disinfection process and is commonly found in low concentrations in both effluent and

biosolids. Ethylbenzene, toluene and xylene comprise three of the four aromatic hydrocarbon compounds collectively known as BTEX (benzene, ethylbenzene, toluene and xylene). These compounds are primarily associated with gasoline contamination and are also occasionally detected within effluent samples at low concentrations. As discussed in Section 2.2.12, DEHP has been consistently detected at low levels in effluent and biosolids samples collected throughout the past decade. Because of its mobility, high vapor pressure, and the massive scale of production, DEHP has become pervasive in the environment. There are no limits on any of these compounds in State and Federal regulations governing biosolids.

The other compounds listed in Table 2.6 further characterize the biosolids, as required in the waste discharge requirements. Although testing for asbestos is no longer required as part of the NPDES permit, it was included for completeness. Additionally, a modified WET test (STLC) for total dissolved solids was conducted in response to a request from the composter.

Table 2.6. Comparison between Measured Biosolid Concentrations and State and Federal Limits

Constituent	Units	Wet Weight				Dry Weight		
		Measured		Limit		Measured	Limit	
		Bulk	WET ¹	STLC ²	TTLT ³	Bulk	Monthly ⁴	Ceiling ⁵
Solids	%	83.8	— ⁶	—	—	—	—	—
Cyanide	ppm	0.68	—	—	—	0.81	—	—
Antimony	ppm	≈3.2 ⁷	—	15.	500.	≈3.8	—	—
Arsenic	ppm	4.2	—	5.	500.	5.0	41.	75.
Barium	ppm	430.	—	100.	10,000.	510.	—	—
Beryllium	ppm	≈0.23	—	0.75	75.	≈0.28	—	—
Boron	ppm	17.	—	—	—	20.	—	—
Cadmium	ppm	3.4	—	1.	100.	4.0	39.	85.
Chromium (Total)	ppm	45.	—	560.	2500.	54.	—	—
Chromium (Hexavalent)	ppm	<0.4 ⁸	<0.07	5.	500.	<0.5	—	—
Cobalt	ppm	3.8	—	80.	8,000.	4.6	1,500.	4,300.
Copper	ppm	580. ⁹	9.3	25.	2,500.	690.	1,500.	4,300.
Lead	ppm	43.	0.38	5.	1,000.	52.	300.	840.
Mercury	ppm	0.69	—	0.20	20.	0.82	17.	57.
Molybdenum	ppm	21.	—	350.	3,500.	25.	—	—
Nickel	ppm	34.	—	20.	2,000.	41.	420.	420.
Selenium	ppm	6.2	—	1.	100.	7.4	100.	100.
Silver	ppm	4.3	—	5.	500.	5.1	—	—
Thallium	ppm	<0.73	—	7.	700.	<0.87	—	—
Vanadium	ppm	27.	—	24.	2,400.	32.	—	—
Zinc	ppm	1,300.	—	250.	5,000.	1,500.	2,800.	7,500.
Asbestos	%	<1.0	—	—	1.	<1.2	—	—
Bis(2-ethylhexyl) phthalate	ppm	36.	—	—	—	43.	—	—
Ethylbenzene	mg/kg	0.033	—	—	—	0.040	—	—
Toluene	mg/kg	0.036	—	—	—	0.043	—	—
Xylenes	mg/kg	0.11	—	—	—	0.13	—	—
Hydrogen-Ion	pH	6.55	—	—	—	—	—	—
Phosphate	mg/kg	58,000.	—	—	—	69,000.	—	—
Ammonia	mg/kg	5,900.	—	—	—	7,100.	—	—
TKN	mg/kg	32,000.	—	—	—	39,000.	—	—
Organic Nitrogen	mg/kg	26,100.	—	—	—	31,900.	—	—
Nitrate as NO ₃	mg/kg	360.	—	—	—	420.	—	—
Oil & Grease	ppm	34,000.	—	—	—	41,000.	—	—
Total Dissolve Solids	ppm	—	5,600.	—	—	—	—	—

¹ Waste Extraction Tests (WET) measure the soluble leachate or the extractable amount of a substance contained within a bulk sample of biosolids. A WET is indicated if the bulk wet-weight concentration of a contaminant exceeds ten times the STLC.

² Soluble Threshold Limit Concentrations (STLC) apply to the measured concentration in the liquid extract from a biosolid sample, as determined by a WET. Biosolids with leachate concentrations exceeding the STLC are classified as hazardous in the State of California, as described in the California Code of Regulations (CCR 2003).

³ Total Threshold Limit Concentrations (TTLT) apply to the total wet-weight concentration of a contaminant within a bulk biosolid sample consisting of the entire millable solid matrix, rather than just the leachate. Biosolids are designated as hazardous wastes in the State of California if measured bulk concentrations exceed the TTLT, as described in the CCR (2003).

⁴ Federally mandated dry-weight limits imposed on biosolids suitable for application on agricultural land apply to monthly average concentrations as defined in Table 3 of the Code of Federal Regulations (USGPO 1997b). [40 CFR §503.13(b)(1)].

⁵ Federally mandated dry-weight ceiling concentrations above which biosolids are considered hazardous waste as defined in Table 1 USGPO (1997b).

⁶ “—” indicates that the measurement was not required or its limit was not specified.

⁷ Concentrations preceded by an “approximation” symbol (≈) were too low to be reliably quantified and represent estimated concentrations because they were reported below the PQL but above the method detection limit (MDL).

⁸ A “less-than” symbol (<) indicates that the substance was not detected at a concentration above the MDL, which is listed after the “<” symbol.

⁹ Bulk concentrations shown in bold were greater than ten times the STLC and a WET was conducted.

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CHAPTER 3

Receiving Water Quality

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3.0 RECEIVING WATER QUALITY

This chapter describes environmental conditions within the ocean waters immediately adjacent to the MBCSD wastewater discharge during 2010. The first section presents the details of the monitoring program that assesses compliance with the water-quality objectives of the California Ocean Plan (COP; SWRCB 2005) as embodied in the NPDES permit covering the MBCSD discharge (hereinafter referred to as “the NPDES permit,” RWQCB–USEPA 2009). The second section discusses the disposition of the effluent plume within the receiving waters and how it is influenced by the hydraulic design of the outfall and stratification of the receiving waters. The final section of this chapter provides a synopsis of the offshore measurements collected during the four water column surveys conducted in 2010 (MRS 2010cdef) and compares them with the waste discharge requirements specified in the NPDES permit. Quantitative analyses of continuous instrumental measurements and the qualitative visual observations are both addressed in the last section. All of these observations demonstrate that the diffuser structure was operating as designed; it was efficiently diluting treated wastewater within the zone of initial dilution (ZID) that surrounds the outfall.

During all four of the 2010 offshore receiving-water surveys, dilute wastewater was detected within the receiving waters. The weak discharge-related perturbations in the water-property fields indicated that the treated wastewater was rapidly mixed upon discharge, and all of the observed perturbations were small compared to the natural variability in seawater properties observed along this portion of the central California Coast. Projected contaminant concentrations were far below the receiving-water limitations specified in the NPDES permit, and the discharge fully complied with the objectives of the COP. In summary, the highly localized, transient seawater perturbations associated with the effluent discharge were too small to be of environmental significance.

3.1 MONITORING PROGRAM

Wastewater chemistry (Chapter 2), receiving waters (this chapter), and the biology and physicochemistry of seafloor sediments (Chapter 4) constitute the three major components of the MBCSD monitoring program. During 2010 and for the past 24 years, receiving-water monitoring has included quarterly offshore surveys conducted near the wastewater discharge within northern Estero Bay and periodic surfzone coliform sampling along the adjacent shoreline. Measurements collected during the offshore surveys included instrumentally recorded seawater-properties, flow velocity determined from drifter trajectories, qualitative observations of general oceanographic and meteorological conditions, and visual observations of beneficial uses.

3.1.1 Objectives of Sampling

Receiving-water monitoring is required under provisions of a 301(h)-modified NPDES permit to determine compliance with the water-quality objectives of the COP (SWRCB 2005) and the Central Coast Basin Plan (RWQCB 1994). The monitoring program also satisfies the provisions of the Clean Water Act (40 CFR 125.63c) which require a receiving-water monitoring program that “*provide[s] adequate data for evaluating compliance with water quality standards or water quality criteria.*” In addition, water column measurements provide background information on the vertical structure of ambient marine waters near the discharge location. This information aids in estimating minimum initial dilution rates, which occur when the receiving waters are strongly stratified, as described in Section 3.2.2.

3.1.2 Scope of Monitoring

One goal of the monitoring program is to assess whether the discharge meets the water-quality objectives of the COP. These objectives are summarized in Table 3.1, and ensure the reasonable protection of beneficial uses and the prevention of nuisance. They apply to samples collected within the discharge's wastefield after initial dilution has been completed. Initial dilution is the rapid, turbulent mixing of wastewater and seawater in the area immediately surrounding the point of discharge.

Ambient seawater is forcibly entrained into the discharge plume by two physical processes. Close to the diffuser ports, the momentum of the wastewater jet induces turbulent shear that rapidly entrains near-bottom seawater, thereby diluting the effluent. Additional turbulent mixing occurs as the warm, buoyant effluent-seawater mixture rises through the water column. This buoyancy-induced entrainment causes the density of the effluent plume to approach that of ambient seawater (neutral buoyancy) at some point in the water column. Depending on ambient stratification at the time of the discharge, the plume either can reach the surface or become trapped at some intermediate depth level. Thus, initial dilution, where a majority of effluent dilution is achieved shortly after discharge, is complete when the diluting wastewater ceases to rise in the water column and begins to spread horizontally.

To better assess compliance with the COP standards, the receiving-water monitoring program was extensively modified when the previous NPDES permit was issued in 1999 (RWQCB–USEPA 1998b). Prior to 1999, the effluent plume was rarely observed in the instrumental measurements and its lateral extent was largely indeterminate when it was observed. This was partially due to the wide spacing of water-sampling stations that, at that time, coincided with the benthic sampling pattern. Additionally, the earlier permit required collection of discrete water samples to be analyzed for suspended solids, coliform, and oil and grease. This water-bottle sampling was time-consuming and compromised the synoptic nature of the instrumental measurements. Beginning with the 1999 surveys, bottle casts were eliminated and the lateral extent of the survey was reduced from 1000 m to 100 m, while the number of sampling stations was doubled from eight to sixteen. Rapid instrumental sampling within this tighter sampling pattern consistently provided high-resolution synoptic snapshots of the ocean waters immediately surrounding the outfall. As a result, the disposition of the effluent plume has been accurately delineated in all 48 surveys conducted since the beginning of 1999.

Further improvements in the receiving-water monitoring program were implemented in 2009 as part of the current NPDES permit (RWQCB–USEPA 2009). For example, the navigational accuracy of positioning systems had advanced to the point where the location of individual measurements could be precisely determined relative to the discharge point. This precise determination of the plume's spatial extent is important for assessing compliance with water-quality objectives that only apply beyond the ZID. With that in mind, the receiving-water monitoring program in the current permit added a requirement for a tow survey, where the instrumentation package is towed horizontally across and around the diffuser structure at two different depth levels. Collection and analysis of this tow data began with the second-quarter receiving-water survey conducted in 2009, and continued throughout the four surveys conducted in 2010. Additionally, all four surveys conducted in 2010 included the collection of vertical profiles of seawater properties at six sampling stations aligned along a north-south, alongshore, transect within 100 m of the diffuser structure.

Table 3.1 Water-Quality Objectives of the California Ocean Plan

B. Bacterial Characteristics

1. Water-Contact Standards

Within a zone bounded by the shoreline and a distance of 1,000 feet from the shoreline or the 30-foot depth contour, whichever is further [sic] from the shoreline and in areas outside this zone used for water contact sports, as determined by the Regional Board, but including all kelp beds, the following bacterial objectives shall be maintained throughout the water column:

- a. The 30-day geometric mean of the five most-recent seawater samples from each site shall not exceed a total coliform density of 1,000 per 100 ml; a fecal coliform density of 200 per 100 ml; or an enterococcus density of 35 per 100 ml.
- b. A single seawater sample shall not exceed a total coliform density of 10,000 per 100 ml; a fecal coliform density of 400 per 100 ml; an enterococcus density of 104 per 100 ml, or a total coliform density of 1,000 per 100 ml when the fecal to total coliform ratio exceeds 0.1.

The "Initial Dilution Zone" of wastewater outfalls shall be excluded from designation as "kelp beds" for purposes of bacterial standards and Regional Boards should recommend extension of such exclusion zone where warranted to the State Board. Adventitious assemblages of kelp plants on waste discharge structures (e.g., outfall pipes and diffusers) do not constitute kelp beds for purposes of bacterial standards.

2. Shellfish Harvesting Standards

Throughout the water column in all areas where shellfish may be harvested for human consumption, as determined by the Regional Board, the median total coliform density shall not exceed 70 per 100 ml and not more than 10 percent of the samples shall exceed 230 per 100 ml.

C. Physical Characteristics

1. Floating particulates and grease and oil shall not be visible.
2. The discharge of the waste shall not cause aesthetically undesirable discoloration of the ocean surface.
3. Natural light shall not be significantly reduced at any point outside the initial dilution zone as a result of the discharge of waste.
4. The rate of deposition of inert solids and the characteristics of inert solids in ocean sediments shall not be changed such that benthic communities are degraded.

D. Chemical Characteristics

1. The dissolved oxygen concentration shall not at any time be depressed more than 10 percent from which occurs naturally, as a result of the discharge of oxygen demanding waste materials.
2. The pH shall not be changed at any time more than 0.2 units from that which occurs naturally.
3. The dissolved sulfide concentration of waters in and near sediments shall not be significantly increased above that present under natural conditions.
4. The concentration of substances set forth in Chapter II, Table B in marine sediments shall not be increased to levels which would degrade indigenous biota.
5. The concentration of organic materials in marine sediments shall not be increased to levels which would degrade marine life.
6. Nutrient materials shall not cause objectionable aquatic growths or degrade indigenous biota.
7. Numerical water quality objectives in Table B apply to all discharges within the jurisdiction of this plan.

E. Biological Characteristics

1. Marine communities, including vertebrate, invertebrate and plant species, shall not be degraded.
2. The natural taste, odor and color of fish, shellfish, or other marine resources used for human consumption shall not be altered.
3. The concentration of organic materials in fish, shellfish or other marine resources used for human consumption shall not be bioaccumulated to levels that are harmful to human health.

F. Radioactivity

1. Discharge of radioactive waste shall not degrade marine life.

An automated probe system was used to collect precise *in situ* measurements of seawater properties during each of the four quarterly receiving-water surveys of 2010. Measured seawater parameters consisted of temperature, salinity, dissolved oxygen (DO), acidity/alkalinity (pH), and light transmittance (water clarity). Qualitative visual observations made during the offshore surveys provided information on any potential wastewater contributions to levels of floating particulates, seawater discoloration, odors,

algal blooms, and surface water clarity. Wildlife and recreational use, as well as general weather and sea conditions, were also noted.

In addition to the quarterly sampling used to delineate the discharge plume offshore, monitoring of the adjacent surfzone along Atascadero State Beach has historically been conducted to assess aesthetic conditions for the beneficial uses described in Section 2.1.2. Bacteriological conditions along the shoreline are of particular interest for shellfish harvesting and for water-contact recreation, namely swimming and surfing. However, disinfection of MBCSD effluent routinely reduces bacterial densities to levels well below receiving-water standards prior to discharge, and the more than 100-fold dilution that occurs shortly after discharge renders the plant's bacterial loading imperceptible. Consequently, surfzone bacterial samples are too distant to be materially affected by the discharge, and are instead dominated exclusively by onshore sources and runoff (MRS 1994 – 2010). Because of this, the current permit no longer requires regular monitoring of surfzone bacteria, but triggers monitoring at eight surfzone locations along Atascadero State Beach when there is an upset in the WWTP's disinfection process that causes total coliform density in the effluent to exceed 2400 MPN/100 ml. The surfzone stations are located at gradient distances upcoast and downcoast relative to Station C, which is positioned at the onshore site closest to the offshore discharge location (See Table 3.2 and Figure 3.1). During 2010, however, there were no instances of elevated effluent coliform that triggered the requirement for surfzone sampling.

Other beneficial uses, such as fishing and non-water-contact recreation, including beachcombing, boating, and picnicking, were addressed by visual observations of aesthetic conditions noted during the offshore surveys conducted in 2010. These auxiliary observations included weather conditions, ocean currents, tides, and any evidence of water discoloration, floating oil and grease, turbidity, odor, or materials of sewage origin on the beach or in the water.

3.1.3 Sampling Station Design

Offshore receiving-water sampling focuses on the water column close to the discharge location (Figure 3.1). During 2010, water sampling was conducted at six offshore stations situated at three gradient distances upcoast and downcoast from the ZID (Figure 3.2).

The closest portion of the diffuser structure lies 827 m from the shoreline, while the diffuser structure itself extends an additional 52 m toward the northwest along the seafloor (Figure 3.1).

Table 3.2 Target Locations of Surfzone Sampling Stations

Station	Description	Along-Shore Distance ¹ (m)	Latitude ²	Longitude
A1	Upcoast Reference	1330 N	35° 23.967' N	120° 52.116' W
A	Upcoast Midfield	912 N	35° 23.750' N	120° 52.067' W
B	Upcoast Nearfield	488 N	35° 23.517' N	120° 52.000' W
C	Onshore of Diffuser	0	35° 23.250' N	120° 51.950' W
D	Downcoast Nearfield	426 S	35° 23.033' N	120° 51.917' W
E	Downcoast Midfield	922 S	35° 22.767' N	120° 51.9005' W
F	Downcoast Reference	1602 S	35° 22.400' N	120° 51.883' W
G	Morro Creek ³	— ⁴	—	—

¹ Along-shore distance and direction from Station C

² As described in the glossary, all coordinates cited in this report are referenced to the WGS84 datum.

³ Immediately before flowing to the ocean

⁴ Location varies with the along-shore migration of the mouth of Morro Creek.

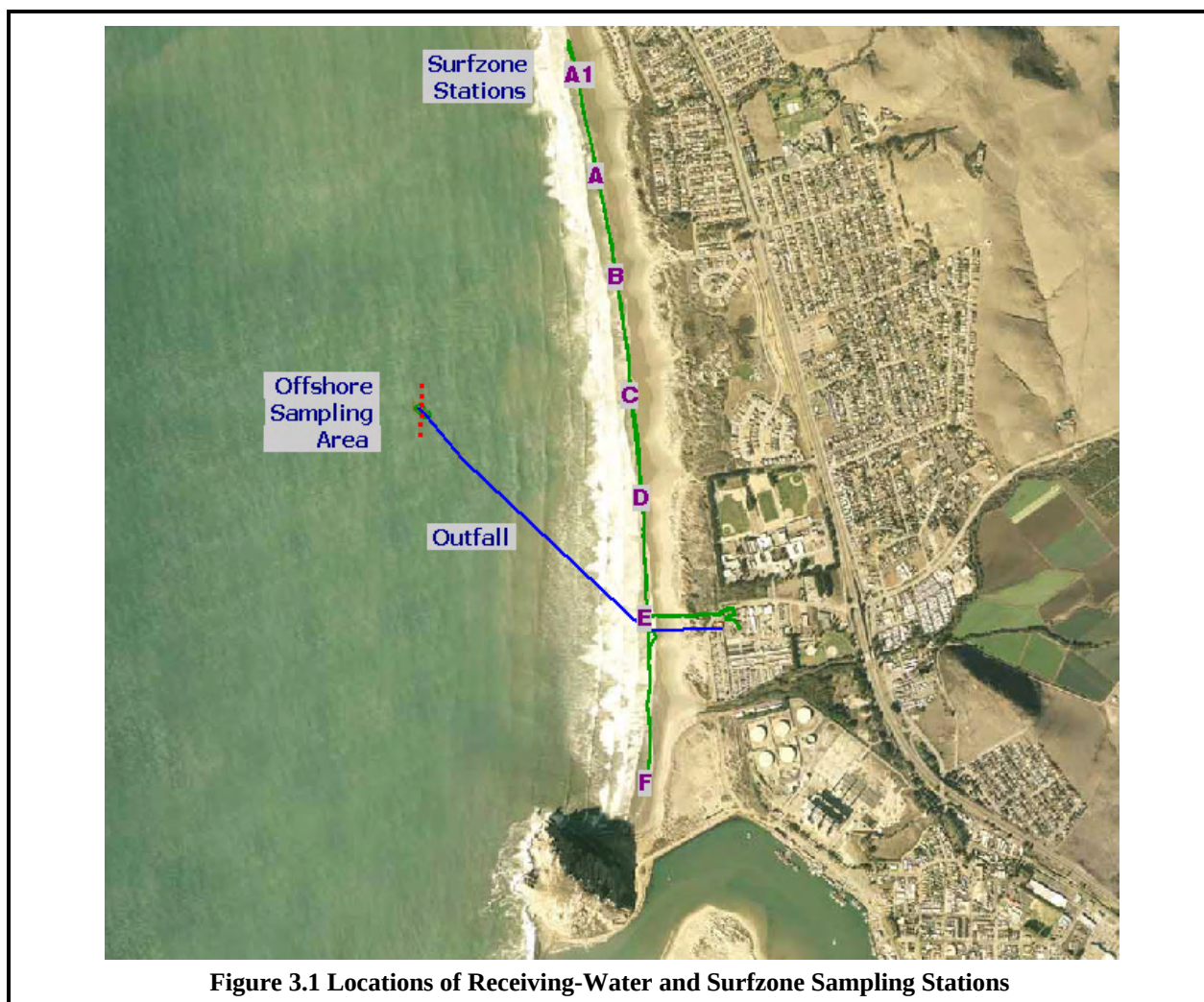


Figure 3.1 Locations of Receiving-Water and Surfzone Sampling Stations

Twenty-eight of the 34 available ports discharge effluent along a 42 m section of the diffuser structure. The diffuser ports were hydraulically designed to rapidly dilute effluent within the receiving seawater immediately upon discharge. Most of this turbulent mixing occurs within a zone of initial dilution (ZID), which extends laterally to a distance of approximately 15 m from the center of the diffuser structure.

Over longer periods, energetic waves, tides, and coastal currents within Estero Bay further disperse the effluent plume within open-ocean receiving waters beyond the ZID. Areas of special concern, such as sanctuaries and estuaries are too distant to be materially affected by the treated wastewater discharge. For example, the southern boundary of the Monterey Bay National Marine Sanctuary is located 38 km to the north, while the entrance to Morro Bay lies 2,800 m to the south of the discharge. In 1995, Morro Bay was included in the National Estuary Program; however, because of its distance from the discharge, incursion of unmixed wastewater into the Bay is highly unlikely. Direct seawater exchange between the discharge point and Morro Bay is restricted by Morro Rock, which lies between the outfall and the south-facing entrance to the Bay. Morro Rock is the largest physiographic feature along the adjacent coastline and extends into Estero Bay approximately 2,000 m south of the point of discharge (Figure 3.1).

During 2010, the discharge's region of influence was evaluated quarterly using water-quality data collected at the six offshore stations situated at three gradient distances upcoast and downcoast from the ZID (Figure 3.2). The two closest stations, which are on the margin of the ZID, were located 15 m from the closest point on the diffuser structure rather than its center point. The remaining more-distant stations were located relative to the center point of the diffuser structure.

It is important to consider the “closest-approach” distance when evaluating impacts at stations near the wastewater discharge. Although the discharge has historically been considered a “point source” for most large-scale modeling purposes, it does not occur at a single location of infinitesimal size. Because the discharge is distributed along a 42 m section of the seafloor, its finite size affects assessments of wastewater dispersion at sites close to the discharge. Specifically, the amount of wastewater dispersion at a given point in the water column is determined more by its distance to the closest diffuser port rather than its distance to the center point of the diffuser structure. Near the source, this “closest-approach” distance can be much less than the actual distance to the center of the diffuser structure (Table 3.3, Figure 3.2). As such, it would be unsuitable to design a nearfield sampling pattern based on center-point distances rather than closest-approach distances.

With the closest-approach distances in mind, the six monitoring stations were aligned along a north-south axis at the same isobath (15.2 m) as the diffuser center point. Receiving-Water Stations RW3 and RW4 were positioned at the boundary of the ZID at a distance of 15 m upcoast and downcoast of the closest diffuser ports (Table 3.3). Stations RW2 and RW5 were located at nearfield distances (60 m) from the diffuser center point. Midfield Stations RW1 and RW6 represent reference stations situated 100 m upcoast and downcoast of the center point. Depending on the direction of the local oceanic currents at the time of sampling, one or more of these near and midfield stations could conceivably be influenced by wastewater discharge. Under those circumstances, the midfield station on the opposite side of the diffuser acts as a reference station. Comparisons of water properties at these antipodal stations quantify departures from ambient seawater properties used in the evaluation of compliance with the NPDES discharge permit.

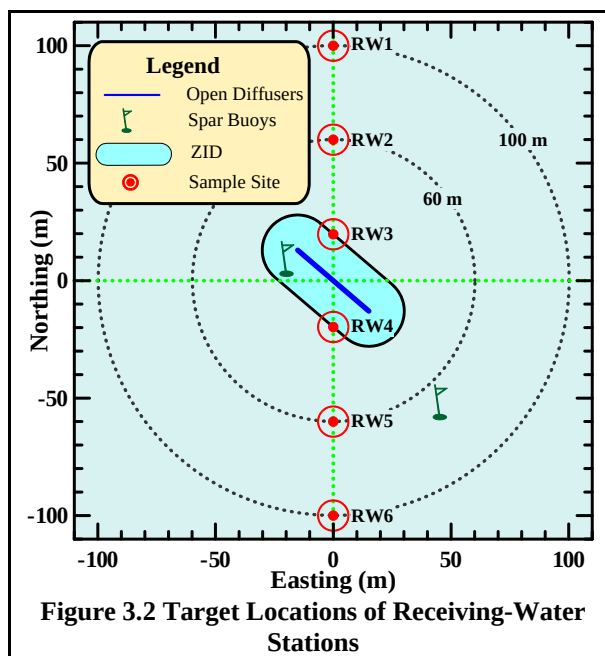


Table 3.3 Target Locations of Receiving-Water Stations

Station	Description	Latitude	Longitude	Closest Approach Distance ¹ (m)	Center Distance ² (m)
RW1	Upcoast Midfield	35° 23.253' N	120° 52.504' W	88.4	100
RW2	Upcoast Nearfield	35° 23.231' N	120° 52.504' W	49.4	60
RW3	Upcoast ZID	35° 23.210' N	120° 52.504' W	15.0	20
RW4	Downcoast ZID	35° 23.188' N	120° 52.504' W	15.0	20
RW5	Downcoast Nearfield	35° 23.167' N	120° 52.504' W	49.4	60
RW6	Downcoast Midfield	35° 23.145' N	120° 52.504' W	88.4	100

¹ Distance from the closest open diffuser port

² Distance to the center of the open diffuser section

3.1.4 Navigation

Vessel positioning within the compact offshore sampling pattern has improved with the availability of Differential Global Positioning Systems (DGPS). DGPS, with typical position errors of less than 4 m, significantly enhances the accuracy of traditional GPS navigation systems, which have position errors as large as ± 15 m, a span half the width of the ZID itself. At the beginning of 1998, the survey vessel F/V *Bonnie Marietta* was fitted with a Furuno™ GPS 30 and FBX2 differential beacon receiver. This navigational system was used on 29 July 1998 to precisely locate the position of the open section of the diffuser structure (MRS 1998b). Carson Porter, a diver performing the annual outfall inspection, deployed temporary buoys marking the first and last open diffuser ports. The DGPS locations of these buoys were then used to establish the new target locations for the offshore monitoring stations listed in Table 3.3.

Specifying the precise location of each measurement relative to the diffuser is crucial for accurate interpretation of the water property fields. For example, during vertical profiling, the actual sampling locations do not coincide with the exact target coordinates listed in Table 3.3. The combined influences of winds, waves, and currents induce vessel offsets of tens of meters within the minute or so it takes to complete the water-property profile at each station. Even during quiescent periods, drift is induced by residual vessel momentum remaining after station approach. Prior to the use of DGPS, these offsets could not be resolved by the available navigation, but, during the 2010 surveys, the sampling locations were precisely determined throughout the vertical profiling conducted at each station.

Determination of vessel drift during vertical profiling is an important consideration because it caused some of the measurements in 2010 to be collected within the ZID, where the water-quality objectives in the COP do not apply (see shaded entries in Table 3.4). The average closest-approach distances in Table 3.4 can be compared with the target offsets listed in Table 3.3 to assess the fidelity of the sampling locations with respect to diffuser-structure proximity. From the standpoint of an ideal compliance evaluation, all measurements would be made at or beyond the ZID boundary, namely, at distances of more than 15 m from the diffuser structure. However, measurements collected well within the ZID, and close to the diffuser structure, are also valuable because they capture the dynamics of the plume undergoing rapid initial mixing, and lend timely insight into the dispersive capabilities of the diffuser structure. These close-in measurements have demonstrated that the MBCSD discharge routinely meets the COP receiving-water objectives well within the ZID.

Table 3.4 Station Proximity to the Discharge

Station	Description	Closest-Approach Distance ¹ (m)				
		Target	January	April	August	October
RW3	Upcoast ZID	15.0	23.2	21.6	15.3 ²	10.7
RW4	Downcoast ZID	15.0	10.2	0.9	0.3	7.1
RW2	Upcoast Nearfield	49.4	61.1	52.7	54.8	49.7
RW5	Downcoast Nearfield	49.4	44.2	48.7	41.9	56.9
RW1	Upcoast Midfield	88.4	87.0	91.7	97.4	101.7
RW6	Downcoast Midfield	88.4	80.3	88.7	87.1	94.0

¹ Distance from the closest open diffuser port to the average station position

² All or portions of the profiles highlighted in bold typeface with shading were sampled within the ZID.

3.1.5 Sampling Equipment and Methodology

The 38-ft F/V *Bonnie Marietta*, owned and operated by Captain Mark Tognazzini of Morro Bay, provided vessel support for the four offshore surveys in 2010. Bonnie Luke and Douglas Coats of Marine Research Specialists (MRS) provided scientific support and Captain Tognazzini supervised vessel and deck-equipment operations, while William Skok served as marine technician.

Standard observations for weather, seas, water clarity/coloration, Secchi depth, and the presence of any odors and floating debris were recorded during the surveys. Wind speeds and air temperatures were measured with a Kestrel® 2000 Thermo-Anemometer. These observations were collected during the vertical profiling conducted at each of the six stations.

Auxiliary Measurements

As vertical profiles were collected at each station, a Secchi disk was lowered through the water column to determine its depth of disappearance. This provided a visual measure of the water clarity within the upper water column. The depth of disappearance is inversely proportional to the average amount of organic and inorganic suspended material along a line of sight immediately below the sea surface. As such, Secchi depth is a measure of ambient light penetration, which can be limited during upwelling when plankton density increases within the near-surface euphotic zone. The depth of the euphotic zone, where most oceanic photosynthesis occurs, extends to approximately twice the Secchi depth. Because Secchi depths are less precise than measurements collected with electronic sensors, these and the other qualitative observations described above, were ancillary to the digital measurements of seawater parameters collected throughout the water column.

At the beginning of each survey, a drifter was deployed at the center of the open section of the diffuser structure. The drifter was drogueed at mid-depth (7 m) using the curtain shade design of Davis et al. (1982). In this configuration, the drifter trajectory was largely determined by the oceanic flow field rather than surface winds. Satellite navigation onboard the drifter allowed continuous recording of the precise time and position of the drifter trajectory throughout its deployment, and the vessel's locations during deployment and recovery were recorded for navigational intercomparison. These trajectory measurements established the ambient flow velocity throughout each survey, and indicated the path of plume transport for use in the interpretation of seawater property distributions.

At the beginning of the August 2010 survey, the drifter was irretrievably lost due to a failure in the drogue's harness attachment. A substitute drogue was utilized to complete the survey, and a replacement drifter was constructed prior to commencement of the October 2010 survey. The new drifter is slightly larger (by approximately one-third), although otherwise comparable to the original drifter in its design.

Instrumental Measurements

A Sea Bird Electronics SBE-19 Seacat CTD⁹ instrument package was deployed in both a vertical water-profiling mode, as well as a horizontal-tow configuration. It collected measurements of conductivity, temperature, light transmittance, dissolved oxygen (DO), pH, and pressure at a sampling rate of 2 Hz (0.5-s intervals). A submersible pump on the CTD continuously flushed water through the conductivity cell and oxygen plenum at a constant rate, independent of the CTD's motion through the water column.

The CTD instrument package receives regular maintenance and calibration. After the October 2001 survey, the CTD was returned to the factory for comprehensive testing, repair, and calibration. The DO

⁹ Conductivity, temperature, and depth (CTD)

and pH sensors were returned to the factory in May 2003 and June 2006 for testing and calibration. Because of increasing temporal drift associated with aging DO probes, the DO probe was replaced on both occasions. As is the case before all surveys, the CTD system was calibrated at the MRS laboratory prior to each of the 2010 surveys. The upper-bound DO calibration point at full saturation was established by immersing the CTD in an aerated, temperature-controlled calibration tank. Similarly, a zero-oxygen calibration point was determined by filling the oxygen-sensor plenum with an 8% solution of sodium sulfite (Na_2SO_3). Oxygen calibration coefficients were determined by regression analysis of sensor-membrane current and temperature, as recommended by the manufacturer (SBE 1993). The pre-cruise calibration coefficients determined by MRS closely corresponded with prior factory calibrations.

The six seawater properties used to assess receiving-water quality in this report were derived from the continuously recorded output of the CTD's probes and sensors. Pressure housing limitations on the combination oxygen/pH sensor confine the CTD to depths less than 200 m (Table 3.5), which is well beyond the maximum depth of the deepest station in the

Table 3.5 CTD Specifications

Component	Depth ¹	Units	Range	Accuracy	Resolution
Housing	600	—	—	—	—
Pump	3400	—	—	—	—
Pressure	680	psia	0 to 1000	± 5.0	± 0.5
Depth	—	meters	0 to 690	± 3.0	± 0.3
Conductivity	600	Siemens/m	0 to 6.5	± 0.001	± 0.0001
Salinity	600	‰	0 to 38	± 0.006	± 0.0006
Temperature	600	° C	-5 to 35	± 0.01	± 0.001
Transmissivity	2000	%	0 to 100	± 0.1	± 0.025
Dissolved Oxygen	200	mg/L	0 to 21.5	± 0.14	± 0.014
Acidity/Alkalinity	200	pH	0 to 14	± 0.1	± 0.006

¹Maximum depth limit in meters

outfall survey. The precision and accuracy of the various probes, as reported in manufacturer's specifications are also listed in the Table. Salinity (‰) was calculated from conductivity measurements reported in units of Siemens/m. Density was derived from contemporaneous temperature (°C) and salinity data, and was expressed as 1000 times the specific gravity minus one, which is a unit of sigma-T (σ_t).

All three of the physical parameters (salinity, temperature, and density) helped determine the lateral extent of the effluent plume during the towing phase of the survey. Additionally, during the vertical-profiling phase, they quantified layering, or vertical stratification and stability of the water column, which determines the behavior and dynamics of the effluent as it mixes with seawater within the ZID. Data on the three remaining seawater properties, light transmittance (water clarity), hydrogen-ion concentration (acidity/alkalinity – pH), and dissolved oxygen (DO), further characterized receiving waters and were used to assess compliance with water-quality criteria. Light transmittance was measured as a percentage of the initial intensity of a transmitted beam of light detected at the opposite end of a 0.25-m path. Increased transmittance indicates increased water clarity and decreased turbidity.

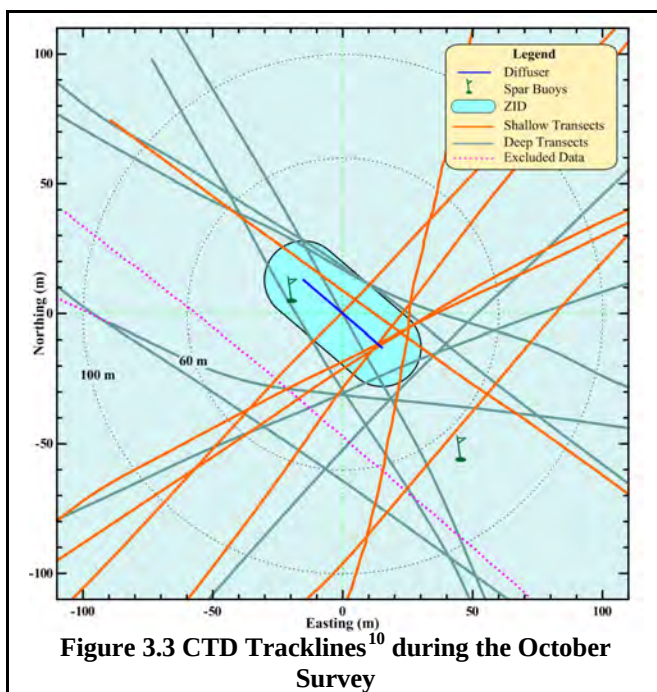
During the pre-cruise calibrations, coefficients for the pH sensor were determined from a linear regression of output voltage after immersion in six separate buffered solutions of known pH. Buffering solutions with a pH of 4 ± 0.01 , 6 ± 0.01 , 7 ± 0.01 , 8 ± 0.01 , 9 ± 0.02 , and 10 ± 0.02 were used to bracket the range of in situ measurements. The SeaTech transmissometer was air calibrated by fitting the voltages recorded with and without blocking of the light transmission path in air, as recommended by the manufacturer (SBE 1989). Algorithms that converted sensor voltage to engineering units during processing of the field data relied on calibration coefficients determined before the survey.

Comparison with the factory calibration of the entire CTD package conducted in December 2001, and the more recent June 2006 replacement and calibration of the DO probe, confirmed the continued accuracy

and stability of the temperature, pressure, and conductivity sensors, as well as the operational integrity of the oxygen and pH probes. To correct for a slight drift in the pressure strain gauge since its calibration in 2001, a -0.25 Psia offset was incorporated in the conversion to depth measurements. In addition, slight temporal trends in pH, and occasionally DO, arose from the ongoing equilibration of these sensors during some of the surveys. The trends were removed by fitting smooth orthogonal polynomials to the sensor time series. Maximum adjustments were small, and on the order of sensor accuracy.

During its initial deployment for each survey, the CTD was held below the sea surface for an equilibration period. Subsequently, the CTD was raised to within 0.5 m of the sea surface and vertical profiling commenced. The CTD was lowered at a continuous rate of speed to the seafloor. Measurements at all six stations were collected during a single deployment of the CTD package by towing it below the water surface while transiting between adjacent stations. Upon retrieval of the CTD, the data were downloaded to a portable computer and examined for completeness and range acceptability. Data collected during vertical profiling were processed in accordance with standard analysis procedures (SCBFMC 2002), which resulted in bin-averaged data across 0.5-m standard depth intervals. The profile data were collated in individual survey reports (MRS 2010cdef), and digitally archived within the USEPA STORET database.

Following collection of the vertical profiles, the CTD was redeployed and continuously towed around and across the ZID at two separate depths in accordance with the receiving-water monitoring requirements of the current NPDES discharge permit. An example of the tow pattern, from the fourth-quarter survey, is shown in Figure 3.3. As seen in the figure, the sampling pattern during this survey was shifted slightly to the southeast, in the prevailing direction of the midlevel flow, to better capture the full extent of the plume as it rose through the water column. Prior to the tow survey, the CTD instrument package was fitted with a depth-suppressor and horizontal stabilizer to achieve constant-depth tows with forward-looking sensor probes. The appropriate length of towline was deployed, and the reconfigured CTD package was towed near the sea surface, passing close to the diffuser structure at least five times. Subsequently, an additional length of towline was paid-out, and at least five additional passes were made at mid-depth.



3.2 PLUME DISPERSION

Offshore monitoring is conducted to determine whether the wastewater discharge is causing significant impacts on the receiving waters of Estero Bay beyond the ZID. Section 3.3.1 makes this determination by comparing the water quality at the boundary of the ZID, and gradient areas beyond the ZID, with

¹⁰ Data were excluded along one of the shallow-tow transects (dashed purple line) because the CTD snagged a piece of drift kelp, which resulted in the acquisition of data at much shallower depth than the other transects

background water properties. However, the complex interaction between physical oceanographic processes and ambient seawater properties near the outfall makes detection of the relatively minor discharge-related changes challenging. The significance of potential water-quality impacts is assessed through a comparison between the amplitude of discharge-related anomalies and the inherent variability in ambient seawater properties. Statistically speaking, if the amplitude of the effluent anomaly is small compared to the inherent variability in ambient seawater properties, then the impact cannot be deemed significant.

The first two subsections of this section describe the nature of wastewater dispersion from the MBCSD diffuser structure. The first subsection discusses the configuration of the multiport diffuser structure and describes how its hydraulic design determines the dimensions of the ZID. The second subsection describes the dynamics of the rapid mixing that occurs within the ZID immediately after discharge from the diffuser.

The last two subsections describe oceanographic processes that affect ambient seawater properties within northern Estero Bay, and quantifies ranges in natural variability caused by these processes. These measures of natural-variability are used to establish thresholds for determining whether discharge-induced changes are significant. Regional processes cause major fluctuations in the character of the receiving waters near the diffuser, and large seasonal changes in the vertical structure directly affect the dispersive capability of the outfall.

3.2.1 Zone of Initial Dilution

Treated wastewater from the MBCSD WWTP is discharged into northern Estero Bay through a 1,450-m outfall-diffuser system (Table 3.6). The existing outfall was constructed in 1982 with an upgraded 0.686-m diameter steel pipe lined and coated with cement mortar. The outfall extends to a water depth of about 15.2 m (50 ft), approximately 0.5 nautical miles offshore of Atascadero State Beach. At its terminus is a multiport linear diffuser consisting of 34 ports, each 5.08 cm in diameter. The ports are spaced 1.52 m apart on alternating sides of the pipe. The current level of discharge from the WWTP only requires the use of 28 of the 34 available ports.

For regulatory and modeling purposes, an idealized ZID is envisioned around the diffuser structure, where the most intense turbulent mixing of effluent is thought to take place shortly after discharge. It is assumed to extend beyond the dimensions of the diffuser structure to a horizontal distance equal to the water depth (USEPA 1994). The water depth at the center point of the diffuser structure is 15.24 m (50 ft) measured relative to the MLLW tidal datum. Consequently, the ZID forms a vertical cylinder whose horizontal cross-section is an elongated ellipse as shown in Figure 3.2 on Page 3-6. Based on the diffuser specifications, the dimensions of the ZID are 73.15 m (240 ft) in length, 31.2 m (102.4 ft) in width, and 15.24 m (50 ft) in height. The length is twice the water depth (15.24 m)

Table 3.6 Hydraulic Characteristics of the Outfall

Parameter	Measurement
Outfall diameter (m)	0.686
Outfall length (m)	
Land	207
Ocean	1,449
Diffuser diameter (m)	0.686
Diffuser length (m)	51.8
Port orientation (° from horizontal)	0
Port diameter (m)	0.0508
Orifice contraction coefficient	0.89
Center point depth of outfall ports (m MLLW)	15.2
Number of ports open	28 ¹
Port spacing ² (m)	1.52
Design flow rate for each port (m ³ /s)	0.01 ³

¹ 28 of 34 ports available.

² Ports are located on alternating sides of the diffuser. Distance between ports on the same side of the diffuser is 3.04 m.

³ Flow rate assuming 34 ports open in a total flow of 0.340 m³/s (7.76 MGD). The outfall design capacity is 0.358 m³/s (8.17 MGD).

added to the 42.67 m (140 ft) long diffuser section where ports are open. The width of the ZID is twice the water depth added to the inside diameter (0.68 m) of the diffuser pipe. Coatings, which add 0.2 m to the outside diameter of the pipe, and the angled diffuser ports, which extend beyond the edge of the pipe, were neglected for the purposes of determining ZID dimensions. The ZID covers an ocean surface area of approximately 3000 m².

In reality, at any given time, the actual initial dilution zone departs markedly from the idealized vertical cylinder described above. On a regular basis, the prevailing current flow carries the effluent plume beyond the boundaries of the idealized ZID, long before it achieves buoyant equilibrium and before initial mixing is complete. Nevertheless, because wastewater is rapidly diluted immediately upon discharge, and well before initial mixing is fully realized, the water-quality objectives of the COP are consistently met, even within the boundary of the ZID.

3.2.2 Critical Initial Dilution Ratio

Shortly after discharge, wastewater dilution is determined by the physical characteristics of the diffuser system and stratification within the receiving waters. The most rapid mixing occurs close to the diffuser structure within the ZID. There, the turbulent processes associated with the high-velocity discharge jet emanating from the diffuser ports, and the buoyant rise of the effluent plume through the water column, result in the rapid dilution of discharged wastewater. Subsequent transport and dispersion by regional oceanographic processes further dissipate the effluent, albeit at a slower rate. The dispersion associated with these oceanographic processes is not considered part of initial dilution.

The limiting concentrations for wastewater constituents specified in the NPDES permit (see Chapter 2) were determined by applying the critical initial dilution ratio for the MBCSD outfall to the open-ocean water-quality objectives specified in the COP for individual contaminants (Table B of SWRCB 2005). The critical initial dilution applicable to the MBCSD outfall was conservatively estimated to be 133:1 (Tetra Tech 1992). The following example shows how this dilution factor was applied to determine the wastewater limits that were established for cadmium in the NPDES permit. The COP's water-quality objective for cadmium in receiving waters has an instantaneous maximum concentration of 0.01 mg/L or less (SWRCB 2005). Based on modeling under extremely stratified conditions, there will be at least 133 parts of ambient water mixed with each part of wastewater after completion of initial mixing. From the definition of dilution (Fischer et al. 1979), the concentration of a particular contaminant in wastewater is given by:

$$C_e \equiv C_o + D (C_o - C_s) \quad \text{Equation 3.1}$$

where: C_e = the concentration of a constituent in the wastewater effluent,
 C_o = the concentration of the constituent in the ocean after dilution by D ,
 D = the dilution ratio of the volume of seawater mixed with wastewater, and
 C_s = the background concentration of the constituent in ambient seawater.

The background concentration (C_s) for cadmium in seawater is negligible so the wastewater limit is ($D+1$) times the COP objective (C_o). Thus for cadmium, the instantaneous maximum concentration in wastewater should be no more than 1.34 mg/L, or 134 times the seawater objective of 0.01 mg/L. Thus, under the worst-case scenario, wastewater containing 1.34 mg/L of cadmium will dilute to a concentration of 0.01 mg/L upon reaching the boundary of the ZID, and the receiving water objective will be met. This is how the maximum effluent limit on cadmium concentration (1.34 mg/L) was established in the NPDES discharge permit granted to the MBCSD.

The foregoing calculation demonstrates how strongly the assumed initial dilution influences the wastewater limitations that are specified in the discharge permit. Because a low value (133:1) was specified for the critical initial dilution, conservative wastewater limitations have been established for the MBCSD discharge. As discussed in Section 3.3.1, however, direct observations collected close to the diffuser during the 2010 surveys indicate that dilutions much higher than 133:1 were achieved well within the ZID and below the assumed plume-trapping depth of 6.4 m. In fact, the original plume modeling that established the 133:1 critical dilution (Tetra Tech 1992) included 34 open diffuser ports instead of the 28 ports that are currently in use, thereby underestimating the flow rate from individual diffuser ports. Additionally, the model applied an especially stringent vertical stratification that is not generally representative of the receiving waters close to the outfall.

Specifically, the critical initial dilution computed by the original modeling was overly conservative because the density profile used to establish the MBCSD critical initial dilution was collected 1 km south of the diffuser structure, where the water column was highly stratified due to the influence of the thermal discharge from the Morro Bay power plant¹¹. At the time the “critical” density profile was measured, the energy plant was discharging heated water to the ocean near Station F next to Morro Rock (see Figure 3.1 on Page 3-5).

Because this monitoring station consistently exhibited anomalous water properties relative to ambient conditions near the MBCSD outfall, it was discarded when the receiving-water monitoring program was revised in 1999. Nevertheless, the original plume modeling, which established both the critical initial dilution ratio currently applied to the outfall and present effluent limits, incorporated a heavily stratified profile from this station. The model predicted that the receiving waters would trap the effluent plume 6.4 m below the sea surface. More recent dilution modeling, however, demonstrates that with the weaker vertical stratification typical of the water column near the diffuser, a critical initial dilution of approximately 200:1 with a plume trapping depth of 1.4 m is more representative of worst-case outfall performance (Lindstrom 1998).

Nevertheless, even with dilutions of only 133:1, the highly sensitive CTD instrumentation would have a difficult time detecting the signature of the wastewater discharge except very close to diffuser ports. Accordingly, most wastewater-induced perturbations in water quality are imperceptible beyond the ZID, particularly in the presence of the large, natural oceanic variability that exists within northern Estero Bay.

3.2.3 Regional Oceanographic Processes

A broad suite of complex oceanographic processes determines the disposition of coastal marine waters within northern Estero Bay. Close to shore, an energetic wave field occasionally dominates the oceanographic conditions along this section of the central California coast. This wave energy increases the turbulence within nearshore waters and causes significant sediment resuspension and sand transport along the outfall corridor. Farther offshore, bands of counter currents move ocean waters in alternating directions along the continental shelf.

¹¹ The plant is currently owned by Icahn Enterprises, but has formerly been owned by the following entities: Pacific Gas and Electric, Duke Energy, LS Power Group, and the Dynegy Corporation.

This large-scale, along-shore current flow is interrupted by cross-shore tidal currents and by turbulent jets that occasionally form at major promontories such as Point Piedras Blancas, Point Buchon, and Point Arguello. These narrow, energetic jets transport materials far from the coast, and they are repeatedly observed extending from upwelling centers located south of major coastal headlands in satellite imagery (Figure 3.4). In addition to these processes, wind-driven upwelling alters the vertical distribution of water properties within Estero Bay and contributes to the remarkably high productivity of the marine waters there.

The open-ocean flow field largely controls ambient seawater properties within Estero Bay. Beyond the continental slope (>50 miles), the diffuse southward-flowing California Current represents the eastern limb of the clockwise-flowing gyre that covers much of the North Pacific Ocean. Before turning south to form the California Current, subarctic water is carried along at high latitudes where it is exposed to atmospheric cooling, nutrient regeneration, and precipitation. As a result, the waters of the California Current are characterized by a seasonably stable low salinity (32‰ to 34‰), low temperature (13°C to 20°C), and high nutrient concentration. Because of this stabilizing effect, seawater off the central-coast undergoes less seasonal variation than surface waters at similar latitudes along the eastern seaboard.

Immediately shoreward of the California Current, along the continental slope and shelf, is a countercurrent that carries water northward from the Southern California Bight. These southern waters are warmer, more saline, and less oxygenated than waters farther offshore. This northward-flowing Davidson countercurrent exhibits strong seasonal variability in intensity. Nevertheless, it maintains a sustained northward flow near Estero Bay, despite reversals observed elsewhere along the California Coast (Coats et al. 1991). The seasonal variability in the Davidson countercurrent coincides with large-scale changes in coastal winds.

Throughout much of the year, winds along the central coast blow from the northwest, parallel to the coast and in opposition to the northward-flowing Davidson countercurrent. These strong southwestward winds induce upwelling near Points Estero, Buchon, and Sal. During the upwelling season, surface water near the coast is transported offshore and is replaced by deep cool, nutrient-rich seawater as shown in Figure 3.4. When these southwestward winds relax, usually between December and February, the Davidson countercurrent is usually strongest. A spring transition back to strong southwestward winds typically occurs fairly rapidly between March and June.

Significant inter-annual variations in oceanographic and marine biological properties also occur along the central California coast, and have strongly influenced the waters of Estero Bay throughout the last half century (Figure 3.5). These large amplitude variations are associated with the El Niño–Southern Oscillation (ENSO), which cycles at a period of 3 to 5 years (Graham and White 1988). El Niño and its counterpart, La Niña, are oscillations of the ocean-atmosphere system in the tropical Pacific. El Niño is characterized by unusually warm sea surface temperatures and La Niña by unusually cool temperatures in

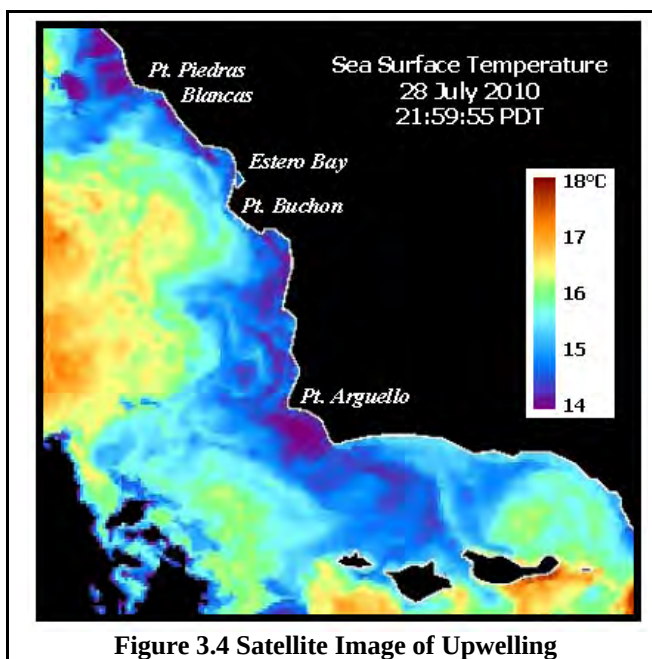
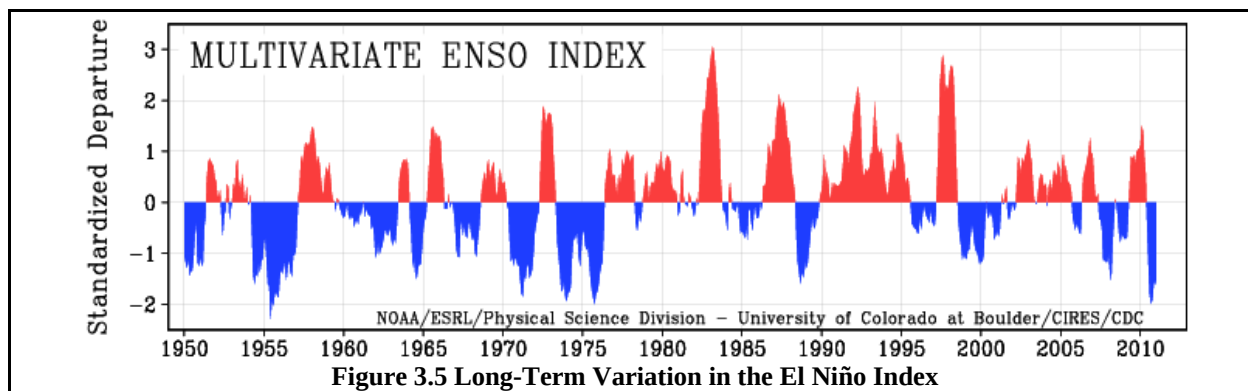


Figure 3.4 Satellite Image of Upwelling



the equatorial Pacific Ocean. For example, the dark blue areas in the center of the satellite image in Figure 3.6 depict abnormally cool sea surface temperatures present in the Central and Eastern Tropical Pacific during late 2010 that are indicative of an unusually strong La Niña event.

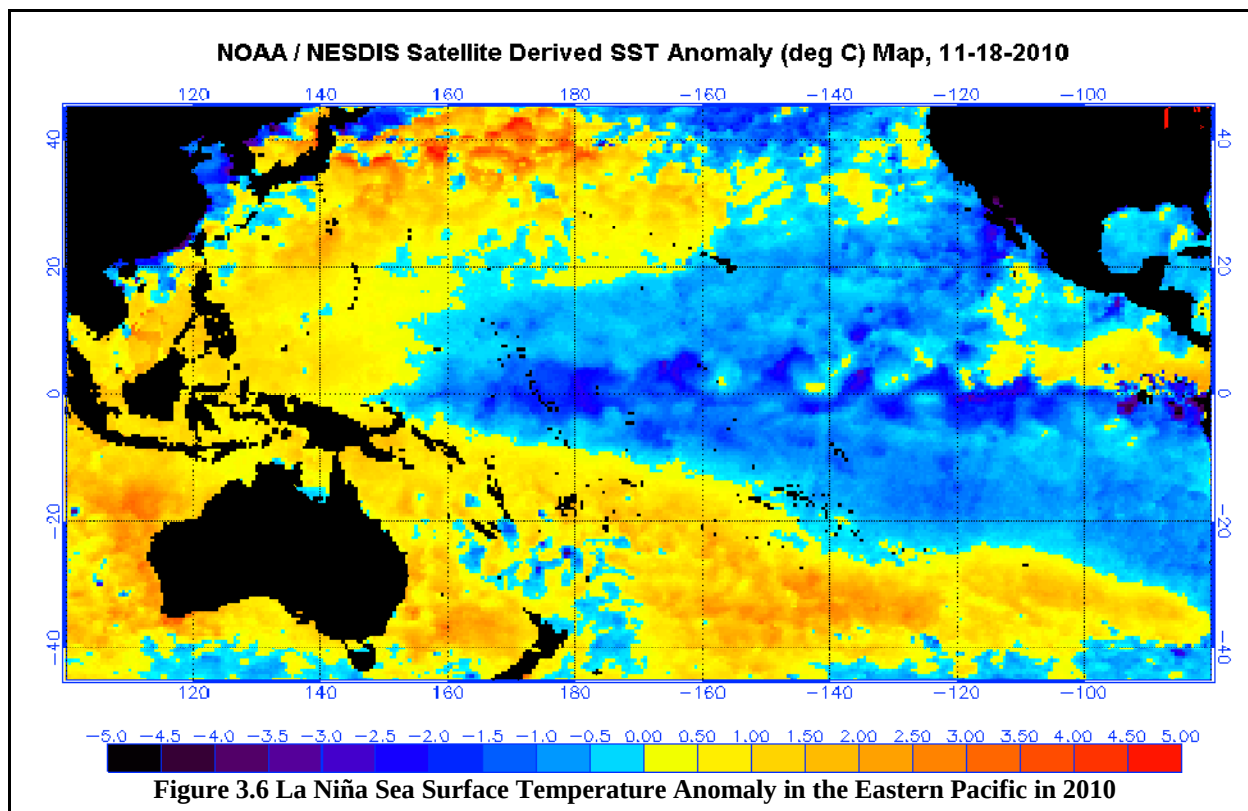
Typically, each period in the cycle lasts approximately 12 months (Figure 3.5). During strong El Niño periods, such as between 1982 and 1983, and between 1997 and 1998, basin-wide changes in the dynamic balance of wind-driven currents result in modified flow patterns along the coastline of western North and South America (Chelton et al. 1982). Changes in the study region include an anomalous strengthening of Davidson countercurrent outflow from the Southern California Bight. El Niño events also generally coincide with increased winter storm activity, reductions in zooplankton biomass, and the introduction of marine organisms typically found far to the south. For example, the relatively strong El Niño condition that was present during the latter half of 1997 and the beginning of 1998, resulted in a substantial increase in rainfall during the early part of 1998, and heavily impacted central-coast ocean waters and associated biota.

The most recent El Niño oscillation began in the summer of 2009, and grew substantially in strength during the fall of 2009. However, this moderate to strong El Niño (NOAA 2010) ended abruptly in May 2010 and was followed by a rapid transition to a very pronounced La Niña phase, the like of which has not been seen in over 35 years (Figure 3.5).

During La Niña events, high pressure builds in the eastern equatorial Pacific while low pressure develops to the west, producing a stronger equatorial pressure gradient. The easterly trade winds strengthen, causing upwelling off the coastlines of Peru and Ecuador to intensify, and lowering sea surface temperatures throughout the Eastern Pacific Ocean (dark blue areas in center of Figure 3.6), including along California's central coast.

Stronger-than-normal winds measurably increased the persistence and strength of upwelling events along the central coast throughout the summer of 2010. Combined with the rapidly strengthening La Niña condition, this acted to depress seawater temperatures in the region well below normal levels. In fact, seawater temperatures at the nearby Diablo Canyon Nuclear Power Plant intake averaged only 12° C throughout most of the spring and summer. This is a full two degrees cooler than normal for this time of year, and represents the lowest average temperature since records started being kept in 1976.

In addition to, and superimposed on these large-scale oceanic flows are a variety of transient phenomena including intense eddies, swirls, filaments, meanders, and narrow jets of flow. Many of these cross-shore turbulent features are evident in the complex surface flow pattern depicted in satellite images. For example, in Figure 3.4, a series of upwelling-induced cold-water jets, delineated in shades of purple and dark blue, emanate from major coastal promontories. Some of these jets, such as those near Pt. Arguello,



extend far offshore, while others, such as those near Pt. Buchon and Pt. Piedras Blancas, form recirculating eddy-like features closer to shore. Embedded in these large-scale features are smaller filaments of flow that add further complexity to the surface flow pattern. All of these cross-shore flow features are capable of transporting significant quantities of coastal heat, nutrients, and pollutants to offshore waters (Savoie et al. 1991).

Tidal currents provide another mixing mechanism for ocean waters in the study region, although they are not responsible for significant net transport. Estero Bay experiences astronomical tides of diurnal inequality, meaning that the two daily sets of tidal extrema are of unequal amplitude. Tidal fluctuations of as much as 2.1 m can combine with storm surges of up to 0.3 m. Typically, however, the tidal range near the outfall site is approximately 1 m between mean high and low water.

At shorter periods, shoaling internal waves and surface gravity waves also mix coastal water properties in both the horizontal and vertical directions. This region of the central coast is relatively unprotected and experiences a comparatively high flux of wave energy, especially in winter when intense storm events are prevalent. Under certain conditions, this wave energy impinges on Atascadero State Beach at oblique angles, generating substantial alongshore transport within the coastal littoral cell between Point Estero and Morro Rock (Figure 3.7). The wave-generated littoral cell can extend well offshore into Estero Bay, encompassing the MBCSD discharge location. Four primary meteorological sources generate waves in this region: 1) extratropical winter cyclones in the northern hemisphere, 2) southwestward winds after the spring transition to upwelling conditions, 3) tropical disturbances off shore of Mexico, and 4) extratropical storm swells generated in the southern hemisphere during summer. The first two are the

dominant influences on the wave climate along this section of the central California coast. The last two generate swells from the south, which are diminished near the outfall site by the sheltering effects of Point Buchon (Figure 3.7).

Winter storm waves generated by extratropical winter cyclones are often accompanied by locally severe weather along the south-central coast. These extratropical storms are associated with low-pressure systems that develop along the polar front in the North Pacific Ocean, and they propagate westward toward the central coast. Thus, major wave events often coincide with an increased discharge from the outfall due to heavy rainfall and increased I&I. These storms occur predominantly in winter (December through March). Less than 5% of all major deepwater wave events ($H_s > 4$ m) occur between the months of May and October (Everts Coastal 1996).

With the exception of major storm events, prevailing southwestward winds are the predominant mechanism for generating waves near the outfall. These winds dominate during the spring and summer when a high-pressure system is established over the eastern North Pacific Ocean. The winds are highly coherent over this section of the central coast and, consequently, can generate wind waves over a large fetch (Chelton et al. 1987). These locally generated waves tend to be of shorter period and smaller height than those generated by major winter storms.

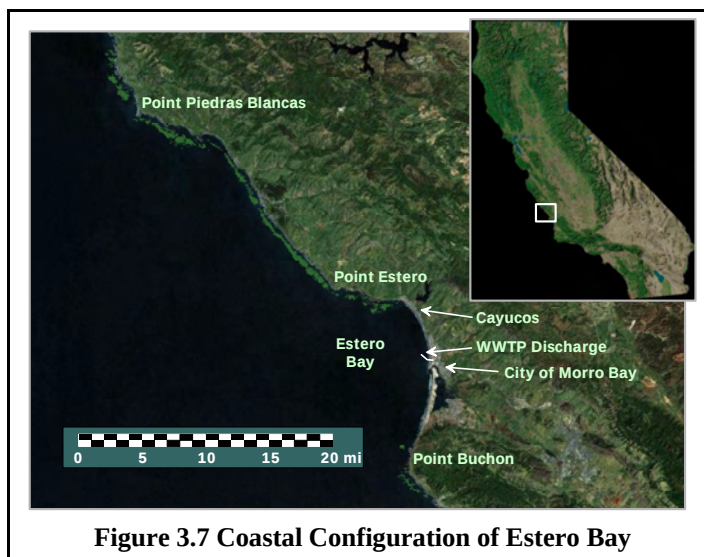


Figure 3.7 Coastal Configuration of Estero Bay

3.2.4 Ambient Seawater Properties

A detailed understanding of ambient seawater properties, and their natural variation within the region surrounding the outfall, is an integral part of compliance evaluation. The receiving-water limitations in the NPDES permit echo the objectives listed in the COP (Table 3.1 on Page 3-3), and the central coast Basin Plan (RWQCB 1994). The offshore receiving-water surveys are designed to assess compliance with objectives dealing with undesirable alterations to six physical and chemical characteristics of seawater. Other components of the monitoring program, described in other chapters of this report, address the remaining permit limits.

For the receiving waters, the permit states that wastewater constituents within the discharge shall not cause the limits listed in Table 3.7 to be exceeded (See Sections V.E through V.K of the permit). The first two receiving-water limits, P1 and P2, rely on qualitative visual observations for compliance evaluation. Compliance with the remaining four receiving-water limitations can be quantitatively evaluated through comparison of instrumental measurements and specific numerical limits listed in the NPDES permit. For example, the numeric limits on absolute values of DO (>5 mg/L) and pH (7.0 to 8.3), which reflect Basin Plan objectives, can be directly compared with observed excursions caused by the presence of wastewater constituents.

However, the COP narrative limits define unacceptable water-quality impacts in terms of “significant” excursions beyond that which occurs “naturally.” Quantitative evaluation of these limits requires a comparison of any excursion with numerical thresholds that reflect the natural variation in transmissivity,

Table 3.7 Permit Provisions Addressed by the Offshore Receiving-Water Surveys

Limit#	Provision	Source	Limit
P1	V.E	COP C.1	Floating particles or oil and grease to be visible on the ocean surface
P2	V.F	COP C.2	Aesthetically undesirable discoloration of the ocean surface
P3	V.I	Basin Plan	Temperature of the receiving water to adversely affect beneficial uses
P4	V.G	COP C.3	Significant reduction in the transmittance of natural light at any point outside the initial dilution zone
P5	V.J	Basin Plan COP D.1	The DO concentration outside the zone of initial dilution to fall below 5.0 mg/L or to be depressed more than 10 percent from that which occurs naturally
P6	V.K	Basin Plan COP D.2	The pH outside the zone of initial dilution to be depressed below 7.0, raised above 8.3, or changed more than 0.2 units from that which occurs naturally

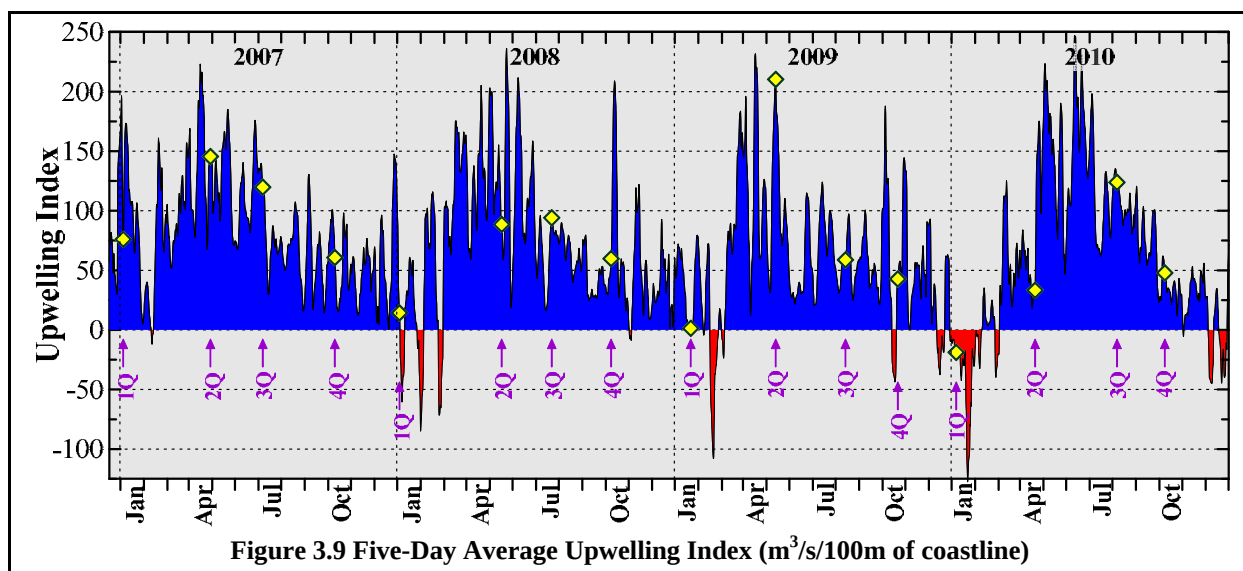
DO, and pH within the receiving waters surrounding the outfall. The historical 24-year record of quarterly receiving-water surveys conducted as part of the MBCSD monitoring program provides the necessary insight into this natural temporal and spatial variation in ambient seawater properties close to the outfall.

The oceanographic processes described in the previous subsection determine the spatial distribution of ambient seawater properties near the outfall, and how it changes seasonally. Of particular interest are upwelling and downwelling processes that not only determine average properties at a given time, but also the degree of water-column stratification, or spatial variability during any given survey. An accurate characterization of stratification helps distinguish between discharge-related changes that arise from the presence of wastewater constituents, which are subject to the compliance evaluation, and changes that arise from the upward movement of ambient seawater, which are specifically excluded from the compliance evaluation. For the most part, however, temporal differences in seawater properties among surveys are far larger than spatial differences within individual surveys. For example, when the water column is moderately to highly stratified, vertical differences in seawater properties tend to be much larger than lateral differences.

The influence of seasonal variability on receiving-water properties is reflected in conditions observed during the four offshore surveys conducted in 2010 (Table 3.8). The strength of upwelling that prevailed at the time of each survey tends to influence the degree of stratification. The blue areas in Figure 3.9 represent times when southeastward-directed winds prevailed near Estero Bay. These winds drive surface waters offshore, thereby inducing upwelling near the coast. For example, the second, third, and fourth-quarter surveys of 2010 were all conducted during periods of upwelling (Figure 3.9). Conversely, the sharp, red spikes that coincide with the first quarter (January) survey reflect periods of downwelling

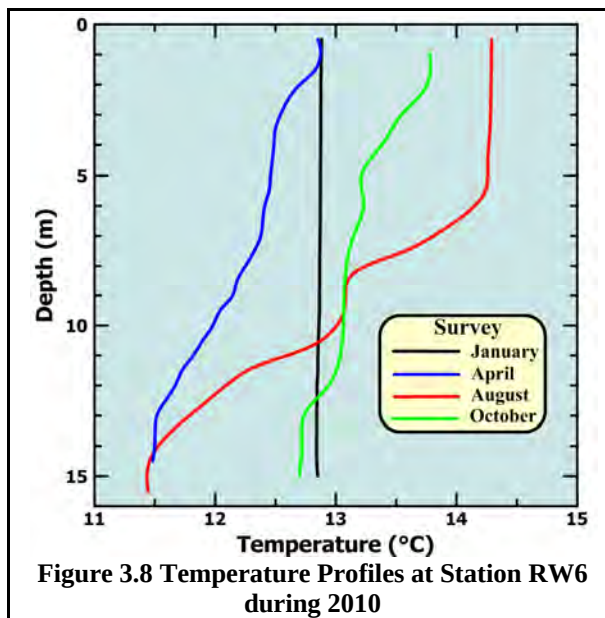
Table 3.8 Oceanographic Conditions during the Quarterly Receiving-Water Surveys

Conditions	January (winter)	April (spring)	August (summer)	October (fall)
Tide	Flood	Flood	Ebb	Ebb
Wave Height (from)	3 WNW	3 NW	3 NW	4 NW
Flow Direction (toward)	NW	NE	SE	SE
Stratification	Weak	Moderate	Strong	Moderate
Water Clarity	Moderate	High	Low	Moderate
Upwelling	Downwelling	Moderate	Intense	Moderate
Plume Visible	No	No	No	No
Plume Signature	Yes	Yes	Yes	Yes



caused by passing storms which generate winds in the opposite direction (toward the northwest) creating an onshore surface flow. Downwelling associated with this onshore flow displaces deep water masses offshore, where they no longer provide a nearshore vertical contrast in seawater properties, thereby producing a uniform water column within the survey area.

Temperature profiles at Station RW6 reflect the influence of upwelling at the time of each of the quarterly surveys, both in the degree of stratification and in average temperatures (Figure 3.8). For example, broad thermoclines extended through the entire water column in both April (blue) and October (green), while stratification was negligible in January (black). Meanwhile, the August (red) profile exhibits a pronounced double thermocline where cold, dense, saline, turbid, and oxygen-poor water was transported onshore at depth to replace surface water transported offshore by upwelling winds.



Although upwelling is recognized as the primary driver behind the productive fisheries of the central California coast, the persistence and strength of the upwelling that occurred in 2010 resulted in an eventual depletion of dissolved oxygen within the nearshore waters of Estero Bay. As seen in Figure 3.10, ambient dissolved oxygen levels dropped significantly between the time of the April survey, just after the beginning of upwelling season, and the time of the August survey which occurred after a period of more than three months of intense, almost entirely uninterrupted upwelling (Figure 3.9). This persistent upwelling facilitated phytoplankton blooms that produced oxygen and consumed carbon dioxide. However, as the phytoplankton died and fell to the seafloor, their decomposition used up oxygen in the nearshore waters.

Normally, the northwesterly winds that promote upwelling are not constant, and during periods when they intermittently relax, mixing of the waters on the continental shelf takes place, replenishing the subsurface waters with oxygen. Without this periodic relaxation of the winds however, oxygen levels along the continental shelf began to fall during the summer of 2010. During the August survey, DO concentrations near the sea surface, where seawater is normally saturated through atmospheric equilibrium, fell to 5.2 mg/L (62% saturation, Figure 3.10). At the same time, DO concentrations near seafloor approached 2.9 mg/l (33% saturation), well below the previous historical lows of 4.5 mg/L (52% saturation), and approaching hypoxic conditions below which most aerobic marine life cannot survive (Levin et al. 2009).

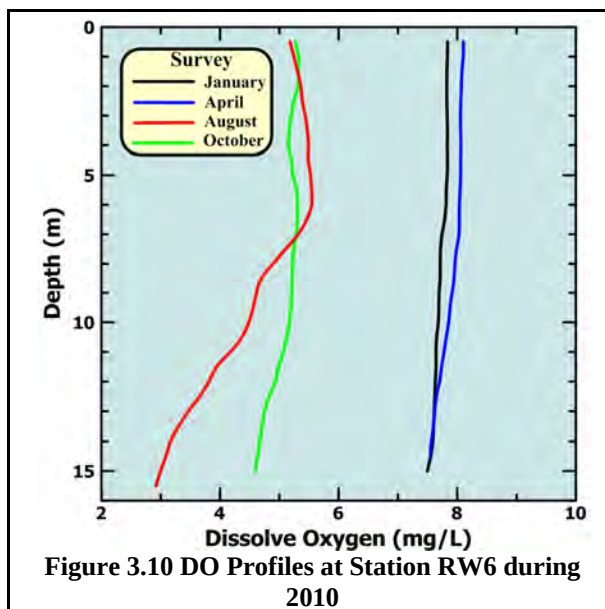


Figure 3.10 DO Profiles at Station RW6 during 2010

This pattern of unrelieved upwelling continued well into fall of 2010, with little decrease in intensity until the very end of September. Nevertheless, DO levels at depth had recovered slightly by the time of the October survey (Figure 3.10).

3.3 COMPLIANCE EVALUATION

This section evaluates the compliance of the MBCSD discharge in 2010 with the six permit limits listed in Table 3.7. The water-quality limitations are based on criteria in the COP (Table 3.1), the Central-Coast Basin Plan, and other state and federal policies that were designed to protect marine life and beneficial uses of ocean waters. Because the limits only pertain to changes in water properties that are caused by the presence of wastewater constituents beyond the ZID, instrumental measurements undergo a series of screening procedures prior to numeric comparison with the permit thresholds.

The quantitative analyses described in this section focus on water-property excursions caused by the presence of wastewater constituents beyond the ZID, and whose amplitudes can be reliably discerned against the backdrop of ambient fluctuations. The results of these analyses applied to data collected during 2010 demonstrate that the MBCSD discharge complied with the NPDES discharge permit, as has been the case for the prior two decades. Moreover, although observations close to the diffuser structure are not subject to compliance evaluations, they often meet the prescribed limits because dilution levels exceed the conservative design specifications assumed in the discharge permit. Thus, the quantitative evaluation described in this section documents an outfall and treatment process that was performing at a high level during 2010.

3.3.1 Lines of Evidence

Evaluating whether any of the 19,977 receiving-water measurements collected in 2010 exceeds a permit limit is a complex process. For example, apparently significant excursions in an individual seawater property may be unrelated to the presence of wastewater constituents, and may instead be due to any number of confounding factors. These confounding factors include statistical uncertainties, instrumental errors, natural processes, anthropogenic influences unrelated to the discharge, entrainment and upward transport of ambient bottom waters in the rising effluent plume, and ongoing initial mixing within and beyond the ZID.

Because of this complexity, compliance is evaluated using multiple lines-of-evidence (LOE). Specifically, each receiving-water observation is screened for compliance by evaluating the measurement using the series of questions (lines of evidence) outlined in Table 3.9. For example, application of the first two lines of evidence serves to restrict attention to the oceanic area where the permit provisions apply, and to eliminate excursions unrelated to the discharge.

Individual water properties within the remaining measurements are then evaluated collectively to arrive at a “best explanation” of their origin and significance using abductive inference (Suter 2007). This process, which has been used to implement sediment-quality guidelines for California estuaries (SWRCB 2009), emphasizes a pattern of reasoning which accounts for both the discrepancies among multiple lines of evidence as well as concurrences. A best explanation approach serves to limit the uncertainty associated with each individual CTD measurement and provide a more robust compliance assessment.

As described below, detailed analysis demonstrates that there were no out-of-compliance events caused by the presence of wastewater constituents that exceed receiving-water limitations in 2010.

Completion of Initial Dilution

The COP states that compliance with its receiving-water objectives “*shall be determined from samples collected at stations representative of the area within the waste field where initial dilution is completed.*” Initial dilution includes the mixing that occurs from the turbulence associated with both the ejection jet, and the buoyant plume’s subsequent rise in the water column. During the plume’s rise in the water column, strong currents can transport it a substantial distance from the discharge point. This is evident because the signature of the positively buoyant plume is occasionally observed at mid-depth well beyond the ZID when current flow is strong, indicating that the plume is continuing to undergo initial mixing beyond the boundaries of the ZID.

However, the COP also states that dilution estimates shall be based on “*the assumption that no currents, of sufficient strength to influence the initial dilution process, flow across the discharge structure.*” Because of this, modeling used to establish the MBCSD critical initial dilution of 133:1 assumed completion of dilution within a standard regulatory mixing distance equal to the 15.2-m water depth of the discharge. For the purposes of an initial screening of receiving-water data for compliance, LOE#01 restricts attention to observations measured beyond the idealized ZID, although the actual dilution stage of measurements located beyond the ZID is further examined in LOE#05.

Application of the ZID-distance threshold (LOE#01) to the original 19,977 receiving-water observations eliminates 1,797 receiving-water observations from further consideration because they were collected within the ZID. As described below (LOE#05), some of the remaining 18,180 observations were collected within the buoyant effluent plume as it continued mixing beyond the ZID; however, for initial for screening purposes, all of these measurements were carried forward in the compliance analysis.

Presence of Wastewater Constituents

The MBCSD discharge permit restricts application of the numerical receiving-water limits to excursions caused by the presence of wastewater constituents. This confines the compliance analysis to changes caused “*as the result of the discharge of waste,*” as specified in the COP, rather than anomalies that arise from the movement of ambient seawater entrained in the effluent plume. Analyses conducted on quarterly receiving-water surveys over the last decade have demonstrated that the direct influence of dilute wastewater is almost never observed in any seawater property other than salinity, except very close (<1 m) to a diffuser port and within its ejection jet.

Table 3.9 Receiving-Water Measurements screened for Compliance Evaluation based on Lines of Evidence

LOE	Topic Addressed	Screening Questions	Answer		Parameter
			No	Yes ¹²	
01	Anomaly Location	Was the measurement collected beyond the 15.2-m ZID boundary where modeling assumes that initial dilution is complete?	1,797	18,180	All
02	Salinity Association	Did the beyond-ZID measurement coincide with a quantifiable salinity anomaly ($\leq 550:1$ dilution level) indicating the presence of detectable wastewater constituents?	17,809	371	All
03	Outside Natural Range of Variation	Did seawater properties associated with the 371 low-salinity, beyond-ZID measurements depart significantly from the expected range in ambient seawater present at the time of each survey?	371	0	Temperature
			348	23	Transmissivity
			371	0	DO
			371	0	pH
04	Downstream Transport	Were the 23 potentially significant anomalies collected downstream of the prevailing flow path?	0	23	All
05	Initial Dilution	Was initial dilution complete, as indicated by the absence of a negative density anomaly that coincided spatially with the 23 significant salinity and transmissivity anomalies?	23	0	Density
06	Seafloor Turbidity	Were the 23 significant reductions in transmissivity less than the minimum ambient transmissivity measured within the seafloor turbidity layer, indicating that entrainment could not have caused the observed transmissivity reductions within the upper water column?	23	0	Transmissivity
07	Effluent Source	Could dilute wastewater particulates discharged on the day of the survey generate transmissivity reductions as low as those observed in the 23 significant anomalies?	23	0	Transmissivity

¹² Number of CTD observations of potential compliance interest based on this LOE

In fact, negative salinity anomalies are the only consistent indicator of the presence of wastewater constituents within receiving water. Wastewater salinity is negligible compared to that of the receiving seawater, so the presence of a distinct salinity minimum provides *de facto* evidence of the presence of wastewater constituents. Because of the large contrast between the nearly fresh wastewater and the salty receiving water, salinity provides a powerful tracer of dilute wastewater that is unrivaled by other seawater properties. Other properties do not exhibit such a large contrast and, as such, their signatures dissipate rapidly upon discharge with very little mixing. Wastewater's lack of salinity, however, provides a powerful marker that allows the presence of effluent constituents to be identified even after dilution many times greater than the 133-fold critical initial dilution assumed in the discharge permit.

Detection Threshold

Wastewater-induced reductions in salinity can be used to directly determine the amount of dilution achieved by initial mixing. Because wastewater has essentially no salinity, C_e can be neglected in Equation 3.1, and dilution (D) can be computed from the salinity anomaly ($A = C_o - C_s$) as:

$$D = \frac{-C_o}{(C_o - C_s)} \equiv \frac{-C_o}{A} \quad \text{Equation 3.2}$$

where:

D = the dilution ratio of the volume of seawater mixed with wastewater,

C_o = the salinity of the wastewater-seawater mixture after dilution by D ,

C_s = the background seawater salinity, and

$A = C_o - C_s$ = the salinity anomaly.

The smallest reduction in salinity that can be reliably detected within receiving waters is 0.062‰, which reflects a dilution level of at least 542-fold when substituted into Equation 3.2. The 0.062‰ salinity-reduction threshold was determined from a statistical analysis of the natural variability in salinity readings measured within the survey area over the last five years. The analysis of natural salinity variability excluded salinity readings potentially affected by the presence of wastewater constituents, and included more-than 9,200 ambient-seawater observations collected during 20 quarterly surveys conducted between 2004 and 2008. Within individual surveys, salinity was found to vary naturally by 0.062‰,¹³ indicating that smaller wastewater-induced salinity reductions could not be reliably discerned against the backdrop of natural variation. This statistical measure of the smallest detectable salinity anomaly was substituted into Equation 3.2 (as $-A$) along with the 33.59‰ mean salinity determined from the ambient database (C_o) to provide a conservative estimate of the 542:1 maximum detectable dilution. The actual maximum detectable dilution is smaller than this threshold because C_o , the salinity of the dilute wastewater specified in Equation 3.2, will be less than the 33.59‰ background salinity (C_s) used in the equation.

As a final level of conservatism, the dilution threshold used in LOE#02 was rounded up to 550-fold. Observations eliminated based on the application of LOE#02 restrict attention to wastewater-induced excursions in temperature, light transmittance, DO, and pH that could be caused by the presence of wastewater constituents, rather than some other discharge process, such as bottom-water entrainment. Application of LOE#02 to the 2010 receiving-water database eliminated 17,809 of the 18,180 observations remaining after the application of LOE#01. For those observations, measured reductions in salinity were less than 0.062‰ relative to average levels within each survey, and represent dilutions

¹³ Lower one-sided single-sample 95% confidence interval computed in accordance with the COP definition of "significant" as a "statistically significant difference in the means of two distributions of sampling results at the 95 percent confidence level"

above 550:1 that are not reliably resolved in the database. In addition, at those high dilution levels, wastewater-induced changes in seawater properties other than salinity would be impossible to discern.

Application of the first two LOEs to the instrumental measurements collected during 2010 eliminated approximately 98% of the original 19,977 measurements from further consideration, leaving a total of only 371 measurements of interest from a compliance standpoint. In fact, screening with LOE#01 and LOE#02, eliminated all of the measurements collected during the October 2010 survey. Most (294) of the remaining measurements of interest were associated with the third-quarter (August) survey when the water column was strongly stratified due to intense upwelling (Table 3.8; Figure 3.8). Subsurface trapping of the effluent plume during strongly stratified conditions reduces initial dilution levels, so an increased number of perceptible salinity anomalies is expected.

Natural Variability

An integral part of the compliance analysis is determining whether a particular measurement was perceptibly altered by the presence of wastewater constituents, or whether it differed from other observations at the same depth level because of naturally occurring fluctuations in the marine environment. If the measurement did not significantly depart from the natural range in ambient seawater properties at the time of the survey, then it is difficult to ascribe it to the influence of dilute effluent. Thus, quantifying the natural variability around the outfall is necessary for evaluating discharge compliance (LOE#03).

A statistical analysis of the large historical database of receiving-water data collected around the outfall was used to quantify the range of variability in site-specific natural conditions, and the departures from those conditions that could be indicative of adverse effects on water quality. The same five-year database used to establish the within-survey salinity variation was used to establish one-sided 95% confidence bounds on transmissivity (-10.2%), temperature (+0.82°C), DO (-1.4 mg/L), and pH (± 0.94). These were combined with 95th percentiles for seawater properties from each survey, in a manner analogous to COP Appendix VI. The percentiles were determined from vertical profile data excluding measurements potentially affected by the discharge. This resulted in a set of thresholds for water properties that were used to screen data from each survey for a significant departure from natural conditions (Table 3.10).

Table 3.10 Thresholds for Significant Departures from Natural Conditions

Water Property	January	April	August	October
Temperature (°C)	>13.70	>13.68	>15.13	>14.59
Transmissivity (%)	<49.1	<67.1	<49.9	<61.0
DO (mg/L)	<6.35	<6.18	<1.75	<3.24
pH (minimum)	<8.647	<8.576	<6.952	<7.317
pH (maximum)	>8.856	>8.834	>7.512	>7.622

Only 23 measurements out of the 371 measurements that were potentially related to the presence of wastewater constituents beyond the ZID, exceeded the ambient seawater ranges listed in the table. Specifically, application of LOE#03 identified 23 anomalously low transmissivity measurements, ranging between 38.1% and 48.5%, that were recorded during the January 2010 survey that warranted further investigation. None of the measurements of interest exceeded the natural range of variability for any of the other seawater properties, including temperature, DO, or pH.

Downstream Transport

The 23 significant reductions in transmissivity were all observed while towing the CTD at a shallow depth (3.5 m) during the January 2010 survey. These anomalous measurements were clustered tightly together immediately outside of the northwestern boundary of the ZID, in a location consistent with the

northward transport of the effluent plume delineated by the drifter track (LOE#04) (Figure 3.11). The transmissivity reductions were highly localized and coincided with a small salinity anomaly that identified the presence of wastewater constituents that had already been diluted more than 300-fold.

Ongoing Initial Dilution

Negative density anomalies coincided with all the significant salinity anomalies, indicating that the effluent plume was still undergoing initial dilution (LOE#05, Figure 3.12). This suggests that the salinity anomalies were actually associated with the effluent plume, rather than with salinity spikes or some other instrumental artifact.

More importantly, however, the negative density anomalies demonstrate that the plume was still buoyant at that shallow depth level, and would continue to undergo turbulent mixing during its subsequent rise to the sea surface. As such, the plume had yet to complete the initial dilution process, and thus, these measurements were not subject to compliance evaluation under II.A.3 of the COP. In addition, the 305-fold dilution estimate associated from the largest measured salinity anomaly underestimated the dilution ultimately achieved by the plume after it reached the sea surface at a location well north of the idealized boundary of the ZID.

Seafloor Turbidity Layer

Effluent mixes with ambient seawater near the seafloor immediately upon discharge. As a result of this rapid entrainment, the buoyant effluent plume acquires the properties of ambient bottom water and carries them upward as it rises through the water column. Significant vertical differences can arise because upwelling induces stratification that results in marked differences between water properties within surface and deep layers, such as occurred during the April, August, and October surveys (blue, red, and green lines in Figure 3.8). When the water column is well stratified, the ambient seawater properties near the seafloor differ from those within the water column, and their juxtaposition within the rising plume appears as a lateral anomaly at mid-depth.

These entrainment anomalies are not subject to compliance evaluations because they are not generated by the presence of wastewater constituents. Nevertheless, they do not generally exceed the estimated range in natural variability within a given survey because vertical differences extend throughout the water column,

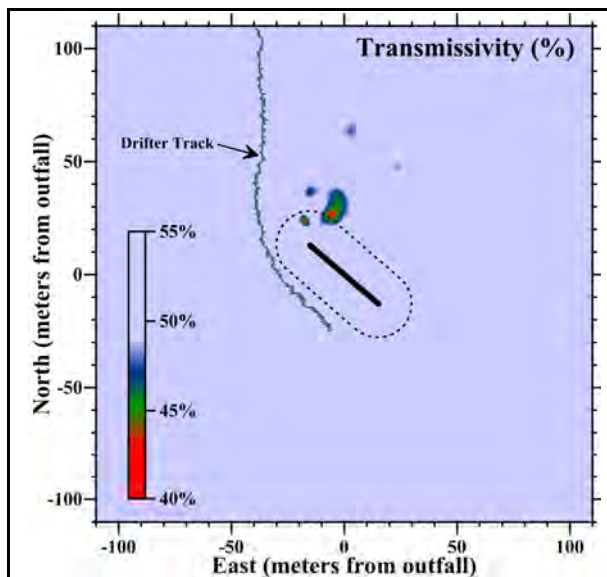


Figure 3.11 Shallow Horizontal Transmissivity Distribution during the January Survey

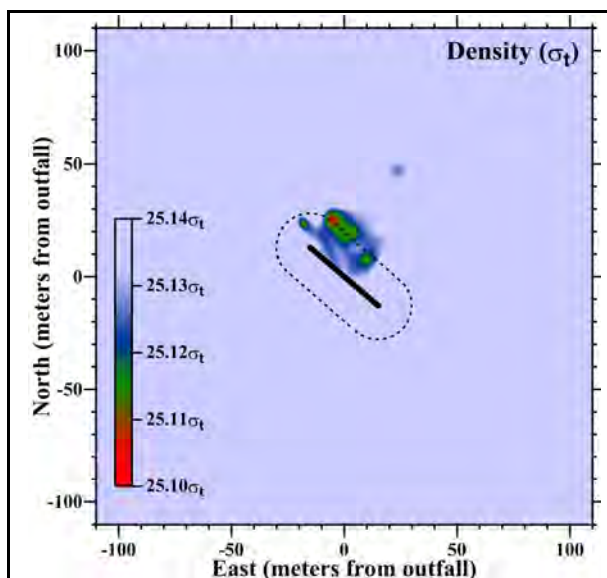


Figure 3.12 Shallow Horizontal Density Distribution during the January Survey

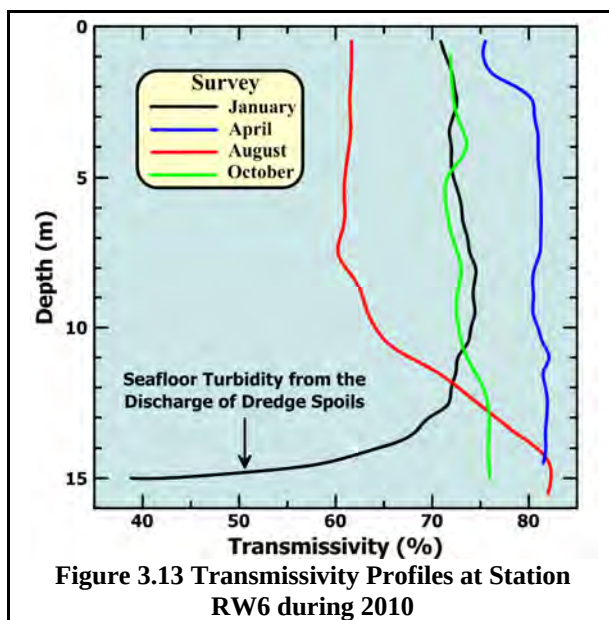
and thus are captured by the 95th percentiles that statistically characterize the expected range in ambient variation listed in Table 3.10. However, the range thresholds are statistical constructs, and the 95th percentiles, by definition, only encompass 19 out of every 20 observations. While this is generally adequate for capturing vertical changes (stratification) that extend over a significant portion of the water column, the January survey (black line in Figure 3.8) had very little vertical stratification and the corresponding range in ambient properties was small, except for transmissivity. Under these conditions, the range thresholds can miss changes that are restricted to thin seafloor layers, as described below.

Specifically, in contrast to upwelling-induced stratification, which results in broad vertical gradients that extend through most of the water column, a thin, dense, and extremely turbid seafloor layer was present throughout the survey region during the January 2010 survey (black line in Figure 3.13). This unusually turbid seafloor layer was not of natural origin, but was caused by the discharge of material dredged from the Morro Bay harbor mouth, which was being deposited onto the beach adjacent to the survey region during the survey. The dense sediment-laden slurry flowed down the beach and into the surfzone, where it was visually apparent as a turbid plume extending throughout much of the nearshore littoral zone shoreward of the survey area.

Because of their particulate load, the spoils formed a density current that descended to the seafloor and spread downslope and into the offshore survey area where the presence of the dredge spoils markedly increased near-bottom turbidity within all of the January transmissivity profiles. The dense particulate-laden bottom layer resulted in a sharp transmissivity decrease that was restricted to a very thin layer immediately above the seafloor (black line in Figure 3.13). Because of its very limited extent within the otherwise uniform water column, only a few transmissivity observations (less than one-in-twenty) captured the very low transmissivities (<40%) within the dredge-spoil layer. Consequently, they were not adequately represented in the 95th percentile (49.1%) threshold on natural variability listed in Table 3.10.

The dredge spoils that impinged on the diffuser structure were entrained within the rising effluent plume. Their presence within the effluent plume was responsible for the 23 low transmissivities measured at a depth of 3.2 m just outside of the northern boundary of the ZID (LOE#06; Figure 3.11). The thin layer of turbid water was clearly not associated with the discharge of wastewater particulates because Station RW6, where the signature was most prevalent, was distant from the wastewater discharge, and closest to the onshore location where the dredge spoils were being released. In fact, during all four of the 2010 surveys, Station RW6 was located far beyond the influence of the wastewater discharge, and was therefore used in Figure 3.8, Figure 3.10, and Figure 3.13 to compare ambient stratification among the surveys. Nevertheless, transmissivity profiles at other stations distant from the diffuser structure also captured this widespread turbid seafloor layer beneath very clear seawater in the upper water column. All but one station exhibited vertical profiles similar to the black line shown in Figure 3.13.

One exception was the transmissivity profile measured at Station RW3, which was located near the 23 significant transmissivity anomalies along the northern ZID boundary (Figure 3.14). This profile clearly reflected the presence of dredge spoils that were entrained in the buoyant plume and carried upward into



the water column.. Nevertheless, the 57% transmissivity measured within the vertical profile at RW3 (Figure 3.14) was substantially greater than the lowest transmissivity (38%) measured in the center of the rising plume during the high-resolution tow survey. Even within the tow survey, however, all 23 of the significant transmissivity measurements were greater than or equal to the lowest transmissivity measured within the seafloor layer at Station RW6 which was unimpacted by the discharge from the diffuser.

Thus, the entrainment of dredge spoils within the diffuser ejection jets shortly after discharge provides the most plausible explanation for the transmissivity reductions observed within the upper water column during the January survey. The dredged particulates were incorporated into a turbid plume that rose through the water column as it was transport northward in the direction of the prevailing flow (LOE#06).

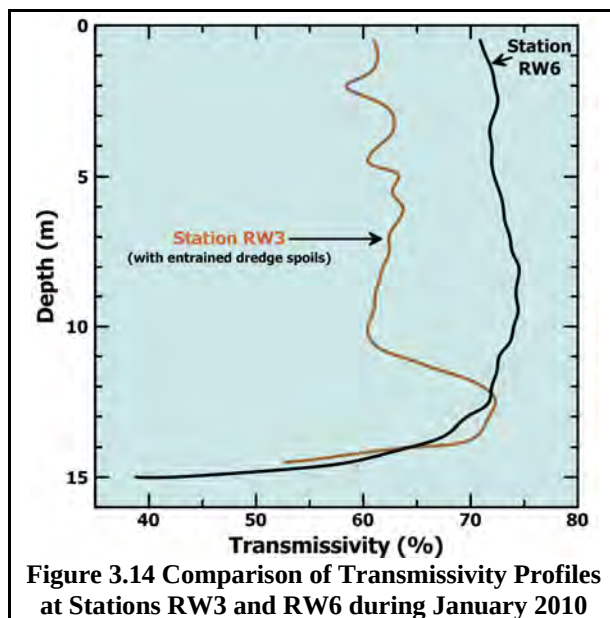


Figure 3.14 Comparison of Transmissivity Profiles at Stations RW3 and RW6 during January 2010

Effluent Source

The last and most compelling line of evidence (LOE#07) for the lack of perceptible impacts from wastewater particulates comes from the TSS concentration measured onshore within effluent prior to discharge on the day of the January survey. It demonstrates that the wastewater particulate load discharged by the plant could not have materially contributed to the observed reductions in transmissivity within the effluent plume. On 5 January, the suspended-solids concentration within discharged effluent was 35 mg/L (MBCSD 2010a), which was close to the historical average of 32.3 mg/L (Table 5.1). After dilution by at least 305-fold, as determined from the largest salinity anomaly within the 23 significant transmissivity reductions, the effluent TSS concentration would have the reduced ambient transmissivity, by only 0.7%. Thus, the presence of wastewater particulates within the effluent plume would only have reduced the ambient transmissivity from 72.3% to 71.6%; a change that would have been imperceptible against the backdrop of naturally occurring variations in ambient transmissivity. Instead, the observed 34% reduction was nearly 50-times larger, demonstrating that the presence of dilute wastewater particulates could not have been responsible for the 23 significant reductions in transmissivity.

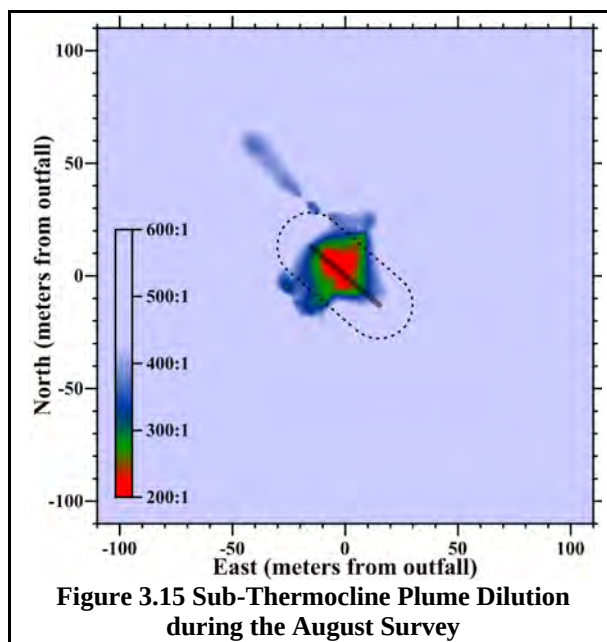
The dilution computation also demonstrates why turbidity associated with wastewater particulates within the MBCSD effluent is rarely observed within receiving waters, except very close to a diffuser port. As described in Chapter 2, the treatment process removes the vast majority of suspended matter from the influent stream. As a result, a dilution of only 16-fold would make suspended particulates within effluent imperceptible within the 10.2% natural variation in receiving-water transmissivity. That level of dilution is achieved well within the turbulent discharge jet emanating from a diffuser port. Thus, wastewater turbidity is generally only be discernable, if at all, within 1 m of a discharge port.

3.3.2 Numerical Limits

As in prior years, instrumental measurements collected during the 2010 surveys demonstrated that the discharge fully complied with receiving water limitations. Irrespective of the cause or location of the

observed seawater perturbations, none constituted an exception to the limitations promulgated by the NPDES discharge permit, the COP, or the central-coast Basin Plan.

The addition of tow-surveys to the monitoring program in May of 2009 provided enlightening insight into the limited footprint of the discharge. Prior monitoring, which relied on vertical profiles spaced 30 m apart could not accurately delineate the lateral extent of a plume whose influence was largely restricted to the 15-m-wide ZID (Figure 3.15). Specifically, the inclusion of the tow-survey requirement in the current permit allowed precise delineation of the effluent plume. This significantly expedited compliance evaluations based on multiple lines of evidence by screening irrelevant observations from consideration, namely, those that lie within the ZID (LOE#01) and those that are unrelated to the detectable presence of wastewater constituents (LOE#02).



These high-spatial-resolution instrumental measurements demonstrated that even within the ZID, where exceptions to numeric limitations in the COP are allowed, wastewater was diluted to levels far higher than expectations based on dilution modeling. In general, only slight salinity and density anomalies revealed the presence of very well mixed effluent close to the diffuser structure. For example, during the August survey (Figure 3.15), dilution exceeded 200-fold at a lateral distance of only 1.4 m from the nearest diffuser port, well before the initial-dilution process was complete. Those and other observations consistently demonstrated that discharged wastewater was undergoing rapid dilution immediately after discharge, and that the diffuser structure was consistently operating at a higher level than originally designed, namely, effluent was being diluted to levels exceeding the critical 133:1 mixing ratio within the ejection jet and long before completion of the dilution process. As a result, the effluent routinely meets the numerical receiving-water limits even within the ZID.

In addition, compliance with permit limits on individual effluent constituents was discussed in Chapter 2. Because those limits were based on the conservative 133:1 mixing ratio, and because dilution levels routinely exceeded that ratio, the COP receiving-water objectives were being easily met by MBCSD discharge during 2010.

The general absence of perceptible wastewater-induced fluctuations in seawater properties, such as turbidity, DO, and pH also demonstrated the efficacy of the onshore treatment process during 2010. The treatment process effectively eliminates the vast majority of suspended solids and oxygen-demanding material from the wastestream. The remaining residual material was rapidly dispersed shortly after discharge into the particularly well-flushed, open-ocean environment of Estero Bay. As a result, wastewater constituents neither accumulated on the seafloor nor imposed an oxygen demand on ambient seawater.

COP and Thermal Plan Allowances

The COP does not explicitly require that wastewater-induced changes to receiving waters remain within the ranges in natural variation listed in Table 3.10, even though they were conservatively used in the data screening process described in the previous subsection. Instead, the COP allows discharge-related changes in DO and pH to extend beyond these natural conditions, and in the case of turbidity, the COP effectively restricts limits on transmissivity reductions to the euphotic zone. However, these allowances can be combined with the thresholds listed in Table 3.10 to establish explicit numerical limits on changes to seawater properties (Table 3.11). Specifically, the ranges in natural variation applicable to each survey were useful for quantitatively evaluating whether a potential discharge-related change in a seawater property was perceptible against the backdrop of natural variation.

Screening for only statistically significant changes in seawater properties, namely, those beyond natural variation, appropriately restricts attention to measurements of potential compliance interest, as described in the previous section.

Table 3.11 COP Limits on Discharge-Related Changes to Seawater

Water Property	January	April	August	October
Temperature (°C)	>15.92	>15.90	>17.35	>16.81
Transmissivity (%)*	<49.1	<67.1	<49.9	<61.0
*Applicable Depth (m)	<10	<16	<8	<12
DO (mg/L)	<5.72	<5.56	<1.58	<2.92
pH (minimum)	<8.447	<8.376	<6.752	<7.117
pH (maximum)	>9.058	>9.034	>7.712	>7.822

The numerical limits were determined by applying COP allowances to the thresholds of natural conditions listed in Table 3.10. For example, the COP allows DO to be depressed 10% below natural conditions due to the presence of oxygen-demanding material within effluent (COP §II.D.1; Permit Provision P5 in Table 3.7). Likewise, pH is allowed to extend 0.2 units beyond natural ranges (COP §II.D.2; Permit Provision P6 in Table 3.7). Although the COP remains silent regarding thermal changes, it incorporates the California Thermal Plan (SWRCB 1972) requirements by reference (COP Introduction §C.3). The thermal plan limits temperature increases in coastal waters from new discharges to less than 2.22°C (4°F).

None of the 19,977 temperature, pH, and DO measurements collected during 2010 were found to differ significantly from natural conditions. Specifically, none of these seawater properties ranged beyond the thresholds on natural conditions listed in Table 3.10. Accordingly, none exceeded the wider COP limits specified in Table 3.11. This was true for all the measurements, regardless of whether they were recorded within or beyond the ZID (LOE#01), or whether they were associated with the presence of dilute wastewater particulates or not. Thus, the discharge also complied with the COP-related limits on receiving-water changes in these three properties (DO, pH, and temperature) that are included in the current NPDES discharge permit.

Although there are no explicit numerical objectives for discharge-related decreases in transmissivity, the COP narrative objective limiting significant reductions in the transmission of natural light can also be easily translated into a numerical objective as well. Because the COP does not specify an allowance beyond natural conditions, the same thresholds on ambient transmissivity variations are listed in Table 3.11 as numerical limits. However, natural light is restricted to the euphotic zone, which extends to approximately twice the Secchi depth. Thus, the limit on transmissivity reductions only applies above the euphotic-zone depths listed in Table 3.11, which were computed from twice the maximum Secchi depth measured during each survey. As a result, the extremely low transmissivities measured within the dredge-spoil layer above the seafloor during the January were not subject to the transmissivity limit because the dredge-spoil layer was restricted to depths more than 13 m (Figure 3.13), which was well below the 10-m euphotic zone present during the survey.

However, as described previously, entrainment of dredge particulates within the rising plume resulted in transmissivity reductions within the upper water column during the January survey. Because of the strong northward current flow at the time of the survey, some of this turbid water was transport beyond the ZID and resulted in 23 measurements with transmissivities below the limit specified in Table 3.11. However, because the transmissivity reductions were not caused by the discharge of wastewater particulates, they did not contravene the COP objective limiting reductions in natural light “as a result of the discharge of waste” (Table 3.1).

Shallower Secchi depths were also measured north of the diffuser structure during the January survey as a result of the entrained dredge spoils. However, the differences were not large enough to result in a material difference between average Secchi depths located near and distant to the ZID (Table 3.12). Secchi depths are only accurate to within 0.5 m, and the differences in average depths were equal to, or less than the uncertainty in those measurements.

**Table 3.12 Average Secchi Depths (m)
measured near the Diffuser and at Distant
Locations**

Survey	Nearfield¹	Reference
January	4.0	4.3
May	8.0	7.9
August	3.8	4.0
October	5.5	6.0

¹ Within 27 m of the diffuser structure

Basin Plan Limits

In contrast to the COP, fixed Basin-Plan numerical limits are incorporated in the NPDES permit without specific guidance as to how they might change in response to wide-spread changes in oceanographic conditions unrelated to the discharge. In addition to the fixed numerical limits restricting DO concentrations to no less than 5 mg/L (P5 in Table 3.7), and pH levels to the 7.0-to-8.3 range (P6), the Basin Plan limits temperature excursions to those that will not adversely affect beneficial uses (P3). As described above, the presence of dilute wastewater particulates exerted no perceptible thermal effect and thus, did not affect any of the beneficial uses designated for the receiving waters surrounding the outfall.

The DO and pH limits, however, are substantially more restrictive than the COP numerical limits listed in Table 3.11, and do not automatically account for natural seasonal variations in pH, or for the large reduction in DO that arose from the intense La Niña event in the latter half of 2010. Appropriately, the NPDES permit implements those limits only when the excursions are caused by the presence of wastewater constituents beyond the ZID. As demonstrated by LOE#s 01, 02, and 03 in Table 3.9, no DO or pH excursions associated with wastewater constituents beyond the ZID could be discerned with any reasonable degree of statistical confidence.

This conclusion concerning compliance with Basin-Plan numerical limits on pH is further supported by the fact that all 9,235 instrumental measurements collected during the January and April surveys had pH levels exceeding the Basin Plan limit of 8.3. It is inappropriate to ascribe pH exceedances to the discharge when background levels already exceed the limit. Additionally, the 7.4 pH level within the effluent that was being discharged during both surveys was far lower than that of the receiving seawater. As such, the discharge could only have decreased seawater pH, not cause an exceedance of the upper-bound limit. All of the pH measurements collected within the other two surveys (August and October) of 2010 remained between 7.0 and 7.6, well within the Basin-Plan numerical limits.

As with the high pH levels during the first two surveys, it is inappropriate to assess compliance with the Basin Plan limit on DO concentrations of no less than 5 mg/L when background concentrations are already below that limit. Naturally occurring DO concentrations below 5 mg/L were not envisioned within coastal waters when the Basin Plan limit on DO was promulgated in 1972. However, as described in Section 3.2.4, this was the case during both the August and October surveys, when exceptionally low

DO concentrations were recorded throughout the water column. Intense sustained upwelling throughout the spring and summer months resulted in background DO concentrations at depth approaching 2.9 mg/L during the August survey (red line in Figure 3.10). This level is well below the historical lows of 4.5 mg/L. The pattern of unrelieved upwelling persisted into fall, and extraordinarily low DO concentrations were again observed throughout the water column during the October survey (green line in Figure 3.10).

Moreover, as with other seawater properties, the MBCSD discharge could not have contributed materially to the observed DO depletion. The MBCSD treatment process routinely removes 80% or more of the organic material, as demonstrated by the low, 50.6-mg/L average biochemical oxygen demand (BOD) within effluent (Table 5.1). That small amount of BOD would have induced a DO depression of no more than 0.023 mg/L after dilution (MRS 2003a). In fact, in the absence of tangible BOD influence, wastewater constituents would actually be expected to increase DO within subsurface receiving waters, rather than decrease it. This is because effluent is oxygenated by recent contact with the atmosphere during the treatment process, whereas receiving waters at depth are typically depleted in DO, particularly during periods of pronounced upwelling such as occurred throughout most of 2010.

3.3.3 Visual Observations

The analysis of instrumental observations described above does not address compliance with the two remaining permit limits addressed by the offshore receiving-water surveys, namely, those dealing with the presence of floating particles, oil and grease, or aesthetically undesirable discoloration of the ocean surface (Permit Limits P1 and P2 in Table 3.7 on Page 3-18). During 2010, there was no visual evidence of these discharge-related impacts to the ocean surface.

3.4 BENEFICIAL USE

Observations of beneficial use demonstrated that the coastal waters in the outfall vicinity and along adjacent shoreline continued to be utilized by humans and wildlife during the 2010 receiving-water surveys. There was no evidence indicating that the discharge detracted from the beneficial uses that were identified for northern Estero Bay in the Basin Plan (see Section 2.1.2). Specifically, fish, marine mammals, and seabirds were observed utilizing the area within and around the ZID area as marine habitat (viz., the MAR beneficial-use identified for the waters of Estero Bay in the Central-Coast Basin Plan, as outlined in Section 2.1.2). The presence of surfers, kayakers, beachcombers, and commercial and recreational fishing boats attested to the use of the waters for water recreation (*REC-1* and *REC-2*), transportation (*NAV*), and fishing (*COMM*).

A variety of marine organisms were observed during the 2010 receiving-water surveys. These included large numbers of California brown pelicans (*Pelecanus occidentalis californicus*), western gulls (*Larus occidentalis*), and Heermann's gulls (*Larus heermanni*) which were generally observed transiting through the survey area during the surveys. Pelagic and Brandt's cormorants (*Phalacrocorax*), which nest on Morro Rock, were also frequently observed during each of the four surveys. Slightly less numerous seasonal visitors included the pigeon guillemots (*Cepphus Columba*) and common murres encountered during the January survey, and the western grebes (*Aechmophorus occidentalis*) and elegant terns (*Sterna elegans*) that were observed during transit to and from the survey area during the April and August surveys.

Several species of marine mammals are also typically observed during the quarterly surveys. Although sightings of a lone harbor porpoise (*Phocoena phocoena*) and a harbor seal (*Phoca vitulina*) took place during the April and August 2010 surveys, overall, marine mammal sightings were dominated by southern sea otters (*Enhydra lutris nereis*) and California sea lions (*Zalophus californianus*) (Figure 3.16). For example, sea otters were observed during each of the four surveys conducted in 2010, while sea lions were observed

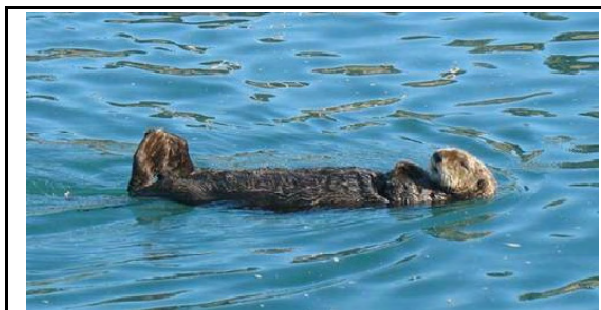


Figure 3.16 Southern Sea Otter within Morro Bay

during all but the January survey. Higher numbers of sea lions and otters were typically observed near the Morro Bay harbor entrance and during transit to and from the survey site, than at the survey site itself; during the April 2010 survey, a total of eight southern sea otters were observed within the confines of the harbor channel, while only two were observed near the actual survey area.

Among the more unusual visitors to the area during 2010 were large numbers of egg yolk jellyfish (*Phacellophora camptschatica*) that were present throughout Estero Bay during the October survey. These large jellyfish have bells up to 60 cm (2 ft) in diameter and clusters of tentacles that can extend over 6 m (20 ft) long. These jellyfish feed primarily on smaller jellyfish and other gelatinous zooplankton. Finally, large rafts of detached giant brown kelp (*Macrocystis pyrifera*) were noted throughout Estero Bay in the aftermath of the spring storms that preceded the April 2010 survey.

Recreational (REC) beneficial uses were also in evidence during the 2010 surveys. For example, non-contact water recreational activities, designated as REC-2 in the Basin Plan, including walking, jogging, and beachcombing were observed along Atascadero Beach. However, beach usage by pedestrians during the January 2010 survey was limited due to the ongoing discharge of dredged materials from the Morro Bay harbor mouth onto Atascadero Beach. Water-contact recreation, designated REC-1 in the Basin Plan, also occurs frequently along the beach adjacent to the outfall. This typically includes activities such as surfing, swimming, body surfing, kayaking, and kite and wind surfing. During the August 2010 survey, a junior lifeguarding class was also observed practicing jetski-assisted surf rescue techniques near the Morro Bay harbor entrance.

Commercial and sport-fishing vessels were also regularly observed during the course of the quarterly surveys, demonstrating the area's ocean-fishing (COMM) usage. In particular, 12 recreational sportfishing boats were observed fishing for salmon during the April survey, while during the August survey, local fishing vessels were typically in search of halibut and sea bass. The abundance of fishing activity seen during the April survey was notable because it heralded the beginning of the first recreational salmon fishing season to take place in California since 2007. Although the season had officially opened nearly three weeks earlier on 3 April 2010, rough weather and unfavorable sea conditions all along the central coast had kept most vessels ashore until the day of the April receiving-water survey.

CHAPTER 4

Marine Sediments and Benthic Biota

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4.0 MARINE SEDIMENTS AND BENTHIC BIOTA

This chapter describes the coastal benthos within Estero Bay where the MBCSD effluent is discharged. The MBCSD Offshore Monitoring Program includes benthic observations to assess potential impacts of wastewater discharge on marine sediments and the infaunal community near the outfall. Benthic environments are important indicators of the presence of marine pollution because they are the major reservoir for most contaminants that enter the ocean. Deleterious changes in the benthic environment, resulting from the deposition of effluent particulates, have been observed around other coastal outfalls (e.g., Stull et al. 1986a); however, no such impacts have been found after 25 years of benthic monitoring around the MBCSD outfall. This includes the October 2010 survey described in this chapter.

In the marine ecosystem, organic and inorganic matter are dynamically interrelated, and the quality of the material deposited on the seafloor directly affects the health of infaunal communities. Therefore, both the physicochemical and biological properties of the benthos are described in this chapter. Infauna residing within sedimentary environments serve as indicators of contaminated sediments because of their limited mobility and well-defined responses to pollution. Numbers of species, abundance, biomass, and other parameters of community composition can indicate contaminant-caused stresses if, for example, gradients are observed extending from a pollutant source to more distant, unaffected areas.

This chapter presents the full results of the benthic survey conducted on 7 October 2010. Physical properties of sediments are tabulated in Appendix C and chemical data from the survey are tabulated in Appendix E of this report, while benthic biological data are provided in Appendix B. BC Laboratories conducted the relevant chemical analyses following methods described by Tetra Tech (1986ab). Marine Research Specialists performed the infaunal community analyses and data synthesis.

The following section describes the benthic-monitoring program, including collection methods and station design. The second section of this chapter presents the findings related to the physicochemical analysis of the sediments. The third section describes the health of the benthic infaunal community residing within Estero Bay during 2010. The last section describes the sediment environment immediately adjacent to the outfall.

4.1 MONITORING PROGRAM

As with the marine receiving-water monitoring described in Chapter 3, sediment samples were collected at reference and outfall stations to investigate any potential discharge-related impacts to the benthos. The samples were analyzed for physicochemical properties and infaunal community composition in order to compare the benthic environment at these two sets of stations, as well as at gradient stations in between.

4.1.1 Scope of Monitoring

On 7 October 2010, offshore sediment samples were collected at seven stations within Estero Bay (Figure 4.1). The field sampling and laboratory procedures adhered to the requirements of the Monitoring and Reporting Program described in the discharge permit (RWQCB-USEPA 2009). During the 25 years of offshore monitoring, the benthic-monitoring program has undergone a number of major modifications. The original permit, issued in 1985, required semiannual sediment collection at six stations with physicochemical analysis of a composite of three replicate grab samples collected at each station. The stations were distributed around the outfall along a north-south isobath. Five of these original stations have continued to be sampled throughout the monitoring program. The sixth station, a “reference” station, located 1 km to the south, was dropped when the permit was reissued in 1993 because it was found to be unrepresentative of the benthic environment near the outfall.

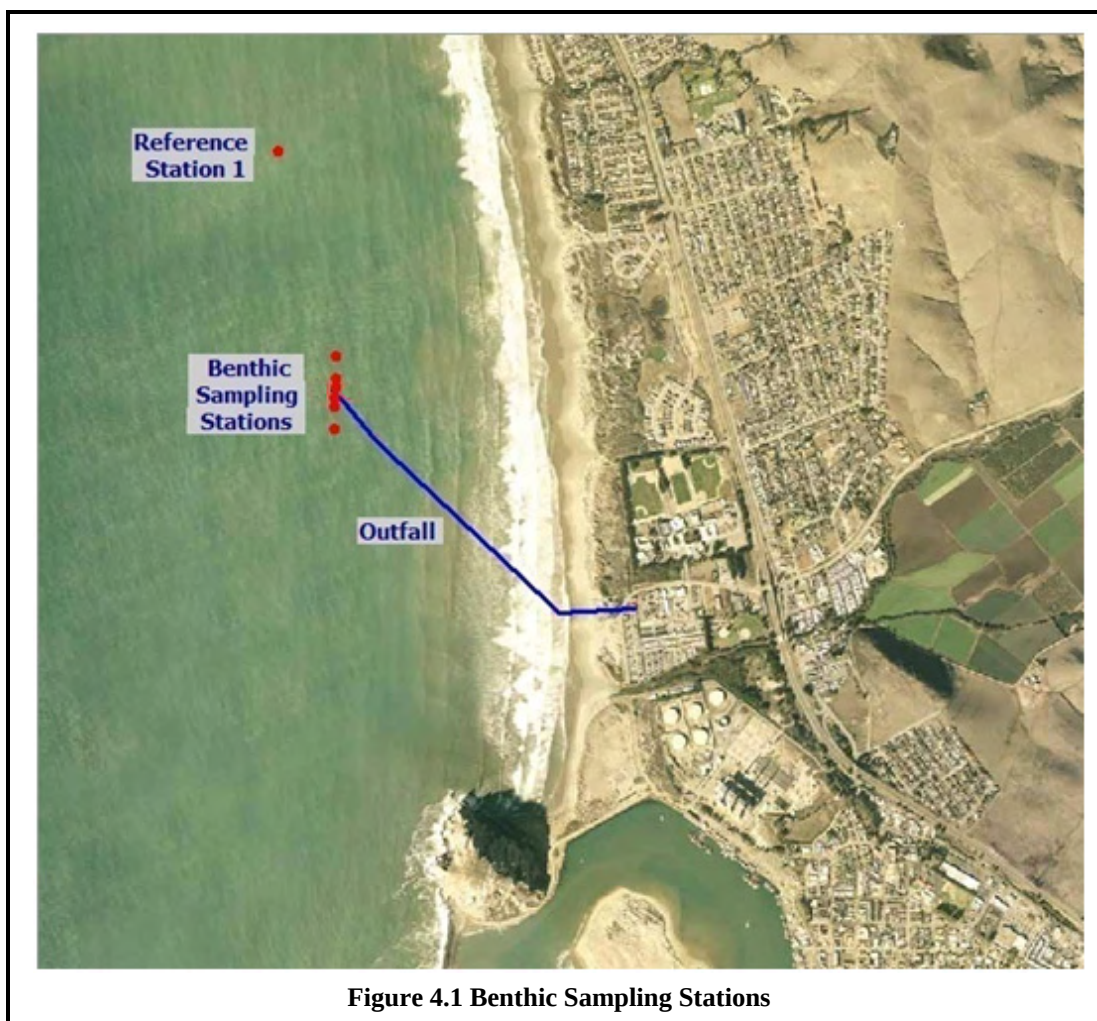


Figure 4.1 Benthic Sampling Stations

The discharge permit that was reissued in 1993 (RWQCB-USEPA 1993ab) also changed laboratory protocols. It required separate chemical analysis of each of the replicate samples collected at the five Stations. Separate analyses of replicate samples quantified the within-station variability and lent insight into the significance of spatial differences among stations. In particular, this report uses the replicate chemical analyses conducted in 1993 and 1994 to establish confidence intervals around concentrations measured at each station. In 1995, chemical analysis reverted to a composite protocol where aliquots from each of the three replicates collected from a station were homogenized into a single composite sample in the laboratory before extraction.

Further modifications were implemented when the NPDES permit was issued in 1998 (RWQCB-EPA 1998ab). After 13 years of monitoring, the amplitude of seasonal fluctuations had been adequately determined, eliminating the need for a post-winter survey. As a result, the focus of monitoring shifted to the determination of interannual changes in spatial patterns. To that end, four additional benthic sampling stations, located 60 m from the outfall, were added to the five historical stations. The cross-shore configuration of two of these new stations (Stations 8 and 9) provided a more spatially balanced sampling pattern capable of detecting potential impacts that might not be restricted to along-shore directions. Finally, chemical analyses were performed on a single grab sample collected at each of the nine stations.

Based on an analysis of the previous 23 years of benthic data, the current permit (RWQCB-EPA 2009), adopted in January 2009, also instituted several changes to the program. First, chemical analysis protocols reverted to those utilized prior to 1998, where aliquots from each of three replicates collected at a station are homogenized into a single composite sample prior to analysis. This reduces uncertainty in the reported station concentrations by reducing within-station variability. Second, the permit eliminated the analyses of sulfides within benthic porewater samples. High-resolution analyses conducted over the previous six years had definitively demonstrated that the Estero Bay sediments do not contain measureable levels of dissolved sulfides. Finally, the cross-shore benthic monitoring stations (Stations 8 and 9) were eliminated from the sampling pattern because the inherent differences in the benthic environments caused by their difference in water depth confounded the interpretation of trends at the remaining stations.

The current permit also eliminated the sampling requirement at the northern reference station (Station B1); however, sampling at this station was still conducted during both the 2009 and 2010 benthic surveys to allow for continued comparison of grain size, infaunal, and metals concentrations. Because of its physical separation (1 km) from the outfall, the reference station has a measurably different infaunal community composition (MRS 1998bi), and sediment physicochemistry from the remaining stations. However, it was retained in both the 2009 and 2010 surveys for its value as one of the six original sampling stations in the program, and for the insight it provides into the larger scale processes working within Estero Bay as a whole.

4.1.2 Sampling Station Design

Benthic sampling in 2010 was conducted at the seven stations shown in Figure 4.1 on Page 4-2 and in Figure 4.2 on Page 4-6. The target positions for sample collection are specified in the current NPDES permit and are summarized in Table 4.1. The stations lie along a north-south isobath (15.2 m) that intersects the center of the diffuser structure. Two stations (B4 and B5) are located within 20 m of the center of the diffuser structure, at the edge of the “zone of initial dilution” (ZID). Two additional stations (B3 and B6) are located at nearfield distances (60 m) from the diffuser structure. Finally, the midfield stations (B2 and B7) are separated by three diffuser lengths from the discharge (150 m). The seventh, reference station (B1) is located 1 km north of the outfall, well beyond the discharge’s sphere of influence.

As described in Section 3.1.3 on Page 3-6, the finite length of the diffuser structure creates ambiguity in the distance measured from the outfall. For discussion purposes, station separations are usually referenced to the center of the diffuser. However, in terms of contaminant dispersion, the closest-approach distance is the controlling parameter.

Table 4.1 Target Locations of Benthic-Sediment Sampling Stations

Station	Description	Latitude	Longitude	Distance (m)	
				Closest ¹	Center ²
B1	Upcoast Reference	35° 23.730' N	120° 52.677' W	1,000	1,016
B2	Upcoast Midfield	35° 23.280' N	120° 52.504' W	138	150
B3	Upcoast Nearfield	35° 23.231' N	120° 52.504' W	49	60
B4	Upcoast ZID	35° 23.210' N	120° 52.504' W	15	20
B5	Downcoast ZID	35° 23.188' N	120° 52.504' W	15	20
B6	Downcoast Nearfield	35° 23.167' N	120° 52.504' W	49	60
B7	Downcoast Midfield	35° 23.118' N	120° 52.504' W	138	150

¹ Distance from the closest open diffuser port

² Distance to the center of the open diffuser section

The upcoast reference station (B1), midfield stations (B2 and B7), and ZID stations (B4 and B5) have all been regularly sampled throughout the 25 years of benthic monitoring. The two nearfield stations (B3 and B6) were incorporated into the program in 1999, and improved the program's ability to resolve potential benthic impacts related to effluent discharge. Although sampling is no longer required at Station B1 under the current permit, samples were voluntarily collected at the station and analyzed for grain size, infaunal composition, and trace-metal chemistry, but not oil and grease.

The extraordinarily long record of infauna, grain size, and trace metals has provided valuable insights into previously unknown trends in Estero Bay's regional benthic conditions. Therefore, although those trends are unrelated to the MBCSD discharge, the lengthy time history at Station B1 was deemed of enough scientific value to warrant continued sampling there. However, although required for compliance evaluation at the other stations, sediment oil and grease concentrations have not been found to be diagnostic of the seafloor environment, or the effects of the MBCSD discharge, so the voluntary sampling at Station B1 did not include these constituents.

4.1.3 Benthic Sample Collection and Processing

Field sampling and laboratory procedures adhered to the requirements of MBCSD Monitoring and Reporting specified in the permit (RWQCB-USEPA 2009). The 38-ft F/V *Bonnie Marietta*, owned and operated by Mr. Mark M. Tognazzini of Morro Bay, provided vessel support during the offshore survey. Dr. Douglas Coats of Marine Research Specialists (MRS) logged navigation fixes, assisted in benthic grab deployment and retrieval, and collected sediment subsamples for chemical assay. Ms. Bonnie Luke, also of MRS, sieved and processed infaunal samples. Mr. William Skok was the marine-equipment technician responsible for benthic grab operations.

Equipment

Sediment chemistry and benthic infaunal samples were collected using a chain-rigged Young grab whose design was modified from that of a Van Veen sediment sampler. The pair of jaws on the grab acquires sediments from a 0.1-m² area of the seafloor. The stainless-steel grab is coated with Dykor[®] and is equipped with a frame that enhances its penetration, stability, and proficiency in collecting a level, undisturbed sample. Dykor[®] has properties similar to Teflon[®]; it improves the chemical inertness of the grab sampler, limiting contamination of the sediment chemistry samples by the grab itself, particularly from trace metals. The grab was completely refurbished by sandblasting and recoating with Dykor[®] in 1999. At that time, a stainless steel lip was also welded to the mouth of the jaw to improve the seal, which aids in sample retention during ascent.

At each of the seven monitoring stations, three replicate grab samples were collected and composited for analyses of sediment chemistry and bulk properties, and five replicate grab samples were collected for benthic infaunal analyses (Table C.1).

Offshore navigation aboard the survey vessel was supplied by a Furuno[™] GPS 30 coupled to an FBX2 differential beacon receiver. Global positioning satellite (GPS) navigational fixes were recorded digitally at 1-second intervals. Electronic recordings of waypoints were used to mark the trip-time of the grab sampler and other pertinent information. Navigational errors inherent in standard GPS readings were greatly reduced with the use of a Differential GPS (DGPS) system that was first implemented by the U.S. Coast Guard. DGPS incorporates a second signal from a nearby land-based beacon. Because the beacon is fixed at a known location, the position error in the reading from the GPS satellites can be precisely calculated. This correction is continuously transmitted to the DGPS receiver and results in extremely accurate offshore navigation, typically with position errors of less than 2 m.

Physicochemical Samples

Prior to and during the survey, the sampling equipment was thoroughly cleaned to eliminate the introduction of non-sediment contaminants into the samples, and to prevent cross-contamination between stations. Before the survey, the grab sampler and sediment scoops were washed with Alconox®, deionized water, and 10% Hydrochloric Acid (HCl). During the survey, the grab and sampling utensils were washed with Alconox®, rinsed with seawater, and subsequently decontaminated with deionized water, methanol, and 1% HCl prior to sampling at each station.

Surficial sediments were collected from the upper 2 cm of the single grab sample recovered from each of nine benthic stations. Sufficient sample volumes were collected to provide material for QA/QC analyses. Samples were stored in the appropriate glass or plastic containers and refrigerated at approximately 4°C prior to analysis. Chain of custody forms accompanied all sample shipments from the field and between laboratories. Appendix E¹⁴ contains the chains of custody, laboratory QA/QC analysis, and the chemical results as reported by the laboratory, while Appendix C includes a physical description of the samples.

The sediments from each of the seven benthic-monitoring stations were separately analyzed for the analytes listed in Table 4.2. A summary of the analytical methods used and their authority is provided in Appendix E.

Table 4.2. List of Analytes in Sediment Samples

• Sediment particle size	• Biochemical oxygen demand	• Total Kjeldahl nitrogen (TKN)
• Moisture content	• Oil and grease ¹⁵	• Total volatile solids (TVS)
• 11 trace metals		

Infaunal Samples

In addition to samples collected for sediment chemistry, five replicate grab samples were collected at each of seven benthic-monitoring stations for infaunal analyses. Upon retrieval of the grab, each sample was inspected for acceptability. Acceptance criteria are based on penetration depth, surface condition, and overall sample integrity and are reported in Table C.1 in Appendix C of this report. Sediment samples that met the acceptability criteria were lightly washed, and elutriated onto a 1.0-mm mesh sieve. The extracted material was then washed into a labeled 16-oz. jar and preserved with 10% buffered formalin. After a minimum fixation period of 48 hours, the formalin was rinsed from the samples on a 0.5-mm mesh sieve and the samples were transferred to 70% alcohol for processing, preservation, and storage. After transfer to alcohol, the infaunal samples were stained with a Rose Bengal solution to aid in sorting of the organisms into the following major taxonomic groups: annelida and nemertea, mollusca, crustacea, echinodermata, and miscellaneous phyla.

All individual organisms were enumerated and identified to species level where possible. Voucher collections have aided in the consistent identification of organisms collected throughout the 25-year benthic-monitoring program. The voucher collections contain specimens representative of each species identified, and are augmented as new taxa are collected. The qualifications and experience of the taxonomic specialists responsible for species identification are presented at the end of Appendix B.

¹⁴ Note that the benthic chemistry results reported by the laboratory in Appendix E for B6 and B7 were reversed due to a labeling error in the field. Results reported elsewhere in this document have been corrected for this error.

¹⁵ As discussed previously, the sediments from the voluntary sampling conducted at B1 were not analyzed for Oil and Grease.

Sampling Location Offsets

Figure 4.2 shows the position of the chemistry (blue) and infaunal (green) grabs, relative to each target location (red) that were recorded for Stations B2 through B7 during the October survey. As described in Chapter 3, a number of factors influence the offset of the actual grab locations from the target locations listed in Table 4.1. Because the vessel is anchored during the benthic survey, differences between the sampling and target positions arise because the vessel swings about the anchor location along a scope of approximately 20 m. How the vessel will set relative to its anchor position is difficult to predict based on the constantly changing wind, wave, and current conditions. Changes in position during sampling at an individual station arise because of these changing conditions, in addition to movement from anchor drag. The within-station position changes during the October 2010 survey are apparent in Figure 4.2 by the spatial dispersion among the three sediment-chemistry grab samples and five infaunal grab samples collected at each station.

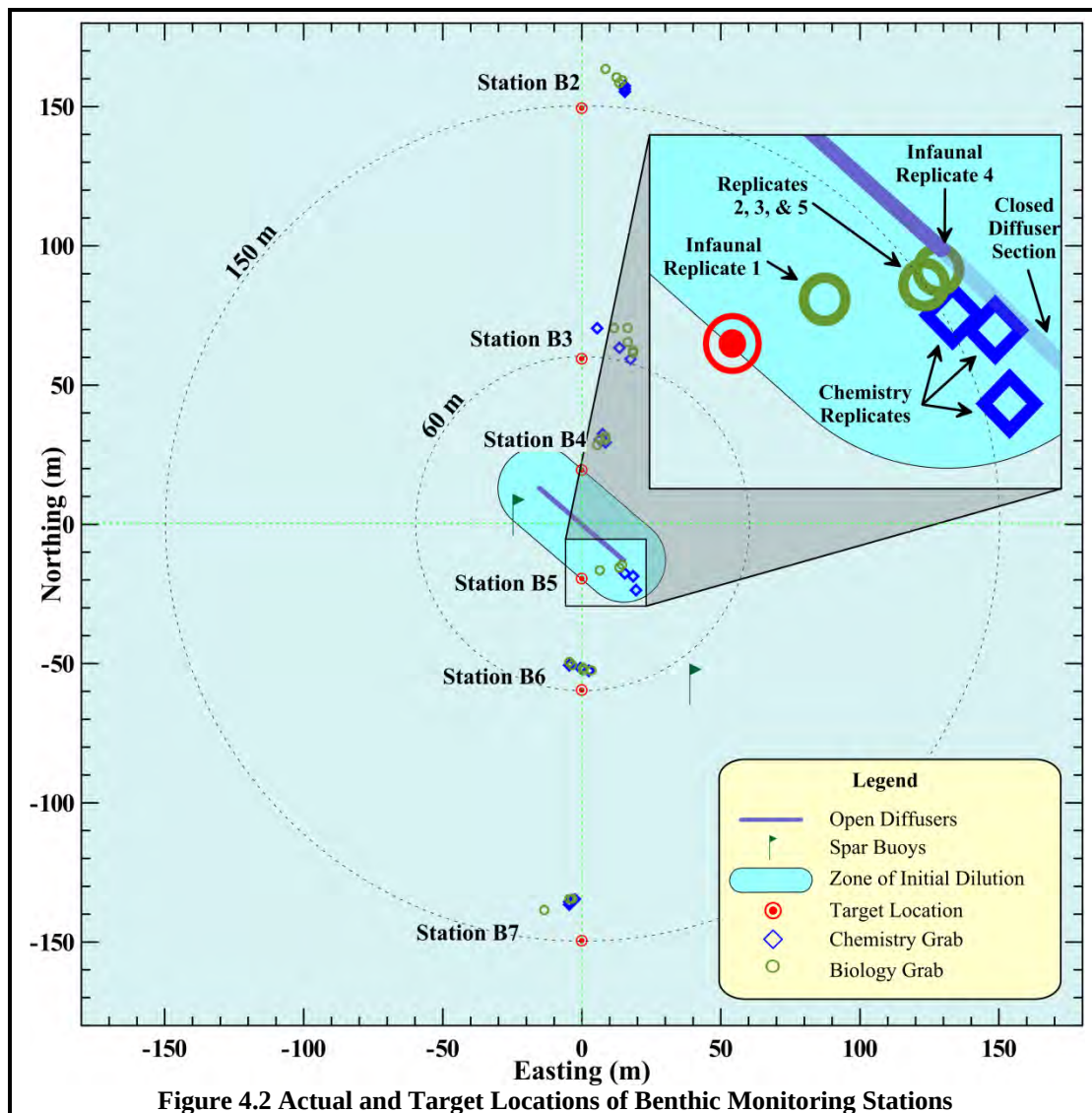


Table 4.3 Average Location of Benthic-Sediment Grab Samples at each Station

Station	Description	Latitude	Longitude	Distance (m)		
				Closest ¹	Center ²	Offset ³
B1	Upcoast Reference	35° 23.729' N	120° 52.680' W	1000	1016	5
B2	Upcoast Midfield	35° 23.285' N	120° 52.495' W	149	160	16
B3	Upcoast Nearfield	35° 23.234' N	120° 52.494' W	60	67	16
B4	Upcoast ZID	35° 23.215' N	120° 52.499' W	28	31	13
B5	Downcoast ZID	35° 23.190' N	120° 52.495' W	4	22	15
B6	Downcoast Nearfield	35° 23.171' N	120° 52.504' W	42	51	9
B7	Downcoast Midfield	35° 23.126' N	120° 52.507' W	124	135	15

¹ Distance from the closest open diffuser port

² Distance to the center of the open diffuser section

³ Average offset from Target Locations listed in Table 4.1

Table 4.3 lists the average position of the eight grabs collected at each station. Despite the many unavoidable factors affecting vessel offset, differences between the target position and average grab location were generally less than half the 30-m width of the ZID. Although it was not possible to collect samples at the precise target locations, knowledge of the actual location where samples were collected allowed the spatial offsets to be factored into the gradient analysis. Without the benefit of differential GPS navigation, most of these offsets would never have been resolved. The enhanced resolution provided by differential GPS also lent insight into minute spatial differences between individual grab samples that could not have been resolved otherwise.

For example, sampling at Station B5 was complicated when the grab sampler repeatedly collided with the diffuser structure, requiring 14 grab attempts in order to obtain the necessary five infaunal samples and three chemistry-grab samples. The difficulty in obtaining samples at Station B5 prompted an unsuccessful effort to reposition the vessel by retrieving some of the anchor rode, once it became apparent that the grab was in danger of damaging the diffuser structure or grab sampler. Previously, in 2008, the anchor was irreparably damaged after it hung on the diffuser structure during retrieval after sampling at Station B5 (MRS 2010a).

Because of the difficulty with vessel positioning at Station B5, all but one of the benthic samples and all of the chemistry samples were collected immediately adjacent to the closed section of the diffuser structure, just beyond southeastern-most open diffuser port (see inset in Figure 4.2). Half of the 14 grab attempts had trip locations within 1 m of the diffuser structure. Although the grab repeatedly encountered the diffuser structure during sampling at Station B5, neither the grab nor the diffuser structure were damaged by the collisions.¹⁶ As discussed in following sections, the benthic sediment samples that were successfully collected at this station were unusual due to their close physical proximity to the diffuser structure.

4.1.4 Benthic Analysis

A wide variety of physical, chemical, and biological parameters were determined from the 56 sediment samples collected during the October 2010 survey. This report examines these parameters for any potential discharge-related spatial patterns. They are also compared to historical measurements to reveal any potential temporal trends that could be associated with a buildup of contaminants. Finally, the

¹⁶ A diver inspection of the diffuser structure conducted during reinstallation of the spar buoys on 11 October (MBCSD 2010j) found no evidence of structural damage, although areas where marine growth had been dislodged by the grab were visible.

interrelation between biological and physicochemical parameters is evaluated for possible toxicological effects.

Organic-Loading Properties

Sediment samples collected at the seven benthic-monitoring stations during the October 2010 survey were analyzed for moisture content, grain size, organic properties, and eleven trace metals. The organic-loading parameters, oil and grease (O&G), total volatile solids (TVS), total Kjeldahl nitrogen (TKN), and biochemical oxygen demand (BOD), are considered relevant for sewage-outfall monitoring. If the volume of organic solids discharged by the outfall is not adequately dispersed, then a buildup of O&G, TVS, TKN, and BOD can occur, and impact areas beyond the ZID.

BOD measures the depletion of dissolved oxygen caused by aerobic microorganisms during decomposition of organic material. Excessive BOD can be deleterious to marine organisms if decomposition significantly depletes dissolved oxygen levels. This can occur when aerobes metabolize excess organic matter deposited by wastewater discharge.

The TVS concentration quantifies the amount of organic matter in the solid fraction of bottom sediments. It is reported as percentage of dry-sample weight. TKN measures the amount of organic nitrogen present as ammonia, as well as that bound into organic compounds in the aqueous phase of the benthic samples. However, natural TKN levels vary widely among seafloor sediment samples, so anthropogenic (human-induced) impacts are difficult to discern from TKN measurements alone. Similarly, other properties that can indicate organic loading from effluent discharge, including dissolved sulfides, O&G, and BOD, are problematic to sample, analyze, and interpret.

For example, O&G concentrations are often below detection limits, even close to the discharge. Similarly, BOD is difficult to accurately measure in sediment samples, and interference from errant pieces of organic material has resulted in erroneously high levels in several previous surveys, particularly during 2000 and prior to 1992 (Figure 4.9b on Page 4-26). Because of persistent interference during BOD determinations, overall confidence in BOD results for benthic sediment samples remains low.

Trace Metals

In contrast to synthetic compounds, the presence of trace metals within seafloor sediments is not necessarily indicative of anthropogenic input. Most trace metals are found in detectable concentrations within naturally occurring mineral deposits, some of which are essential minerals needed by marine organisms to survive. However, elevated levels of certain trace metals can be indicative of anthropogenic input, and excessive levels can cause deleterious effects in marine organisms.

Nine trace metals have been measured in seafloor sediments since the inception of the monitoring program. They are arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc. The toxicity of these metals to marine organisms has been examined in numerous laboratory bioassays and field experiments (Long and Morgan 1991, Long et al. 1995). These studies have been summarized in the form of biological effects levels, most notably an effects-range low (ERL), below which toxic effects are not expected, and an effects-range median (ERM), above which adverse biological effects can be expected.

In 1998, the analysis of aluminum and iron within benthic sediments was added to the monitoring program. Unlike the other nine metals, aluminum and iron are not particularly toxic to marine organisms, and their naturally occurring concentrations are relatively insensitive to anthropogenic input. This latter attribute makes them ideal tracers of natural variations in all the trace metals. Consequently, they have been used to normalize observed concentrations in the other nine metals so that background variation is

reduced and anthropogenic trends can be revealed. In particular, iron has been used as a reference element for determining anthropogenic enrichment of trace metals within the Southern California Bight (Schiff and Weisberg 1997) and in many other offshore regions (Daskalakis and O'Conner 1995).

Physical Properties

Moisture content and grain-size distribution are two important physical properties of marine sediments. Moisture content is a measure of the volume of pore water present in the sediment samples. While not an indicator of discharge effects, it is an important parameter used to convert chemical concentrations measured in the wet sediment sample to a dry-weight basis. Dry-weight concentrations allow a more direct comparison of chemical concentrations associated with bulk sediments by eliminating variations in sample mass that arise from arbitrary differences in water content. Moisture content is also used, along with salinity measurements, to eliminate the bias introduced by salt content in grain-size determinations.

Grain-size distribution is important to quantify because an increase in fine sediments near a municipal ocean outfall can be indicative of excessive effluent-solids deposition. In addition, the amount of fine sediment directly affects the composition of the infaunal community that resides within the sediments; although the precise mechanism for this relationship is rarely clear (Snelgrove and Butman 1994). Finally, natural variation in trace-metal concentrations has been correlated with the fine-sediment (mud) fraction and, like aluminum and iron, has been used to normalize metal concentrations (Dossis and Warren 1980, Ackerman et al. 1983, Horowitz and Elrick 1987).

Accurate measurement of the fine sediment fraction is particularly important for use in the interpretation of the marine biological data. Otherwise, variability in a benthic community's composition could be erroneously ascribed to effluent discharge, when instead it may be the result of natural variation in the distribution of fine particulates. One of the major difficulties in the accurate measurement of the fine fraction in marine sediments is that the standard pipette method described by Plumb (1981) and Folk (1980) overestimates the finest (clay) fraction. This occurs because the procedure incorrectly includes the weight of the dissolved solids (salt) when weighing the dried pipette extraction. This often generates an artificial bimodal grain-size distribution, where the smallest (clay) fraction exceeds the next largest (silt) fraction.

In 1994, the anomalous character of the bimodal size distribution in the MBCSD database led to a number of internal investigations and confirmatory grain-size analyses by outside laboratories (MRS 1995). The refined analysis method that is now in use accounts for the presence of dissolved solids by correcting for the measured salinity in the pipette fractions (MRS 1998i and Coats et al. 1999). This refined particle-size analysis method was instituted in the MBCSD monitoring program beginning in 1998. As a result, the finest size fractions determined in sediment samples collected after October 1997 are far more accurate than those determined in prior surveys. Thus, some of the long-term trends in the MBCSD grain-size database can be ascribed to improvements in methodology, rather than actual changes in the benthic environment.

Biological Parameters

Determining whether the discharge is causing adverse biological effects involves assessing whether a balanced indigenous population (BIP) of shellfish, fish, and wildlife exists in areas potentially affected by the discharge. A BIP is an ecological community, which exhibits characteristics similar to those of nearby, healthy communities existing under comparable environmental conditions beyond the influence of the discharge. Certain biological characteristics of the community are examined in a BIP evaluation, including spatial and temporal distributions of species composition, abundance, biomass, dominance, and diversity. Other overall biological indicators of a BIP include trophic (feeding-habit) structure and the

presence or absence of sensitive indicator species. Most marine monitoring programs determine the presence of a BIP using data on the infaunal organisms that live with sediments surrounding a potential pollutant source.

When assessing a BIP, infauna have many advantages over other marine organisms, such as marine mammals or finfish. First, infauna are relatively easy to collect in numbers large enough for reliable statistical testing. Second, they have limited mobility and cannot easily escape exposure to pollutants. Finally, decades of monitoring studies have established well-defined responses of infaunal taxa to pollutant stress.

In the earliest MBCSD monitoring surveys, analysis of biological samples produced two types of data on infaunal organisms: the number of organisms for each taxon, and the biomass of major taxonomic groups within each sample. Biomass is difficult to interpret, however, because the erratic presence of large, undersampled organisms severely skews the results. Also, in practice, the heavy calcareous shells and exoskeletons of mollusks and crustaceans are troublesome to remove, and alcohol evaporation during weighing affects the determination of wet-weight biomass. Because of these problems, the USEPA does not recommend biomass for inclusion in 301(h) monitoring programs (USEPA 1987). Therefore, beginning in 1998, the NPDES permit no longer required this analysis.

Pollution affects marine ecosystems by changing the number and type of benthic organisms found in the sediments. However, subtle changes in community composition are not always readily apparent in the large volume of raw data generated by a long-term monitoring program. Over the 25 years of MBCSD monitoring, nearly 236,000 individual organisms representing 380 individual taxa have been collected. To assess whether the infaunal community has been impacted, these data must be summarized into concise parameters that are indicative of pollutant stresses.

Biodiversity is a common indicator of the well-being of ecological systems, and forms the cornerstone of most impact assessment studies. Unfortunately, biodiversity is difficult to define quantitatively, in part because it has two major components: species richness and evenness. Species richness measures the variety (number) of species, while evenness measures the distribution of individuals (abundance) among the species (Magurran 1988). Healthy ecosystems are thought to be both rich in species and have an even distribution of individuals among those species.

Although no single measure can accurately represent changes in both evenness and richness along a pollution gradient, many indices attempt to do so. The Shannon Diversity Index (H') is the most widely used diversity index because it exhibits some degree of sensitivity to both evenness and richness. In addition, most diversity indices only measure the diversity within a local area at a particular time, viz., among replicate samples from a single station (α -diversity). In contrast, pollutant stresses tend to induce marked changes in community composition between samples separated spatially and temporally (β -diversity; Smith et al. 1979). Multivariate analysis techniques are better suited to the evaluation of β -diversity than are individual indices.

Most diversity indices are also poorly suited for describing potential impacts to infaunal communities because they lack biological meaning, show little correlation with environmental quality, and are difficult to interpret ecologically (Goodman 1975, Washington 1984, Green 1979). As a result, ambiguous or biased estimates of diversity often occur. Therefore, many indices are not recommended for routine inclusion in 301(h) monitoring programs (USEPA 1987). Nevertheless, the current NPDES permit requires that a number of infaunal community indices be reported and examined for temporal trends (RWQCB-USEPA 2009). However, because of limitations associated with the indices, spatial differences with respect to outfall proximity, which are evaluated using standard statistical hypothesis tests, must be

interpreted carefully. Table 4.4 lists the infaunal indices computed in this report. The associated algorithms and guidance on how to interpret them are presented in Appendix B.1.

Table 4.4 List of Infaunal Parameters

• Number of individuals • Number of individuals per species • Margalef species richness (d) (Margalef 1951) • Simpson dominance (C') (Simpson 1949, Wittaker 1965) • Pielou evenness index (J') (Pielou 1977) • Infaunal Trophic Index (ITI)	• Number of species • Species richness (S) (Magurran 1988) • Shannon-Wiener index (H') • Brillouin index (h) • Swartz dominance (S_w)

4.2 MARINE SEDIMENT QUALITY

The quality of marine sediments surrounding the MBCSD outfall provides a definitive measure of potential marine impacts caused by wastewater discharge. Specifically, discharge-related impacts have been demonstrated in outfall monitoring programs offshore both central and southern California, wherein marked changes in the benthic environment have been observed surrounding the discharge locations (Phillips and Hershelman 1996, Stull et al. 1986b). Discharge-related impacts have also been observed on the continental shelf south of Estero Bay, where sediments were found to exhibit small but statistically significant chemical signatures indicative of drilling mud discharges over widespread areas (Hyland et al. 1994, Coats et al. 1991, Coats 1994). If the MBCSD effluent discharge were causing significant impacts to the marine environment, similar changes in sediment properties would be evident near the diffuser structure. The challenge is to distinguish changes that are caused by naturally occurring processes from changes that result from human activities.

Physicochemical changes in sediments provide a good indication of marine impacts for four main reasons. First, because outfalls are located on the seafloor, sediments are proximal to the source of potential contamination. Second, many contaminants are hydrophobic and tend to preferentially adhere to the fine particulates as they settle out of the effluent plume. Third, contaminants incorporated into seafloor sediments tend to have a long residence time because of the slow dispersive processes that prevail within pore waters. Finally, infaunal organisms that live within seafloor sediments are continuously exposed to contaminants because they cannot easily escape the source of pollution. If seafloor sediments or pore waters become polluted, infaunal organisms can be impacted. Sedentary infaunal organisms provide a food source for other, more mobile organisms, such as finfish and shellfish. These trophic relationships can lead to bioaccumulation of contaminants within the marine food chain.

Despite the sensitivity of the benthos to effluent discharge, there has never been any indication of deleterious impacts to seafloor sediments resulting from the MBCSD discharge. This remained true during 2010, as it has in the previous 24 years of monitoring. The lack of negative benthic impacts is largely due to the comparatively low mass-emission of anthropogenic chemicals from the outfall. There has never been a large industrial contributor to the MBCSD influent stream, and the total discharge volume is small compared to ocean dischargers to the south, where discharge volumes can be over 100-times greater (e.g., SCCWRP 2006).

The lack of benthic impacts is evident from three sets of analyses performed on the chemical properties of sediment samples collected around the MBCSD outfall during the October 2010 survey. Each of these analyses is discussed in the following subsections. First, concentrations of potential contaminants measured in sediment samples were below levels that have been empirically linked to toxicity in marine organisms. Second, the spatial pattern of sediment concentrations near the outfall during 2010 bore no

consistent relation to outfall proximity. Third, sediment concentrations do not exhibit any significant long-term trends that would suggest a buildup of contaminants close to the outfall.

4.2.1 Concentrations below Toxic Levels

In keeping with the COP, narrative receiving-water limitations contained within MBCSD's Waste Discharge Requirements (RWQCB-USEPA 2009) state that the discharge should not cause chemical substances in marine sediments "*to be increased above levels which would degrade indigenous biota.*" This requirement was established because contaminants that reside in sediments for long periods have the potential to exert acute and chronic effects on resident marine organisms (NOAA 1991ab, Finney and Huh 1989, Bertine and Goldberg 1977).

Over the 25 years of continuous benthic monitoring, there has never been any indication of an effluent-related degradation of marine organisms within Estero Bay. In large part, this is due to the consistently low chemical concentrations within the discharged effluent (see Chapter 2). As a result, contaminant concentrations measured within Estero Bay sediments, both near and distant to the outfall, have been below thresholds reliably determined to be harmful to marine biota. In fact, the comparatively pristine marine environment of Estero Bay is reflected in benthic contaminant levels that are well below concentrations measured in sediments offshore southern California.

Thresholds of Biological Effect

Over the years, marine monitoring programs have placed considerable emphasis on benthic contamination. This experience has resulted in a set of thresholds of biological concern that can be used to screen chemical concentrations measured within marine sediment samples at any location. Specifically, these biological benchmarks can be used to assess whether the chemical concentrations measured in sediments have the potential for adverse biological effects. Although the thresholds are not regulatory criteria, they provide toxicological guidelines that help assess the potential environmental significance of specific chemical concentrations measured in the field.

The toxicological benchmarks advanced by NOAA (Long and Morgan 1991) are used in this report to evaluate sediment chemical concentrations measured during 2010. These guidelines are based on a correlation between chemical concentrations and observed biological effects in numerous modeling, laboratory, and field studies (Long et al. 1995). The studies identify two toxicological endpoints, an Effects-Range Low (ERL) and an Effects-Range Median (ERM) concentration. The lower toxicological endpoint (ERL) is associated with the concentration of a particular compound that produced an adverse biological effect in only 10% of the data. Below the ERL, adverse biological effects are unlikely. Above the ERM, which is based on the median of the toxicological data, adverse effects are considered likely to occur. The most conservative benchmark (ERL) was used in this report to determine the potential for marine biological impacts from most of the chemical concentrations that were measured within Estero Bay during 2010. These benchmarks provide a reliable screening tool for most, but not all sediment contaminants. For example, the relationship between nickel concentrations and the incidence of effects in the toxicological database is very weak. Consequently, even the upper (ERM) benchmark for nickel is a poor predictor of levels where biological effects might be expected.

Both trace-metals and organic contaminants are of concern in the benthic environment. However, their natural occurrence differs markedly. Synthetic compounds, such as PAHs, PCBs, and pesticides, are organic constituents that can have the most significant anthropogenic impact if found in sufficient concentrations. However, in this and many other marine sediment studies, their concentrations are below detection levels. In contrast, trace metals occur naturally in the marine environment and are commonly

detected in sediment samples. Because of this, trace metals serve as a powerful surrogate for evaluating the regional transport and fate of a host of other particulate contaminants.

Grain-Size Distribution

Within deep offshore basins, sediment trace metals accurately record the history of contaminant accumulation because they are ubiquitous and long-lived. However, these deep benthic sediments often contain significant fractions of fine-grained sediments, which support an increased number of trace-metal bonding sites per unit of volume. Thus, large differences in trace metal concentrations among sediment samples can be caused by natural differences in mud fractions that are unrelated to human activities. Because of this, many marine benthic studies divide (normalize) trace metal concentrations by the mud fraction. Normalization is intended to reduce inherent natural variability, revealing anthropogenic contaminant patterns normally masked by the natural association between metals and fine particulates (Dossis and Warren 1980).

While this approach works well in deep quiescent basins, it is not as applicable in nearshore environments where energetic oceanographic processes erode fine particles, leaving behind coarser, more transport-resistant sandy sediments. Sandy sediments usually have comparatively low metal concentrations. Also, metals tend to be incorporated into the mineralogy of the sand grains themselves, rather than adsorbed onto their surfaces, as is the case with silts and clays. Therefore, metals are less likely to dissolve and become assimilated by marine organisms residing within sandy sediments. Because of the lower bioavailability of metals in sands, NOAA does not recommend mud fraction normalization of trace-metals for samples with less than 20% fine-grained material (Long and Morgan 1991). Because the Estero Bay sediments consist almost entirely of sand (>99%, Table 4.5), iron- and aluminum-normalized concentrations are assessed instead.

Irrespective of trace-metal normalization, grain-size distributions can be indicative of a buildup of effluent particulates within the surficial sediments if, for example, there is an increase in fine fractions close to the discharge point. Although this was not the case around the MBCSD outfall, the overall character of the grain-size distribution reflects the dynamics within a particular benthic environment. Higher mud fractions reflect more-quiescent depositional environments, while well-sorted sands result from energetic wave environments that winnow fine particulates as they constantly rework the surficial sediments.

Accordingly, statistical analyses of grain-size distributions within the 2010 sediment samples reflect the high-energy environment near the outfall. The samples consisted of well-sorted fine sands with a distribution skewed slightly toward the finer fractions (Table 4.5; Appendix Table C.4). During 2010, mean particle diameters ranged from 145 to 167 μm , lying in the middle of the fine-sand portion of the grain-size distribution. The high degree of sorting is reflected by low standard deviations

Table 4.5 Grain-Size Distribution (%) within Sea-floor Sediment Samples Collected on 7 October 2010

	Clay (9 to 12 ϕ)	Silt (5 to 8 ϕ)	Fine to Medium Sand (1 to 4 ϕ)	Coarse Sand (1 ϕ)	Very Coarse Sand (0 ϕ)	Gravel (-1 ϕ to -3 ϕ)
Station B1	0.41	0.77	98.09	0.70	0.03	0.00
Station B2	0.16	0.31	98.81	0.69	0.03	0.00
Station B3	0.16	0.38	98.48	0.58	0.40	0.00
Station B4	0.04	0.18	99.27	0.45	0.06	0.00
Station B4 ¹	0.07	0.23	98.87	0.74	0.09	0.00
Station B5	0.15	0.16	99.00	0.53	0.16	0.00
Station B5 ¹	0.05	0.19	99.25	0.42	0.10	0.00
Station B6	0.13	0.63	99.02	0.22	0.01	0.00
Station B7	0.12	0.36	98.62	0.85	0.05	0.00
Mean ²	0.13	0.33	98.85	0.56	0.08	0.00

¹ Duplicate analysis of sediment sample

² Mean computed after arc-sine transformation

($\sigma < 0.4$). The small, but consistently positive skew to the distribution reflects a slight excess in the finer fractions relative to larger fractions in the tails of the distributions. Together, these properties point to a highly energetic flow regime that tends to winnow fines from the surficial sediments. The contribution of larger-diameter fractions was negligible in that the combined coarse sand and gravel fractions ($\leq 1\phi$) represented less than 1% of the total sample weight (Table 4.5). These largest fractions consisted mainly of fragments of shell hash that are randomly distributed on the surface of sediments in many shallow subtidal coastal areas. As described below, the presence of coarser sediments and shell hash is characteristic of scour pits around seafloor structures. This explains the slightly higher fraction of very coarse sand found in samples collected immediately adjacent to the outfall at Station B5.

Undetected and Nontoxic Metals

In 2010, trace-metal concentrations within sediment samples were either not detected or were below levels that are potentially toxic to marine organisms (*cf.* mean, ERL, and ERM concentrations in Table 4.6). The only exception was nickel, which is described in more detail below. Cadmium was not detected within the 2010 sediment samples, as has been the case in most prior monitoring surveys. Similarly, although mercury and silver were detected at a few stations, their concentrations were too low to be reliably quantified. Their respective highest estimated concentrations, 0.06, 0.03, and 0.04 mg/Kg, were well below the lowest toxic-effects levels (ERLs) of 1.2, 0.15, and 1.0 mg/Kg where biological effects first become noticeable, and far below median effects levels (ERMs) where biological impacts are expected. Thus, even if these three metallic elements are present in Estero Bay sediments at concentrations approaching their detection limits, they would be unlikely to affect marine organisms.

Table 4.6 Metal Concentrations (mg/Kg-dry) within Seafloor Sediment Samples Collected on 7 October 2010

Station	Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Silver	Zinc
B1	6,400	3.0	<0.05 ¹	62	3.8	10,300	2.5	<0.02	44	≈0.03 ²	18
B2	5,900	3.8	<0.04	50	4.2	9,800	2.2	≈0.02	52	≈0.03	17
B3	5,500	3.8	<0.05	47	3.8	9,300	2.2	≈0.02	50	≈0.03	16
B4	5,200	3.7	<0.04	42	3.3	8,600	2.0	≈0.02	44	<0.04	15
B5	5,300	3.8	<0.04	43	3.4	8,800	2.1	<0.02	43	<0.03	16
B6	5,500	3.9	<0.06	48	3.5	9,400	2.3	≈0.02	44	<0.03	17
B7	6,000	3.4	<0.04	52	3.7	9,800	2.3	≈0.03	45	<0.03	17
Mean³	5,700	3.6	<0.05	49	3.6	9,400	2.2	≈0.03	46	<0.04	16
ERL	— ⁴	8.2	1.2	81	34.0	—	46.7	0.15	20.9	1.0	150
ERM	—	70.0	9.6	370	270.0	—	218.0	0.71	51.6	3.7	410
SCB⁵	—	6.1	0.2	27	11.5	—	10.1	—	28	0.2	43

¹ "<" indicates that the metal was not detected above the method detection limit (MDL)

² "≈" indicates that the reported concentration exceeded the MDL but was not quantified because it was below the practical quantification limit (PQL).

³ After logarithmic transformation

⁴ Guideline not specified

⁵ Concentration that would be considered enriched (99th percentile) relative to background concentrations in the Southern California Bight after normalization by iron (Schiff and Weisberg 1997).

Two of the remaining eight metals, namely aluminum and iron, are not toxic to marine organisms. As described previously, these two metals were added to the monitoring program in 1998 to track natural variations in concentrations of other trace metals that occur because of inherent differences in mineralogy. The other six metals (arsenic, chromium, copper, nickel, lead, and zinc) have been consistently detected within Estero Bay sediments throughout the history of the benthic-monitoring program. Although they each have the potential for anthropogenic enrichment, their mean concentrations have remained comparable to ambient levels for the region. In 2010, as in previous years, five of these six metals had concentrations well below the ERL where biological effects can begin to become apparent. Only the mean nickel concentration was above the ERL, but below the ERM where biological impacts to marine organisms would be expected to occur. Each of the six detected metals is described below.

Arsenic

Although present in measurable amounts (≤ 3.9 mg/Kg), the mean arsenic concentration in Estero Bay sediments was less than half of the lowest toxicity level (8.2 mg/Kg) where adverse biological impacts would first begin to appear, and an order of magnitude smaller than the ERM (70 mg/Kg) where biological impacts become probable. For comparison, approximately 75% of the area within the Southern California Bight (SCB) has arsenic concentrations exceeding the mean level measured in Estero Bay during 2010 (Schiff and Gossett 1998). After adjustment for the mean iron concentration, average arsenic levels would have to be 2.5 mg/Kg higher to be considered enriched relative to background concentrations in marine sediments to the south (SCB = 6.1 mg/Kg in Table 4.6).

Although arsenic is widely distributed throughout nature, pure arsenic is a highly poisonous metallic element used in insecticides, herbicides, solid-state doping agents, and various alloys. However, these anthropogenic sources of arsenic are not a significant component of the wastewater processed by the MBCSD. Instead, most of the arsenic present in the Estero Bay sediments derives from erosion of enriched onshore mineral deposits. Although arsenic occurs naturally in central-coast sediments, mine tailings may contain higher residual levels due to the increased presence of arsenopyrites in the ore, overburden, and soil. Arsenic from mine tailings may be released into surface and ground waters through erosion, and reach Estero Bay through runoff within the adjacent watershed (MRS 2000b).

Chromium

Chromium is also enriched within the sediments throughout Estero Bay, and within the entire south central-coast region. This enrichment is reflected in the 49-mg/Kg mean chromium concentration within samples collected near the outfall in 2010, which is almost double the 27-mg/Kg that would be considered impaired for sediments within the SCB (Table 4.6). However, chromium concentrations within all the 2010 sediment samples remained below the lowest toxicity benchmark where biological effects might first be expected to be observed. The highest concentration (62 mg/Kg-dry) was measured at reference Station B1, and was still well below the ERL of 81 mg/Kg. More importantly, the maximum concentration was one-sixth of the level where biological effects become probable (ERM=370 mg/Kg). Even at that, the potential for marine effects is probably overstated, given that the incidence of effects in the toxicological studies used to establish the levels for chromium were “*greatly influenced and exaggerated by data from multiple tests conducted in only two field surveys*” (Long et al. 1995).

The ambiguity in chromium’s toxic effects levels partially arises from the fact chromium has several oxidation states, each of which has a vastly different toxicity. The presence of hexavalent and metallic oxidation states of chromium generally arises from anthropogenic sources, particularly industrial processes; however, the relatively non-toxic trivalent form of chromium found within the Estero Bay sediment samples occurs naturally in chromite ore. This is evident from the lack of measurable levels of hexavalent forms in sediment samples collected prior to 1999, when chromium speciation was performed

(MRS 1996, 1997c, 1998bi, and 1999b). The elevated chromium levels within Estero Bay sediments originate in naturally occurring chromite minerals that are introduced to the Central Coast's waters by fluvial transport of eroded ultrabasic minerals found in the Franciscan formation. The Franciscan formation outcrops along the headlands north of Point Estero and in the Santa Ynez Mountains. Thus, although chromite ore is a widely distributed mineral deposit, it is more prevalent along the south-central coast of California than in most other areas (SAIC 1986).

Nevertheless, the presence of higher chromium concentrations within central-coast sediments often leads to misinterpretation by regulators and scientists unfamiliar with the local mineralogy. Only around 25% of the SCB had sediments with chromium concentrations higher than those of Estero Bay. Most of this area was within Santa Monica Bay, where a high mass-emission of contaminants from publicly-owned treatment works occurred before 1988. Similarly, elevated chromium levels were observed within the Santa Barbara Basin in the northern reaches of the SCB, which led to speculation that those sediments were impaired as well, even though they can be also be ascribed to the presence of naturally occurring chromite ore in the region (Chow and Earl 1978). The erroneous characterization of an impaired condition in the northern SCB was prompted by an incorrect assertion by Schiff and Gossett (1998) that the elevated chromium concentrations were "*highly predictive of adverse biological effects*" in their review of contaminant concentrations within the SCB. That assertion was in direct conflict with published findings by the developers of the biological-effects levels, who stated that the chromium effect levels were exaggerated (Long et al. 1995).

While erosion of naturally occurring chromite ore along the central coast explains its overall enrichment within the marine sediments of northern Estero Bay, ordinary erosional processes may not be able to account for the trend of increasing chromium concentrations that has been observed in the decade prior to 2000. During that time, long-term increases in chromium, arsenic, copper, and nickel were documented throughout the Estero Bay region, but were unrelated to the MBCSD discharge (MRS 2010a). Although these metals are naturally enriched in onshore mineral deposits, nearshore depositional sediments should have reached equilibrium with onshore sediments that have been eroding within the adjacent watershed throughout geologic time. Instead, the observed increases in marine sediment concentrations that were observed in the monitoring program prior to 2000 suggest that the erosion of these mineral deposits has been accelerated by human activities, such as mining. As described by MRS (2000b, 2001), sediment samples collected in conjunction with a supplementary environmental project indicate that erosion around abandoned chromite mines is the likely cause for the observed trends in metal concentrations within the marine sediments of Estero Bay.

Copper

As with arsenic and chromium, copper commonly occurs within the minerals found along the central coast. However, the 3.6-mg/Kg average copper concentration within marine sediments collected at the seven benthic-monitoring stations in 2010 is well below the 11.5-mg/Kg concentration considered enriched relative to background levels within the SCB sediments. Approximately 90% of the SCB sediments have higher copper concentrations than those measured in Estero Bay. All of the sediment samples collected within Estero Bay during 2010 had copper concentrations that were also far below levels that would begin to affect marine organisms (ERL=34 mg/Kg). In contrast to chromium, the biological effect levels of copper are well defined by toxicological studies. Consequently, biological impacts from the observed copper levels within Estero Bay sediments are highly unlikely given that the highest measured copper concentration (4.2 mg/Kg) was 65-times lower than the ERM level where adverse effects become probable.

Lead and Zinc

Lead and zinc concentrations in Estero Bay sediments are also low compared to ERL levels where adverse biological effects first become noticeable. Additionally, they are low compared to concentrations within the SCB, where approximately 95% of the area has higher concentrations. Most of the elevated lead and zinc concentrations offshore southern California were measured within Santa Monica Bay and on the Palos Verdes Shelf, where large wastewater treatment plants have discharged for many decades. However, most of the metal emissions from these treatment plants occurred prior to the substantial improvements in effluent quality that were realized in 1988. Unfortunately, the historical discharges from these outfalls accumulated within adjacent sediments and have persisted for decades (Stull et al. 1986b). In contrast, the historically low emission of chemicals from the MBCSD treatment plant has had no measurable effect on the high sediment quality within Estero Bay.

Nickel

Although unrelated to wastewater discharge, nickel was the only metal whose concentration in Estero Bay sediments consistently exceeded its ERL level (Table 4.6). In fact, in the more than two decades of benthic monitoring, only one sample contained nickel in concentrations less than the ERL of 20.9 mg/Kg. Despite measured nickel concentrations that consistently exceed marine-toxicological benchmarks, no apparent deleterious impacts to infaunal organisms living within northern Estero Bay sediments have been observed. There are two reasons for this.

First, nickel exhibits a very weak relationship between the incidence of effects and concentrations in the database used to establish the toxic-effect ranges (Long et al. 1995). Because of this weak toxicological relationship, specification of bulk nickel concentrations that induce adverse reactions in marine biota is highly uncertain. Much of this uncertainty arises from wide variability in nickel bioavailability. When nickel is in a dissolved form, or adheres to surfaces of fine-grained sediments, it is much more likely to impact organisms that ingest or come into contact with the sediments. Conversely, nickel that is bound into the mineralogy of larger sand grains has little influence on marine organisms. The sandy sediments within the MBCSD benthic monitoring area fall into the latter category.

The second reason for the lack of impacts from elevated nickel concentrations stems from the fact that nickel occurs naturally in the mineralogy of the southern portion of the central California coast (Steinhauer et al. 1994). Because nickel and chromium often co-occur in mineral deposits, it is likely that the increased nickel concentrations found offshore also derive from the Franciscan geologic formation that outcrops at Point Estero. Thus, much of the measured nickel is bound into the mineral matrix of the sand grains themselves, where marine fauna cannot readily metabolize it. Additionally, if there is a slightly higher dissolved-phase nickel concentration within the pore waters of Estero Bay, it has probably been present for epochs, and benthic organisms in the region may have adapted accordingly.

Nickel and chromium are the only metals whose measured bulk concentrations in Estero Bay sediments consistently exhibit “*anthropogenic enrichment*” relative to background concentrations in the SCB (Schiff and Weisberg 1997). However, this designation is not correct because much of the regional enrichment along the central California coast arises from natural erosional processes, rather than from accelerated erosion of contaminated mine tailings. In fact, the influence of regional mineralogy is also plainly evident in the SCB database where “*background*” nickel concentrations steadily increase from south to north. As with chromium, Schiff and Gossett (1998) did not account for this natural variability in ore deposits and erroneously ascribed observed nickel gradients to anthropogenic contamination within the SCB.

Organic Loading

There are no well-established biological effects levels for organic-loading parameters such as TKN, BOD, TVS, and O&G (Table 4.7). However, the moisture content, mud fraction, TKN, BOD, and TVS measured in the sediment samples collected in 2010 were comparable to levels measured over the last decade.

4.2.2 Spatial Distribution Unrelated to Outfall Proximity

In 2010, as in previous years, the spatial distribution of sediment chemicals did not exhibit a pattern indicative of a benthic environment impaired by wastewater discharge. Specifically, there was no consistent evidence that sediment chemical concentrations near the diffuser structure were elevated relative to distant sites. A gradient of steadily increasing contaminant concentrations with increasing outfall proximity would provide *prima facie* evidence of discharge-related impacts to the marine environment. This pattern of impairment has been observed around larger outfalls servicing more industrialized locales (Phillips and Hershelman 1996, Stull et al. 1986b, Stull 1995, Diener et al. 1995). The lack of contaminant loading around the MBCSD outfall was confirmed through application of rigorous statistical hypothesis tests, and by qualitative visual comparisons of concentrations ranked by distance from the diffuser structure.

The bar graphs in Figure 4.3 show trace-metal concentrations ranked by distance from the diffuser. Potential outfall-related impacts would appear as bar heights decreasing from left to right in many, if not all of the trace metals. On the contrary, all metals except arsenic tended to steadily increase from left to right, suggesting that the perceived spatial distribution of metals was unrelated to the MBCSD discharge.

The steady increase in iron and aluminum concentrations with increasing distance from the outfall demonstrate that the observed gradients were naturally occurring (Figure 4.4). As described previously, normalization of raw trace-metal concentrations by aluminum, iron, or mud concentrations is common

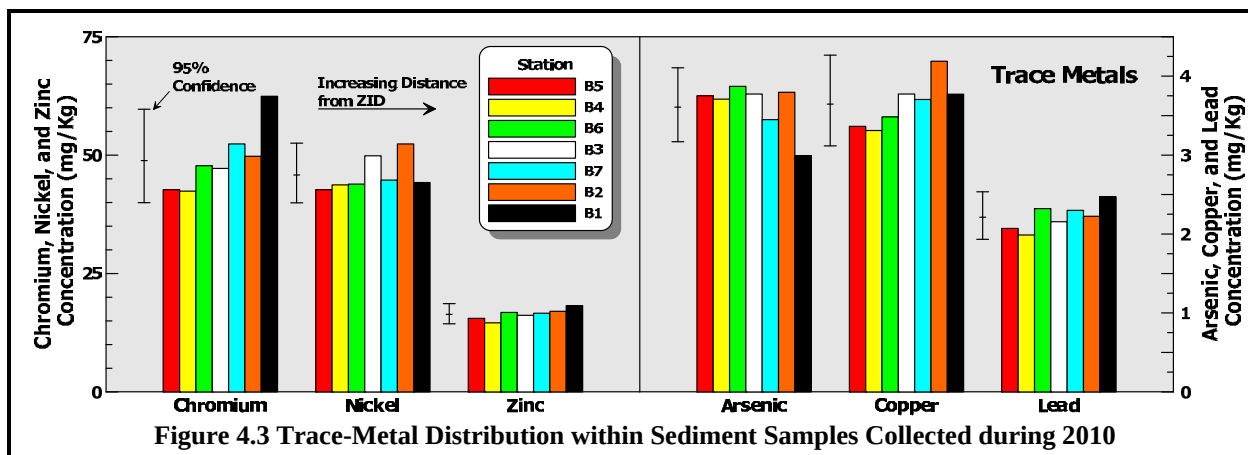
Table 4.7 Non-metal Concentrations (mg/Kg-dry)¹ within Seafloor Sediment Samples Collected on 7 October 2010

Station	Moisture (%)	BOD	Oil & Grease	TKN	Volatile Solids (%)
B1	23.1	39	— ²	195	1.55
B2	23.6	50	<17	170	1.51
B3	25.8	58	≈36	175	1.46
B4	24.5	32	≈32	131	1.32
B5	22.7	30	≈38	98	1.36
B6	22.5	35	≈57	124	1.46
B7	21.7	37	≈22	125	1.40
Mean ³	23.4	39	<31	142	1.44

¹ Unless otherwise indicated as “%”

² Sample not analyzed for O&G

³ Arc-sine transformation for % and logarithmic transformation for mg/Kg



practice in impact-assessment studies because it can reveal anthropogenic patterns that are otherwise masked by variability in background concentrations. Similarly, they can eliminate spatial differences perceived to be related to an impact when they are in fact due to natural variability. When the raw concentrations in Figure 4.3 are normalized by aluminum and iron (Figure 4.4), the perceived gradients largely disappear (Figure 4.5).

Additionally, normalization by iron and aluminum reduces the overall differences in concentrations between individual stations. The uncertainty in the concentration measured at any given station is reflected by the 95% confidence intervals shown to the left of each bar graph. They were determined from the range in concentrations found among replicate samples collected at each individual station.¹⁷ Perceived differences between stations that are smaller than this inherent sampling error, have, by definition, a low degree of confidence. A few raw concentrations, especially at reference Station B1, range outside the confidence interval and may be incorrectly interpreted as a statistically

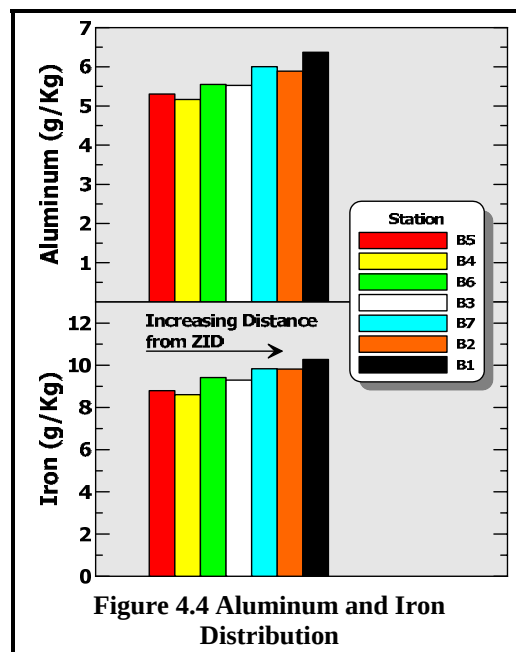


Figure 4.4 Aluminum and Iron Distribution

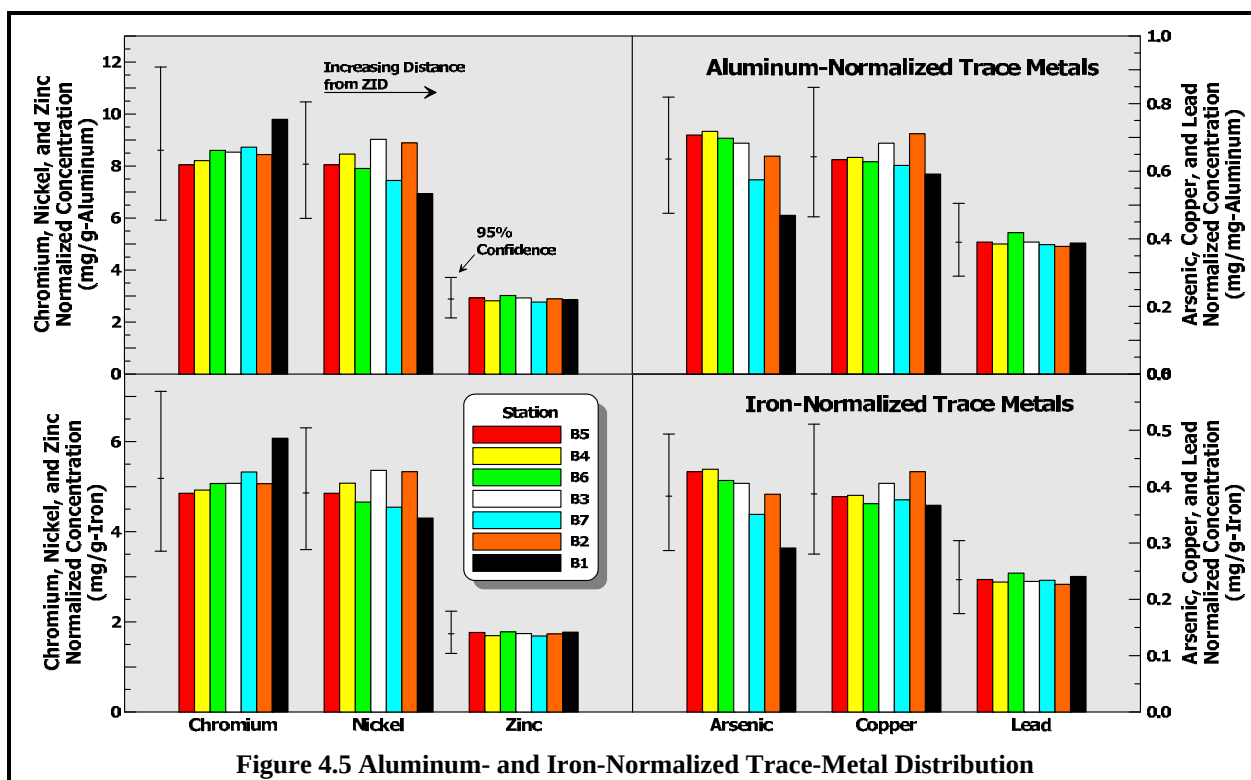


Figure 4.5 Aluminum- and Iron-Normalized Trace-Metal Distribution

¹⁷ The confidence intervals were determined from three replicate chemistry samples that were collected and separately analyzed at each station in 1993 and 1994.

significant spatial difference (Figure 4.3). However, normalization by aluminum and iron substantially reduces overall variability, so that all normalized concentrations remain within the confidence bounds (Figure 4.4).

These qualitative observations indicate that the perceived spatial gradients in raw metal concentrations were not related to MBCSD effluent discharge because they were in the wrong direction, namely, decreasing concentrations with proximity to the discharge, and were instead the result of a naturally occurring spatial distribution that prevailed in Estero Bay at the time of the survey.

Statistical hypothesis tests provide a more rigorous, quantitative method for assessing whether the MBCSD discharge is causing an increase in metal concentrations close to the outfall compared to distant stations. Two types of spatial tests were performed (Table 4.8). First, a test for the presence of a spatial gradient was performed by fitting a line to the concentration versus distance data. If the concentrations consistently decrease with distance, then the negative slope of the line will be statistically significant. The second statistical test evaluated whether mean concentrations at the four stations within 60 m of the discharge differed significantly from average of the three distant stations (Stations B1, B2, and B7), which are located more than 140 m away. In contrast to the first type of test for spatial gradients, the second hypothesis test did not evaluate whether the concentrations steadily changed along a gradient; instead, it assessed whether the average concentration in the group of stations close to the outfall was significantly lower than that of distant stations.

Table 4.8 Tests for Significantly Higher Contaminant Concentrations near the Diffuser

Parameter	Linear Trend		Difference in Means (mg/Kg)				Iron-normalized p^5	Aluminum-normalized p
	Slope	p^1	Near ²	Distant ³	t^4	p^1		
Aluminum (g/Kg)	0.043	[0.01]	5.38	6.08	-4.19	[0.01]	[0.07]	NA
Arsenic	-0.045	0.03	3.78	3.40	1.52	0.13	0.06	0.06
Chromium	0.080	[0.01]	44.9	54.6	-2.57	[0.06]	[0.12]	[0.14]
Copper	0.034	[0.10]	3.48	3.88	-2.28	[0.04]	[0.42]	0.44
Iron (g/Kg)	0.036	[0.01]	9.0	10.0	-3.81	[0.01]	NA	0.06
Lead	0.038	[0.02]	2.13	2.33	-1.96	[0.06]	0.33	0.10
Nickel	0.014	[0.53]	44.9	46.9	-0.67	[0.28]	0.27	0.22
Zinc	0.037	[0.02]	15.7	17.3	-2.26	[0.04]	0.35	0.10
BOD	0.065	[0.34]	37.2	41.6	-0.63	[0.28]		
TKN	0.127	[0.02]	129	161	-1.23	[0.14]		
TVS (%)	0.008	[0.02]	1.40	1.49	-1.60	[0.09]		
Mud (%)	0.048	[0.02]	0.43	0.68	-1.05	[0.18]		

¹ p -value or probability that a linear gradient is not significant or that a higher nearfield mean concentration is not significant (null hypotheses). In this study, p -values less than 0.05 (95% confidence) indicate that there is a linear gradient or that nearfield means are significantly higher, and the null hypothesis can be rejected (shown in bold font). Note, however, that a “one-sided” t -test was performed, in which only higher, rather than lower, nearfield concentrations are meaningful. Consequently, p -values for negative t -values are not pertinent and are indicated with brackets.

² Mean concentration computed among Stations B3, B4, B5, and B6, which lie within 55 m of a diffuser port (the largest closest-approach of chemistry grabs in Figure 4.2). For percent concentrations, an arc-sine transform was applied to the concentrations prior to hypothesis testing. For other units, a logarithmic transform was applied.

³ Mean concentration computed among Stations B1, B2, and B7, which lie more than 120 m from a diffuser port

⁴ t -value computed from the difference in near and far mean concentrations relative to measurement variability. A negative t -value indicates that the computed mean concentration was lower at stations near the diffuser, opposite of that expected in an environment impacted by effluent discharge.

⁵ Results of hypothesis tests performed on trace-metal concentrations normalized by the iron and aluminum concentration to reduce the potential influence of inherent variability in background metal concentrations.

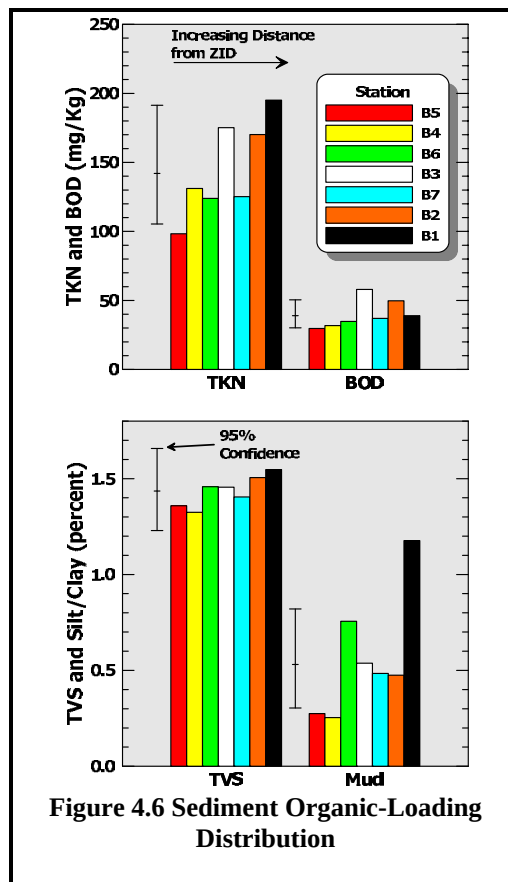
The “*p*-value” forms the basis for the outcome of the hypothesis tests. It quantifies the probability that a perceived spatial gradient could have occurred by chance. When $p < 0.05$, there is less than a 5% risk that the observed spatial gradient was happenstance due to random fluctuations. This threshold for designating potentially significant spatial gradients is consistent with the 95% confidence levels promulgated by the COP and used throughout this report. However, it is important to keep in mind that during any given year, a sediment constituent may exhibit an anomalous concentration at one or more stations that results in a spatial gradient that appears to be related to outfall proximity. Occasionally, that gradient is determined to be statistically “*significant*” at the 95% confidence level. However, by the very definition of the 95% confidence level, one in twenty tests would be expected to reveal a “*significant*” gradient when, in fact, none exists. Over the years, many constituents have been tested for spatial gradients, and occasionally the analysis identifies one that appears to be statistically significant at some particular time. Upon further analysis, however, the gradient has always been found to be unrelated to the discharge. Additionally, approximately half of the time, the statistically “*significant*” gradients reflect decreasing concentrations with increasing proximity to the outfall, which is opposite the spatial gradient expected from impacts associated with effluent discharge.

Such was the case for all the constituents but arsenic in 2010 (Table 4.8). As is visually apparent in the bar graphs, all concentrations other than arsenic increase with distance from the diffuser, and accordingly, gradients are positive (slope column in the table), and average concentrations at distant stations are higher than nearfield averages (negative *t*-value in the table). Because those gradients could not result from contaminant loading within the MBCSD effluent, their associated *p*-values are enclosed in brackets. Even though the associated spatial tests are not relevant to the MBCSD impact assessment, it is noteworthy that spatial gradients for many of the constituents were found to be statistically significant (*p*-values highlighted in bold in the table). This indicates that during 2010, phenomena unrelated to the effluent discharge had resulted in significant spatial differences within the seafloor environment of Estero Bay. This finding is supported by the highly significant ($p=0.01$) gradients observed in aluminum and iron, both of which are relatively insensitive to anthropogenic input. Accordingly, hypothesis tests performed on normalized trace-metal concentrations found no significant differences between near and distant averages ($p \geq 0.06$ in the last two columns of Table 4.8). In many cases, normalization reversed the spatial gradient (*p*-values no longer enclosed by brackets), and in the case of arsenic, increased the difference between near- and far-field concentrations and resulted in a smaller *p*-value (0.06 versus 0.13 for raw concentrations). Although the difference between near and distant mean arsenic concentrations was not found to be statistically significant, even for the normalized data, the spatial gradient in raw arsenic concentrations was found to be statistically significant ($p=0.03$).

However, visual inspection of the raw and normalized arsenic bar graphs in Figure 4.3 and Figure 4.5 shows that a markedly lower concentration at the reference Station B1 (black bar), rather than elevated concentrations near the outfall, accounts for the large difference in near and distant means. This is not indicative of an accumulation of arsenic near the outfall, and instead demonstrates that the sediments at Station B1 differed fundamentally from those of the other monitoring stations. This is primarily due to Station B1’s large 1-km distance from the outfall compared to all other stations, which are located 150 m or less, from the outfall. The fundamental differences in sediments at Station B1 were well documented by previous surveys, and were the reason this reference station was dropped from monitoring requirements in the current permit. Also, because of the much larger outfall distance, the low arsenic concentration at Station B1 exerts an inordinate amount of influence on the linear regression, and accounts for the statistically significant ($p=0.03$) negative slope (Table 4.8). Hypothesis tests conducted without Station B1 found no statistically significant spatial gradient ($p=0.55$), and doubled the probability that the difference in near and distant mean concentrations is not real ($p=0.13$ with Station B1, and $p=0.27$ without), including normalized concentrations ($p=0.06$ with, and $p=0.12$ without).

The statistical hypothesis tests reinforce the finding that, in 2010, many of the observed differences among the stations can be ascribed to inherent sampling variability rather than to actual differences in chemical concentrations within the sediments. This was visually apparent from the size of the confidence limits in Figure 4.3 and Figure 4.5, which encompass nearly all of the bar graphs. It was quantitatively demonstrated by the large number of *p*-values exceeding 0.05 (Table 4.8).

Table 4.8 also provides hypothesis tests for significant differences in near- and far-field concentrations for the four organic loading parameters. As with trace-metal concentrations, none of the organic properties exhibited enrichment near the outfall, and instead, three of the four properties exhibited significant gradients of increasing concentrations with distance from the outfall (*p*=0.02). These spatial gradients are also visually apparent in Figure 4.6, although the BOD gradient was weak, and the mud gradient was dominated by a mud fraction at Station B1 that was nearly double of that at the other six stations. The bar graphs of organic constituents also show that concentrations reported at individual stations were generally within the measurement error given by the 95% confidence interval that reflects inherent sampling uncertainty at any given station. Thus, the perceived differences between stations were small, and less than our ability to discern spatial differences in the presence of fluctuations caused by uncertainty in chemical assays and by natural phenomena.



4.2.3 No Buildup over Time Related to Wastewater Discharge

The previous section examined the spatial distribution of constituents at a single point in time, namely, during the October 2010 survey. However, the characteristics of ambient sediments at individual stations can be inherently different because of slight differences in their water depth, or because of differences in the depositional characteristics of their geographic location. For example, Station B1 lies in a more quiescent area north of the outfall, which may account for its higher mud fraction.¹⁸ These factors complicate the interpretation of any perceived spatial gradients with respect to effluent discharge. Examining changes in spatial distributions over time, however, significantly improves the power to detect potential discharge-related impacts. Specifically, if there were any measurable marine impacts from wastewater discharge, they would be revealed by a long-term buildup of contaminants in sediments surrounding the outfall, as compared to distant stations. Consequently, examining spatial trends in contaminant concentrations over time can reveal discharge-related trends that may be masked in a spatial analysis applied to a single survey.

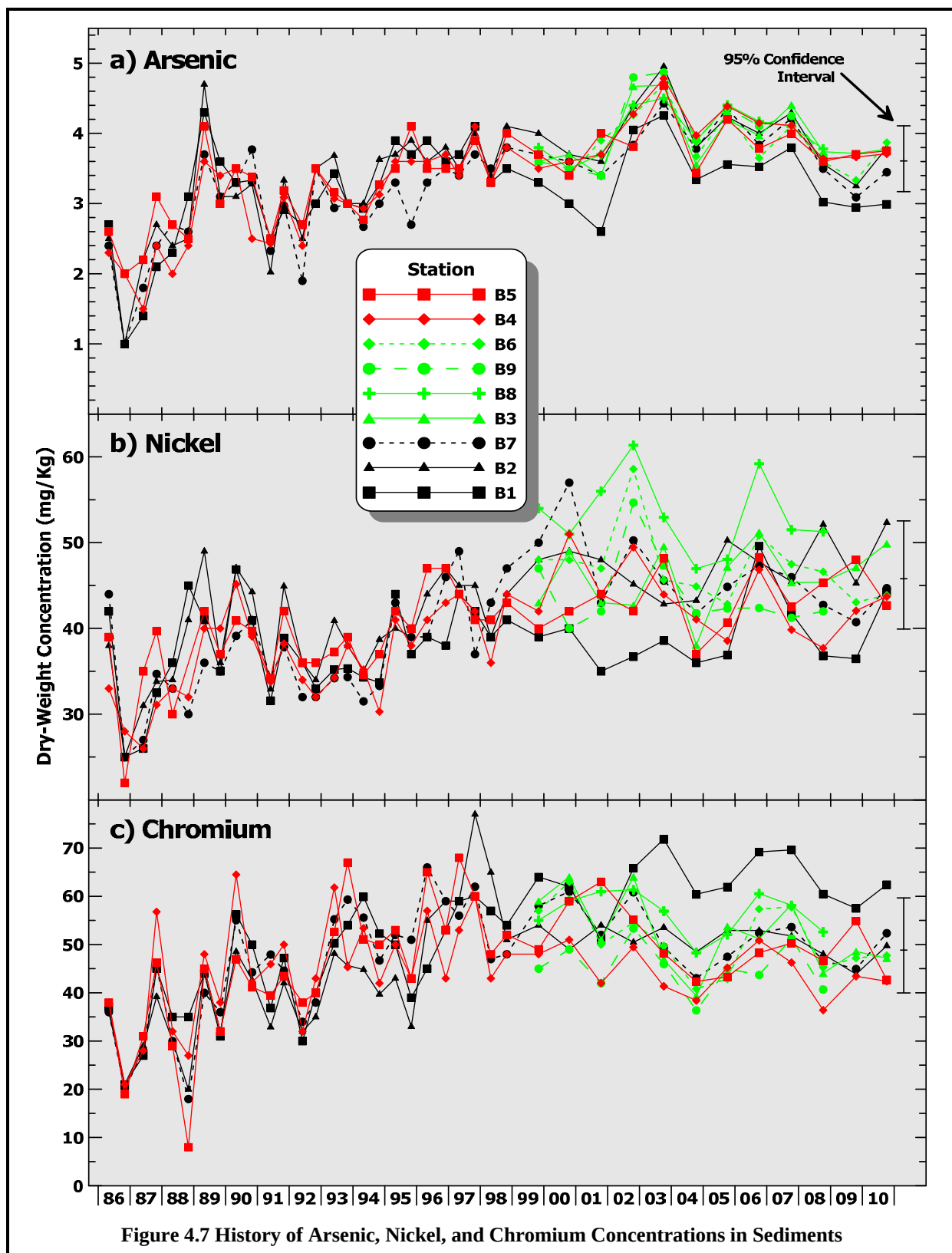
¹⁸ The prevailing wave field is from the northwest and much of northern Estero Bay is in the wave shadow of Point Piedras Blanca and Point Estero (Figure 3.7).

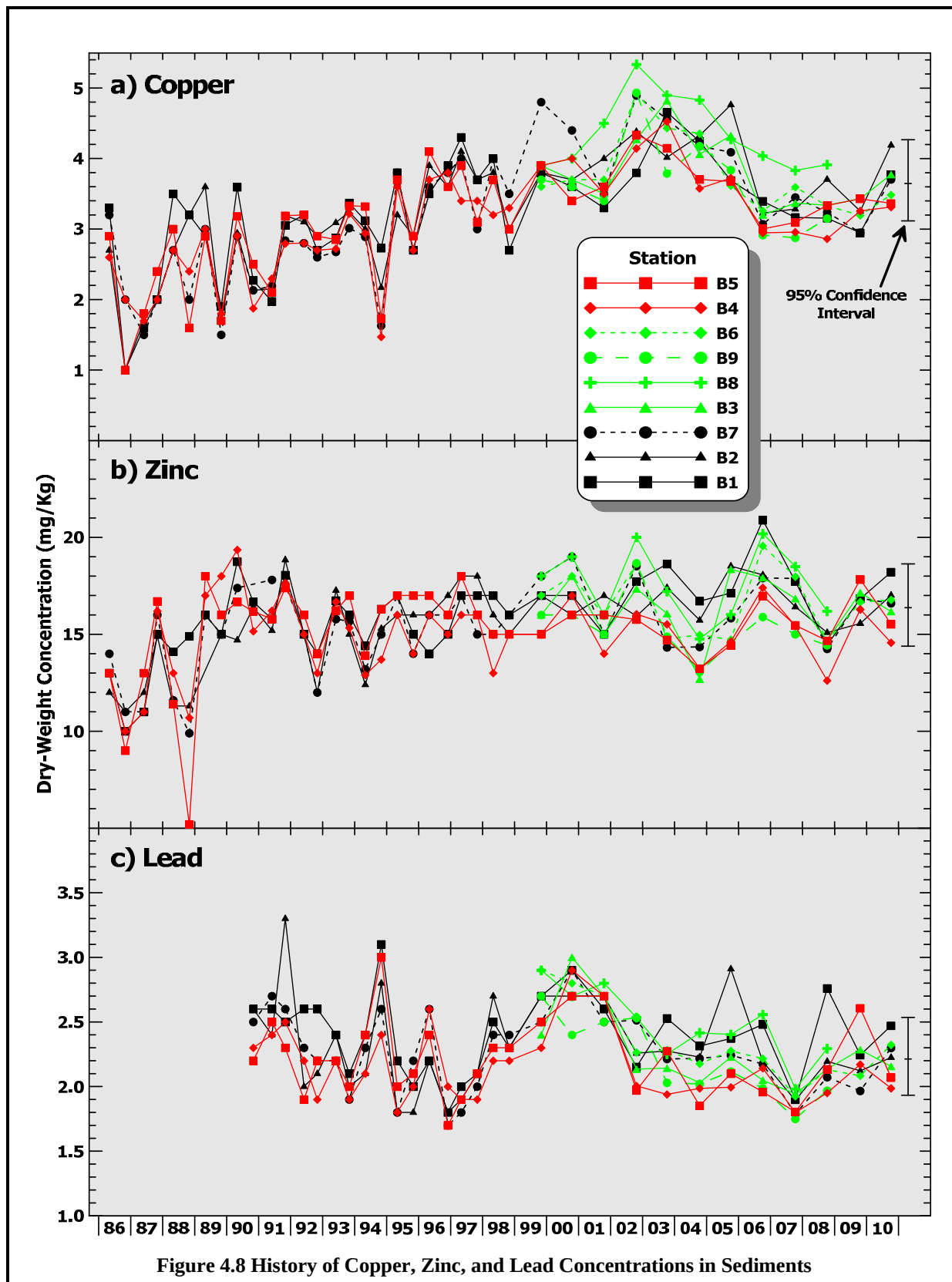
However, perceived temporal trends in contaminant concentrations must be interpreted carefully because natural and anthropogenic processes unrelated to the effluent discharge can cause large and widespread changes in chemical concentrations within sediments. These regional influences are apparent in the time series of sediment chemical concentrations shown in Figure 4.7, Figure 4.8, and Figure 4.9. Large-amplitude fluctuations occur over periods of a few years and a long-term increase in the concentrations of some constituents is apparent in the decade-and-a-half prior to 2000 (Figure 4.7abc, Figure 4.8a, and Figure 4.9c).

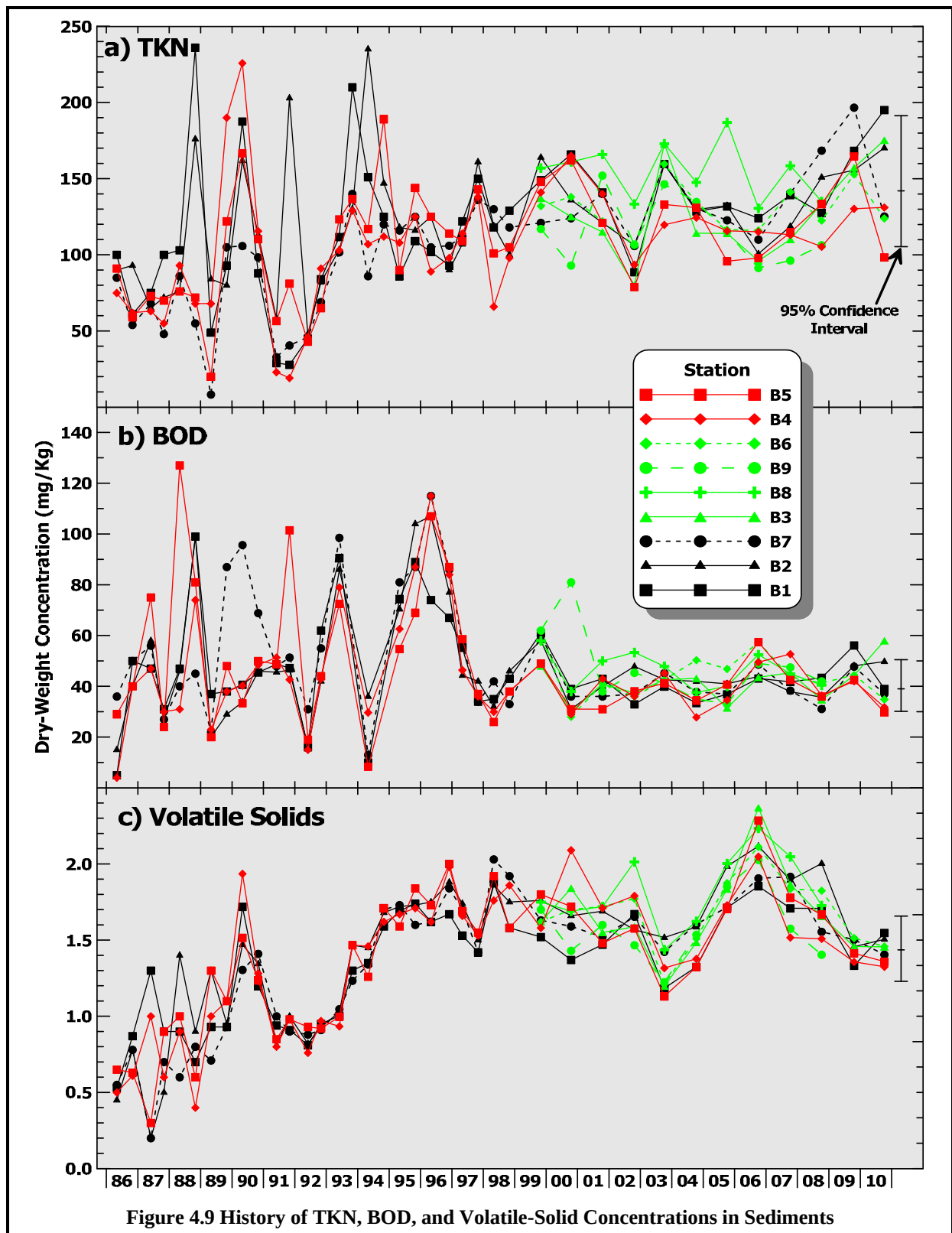
Nevertheless, these large interannual fluctuations and long-term increases tend to occur in unison at all stations, so the spatial differences among samples collected at a given time (i.e., within a given survey) are comparatively small. In other words, the stations generally tracked one another through time. This indicates that changes in sediment concentrations that arise because from regional influences throughout Estero Bay are far larger than those induced by any localized effects. During a given survey, spatial differences in sediment concentrations tend to remain within the 95% confidence interval (shown at the right of each time series) that quantifies the uncertainty in individual measurements. As described in the previous section, these confidence bounds indicate that most spatial differences within a given survey are not statistically significant, while interannual fluctuations and long-term trends are large enough to be reliably quantified in the presence of sampling uncertainty. Any subtle spatiotemporal trends in sediment chemistry that may be related to the MBCSD discharge are difficult to discern in the presence of these large regional excursions.

The pre-2000 long-term increase in some sediment metal concentrations was the subject of intensive investigation in prior annual reports (MBCSD 2010) and in an independent separate field study (MRS 2000b). Those analyses unequivocally demonstrated that the observed increase could not be caused by the MBCSD discharge because the accumulation occurred at all stations, including stations distant from the outfall, because the MBCSD metal emission was far too small to account for the widespread increase, and because the discharge remained unchanged while the trend in average concentrations leveled out after 2000. Instead, the steady increase in sediment metal concentrations prior to 2000 was ascribed to accelerated erosion of contaminated mine tailings at abandoned chromite mines within the adjacent watershed. After 2000, sediment concentrations appear to have reached equilibrium with the metal loading within runoff into Estero Bay.

Discerning subtle localized impacts within the backdrop of large interannual fluctuations and trends requires a special statistical technique that overcomes limitations associated with purely spatial or purely temporal approaches to impact evaluation (Coats et al. 1999, Skalski et al. 2001). The parallelism technique assumes that the large temporal excursions in concentrations occur in unison at all stations and represent a simultaneous response to regional influences unrelated to the MBCSD discharge. Under those circumstances, discharge-related spatiotemporal changes would appear as a gradual separation of the colors in Figure 4.7, Figure 4.8, and Figure 4.9, as contaminants preferentially accumulate near the outfall over time. Concentrations at nearfield stations (shown in red) would slowly increase relative to concentrations at mid-field (green) and distant reference stations (black). However, because of the large coherent fluctuations that occur over time, subtle spatiotemporal changes may be present but not visually apparent in the time series.

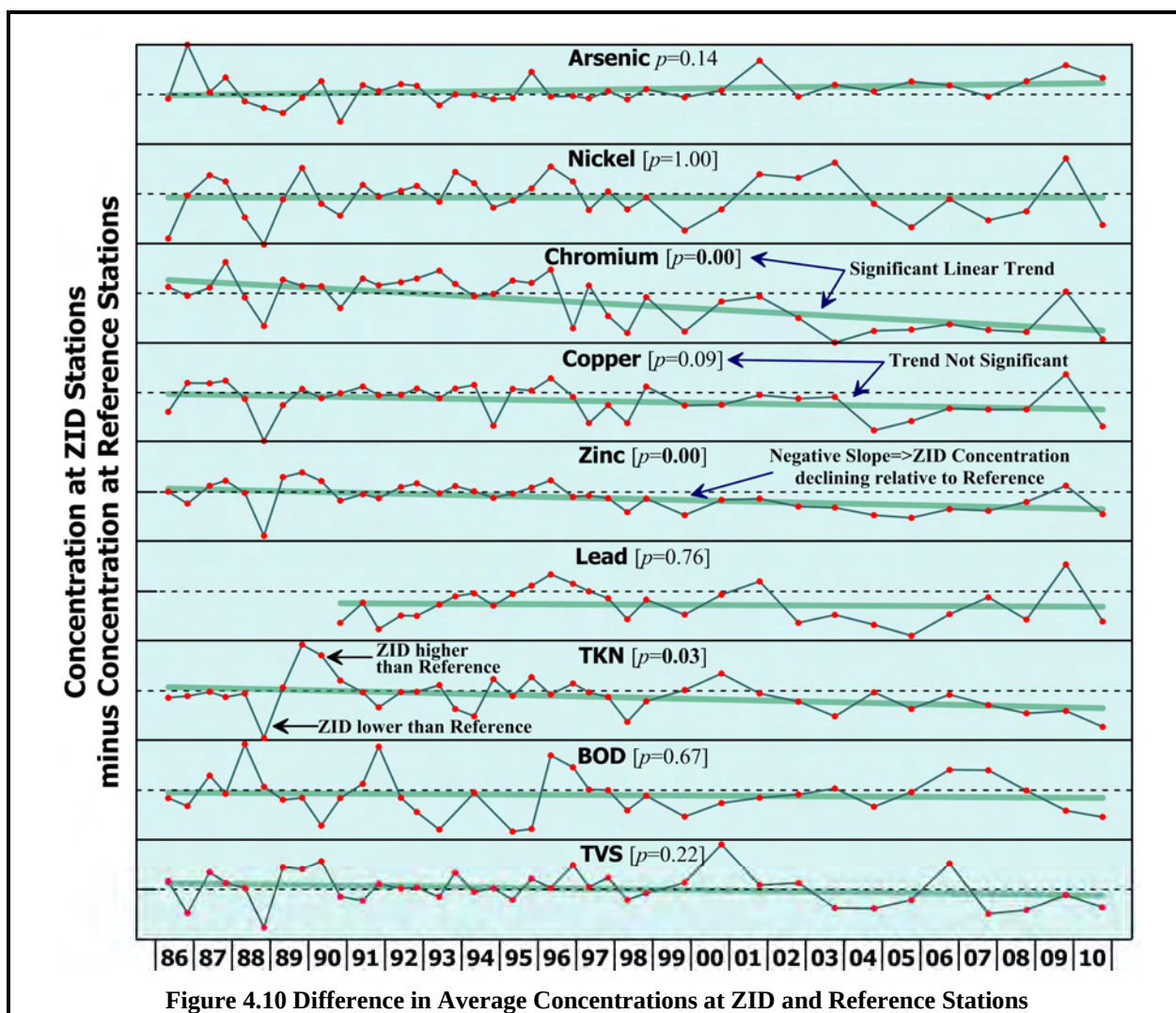






Instead, analysis of the difference between average concentrations at stations located near the outfall, and those that are distant from the outfall, effectively removes the temporal oscillations that occur on a seasonal and interannual basis. Specifically, if the time series of average concentrations near the outfall parallel those of distant stations, then there is little evidence for a discharge-related accumulation. A parallelism test is also insensitive to inherent differences in the sedimentary environment at the two groups of stations, for example, as was previously described for reference Station B1. Distant stations may have consistently higher (or lower) average concentrations because of natural spatial differences in the benthic environment, but because the parallelism test only deals with trends in the difference between the two groups of stations, rather than their absolute values, such natural spatial variations are rendered irrelevant.

Time series of differences in sediment concentrations at ZID and distant stations are presented in Figure 4.10. If contaminants discharged by the MBCSD discharge were accumulating in sediments near the outfall, then concentrations at stations near the outfall (B4 and B5) would slowly increase relative to distant stations (B1, B2, and B7). This would appear as a positive slope in the average difference shown in the Figure. A regression test for a statistically significant trend (slope) in the difference is equivalent to



a test of the null hypothesis that the contaminant concentrations at impacted and non-impacted sites remain consistent (parallel) over time.

Arsenic was the only chemical constituent that exhibited a positive slope. This suggests the possibility that concentrations near the outfall may have increased relative to reference stations over the last two-and-a-half decades, which may be indicative of a buildup of contaminants close to the discharge. However, the associated p -value (0.14), which measures the confidence level for the slope of the line, indicates the trend was not statistically significant, and that the trend was too weak to be adequately resolved given the overall scatter in the record of measurements. The high probability ($p=0.14$) of the statistical test compared to the 95-percentile threshold ($p<0.05$) demonstrates that there was no compelling evidence to reject the null hypothesis that the arsenic time series at near and distant sites were parallel throughout time.

All of the other chemicals exhibited negative slopes indicating that ZID concentrations generally decreased over time relative to reference stations (Figure 4.10). Because this trend is opposite of that expected from a buildup of contaminants near the discharge, the parallelism hypothesis test is irrelevant as indicated by the brackets surrounding the p -values. Nickel concentrations were nearly perfectly parallel over the record of measurements, as demonstrated by the negligible slope of the linear regression that leaves little reason to reject the null hypothesis of parallelism ($p>0.999$).

Chromium exhibited the strongest case for rejecting parallelism ($p<0.001$), and accepting the alternative hypothesis that chromium concentrations actually decreased near the outfall compared to distant stations. Although this trend is clearly unrelated to contaminant buildup around the discharge, it appears to be confirmed by the individual time series shown in Figure 4.7c. Early in the record, chromium concentrations at the most-distant reference station (B1), shown by the black squares, were comparable to that of other monitoring sites. In the latter half of the record, B1 concentrations began to diverge from the group, and in each of the last seven years, have been significantly higher than any of the other stations. This probably results from its large geographic separation from the rest of the group. As described previously, Station B1 is located in a more quiescent depositional regime, which is reflected in a much-higher mud fraction (black bar in the lower-right bar graph of Figure 4.6). Although trace-metal concentrations tend to be naturally higher in fine-grained sediments, this does not adequately explain why the same trend is not observed in the other metals. Instead, the slowly increasing chromium concentrations at Station B1 may have arisen because of its proximity to the mouth of a creek whose watershed encompasses a relict chromite mine, and where its contaminants are preferentially deposited.

Zinc ($p<0.005$) and TKN ($p=0.034$) also exhibit similar, statistically significant trends, where concentrations distant from the outfall have been steadily increasing relative to outfall reference stations. In both of those cases, however, the divergence in the (non-parallel) time series is not readily apparent in the individual time series (Figure 4.8b and Figure 4.9a). This demonstrates the value of parallelism tests, which eliminate large coherent fluctuations and allow the more relevant long-term trends to be revealed. Another attribute of parallelism is that it only addresses trends, and masks inherent differences in overall concentrations within the two groups of stations. This attribute is apparent in the lead time series (Figure 4.10). Although the average lead concentrations at ZID and reference stations closely tracked one another, and there was strong evidence that the trends were parallel ($p=0.76$), the average ZID concentrations were almost always lower than the reference station averages. This difference is apparent in the negative offset of the green regression line. Thus, parallelism tests only address long-term trends in the difference in contaminant concentrations. They appropriately disregard absolute concentration values that may be inherently different between the two groups of stations due to natural causes.

4.3 BENTHIC INFAUNAL COMMUNITY

The infauna living within the surficial sediments of northern Estero Bay act as sentinels for possible impacts caused by the discharge of MBCSD wastewater. Infauna serve as the best indicators of marine pollution because they have limited mobility and cannot easily escape exposure to contaminants in their immediate environment. Other organisms, such as marine mammals and finfish, range more widely, making it impossible to determine where the organisms were exposed to contaminants.

The diffuser structure lies on the seafloor, where particulate contaminants discharged into marine waters ultimately settle and accumulate. Because infauna reside within seafloor sediments, they are close to the potential source of pollution. Additionally, infaunal species vary in their sensitivity to pollutant stressors. As such, changes in relative abundance among species can signal alterations in their environment. Infauna are also important organisms to monitor because of their low trophic level within the marine food web. They are a major food source for more-mobile epifaunal and pelagic marine organisms, such as crabs, finfish, and marine mammals.

In recognition of infauna's role as an early detector of marine pollution, the MBCSD discharge permit requires regular monitoring of the overall health of the benthic community within Estero Bay. Infaunal monitoring also addresses the COP requirement that the discharge not degrade indigenous marine biota (see Objective E.1 in Table 3.1 on Page 3-3). The benthic monitoring has now amassed 25 years of infaunal data. During that time, 236,000 specimens representing more than 380 individual taxa have been examined. Throughout the monitoring program, there has never been any indication of deleterious discharge-related impacts to the benthic community. Instead, the data have revealed a consistently healthy indigenous infaunal community with uniformly high diversity beyond the ZID, and no evidence of spatial changes in the infaunal assemblages in relation to ZID proximity.

These observations hold true despite widespread variations in the abundance of individual organisms. Over the years, the dominance of individual taxa have waxed and waned in response to natural changes in the environment. Additionally, for many taxa, distinct differences in abundance are evident between the winter and summer sampling seasons. Other species come and go in response to powerful long-term variations in the oceanographic environment. One such variation is the El Niño – Southern Oscillation, whose impact has been evident in benthic sediment samples collected within Estero Bay on at least four occasions during the last two decades of MBCSD monitoring. The first event was in 1988, and the second began at the end of 1997 and extended into 1998. Its influence on benthic organisms was still evident during 1999. Another minor event may have occurred in 1991, however, the event with the largest influence on faunal populations around the outfall occurred in 2009 when the faunal density was 100-times higher than average due to a huge explosion in the sand-dollar population. (NOAA 2010). The effects of this population boom continued to be apparent in the 2010 data.

Almost 7,000 individual organisms were enumerated in the 35 sediment samples that were collected during the benthic survey conducted in October 2010. A compendium of the taxonomic identifications and enumerations conducted on year-2010 sediment samples is provided in Tables B.1 through B.8 in Appendix B at the back of this report. Tables B.9 and B.10 list infaunal indices that were computed from infaunal data, as required by the NPDES monitoring and reporting program. This section of the annual report combines these data with biological data collected over the prior 24 years to determine whether there have been discharge-related impacts to the benthic biota.

Three analyses demonstrate that there have been no deleterious impacts to benthic organisms as a result of the discharge. First, the organisms that inhabit the sediments around the outfall are indicative of an indigenous community of filter feeders that thrive only in clean sediments. Second, infaunal data collected during 2010 show no evidence of spatial gradients indicative of biotic degradation attributable

to effluent discharge. Third, despite wide fluctuations in community parameters over time, there were no long-term trends indicative of an increasingly degraded benthic environment around the outfall. All the stations tended to respond in unison to large interannual and seasonal influences on the infaunal community. To date, the indigenous benthic community remains healthy, with no perceptible influence from ambient contaminant levels, including the previously discussed long-term trends in trace-metal concentrations that have occurred throughout Estero Bay.

4.3.1 Indigenous Infaunal Community

The type and abundance of benthic organisms directly reflect the quality of the marine sediments where they live. Infaunal communities residing in degraded sediments tend to exhibit low species richness and diversity because they are primarily populated by only a few opportunistic taxa that feed on detritus and thrive in sediments that are high in subsurface organics. In contrast, clean sediments are populated by diverse assemblages of organisms that include filter feeders, which extract nutrients from suspended particulates. These suspension feeders are sensitive to excessive particulate loads such as those that can be discharged from low-performance treatment works. The widespread presence of suspension feeders around the MBCSD outfall clearly indicates that the discharge is not adversely affecting them. One such suspension feeder is the club-tipped anemone (*C. californica*). As documented in the diver inspection report (Appendix D), anemones were found carpeting the diffuser ports in 2010, as they have in prior years (see the photograph in Figure 2.2 on Page 2-4). Their presence is indicative of the benign nature of the suspended sediments discharged by the treatment plant.

Excluded Organisms

The populations of two organisms, *Diopatra ornata* and *Dendroaster exentricus*, have a profound effect on the MBCSD infaunal database. However, these organisms and their attached taxa are not particularly sensitive to changes in sediment quality, and their presence frequently confounds impact assessments. Consequently, their populations were removed from the database prior to the impact assessments described in this section.

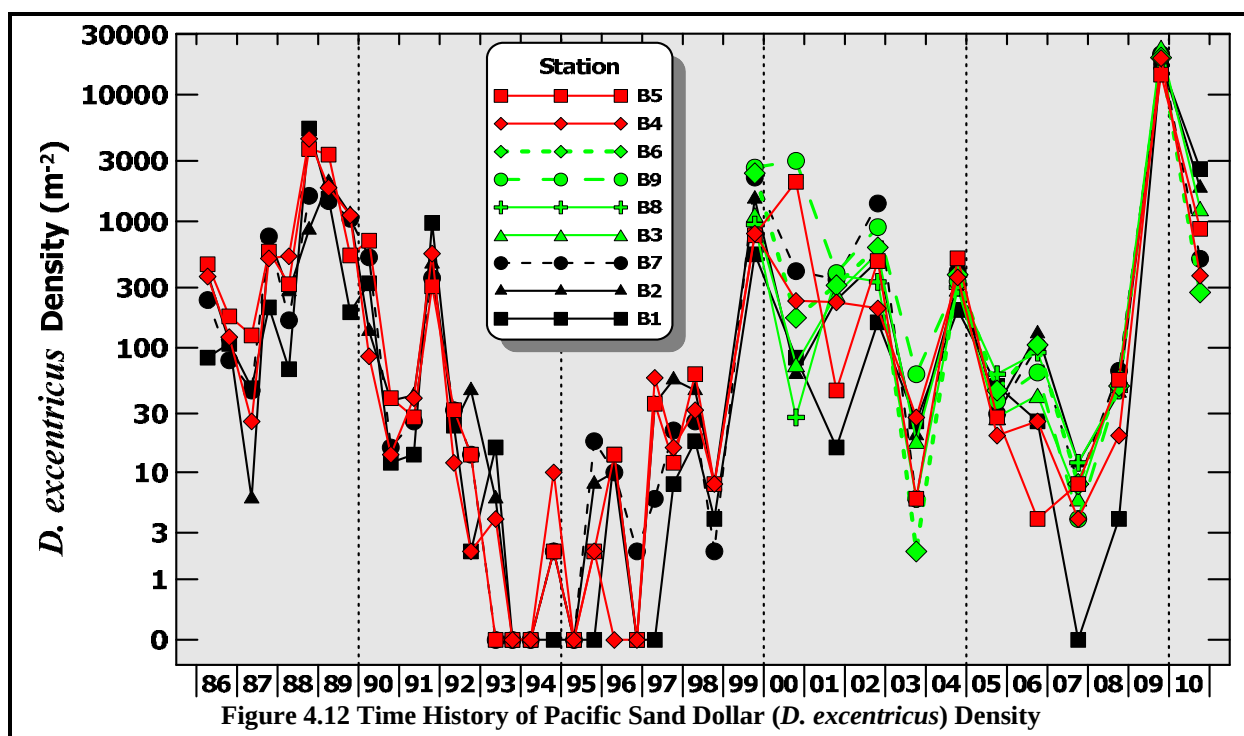
Since 2000, the parchment tubes of the Ornate Tubeworm (*Diopatra ornata*) have routinely been separated in the field prior to sieving of the infauna. Ornate tubeworms are so called for the elaborate layering of pieces of shells, algae, sticks, and other debris onto the outside of their large parchment tubes (Figure 4.11). The inclusion of large numbers of nestling epiphytes that reside on the microhabitats created by these tube casings, particularly small crabs and other crustaceans, can dramatically skew the enumeration of marine infaunal organisms in samples where they are present. Because epifauna live on the surface of marine substrates, they tend to be more mobile and less susceptible to sediment pollutants than infauna, which live in the interstices between sand grains. Removal of the parchment tubes in the field, prior to sieving, avoids the inclusion of large populations of epiphytes. The tubeworms themselves, however, are included in the enumerations because they tend to congregate in higher densities close to both natural reefs and manmade structures, such as outfalls (Davis



Figure 4.11 Photograph of a Tubeworm (*Diopatra* sp.)

et al. 1982). During the October 2010 survey, several *D. ornata* tube casings were separated from samples collected at Stations B1, B5, and B7. However, adult *D. ornata* were only identified from the samples collected at Stations B5 and B7.

Statistical analyses performed on the 2010 benthic samples also excluded Pacific sand dollar (*Dendraster excentricus*) populations. Although sand dollars are filter feeders and can be sensitive to pollution, they are removed from the database prior to statistical analysis because they exhibit extreme population fluctuations from year to year (Figure 4.12) which can potentially mask discharge-related impacts on less-dominant taxa.



Sand dollars form dense beds just seaward of the wave break, which acts as a barrier for predacious sea stars. At that location, predation is limited because sea stars can move over the sand-dollar bed only at significant risk of tumbling into the surf zone with a passing wave (Morin et al. 1985). Consequently, sand-dollar beds migrate shoreward in the summer and seaward in the winter in response to seasonal wave action (Oliver et al. 1980). A winter of strong wave action, usually associated with El Niño, reduces predation, permitting enhanced recruitment of juvenile sand dollars. Specifically, the increased sand dollar recruitment that occurred in late 1988, 1991, 1999, and 2009 was probably associated with high-waves generated by El Niño events in 1988, 1998, 2009 and the weaker one in 1991.

Similarly, the population drop documented in 2003 may have been linked to a predation event in late 2002. On numerous occasions during the October 2002 survey, short-spined sea stars (*Pisaster brevispinus*) became jammed in the jaws of the grab sampler, resulting in an unusually high number of repeated grab sampling attempts at several stations. Accordingly, sand dollar populations in the following year 2003 were markedly diminished, suggesting that predation may have played a significant role in the reduction observed between 2002 and 2003.

Because their large numbers overwhelmingly dominate the population statistics during high-recruitment years, sand dollars have the potential to mask any influence from the discharge on less-dominant taxa whose populations are more consistent and sensitive to potential discharge impacts. For example, historically, average sand dollar densities have ranged from a high of 19,000 m⁻² in October of 2009 to less than 50 m⁻² between May 1992 and October 1998. During 1999, however, recruitment peaked slightly before engaging in a general decline through 2007 when a total of only 31 sand dollars were collected. During those years, removal of the few *D. excentricus* specimens from the database had little impact on the statistical analyses.

In 2010, however, a total of 3,869 individual sand dollars were enumerated within the 35 infaunal samples collected within the survey. These sand dollars represent the surviving individuals from the extremely successful recruitment event that took place during 2009. These two populations clearly belonged to the same age group (cohort) of sand dollars because the individuals within each year were of uniform size, but the 2010 population was much larger in size and fewer in number (Figure 4.13). Nevertheless, the 2010 population was among the largest recorded in the course of the monitoring program, with 1,297 specimens collected at Station B1 alone. In comparison, the amassed total of all other benthic organisms collected during 2010 sampling came to only 3,084 individuals.

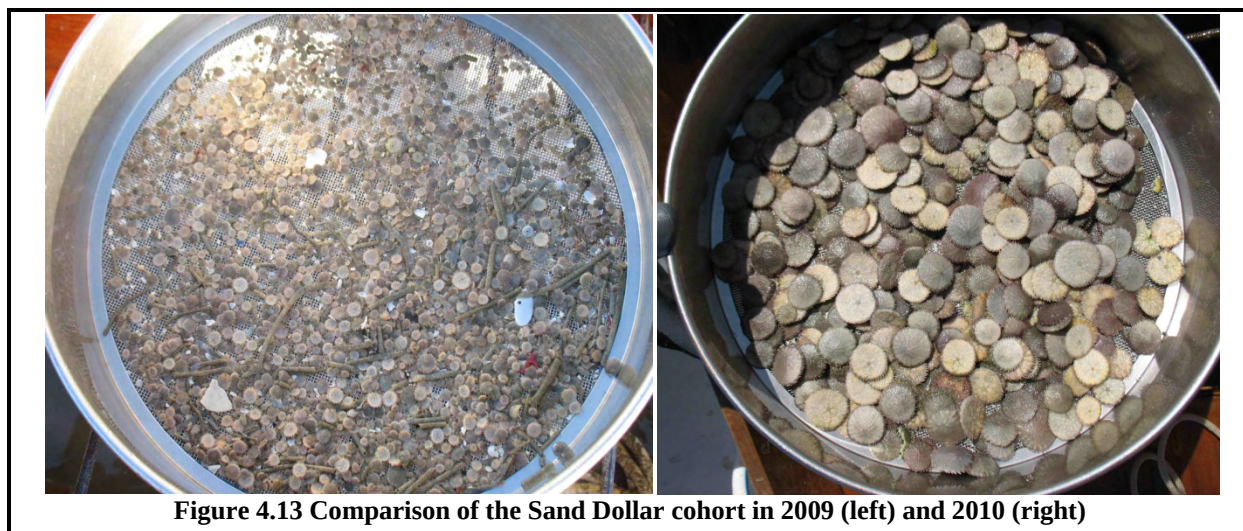


Figure 4.13 Comparison of the Sand Dollar cohort in 2009 (left) and 2010 (right)

Because their populations were comparatively large, community indices computed with the 2010 *D. excentricus* population (Table B.9) were vastly different from indices computed without their inclusion (Table B.10). Most of the indices, such as dominance and diversity, measure the uniformity in abundance among species. When the overwhelmingly dominant sand-dollar population is included in the indices, trends in the diversity due to population differences in other taxa are completely masked. For example, the Swartz dominance index (*Sw*, see Section B.1.2) is normally a relatively diagnostic and stable measure of the overall health of the infaunal community. However, because sand dollars represent more than 80% of the population in four of the replicate samples collected at Station B1, it remained unchanged from unity (See the *Sw* column in Table B.9) and provided no information about the relative abundances of other taxa. Exclusion of sand dollars from the computation of indices (Table B.10) allows differences in other taxa to be discerned. Note that the infaunal trophic index (*ITI*) is unaffected by the presence of sand dollars because they were not included in the feeding guilds quantified by that index.

Exclusion of the transient sand-dollar population enhances, but does not detract from the impact evaluation because their distribution is clearly unrelated to effluent discharge. As with the chemical constituent time histories, spatial distributions of sand-dollar populations related to outfall proximity would be evident in Figure 4.12 as a separation between the time histories for the ZID stations (red), for midfield stations (green), and for stations well away from the diffuser structure (black). Instead, the large fluctuations in sand-dollar abundance tend to occur equally at all stations. The consistently low density of fully-grown adult sand dollars, even during the high-population periods, demonstrates that their presence is transient; no permanent sand dollar beds exist in the region (Brown and Caldwell 1989, 1993). It is well established that sand-dollar beds are often dominated by a single age cohort, suggesting that recruitment is episodic and only occasionally successful (Cameron 1980, Oliver et al. 1980, Morin et al. 1985, Cameron and Rumrill 1982). Figure 4.13 confirms that the sand dollars collected during the MBCSD benthic surveys tend to be composed of small juveniles of the same cohort.

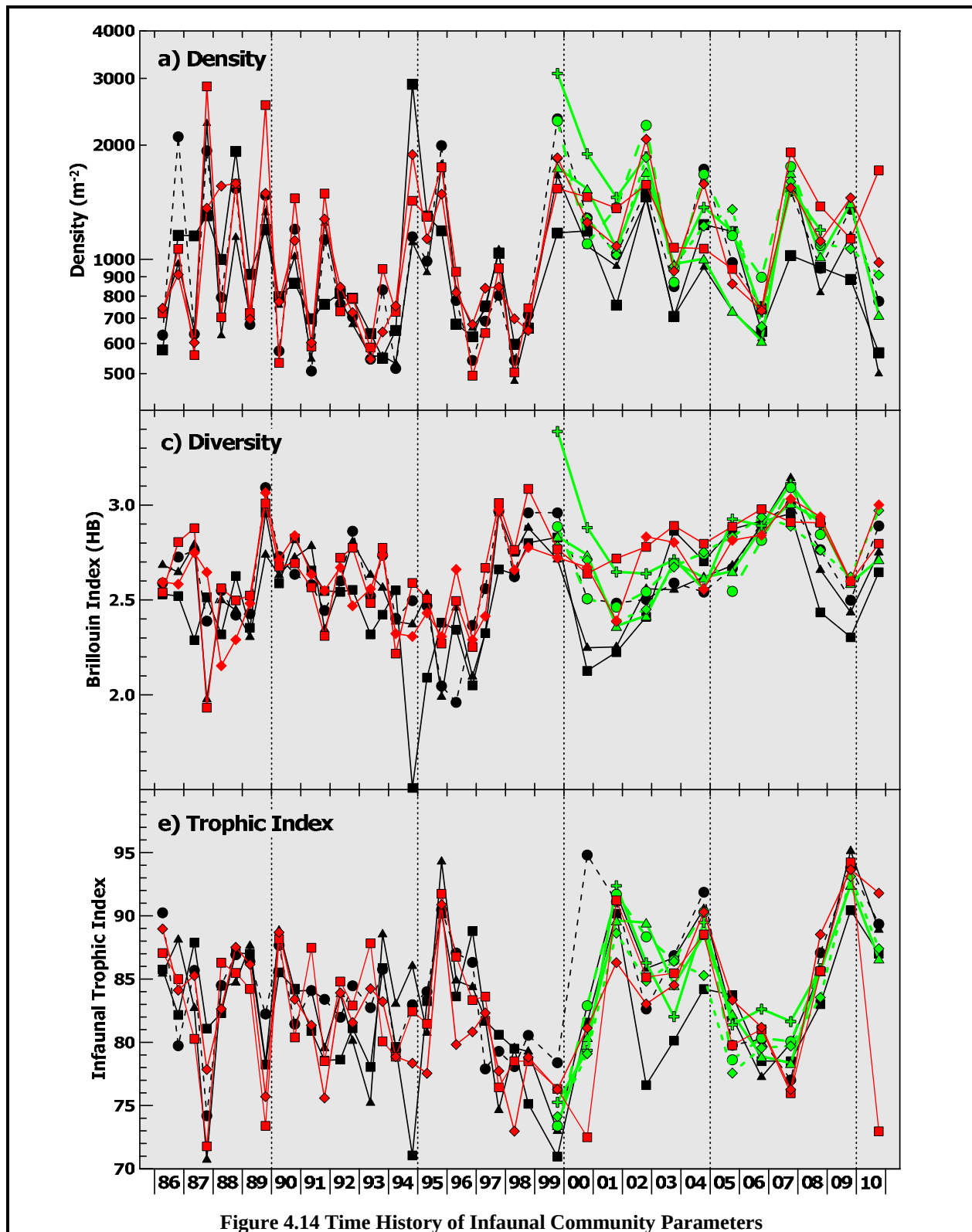
Abundance

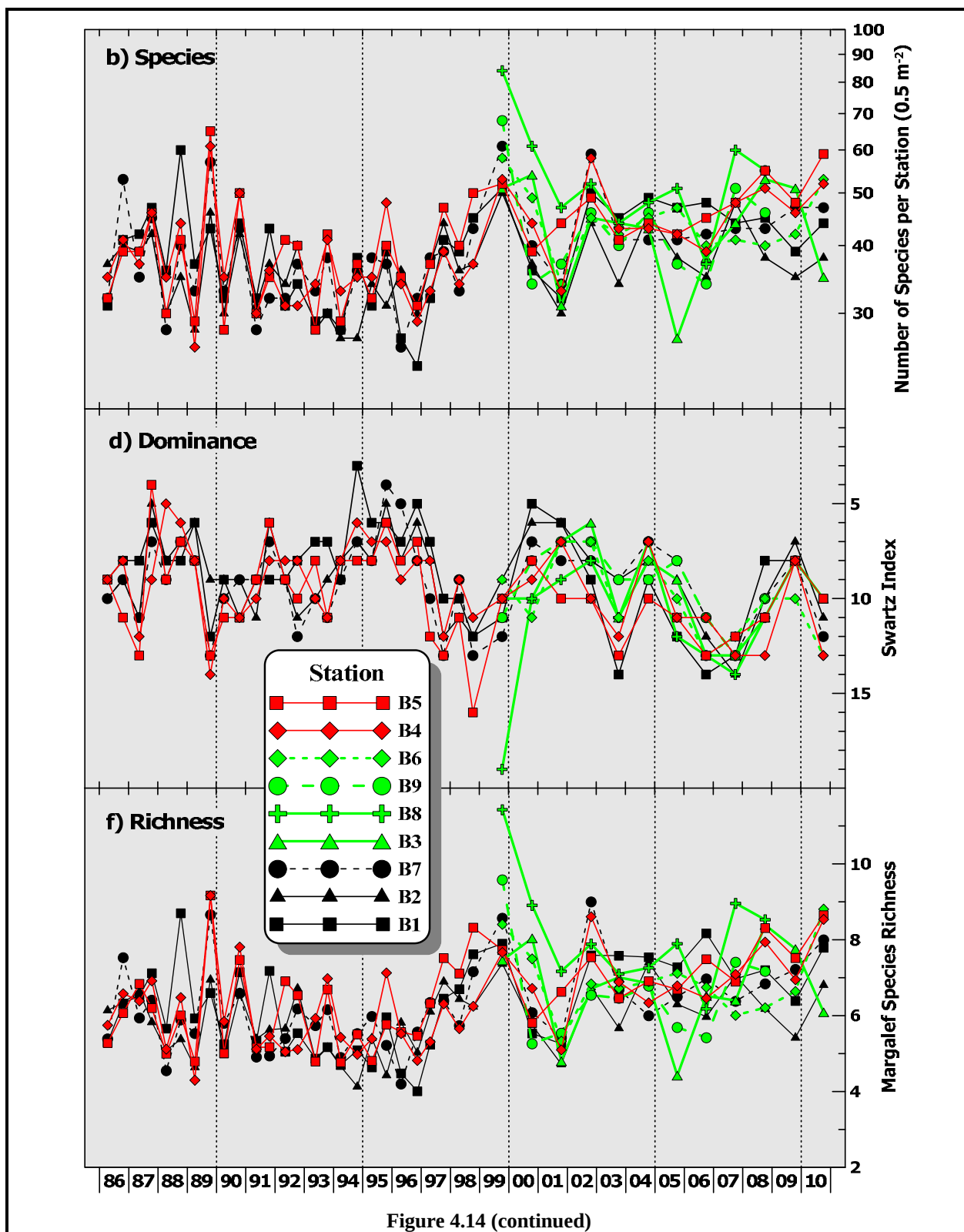
In this report, the overall health of the benthic community within Estero Bay is reflected by the principal population parameters computed from samples collected at each station over the duration of the monitoring program. For the reasons described above, sand dollars (*D. excentricus*) were excluded from the population statistics to better evaluate the overall health of the benthic community. The community parameters provide a succinct description of the abundance, diversity, richness, and trophic (feeding) structure of benthic biota. Figure 4.14 shows the temporal variability in mean community parameters that were computed for each of the nine historic benthic monitoring stations, seven of which have been monitored continuously, including in 2010. Each major category of community parameter is discussed in the sections that follow.

Population density, shown in Figure 4.14a, measures the total abundance, or number of organisms, within a 1-m² area of the seafloor. It is the most basic single measure of a community of organisms, but lacks valuable insight as to how the abundance is distributed among the differing taxa. Because of this deficiency, it is not a useful ecological measure by itself. Nonetheless, major declines in organism density can occur after a rapid increase in sediment contamination. This initial decline is often followed by a marked increase in total abundance as opportunistic species repopulate the degraded environment.

Throughout the monitoring program, the number of organisms collected at each station has fluctuated enormously. Although the range in abundance covers almost an order of magnitude, differences in abundance among individual stations within any given survey were much smaller. Namely, all the stations tend to track the temporal fluctuations as a group, and spatial differences among stations within a given survey are generally small compared to the wide temporal fluctuations between surveys.

The largest population changes occur on a seasonal basis. Post-summer populations (those sampled during the October survey) are generally a factor of three higher than the post-winter populations. The reduced winter population, which was only measured prior to 1999, is a response to harsher oceanographic conditions when storms generate intense wave-induced currents that scour the bottom near the 15-m water depth of the outfall. Post-summer populations reflect recruitment of the more delicate annelid worms that can only survive during quiescent benthic-flow regimes. The absence of winter surveys after 1998 accounts for the uniform increase in density that is apparent in the last decade of the monitoring record.





Any spatial gradients in density are completely masked by the large temporal fluctuations. In particular, abundances at stations near the outfall (shown in red) were not consistently lower (or higher) than the density at distant stations (shown in black), and that lack of spatial division has remained constant throughout the monitoring program. This demonstrates that any accumulation of sediment chemicals from the effluent discharge over the last two decades has had no discernable impact on infaunal abundance, particularly when compared to large seasonal and interannual population fluctuations.

Number of Species

The total number of species is another measure of the overall health of benthic communities (Figure 4.14b). Everything else being equal, infaunal communities respond to environmental stresses by becoming less diverse, as reflected by a substantial reduction in the number of species. However, the number of species encountered in a sample is directly related to the number of organisms in the sample, i.e., it is inherently related to sample abundance. Because rare species are generally undersampled, the number of species automatically increases in samples with more organisms. Thus, it is difficult to tell if a decreased number of species is due to an actual decline in biodiversity, or simply due to decreased sample sizes (abundance). Irrespective of the influence of sample size, reductions in species counts would suggest a decline in diversity and degradation in the marine environment.

There was no obvious temporal trend in numbers of species that would suggest that sedimentary conditions near the outfall were being preferentially degraded (Figure 4.14b). Specifically, there was no divergence in the colors over time, where species counts at stations distant from the outfall, shown in black, steadily increase relative to stations near the outfall. As with abundance, any spatial differences in the 2008 data were minor when compared to seasonal and interannual fluctuations.

Beginning in 1996, there was a steady increase in the number of species encountered in samples. This trend culminated in 1999, when 84 species were collected at Station B8 alone (green line with crosses). However, this increase was largely due to the increased prevalence of ornate tubeworms (*D. ornata*) within some of the samples. For example, between 1990 and 1996, only one, and usually no *D. ornata* specimens were collected during any given survey. However, in the post-winter surveys of both 1997 and 1998, two ornate tubeworms were encountered. In 1999, four of these tubeworms were found at Station B8 alone. These tubes were not removed prior to sieving, and as discussed previously, the inclusion of numerous epiphytic taxa associated with their tube casings resulted in the unusually large number of species recorded in 1999.

The other temporal fluctuations in species counts tended to track the fluctuations in abundance. Consequently, at least some of the variability in the numbers of species can be an artifact of the sample size (abundance) rather than purely an increase in species richness or diversity. In 2010, the number of species enumerated at each station ranged between 35 and 59, which is comparable to the past several years.

Diversity

A large number of interrelated diversity indices have been developed in an attempt to account for the inherent relationship between the number of species and sample size or abundance. Two common indices are the Shannon Diversity (H') and the Brillouin index (HB) (Appendix B.1.1). Both exhibit nearly identical time histories in the MBCSD database, so only the Brillouin index is shown in Figure 4.14c.

Ostensibly, diversity should decrease in a degraded benthos, although significant reductions can also occur in the absence of anthropogenic stresses. Nevertheless, temporal trends in diversity did not exhibit any evidence of a deteriorating benthic environment near the outfall. On the contrary, in recent years the highest diversity was typically observed at one of the two stations located closest to the outfall (shown in

red). Higher diversity at the two ZID stations indicates a healthy infaunal community close to the outfall rather than a community impaired by the discharge of effluent.

Nevertheless, two large historical outliers in diversity warrant some discussion. First, the markedly high diversity (3.39) that was measured at nearfield Station B8 in 1999 was an artifact of the enumeration of additional epiphytes residing on the casings of ornate tubeworms. As discussed previously, the presence of a large number of epiphytic species heavily influenced both the overall abundance, and number of species counted at this station during the 1999 survey (Figure 4.14ab).

The second unusual outlier was the very low diversity (1.51) that was found at Reference Station B1 during the October 1994 survey (black square ■ in Figure 4.14c). As with outlier described above, there were an unusually high number of organisms enumerated in the samples collected at this station in 1994 (Figure 4.14a). However, in this case, the increased abundance was associated with a single species, the spioniform polychaete worm *Magelona sacculata*. Nearly 1,000 specimens were collected at Station B1 during the October 1994 survey. As a result of the numeric dominance of this one taxon, the computed diversity at this station was low.

M.sacculata is often one of the numerically dominant taxa found in northern Estero Bay, but on average, only approximately 50 specimens are typically collected at each station. Interestingly, during the 2010 survey, a total of only 97 specimens was collected between the seven sampling stations; however, the distribution of these specimens was also very uneven, with Station B5 contributing an overwhelming majority (94%) of the specimens collected. In fact, most (83) of these specimens were collected from only two of the replicates at Station B5.

Although magelonids are common in sandy bottom sediments, their distribution is patchy, so a few replicate samples typically contain most of the specimens, while other grab samples from the same station contain none. Nevertheless, the presence of this surface detritus feeder can be considered marginally indicative of degraded sediment conditions. Although the abnormally increased abundance in 1994 occurred at the reference station, and thus bore no relationship to effluent discharge, the same charge cannot be as easily dismissed in the 2010 data, since Station B5 is one of the closest stations to the diffuser. Instead, the unusual character of the Station B5 samples during 2010 was due to their location within the outfall's debris field. As discussed in further detail in Section 4.4 on Page 4-49, these organic-rich debris fields consist of epibiota that detach and fall from seafloor structures, and accumulate on and within the sediments surrounding the structure.

Dominance

The Swartz species dominance differs from the other community indices because it does not make an *a priori* assumption concerning how individuals are distributed among species. Because it is non-parametric, it is less sensitive to the limitations that plague other community indices. It is defined as the total number of species accounting for 75% of the individual organisms collected. As such, it represents an inverted measure, in which increased dominance is associated with lower values of the Swartz index.¹⁹ Increased dominance is expected in degraded benthic communities where a few opportunistic, pollution-tolerant taxa abound in the absence of a wider array of pollution-sensitive organisms. As with the other community parameters, Figure 4.14d shows that differences in dominance among stations in a given survey were generally small compared to temporal fluctuations. Overall dominance was generally low, with five or more species typically sharing numerical superiority. In fact, in most surveys, organisms were

¹⁹ Note that the vertical axis of the Swartz index plot is inverted in Figure 4.14d so that values that are located higher in the plot represent increased dominance.

more evenly distributed among taxa at the outfall stations (shown in red) than at more distant stations. This is opposite of the pattern expected if effluent discharge had degraded the benthic environment.

By far the lowest historical dominance occurred in samples collected at Station B8 during 1999. During that survey, nineteen species accounted for 75% of the specimens collected. Judging from a Swartz index that normally is near eight species, up to 10 of the 19 dominant species that were found at Station B8 during 1999 were epiphytic organisms associated with the presence of ornate tubeworms. The exclusion of these tubeworms from subsequent surveys has resulted in more stable and representative Swartz indices.

On average, eleven species accounted for 75% of the specimens in the benthic samples collected during the October-2010 survey. This indicated that infaunal abundance was evenly distributed among the species. Moreover, uniformly low dominance was found at all the stations in the 2010 survey; with no station having less than 10 species in the top 75% of abundance.

Clean-Sediment Feeding Guilds

The Infaunal Trophic Index (*ITI*) (Word 1978, 1980, 1990) compares the abundance of four soft-bottom assemblages that are distinguished by their feeding behavior. Because sensitivity or tolerance to organic enrichment differs among the four groups, shifts in the dominance of the individual feeding groups, as reflected by a change in the Trophic Index, can be indicative of a benthic environment degraded by organic material. The *ITI* ranges between 0 and 100. When species in Group I (suspension feeders) and Group II (surface-detritus feeders) dominate, index values are above 58, indicating that sediments are relatively clean. Lower infaunal indices occur when populations of species in Group III (surface deposit feeders) and Group IV (subsurface detritus feeders) are prevalent, which reflects sediments high in organic material.

The *ITI* has been exceptionally high throughout the monitoring program, typically exceeding 80, and in 2009, exceeding 90 (Figure 4.14e). This reflects a community dominated by suspension-feeding organisms, with few organisms that depend on organic material to survive. The exceptionally clean sediments of Estero Bay have always been reflected in a trophic index well above the critical *ITI* of 58, below which organically altered benthic conditions are thought to exist. In fact, trophic indices have always exceeded 70 at the MBCSD benthic stations, confirming the consistent dominance of suspension and surface-detritus feeders in the relatively clean sedimentary environment offshore Morro Bay and Cayucos.

Moreover, there is no consistent pattern of organic degradation close to the outfall evident in the *ITI* time series. Effluent-related degradation would appear as a gradual separation in colors over time, with stations closest to the diffuser structure (shown in red) eventually having the lowest *ITI*. This would be followed by a slightly higher *ITI* at nearfield stations, shown in green. Instead, as with the other community indices, and with the chemical concentrations, there is no consistent pattern of color separation from year to year.

Occasionally, however, an outlier *ITI* will occur within a given survey. For example, there have been two anomalously low *ITIs* associated with ZID Station B5: one in the year-2000 survey, and the other in 2010 (red squares in Figure 4.14e). Although they were not particularly low compared to *ITIs* reported in some other years, and they remained above the critical *ITI* indicative of organically altered conditions, they stand well apart from the other *ITIs* reported in the same year for all other stations. These outliers raise the question as to the source of organic material that caused a marked increase in subsurface detritus feeders at that particular sampling station.

As described in Section 4.4 on Page 4-49, several of the replicate grab samples at Station B5 were unavoidably collected immediately next to the outfall pipe (see the inset in Figure 4.2). Specifically, Replicates R4 and R5 at Station B5 were collected within the outfall's organic debris field. These samples contained significant amounts of shell hash and debris that made them visually and volumetrically distinguishable from both the other replicates at Station B5 as well as from samples collected at the other Stations. The unusual amount of shell hash was noted in the field notes (see the comments for these samples in Table C.1), and was so unusual that the debris was photodocumented during sieving offshore (Figure 4.15). During sorting in the laboratory, the residue volume for Replicate R4 was approximately five times greater than the volume of any other sample from this survey.



Figure 4.15 Photograph of Shell Debris from Replicate Sample R4 at Station B5

Significant amounts of organic debris accumulate in the sediments next to seafloor structures like the outfall pipe, as epifauna die and slough off the structure. In the case of the outfall, debris is also purposely dislodged by divers cleaning the diffusers, or accidentally dislodged by collisions by the grab. Like the shell mounds below offshore platforms, the accumulation of organic debris can be quite large but is localized very close to the structure. However, this debris field often supports a unique community of benthic organisms with an affinity for high concentrations of organic material.

Not surprisingly, the populations of two subsurface detritus feeders within *ITI* feeding Guild IV were elevated in the replicates that were collected immediately adjacent to the outfall, opportunistically feeding on the organics within the sediments there. As a result, Replicate R4 had an *ITI* of 60 (Table B.9 in Appendix B), which was among the lowest replicate-sample *ITI* measured within the 25-year database. The *ITI* of 73 within Replicate R5 was also unusually low and together, they brought the overall *ITI* at Station B5 to a level well below that of the other stations. Consequently, Station B5's *ITI* approached the critical *ITI* where benthic conditions could be considered changed by organic enrichment. Nevertheless, an even lower *ITI* of 34 was measured very close to the diffuser in Replicate R2 from Station B5 during the year-2000 survey (MRS 2001). It approached the degraded-condition threshold. Together, those anomalous samples markedly reduced the Station-B5 *ITI* totals, which are apparent as outliers in the *ITI* time history (red squares in Figure 4.14e).

4.3.2 Infaunal Diversity Unrelated to Outfall Proximity

The previous section documented the overall health of the infaunal community surrounding the outfall using a 25-year record of infaunal community indices. This section investigates whether spatial trends related to outfall proximity exist in the infaunal data collected in 2010. As described in Appendix B.1, four of the biological indices are more informative than the other indices. They include the Brillouin Diversity Index, the Swartz Dominance Index, the Margalef Richness Index, and the Infaunal Trophic

Index (ITI). The 2010 spatial distribution of average values for these four indices is shown in Figure 4.16.²⁰

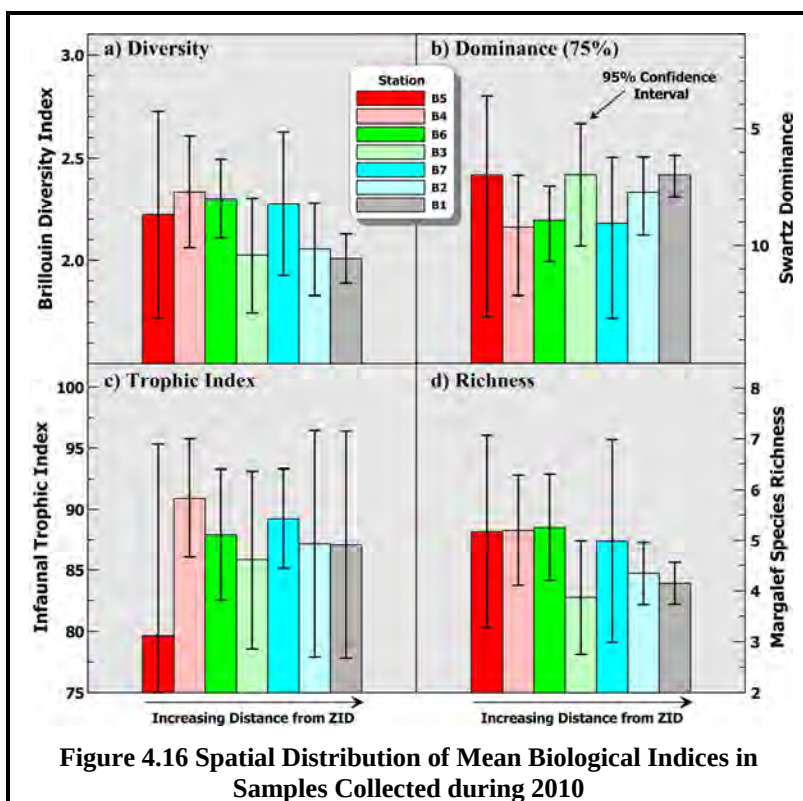
The bars shown in Figure 4.16 are arranged in order of increasing distance from the diffuser structure. The red-colored bars on the left are associated with the ZID stations located closest to the diffuser, while the two green bars in the middle represent the nearfield stations. Finally, the blue and gray bars that are farthest to the right represent the three distant stations, which lie 120 m or more from the outfall.

Impacts to infaunal communities from the discharge would be reflected in the bar chart as a spatial trend of steadily increasing diversity, ITI, or richness from left to right (Figure 4.16acd). In contrast, dominance would be

expected to decrease with increasing distance from the outfall (Figure 4.16b). However, none of these spatial trends is visually apparent in the Figure. If anything, the opposite appears to be the case.

Another way of evaluating whether significant spatial differences exist among the infaunal indices is to test whether any of the average values are significantly different from those of other stations, irrespective of their distance from the outfall. The height of the bars in Figure 4.16 reflects the average index computed from the five replicate samples collected at each station. The 95% confidence intervals surrounding those averages quantify the variability among replicate samples collected at each individual station. As such, the confidence intervals reflect the inherent uncertainty in the determination of average station values. Thus, if the mean at one station is encompassed within the confidence interval at another station (or vice versa), then no statistical significance can be ascribed to any perceived difference between the averages at those two stations, at least with any degree of confidence (viz., a 95% confidence level, $\alpha \leq 0.05$). Visual inspection of Figure 4.16 indicates that the average indices at almost all pairs of stations are encompassed by the associated confidence intervals, except perhaps occasionally at Station B1.

Replicate samples from Station B1 contained infaunal communities that were comparatively similar, and this similarity was reflected in narrower confidence bounds. In contrast, several replicate samples at Station B5 were collected within the organic debris field immediately surrounding the outfall. As a result, the infaunal community represented in these samples differed markedly from samples collected only a short distance away, and the confidence bounds on the average station indices were larger. For most indices, the increased scatter at Station B5 was minimal, reflecting their inability to discern biological



²⁰ Note that the values plotted in the time histories of Figure 4.14 are station totals, and differ from the averages among replicate samples plotted in Figure 4.16.

change. However, the confidence bounds surrounding the average *ITI* at Station B5 were large (Figure 4.16). As described previously, that index was specifically designed to detect changes related to organic enrichment. However, because the *ITI* was markedly lower in only one replicate, the Station-B5 average was not determined with a great degree of confidence. As a result, there was no statistically significant difference in the *ITI* average at Station B5, and the average determined at any other station. The Station-B5 confidence bound encompassed the *ITI* average at all other stations.

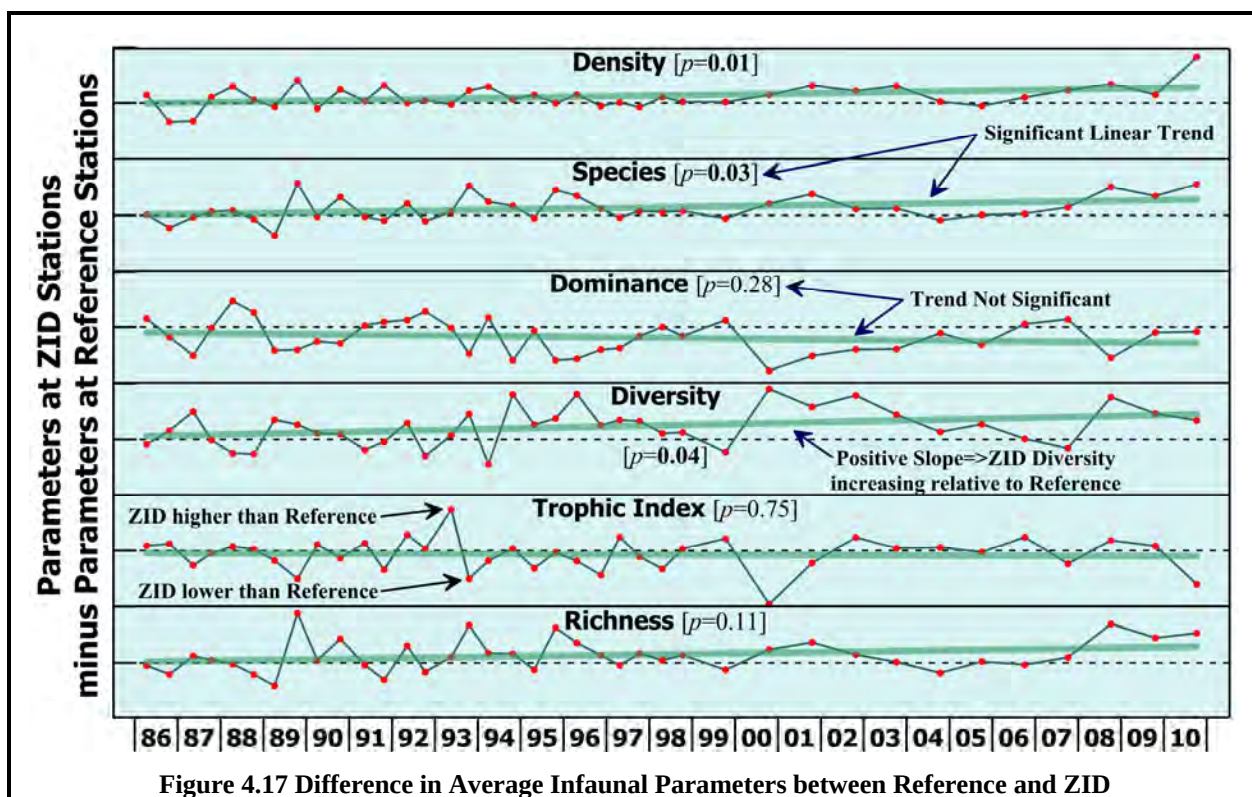
4.3.3 Spatiotemporal Infaunal Trends Unrelated to Outfall Proximity

As with the chemical constituents within northern Estero Bay sediments, subtle spatiotemporal trends in the infaunal community can be difficult to discern in the time series shown in Figure 4.14. The parameters exhibit wide fluctuations between seasons and years. Compared to these large temporal oscillations, the spatial differences among samples collected at a given time (i.e., within a given survey) were comparatively small. In other words, the stations generally tracked one another through time. This indicates that changes in infaunal communities that arise because from regional influences throughout Estero Bay are far larger than those induced by any localized effects. Therefore, within a given survey, spatial differences in infaunal parameters can be difficult to discern, and are likely to be confounded by larger natural differences in the sedimentary environment and other zoogeographic influences.

The limitations associated with purely spatial or purely temporal approaches to impact evaluation are largely eliminated through the use of an analysis technique based on tests for nonparallel trends at impact and reference sites (Coats et al. 1999, Skalski et al. 2001). In this application, statistical analyses based on parallelism are capable of discerning subtle temporal trends in the difference between average indices at stations located near the outfall, and those that are distant from the outfall, even though the indices as a whole widely fluctuate from survey to survey. As described previously, discharge-related spatiotemporal changes would appear in Figure 4.14 as a gradual separation of the colors as contaminants accumulate near the outfall and affect the resident organisms. However, because of the large coherent fluctuations that occur over time, subtle spatiotemporal changes may be present but not visually apparent in that kind of presentation. Taking the difference in average values at distant and near sites removes the temporal oscillations that occur on a seasonal and interannual basis. In effect, parallelism assumes that the large temporal excursions in indices occur in unison at all stations and represent a simultaneous response to regional influences. Time series of differences in parameters at ZID and distant stations are presented in Figure 4.17.

If the MBCSD discharge were negatively affecting the benthic community over time, the infaunal properties of populations at stations near the outfall (4 and 5) would slowly diverge from those of the distant stations (1, 2, and 7). This would appear as a trend or slope in the average difference shown in Figure 4.17. A regression test for a statistically significant trend (slope) in the difference is equivalent to a test of the null hypothesis that the population responses at impacted and non-impacted sites are parallel over time.

Parallelism tests applied to the 25-year time series found a slight, but statistically significant, positive linear trend in the three infaunal indices: density ($p=0.01$), number of species ($p=0.03$), and diversity ($p=0.04$). The slight increases in the difference between these indices at ZID and reference stations are apparent as a small slope in the linear regression lines shown in Figure 4.17. The trends arose because, in recent years, the ZID stations have exhibited increasingly greater density, species counts, and diversity compared to reference stations. This is opposite of the temporal trend one would expect if the effluent discharge was having a deleterious impact on the benthos near the outfall. Rather, higher abundance and diversity at stations close to the outfall reflects a healthier infaunal community compared to the distant



reference stations. Except for this marginal trend, parallelism was strongly indicated ($p \geq 0.11$) for the other indices.

4.3.4 Infaunal Community Structure

As described above, determining whether adverse biological conditions exist near the MBCSD outfall involves assessing whether the existing benthic environment supports a balanced indigenous population (BIP). A BIP is an ecological community that exhibits characteristics similar to those of nearby, healthy communities existing under comparable, but unpolluted, environmental conditions. In evaluating a BIP, infauna have an important advantage over other marine organisms, such as marine mammals or finfish. Infauna are relatively easy to collect in numbers large enough for reliable statistical testing, and they do not move over large areas, so their response is site specific. Pollution affects marine ecosystems by changing the infaunal community structure, namely, the number and type of benthic organisms found in the sediments. However, evaluating the well-being of the infaunal community, and testing its variation over time and space is complicated by the multitude of individual taxa collected within each replicate grab sample. Subtle changes in community composition are not always readily apparent in the large volume of raw data generated by field surveys.

The multivariate complexity of infaunal abundance data makes a BIP analysis challenging because it is difficult to quantify the health of the community into a concise parameters that is indicative of existing environmental conditions. Biodiversity is a common indicator of the well-being of ecological systems, and forms the cornerstone of most impact assessment studies. It was the basis for the impact assessment described in the previous two sections. However, as described in Section 4.1.4 and Appendix B.1, diversity and other univariate parameters can miss subtle changes in community structure that are

reflected by differences in the abundance of individual taxa, but not in the individual indices. For example, two grab samples can have identical infaunal indices, without having any species in common.

Despite the univariate parameter's inability to capture potential changes in community structure, most benthic monitoring studies routinely report standard infaunal community indices, and rely on them in their examinations of temporal and spatial trends. As described in previous sections, the historical record of univariate analyses provides a useful backdrop for evaluating the large infaunal dataset, but the potential for changes at the species level must also be examined. One of the difficulties with infaunal indices is that they only reflect the diversity within a local area at a particular time (α -diversity). In contrast, pollution and other stresses tend to induce changes in community composition between samples that are widely separated spatially and temporally, which is measured by β -diversity (Smith et al. 1979). Thus, analysis of individual measures of α -diversity within samples is not well suited to an infaunal dataset containing moderate levels of β -diversity (heterogeneity), such as in the 2010 infaunal dataset. Compositional differences among the 35 samples collected in 2010 were moderately large, as demonstrated by a Whittaker (1972) β -diversity of 3.7.²¹

Multivariate techniques are better suited to the evaluation of datasets with high β -diversity. The 2010 dataset used in this multivariate analysis consisted of a matrix of counts for 129 taxa²² in 35 samples. Analyzing this complex matrix for potential differences among samples by comparing differences in each individual species is intractable, not just because of the number of species, but because many pairs of samples have few species in common. In response to these challenges, ecologists have, over the last 50 years, developed specialized multivariate analysis tools. These analysis techniques are highly effective at extracting the dominant patterns from complex species-sample databases. The multivariate techniques employed here exploit redundancies (correlations) in the abundance of individual species among the samples, and compress the data into the most meaningful patterns.

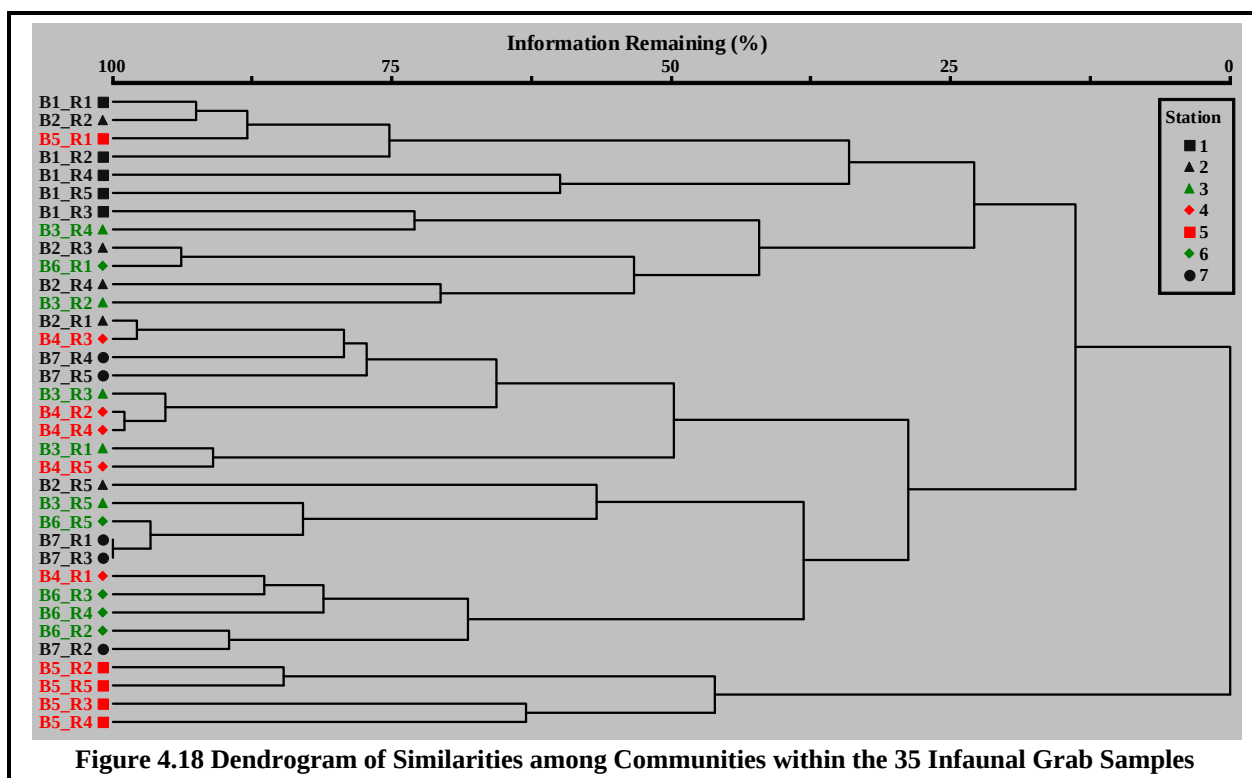
Inherent Sampling Variability

As with the other field measurements, it is crucial to determine the inherent sampling variability associated with the individual field measurements. Variability among repeated replicate grab samples collected from an individual station at a particular time lends insight into the inherent uncertainty of values reported for each station. This within-sample variability is fundamental for testing hypotheses concerning the significance of perceived differences between samples collected at different locations. If the inherent sampling variability is statistically larger than the observed difference between the two stations, then the spatial difference cannot be considered significant.

A dendrogram (tree diagram) produced from the multivariate species database provides a convenient graphical means for determining the relative magnitudes of within-site and between-site infaunal variability among the samples (Figure 4.18). Testing the relative degree of difference among the 35 individual grab samples indicates whether differences among replicates collected at a station are smaller than the differences between the stations, indicating that spatial differences are large enough to be reliably resolved, even in the presence of inherent sampling uncertainty. Dendrograms display the relative similarity among samples, or groups of samples, using a branched diagram similar to the branches on a

²¹ β_w measures the ratio of the total number of species in the dataset to the average number species in the samples, minus 1. If $\beta_w=0$, then all the samples have the same number of species. $\beta_w=3.7$ indicates that the entire database had more than four distinct communities, with nearly five-times as many species (100) as the average individual sample (21).

²² Because the multivariate analysis examined differences in community structure among the samples, and not specifically diversity, additional specimens could be included in the database. These additional specimens were not identified to species level, usually because they were juveniles and too small for reliable taxonomic identification.



tree. Sample pairs that are similar coalesce into a branch toward the left on the percent-information-remaining axis. The horizontal information axis at the top of the dendrogram reflects the amount of information (variability) that is left in the sample-species matrix after two samples are combined. Combining samples with relatively similar species composition results in a minimal loss of information (variability) in the original species-sample matrix. For example, Figure 4.18 shows that the infauna within Replicates R1 and R3 from Station B7 were nearly identical. As more samples, or other groups, are added to each branch, the differences in the communities associated with each group become increasingly larger, and combining these groups results in a more significant loss in the information.

The dendrogram shows that replicate grab samples collected from an individual station often contained communities that were more similar to one another than to the communities present at adjacent stations. Individual replicates are color- and symbol-coded by site. For example, two or more replicate samples from Stations B1, B4, B5, and B7 contained infaunal assemblages that were similar to one another, and distinguishable from the communities at other stations. The infauna within almost all of the replicate samples collected at Stations B1 and B5 clustered together. This suggests that the multivariate analysis was capable of resolving spatial differences in the infaunal communities surveyed in 2010, despite the large variability among replicates from individual stations.

A multivariate analysis of variance (MANOVA) confirmed that the within-station similarity of replicate samples was far greater than expected by chance ($p < 0.0002$). The p -value cited here, and throughout this section, is the probability that the measured difference between groups (stations) could have occurred by chance alone. It is determined by comparing the magnitude of the difference between stations, with the scatter in the replicate samples collected at a particular station. If the scatter in replicate samples is large compared to the difference in sites, then the station difference is more likely to be an artifact of chance alone, rather than a real spatial difference. Generally, differences in groups are considered statistically

significant when p -values are less than 0.05, which corresponds to a 5 percent (1-in-20) probability that the difference occurred by chance alone. The observed infaunal differences among the seven stations in 2010 were very unlikely (0.02 percent) to have occurred by chance.

The strongest replicate groupings were associated with reference Station B1 (black squares) and ZID Station B5 (red squares). However, even the remaining five stations exhibited a significant grouping tendency ($p=0.01$), although it was much less apparent in the dendrogram. The unique character of the infauna within four of the replicate samples collected at Station B5 was especially discernible. They exhibited much greater fidelity with each other, than with any other benthic sample collected during 2010. They were last to link with the combined infaunal community within all other samples, and when they did, they accounted for a large fraction (14%) of the overall variation in the entire dataset.

The dissimilarity among the communities within the replicate samples at Station B5 compared to other stations is not surprising given that four of the five replicate grab samples at this ZID station were collected in very close proximity, if not directly on the diffuser structure (Figure 4.2). It is especially noteworthy that replicate R1 contained infauna that were perceptibly different from the four other replicates, being more like the majority of other samples (near the top of the dendrogram). It was also the only replicate at Station B5 that was not collected immediately adjacent to the diffuser structure (inset in Figure 4.2). Even though it was only 5 m from the rest of the replicates at Station B5, the infauna in Replicate R1 were strikingly different from the other replicate samples collected at that station. As described in the previous section, univariate diversity indices were incapable of identifying the unique character of the community at the diffuser. Only the trophic index (*ITI*) described in the previous section, and the multivariate analyses described in this section were discriminating enough to resolve the highly localized influence of the physical presence of the diffuser structure.

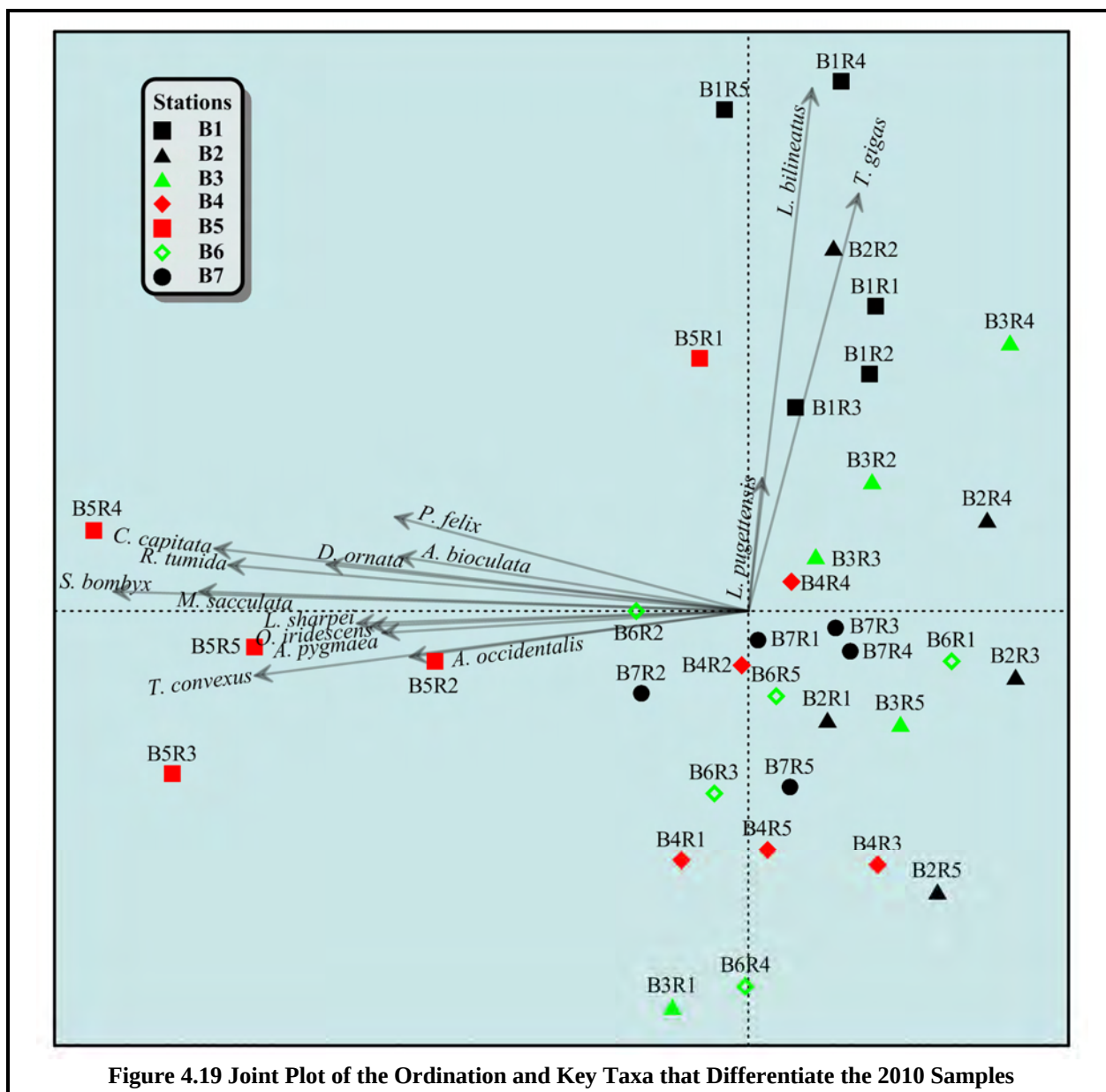
As a whole, this analysis of replicate samples demonstrates that infaunal differences among the stations were generally larger than the variability within replicate grabs collected at individual stations. Thus, the statistical analyses indicate that spatial gradients identified in the infaunal community within this database have been reliably delineated, and are not due to random sampling error.

Spatial Differences

The dendrogram revealed that the most distinct suite of infauna resided within the four replicate samples collected near, or on the diffuser structure at Station B5. This diffuser group formed a cluster at the bottom of the dendrogram and coalesced with the remaining samples only after 86 percent of the variability (information) in community structure had been explained by clustering among the other samples. Samples collected at the distant reference station B1 also contained taxa that were different from most other samples collected in 2010. They clustered in the uppermost branch of the dendrogram along with several samples from other stations, including the remaining replicate (R1) that was collected at Station B5. That upper branch coalesced with the middle group of stations leaving the infaunal community within the diffuser sample group (B5) least like any of the other sediment samples.

A two-dimensional ordination²³ plot provides a visual interpretation of the differences in the infaunal communities found in the 35 samples collected during the 2010 benthic survey (Figure 4.19). It distills the major infaunal differences among samples as a distance between sample points in the multivariate hyperspace. As such, the diagram's axes do not represent distances in physical dimensions. Instead, the locations of the points within the diagram characterize the composition of the community within

²³ The multivariate ordination was derived from a non-metric multidimensional scaling (Mather 1976, Kruskal, 1964) of Sørensen (Bray-Curtis) distance (Sørensen, 1948), the same multivariate distance measure used in the dendrogram. There was less than a 0.4-percent chance ($p=0.004$) that the stress measure of the final solution's fit could have occurred by chance based on Monte Carlo randomization tests.



individual benthic samples. The distance between a pair of points measures the degree of difference in the species compositions contained within those samples. Widely separated points have very dissimilar infaunal communities, namely, few species in common, and they have large differences in the abundance of those species that are common between the samples. In contrast, points that lie close to one another have communities with many common species and where the abundance of individual species within the respective samples is very similar.

In addition, horizontal separations characterize a difference in species composition that fundamentally departs from differences in community composition along the vertical axis. Often, changes along the two axes coincide with different environmental gradients in the samples. In this case, highly localized changes related to the physical presence of the diffuser structure account for the observed differences in

community composition along the horizontal axis, while much larger scale zoogeographic differences correlate with the sample separation along the vertical axis. The distribution of sample points in the ordination diagram reflects the clustering seen in the dendrogram.

Specifically, the ordination points for the four replicates collected near the diffuser at Station B5, which are represented by the red squares, were located along the negative portion of the horizontal axis. Because they were isolated from the other ordination points, it is clear that the infaunal community at this location was quite distinct from the other samples. Additionally, the ordination point for Replicate R4 from that station, which was collected slightly (1.3 m) closer to the center of the diffuser structure, and perhaps hit the structure, was somewhat separated from the other three replicates (Table 4.9).²⁴ As a result, it had a more-negative X-axis ordination score and a positive Y-axis score in contrast to the slightly negative Y-axis scores of the other three replicates. However, the differences among these four replicates were small compared to the separation of the remaining replicate (R1), which was aligned along the positive Y-axis. That particular grab sample was collected 5.3 m farther from diffuser structure.

Table 4.9 Closest-Approach Distance of Replicate Infaunal Samples Collected at Station B5 to the Diffuser Structure

Replicate	Distance (m)
R1	8.3
R2	3.0
R3	3.0
R4	1.7
R5	3.0

Along the vertical ordination axis, all five points for reference Station B1 (black squares) were located along the positive Y-axis, with two of those replicates (R4 and R5) situated well above the cloud of other ordination points. This demonstrates that the taxa within those samples were markedly different from the bulk of other samples, and that the difference was completely unrelated to the infaunal differences seen in the Station B5 samples. The ordination points for the remaining three replicate samples at Station B1, although still situated along the positive Y-axis, were interspersed with ordination points from a few other replicate samples from Stations B2 and B3. All three of these stations were located north of the diffuser structure and well beyond the ZID. It is likely that the vertical-axis ordination scores captured a subtle, naturally occurring, along-shore gradient in infauna within northern Estero Bay that extends over a distance of at least 1 km north of the diffuser structure. These regional zoogeographic differences may be in response to natural changes in the physicochemical character of the benthic environment that were discussed previously, particularly concerning changes in fine grain-size fractions and aluminum and iron concentrations (see Section 4.2.2).

Influential Taxa

The abundances of individual species within a given replicate sample, as compared to that of another sample, are difficult to discern and interpret when an investigator is faced with the massive amount of information contained in the 2010 infaunal database listed in Table B.1. Although perusal of the table may reveal patterns for specific taxa, it is difficult to decide how important the differences in counts of one taxon are, relative to another. Additionally, many species co-occur and yield the same distribution among samples, further confusing the interpretation. Finally, the most abundant taxa are often not the most diagnostic of potential impacts because they are present in substantial numbers within all the samples.

Multivariate community analysis was designed to quantitatively distill this complex set of information, to eliminate redundant or marginal patterns, and to produce most important information concerning how the

²⁴ It is probable that the grab impacted the diffuser structure while collecting sediment sample R4 because the reported 1.7 m separation distance of the grab was at the limit of navigational resolution, was comparable to the lateral dimensions of the grab sampler (0.3 m) and outfall pipe (0.7 m), the surface wire position may have departed from the grab trip position on the seafloor, and an unusually large number of failed attempts (false trips) preceded the acquisition of this grab.

communities within individual samples relate to one another. The analysis described in the previous subsections successfully identified differences among samples that were significant compared to inherent uncertainties due to sampling variability. While this is primary goal of the multivariate analysis, it is only part of the useful information. Multivariate analysis also identifies which taxa primarily influence the community differences among replicate samples. Those influential taxa often have life-history information, such as a tolerance or sensitivity to pollution and organic loading, which can lend further insight into the potential impacts from effluent discharge.

The indicator species analysis that compliments the multivariate sample analyses described above is graphically represented in Figure 4.19, where the degree of influence of individual taxa are represented by arrows (vectors) overlain on the ordination plot discussed previously. The length of an arrow for an individual taxon reflects how strongly it participated in differentiating the samples, and its direction points toward samples that have a comparatively elevated abundance of that taxon.

The elevated presence of three species in samples collected at Station B1 was particularly indicative of the alongshore gradient in regional infaunal communities within northern Estero Bay. For example, the nemertean, *Lineus bilineatus*, and the annelid worm, *Travisia gigas*, were only present at Station B1, albeit in very small numbers (Table B.1). In contrast, the annelid worm, *Leitoscoloplos pugettensis*, was present at several other stations, although their overall abundance was lower, and they were not present in multiple replicates, as they were at Station B1.

A fourth species, *Cancer gracilis*, or the slender crab, also occurred in higher numbers at Station B1 than at any other station, however the abundance of this species was not associated with any biogeographic gradient. Instead the relative abundance of this species was closely linked to the presence of the sand dollar bed (*Dendraster excentricus*). Sand dollar beds have previously been suggested to act as nursery areas for juvenile *Cancer magister*. The successful recruitment event in 2009, and subsequent establishment of a semi-permanent sand dollar bed in the survey area appears to have influenced the distribution of *C. gracilis*. Although *Dendraster* were excluded from the multivariate analyses, due to their ability to obscure trends in other species, the *C. gracilis* distribution was probably related to it.

The increased presence and abundance of many taxa within samples collected very close to the diffuser structure were highly diagnostic of the unusual infaunal community there. For example, *Tecticeps convexus* is a surface deposit feeder that possesses a broad, grinding structure used to chew algae or other plant material and to scrape diatoms and detritus off sand grains. *T. convexus*, which was the fourth most abundant taxon enumerated in the 2010 survey, representing 7% of the non-*Dendraster* specimens collected (Figure 4.20). Almost all (87%) of the *T. convexus* specimens, 189 out of a total of 217, were collected at station B5. occurring within all the replicate samples at that station, except for the slightly more distant replicate R1, which had none. Many of the *T. convexus* enumerated during 2010 were brooding several hundred juveniles each, particularly those specimens occurring at Replicates R2 and R3 at Station B5. However, as the enumerable adults of this species were not particularly elevated within Replicate R4, immediately adjacent to the diffuser, the arrow did not preferentially align with that replicate, as did other taxa (Figure 4.19).

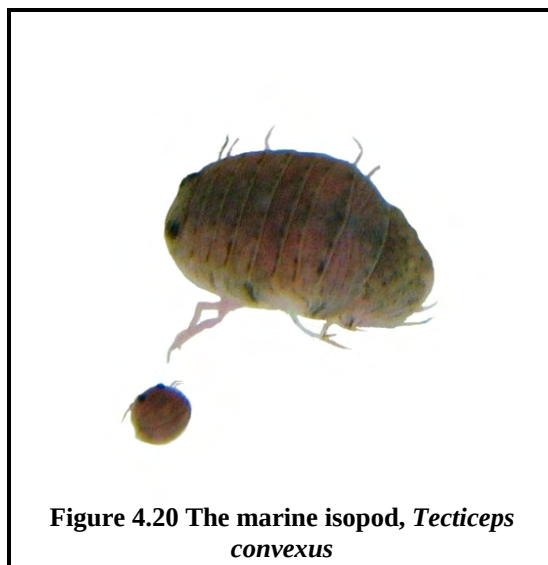


Figure 4.20 The marine isopod, *Tecticeps convexus*

Among the taxa that were strongly associated with the four replicate samples collected close to the diffuser structure, the multivariate analysis differentiated between taxa that were associated with replicate sample R4, which was located slightly closer to the structure, from the other three from the other three close-in samples (Table 4.10). The dissimilarity is apparent in the slight difference in the taxon-arrow angles in Figure 4.19, where arrows pointing toward B5R4, above the horizontal, were different from the *T. convexus* and other arrows that were directed toward the three close-in replicate samples below the horizontal. Although the differences in the indicator taxa appear subtle, such a dissimilar infaunal community is astounding given it occurred across a spatial separation of only 1.3 m. This spatial succession of taxa undoubtedly reflects the highly localized influence of the outfall's physical presence on the infaunal community.

Table 4.10 Taxa Indicative of Samples Collected Very Close to the Diffuser Structure at Station B5

<i>Phylo felix</i>	<i>Leuroleberis sharpei</i>
<i>Armandia bioculata</i>	<i>Onuphis iridescens</i>
<i>Diopatra ornata</i>	<i>Apoprionospio pygmaea</i>
<i>Capitella capitata</i>	<i>Tecticeps convexus</i>
<i>Rocheffortia tumida</i>	<i>Anchicolurus occidentalis</i>
<i>Spiophanes bombyx</i>	
<i>Magelona sacculata</i>	

4.4 OUTFALL ENVIRONMENT

The benthic samples collected at Station B5 during the 2010 benthic survey provide unique insight into the seafloor habitat very close to the outfall pipe. Although the samples were collected well within the ZID and were not subject to the COP water-quality objectives, they demonstrated that the discharge of high quality effluent has not resulted in sediment contaminant accumulation or deleteriously impacts to infauna immediately adjacent to the diffuser structure. Additionally, the subtle differences in the biological and physicochemical properties that were apparent in the replicate benthic samples collected next to the outfall pipe arose because of the physical presence of the structure itself, and not as a result of the accumulation of effluent particulates.

4.4.1 Sampling Location

The COP, and by reference, the MBCSD discharge permit, states that compliance with receiving-water objectives "...shall be determined from samples collected at stations representative of the area within the waste field where initial dilution is completed." The small 15-m lateral dimension of the ZID resulted in a pair of ZID stations (B4 and B5) with target locations that are in close proximity to the diffuser structure and outfall (Figure 4.2).

As with the marine receiving-water surveys, it is inherently difficult to collect benthic samples exactly at the specified target locations. Additionally, with ZID dimensions comparable to the length of the vessel, spatial offsets from the target locations occasionally result in samples collected immediately adjacent to the diffuser structure. Depending on the prevailing currents and winds at the time of the survey, vessel offsets can make sampling at the ZID stations extraordinarily difficult. For example, during the 2008 survey the vessel set was to the southwest, so sampling at Station B5 required anchor deployment very close to the diffuser structure. Unfortunately, the anchor snagged on the diffuser structure and was irreparably damaged. In contrast, during the 2010 survey, the vessel offset was to the northeast, and the although the anchor was well clear of the structure, benthic grab sampler itself repeatedly collided with the outfall pipe. Although slight movements in the vessel position eventually allowed the successful acquisition of the required sediment samples, multiple grab attempts were necessary, and the successful grabs were almost uniformly located immediately adjacent to the outfall pipe. This was also the case during the year-2000 survey (MRS 2001). Additionally, the benthic samples collected adjacent to the outfall pipe during that survey exhibited the same characteristics as the samples described here. In all cases, however, the diffuser structure was not damaged.

The replicate infaunal sample locations at Station B5 during the 2010 survey were offset at three distances from the diffuser structure (green circles in the Figure 4.2 inset). This provided an unusual opportunity to quantify the gradient in infaunal communities extremely close to the outfall (Table 4.9). Replicate grab samples collected for physicochemical analysis (blue diamonds in the Figure 4.2 inset) were also collected very close to the diffuser structure, with offsets of 3 m or less that were comparable to infaunal Replicates R2 through R5. As described below, the observed differences in sediments and infauna collected at Station B5 were inconsistent with an accumulation of wastewater constituents that degraded benthic communities, a condition disallowed by the COP and MBCSD discharge permit beyond the ZID. Instead, the differences resulted from the physical presence of the outfall structure. Although the samples were collected near the southeastern-most extent of the open section of the diffuser structure, a section of the diffuser structure with closed ports extends farther toward the southeast and would continue to influence nearby sediments by its physical presence. Thus, the samples were collected at the transition between the open and closed sections of the diffuser, where wastewater discharge volumes were minimal compared to the open section to the northwest.

4.4.2 Physicochemical Characteristics

As described in Section 4.2, there was no evidence of increased concentrations of organic constituents or toxic contaminants within the three replicate chemistry grabs collected at any of the stations, including Station B5. In fact, the physicochemistry of the Station-B5 composite sample departs from that of more-distant samples in a manner opposite that expected from the buildup of effluent particulates. For example, raw trace-metal concentrations within the Station-B5 composite sample were consistently lower than distant samples (Figure 4.3). Instead, the trends are consistent with winnowing of fine sediments caused by scour around seafloor structures.

The organic loading properties were also lower in at Station B5 (Figure 4.6), and in the case of TKN, BOD, and mud, the difference was statistically significant. The significantly lower mud fraction is particularly diagnostic of a more energetic flow regime that winnows fine sediments in favor of coarser fractions. Even more telling is the higher, very coarse sand fraction in the Station-B5 sample that was substantiated by a duplicate analysis (Table 4.5). Because all the stations are in the same water depth, a preferential increase in orbital velocities from shoaling waves cannot account for the difference. The only other explanation is that the bottom currents were enhanced by the physical presence of the diffuser structure. Enhanced flow around structures extending above the seabed is a well-recognized phenomenon, and results in scour pits within sandy environments. The lateral dimension of these scour features is limited, and typically extends several diameters from the seafloor feature. Not surprisingly, two of the three replicate chemistry samples at Station B5 were located within 3 m of the outfall pipe.

4.4.3 Infaunal Community

The characteristics of the indicator taxa listed in Table 4.10 are particularly telling about the environment immediately surrounding the diffuser structure. Along with the slightly more-distant infaunal Replicate R1, the Station-B5 samples allow determination of spatial gradients across a very small region surrounding the outfall pipe. The life-history traits, trophic (feeding) habits, and ability to resist physical disturbance of the indicator taxa are typical of infaunal taxa that thrive near manmade seafloor structures similar to the MBCSD outfall pipe and diffuser structure. There were no deficiencies in pollution-sensitive taxa within the outfall community, indicating that the infauna were not being impacted by deposition of toxic contaminants potentially discharged in MBCSD effluent.

Davis et al. (1982) studied sand-bottom communities immediately surrounding artificial reefs, oil platforms, and bridge pilings, and found that those communities were profoundly altered shortly after

installation. They determined that currents flowing around the seafloor structures scoured the sediments immediately surrounding the structure, and winnowed fine particulates in a manner consistent with scour around the MBCSD outfall. They also found a buildup in sediment organics within the scour zones that arose from epifauna that sloughed off the structures, and from drift algae and other material that accumulated in the scour pits.

The MBCSD outfall is covered with a rich epifaunal community (Figure 2.2), and the large amount of shell hash in Replicates R4 and R5 from Station B5 (Table C.1, Figure 4.15) attests to its contribution to the organic content of sediments there. However, it is not clear whether the debris in these samples arose from natural sloughing or whether it was dislodged by collisions of the grab sampler with the outfall. In addition, the divers who maintain and inspect the outfall routinely clear marine growth from the diffusers to reduce wave loading. A few days after the benthic survey, divers reinstalled spar buoys and commented on the marine growth that had been cleared by the grab colliding with the diffuser structure. Apparently, the amount of marine growth dislodged by the grab at Station B5 was visually apparent to the divers.¹⁶

Davis et al. also found that the densities of the tube-building polychaete *D. ornata* were enhanced in the immediate vicinity of the artificial reefs. In the case of one small artificial reef, enhancement of *D. ornata* populations occurred only within 0.2 m of the reef, while large offshore oil platforms exhibited dense aggregations within 2 m of the shell mounds beneath the platforms. They postulated that the enhanced abundances of these Ornate Tubeworms near manmade structures arose because it provided a source of shell debris used by the organisms to decorate their parchment tubes (Figure 4.11). It is noteworthy that *D. ornata* was an indicator taxon only within Replicate R4, which was located 1.7 m from the structure, but not within the other Station-B5 replicates, only 3 m from the structure (Table 4.10, Figure 4.19). These distances match the limited field of influence described by Davis et al. around other large seafloor features.

Although Davis et al. ascribed the *D. ornata* distribution to the availability of shell hash; they also observed increased abundances of other infaunal taxa, including the polychaetes *S. bombyx* and *M. sacculata*, near artificial reefs. Increased abundances of both of these polychaete worms were also observed close to the diffuser structure, within Replicate R4, but not at the slightly more distant location where Replicates R2, R3, and R5 were collected (Table 4.10).

Although *S. bombyx* is also a tube-dwelling worm, its tube remains largely below the sediment surface, and is not decorated like *D. ornata*. *M. sacculata* does not produce a tube. This suggests that the presence of shell hash is not the only determining factor for the unique infaunal community immediately adjacent to the outfall. In the case of these two worms, their life history provides a better explanation for their increased presence near the structure. Specifically, both are especially adapted to life in highly unstable environments (McMurray 2007). They have opportunistic life histories with high fecundity and rapid dispersal that suits them to unstable and physically disturbed sedimentary environments, such as those around seafloor structures where surficial layers are repeatedly reworked by wave scour. Another influential species, the small nestling clam (*R. tumida*), tends to co-occur with larger burrowing organisms, so the increased abundance of the three polychaete worms may explain its increased abundance very close to the diffuser structure.

In addition to life history, trophic (feeding) preferences undoubtedly play a pivotal role in determining the infaunal community very close to seafloor structures. Specifically, organic enrichment has long been recognized as a major controlling factor in the relative abundances of soft-bottom assemblages that are distinguished by their feeding behavior. It forms the basis for the *ITI*, which has been routinely used to identify sediments impacted by wastewater discharges within the SCB (see *Clean-Sediment Feeding Guilds* on Page 4-38). However, use of the *ITI* as a pollution index for evaluating the health of benthic

habitats has also been criticized for a variety of reasons (Maurer et al. 1999; Word 1990). One of the major problems is that it does not directly describe the health of a benthic community, especially when organic material is naturally present within sediments, or is introduced by a non-polluting source, such as a physical structure located on the seafloor.

Irrespective of the limitations of the *ITI* as a pollution index, it was able to clearly identify the prevalence of infauna that feed on organic material within Replicate R4, and to some extent R5. The reduced *ITI* within these replicates was largely due to the increased presence of two indicator taxa, the Opheliid lug worm *Armandia bioculata* and the capitellid worm *Capitella capitata* (Table 4.10). Both are non-selective sub-surface deposit feeders that thrive in sediments that are organically enriched below the sediment interface. Because of their feeding strategy, Word (1978) included them in the Group-IV feeding guild and consequently, their presence strongly reduced the *ITI* and indicated the presence of organic material within sub-bottom sediments. The elevated presence of *M. sacculata* within Replicate R4, considered a surface detritus feeder within the Group-II feeding guild, is further indication of the presence of organic surface detritus material.

Notwithstanding the presence of these opportunistic annelids within Replicate B5R4, and to a lesser extent, within Replicates R2, R3, and R5, the accumulation of MBCSD effluent particulates is not the likely source of the organic enrichment. Within a highly energetic, open ocean environment, lightweight flocs of organic material do not readily accumulate near a discharge. Historical impacts from wastewater discharges in the SCB resulted from the discharge of massive amounts thick sewage sludge around major outfalls, such as those within Santa Monica Bay. Such discharges are no longer allowed and, in the case of the MBCSD discharge, where particulates are largely eliminated by the near-secondary treatment, accumulation of sewage organics, even very close to diffuser ports, is highly unlikely.

If wastewater particulates were accumulating within the benthic environment immediately surrounding the outfall, increases in the concentration of trace-metals, BOD, TKN, TVS, and mud fractions would be expected. However, none was observed in the chemistry replicates collected at Station B5. In addition, reductions in the abundance of pollution-sensitive taxa would also be expected, in conjunction with any observed increases in species that thrive in organic-rich environments. For example, Lenihan et al. (2003) found that increases in opportunistic annelid species without a concomitant decrease in arthropods and echinoderms signified the presence of organic enrichment alone, and not the presence of toxicants. Multivariate analysis is adept at identifying deficiencies in the abundance of individual indicator taxa, as well as taxa with enhanced abundances. In the joint plot of Figure 4.19, pollution-sensitive taxa would appear as arrows that point away from samples containing contaminants.

The multivariate analysis did not find any taxa whose abundance was significantly reduced within the replicate samples collected close to the outfall pipe. Normally, opportunistic, pollution-tolerant polychaetes, such as *C. capitata* and *A. bioculata* increase in abundance at the expense of more sensitive phoxocephalid amphipods, namely *Rhepoxynius menziesi* and *Rhepoxynius abronius*, and another gammarid amphipod *Eohaustorius sincillus* (Figure 4.21). Phoxocephalids are active suspension feeders known to be extremely sensitive to pollution (Pearson and Rosenberg, 1978) and because of this, they are routinely used in bioassay testing of marine sediments (ASTM, 1991; USEPA-USACOE, 1991, 1993). However, their combined populations at Station B5 were



Figure 4.21 A Gammarid Amphipod

comparable to that of other stations, and there was no evidence of significant reductions in their abundances within Replicate R4 at Station B5.

The weight of quantitative evidence demonstrates that, even within sediments immediately adjacent to the outfall structure, there is no evidence of a buildup of wastewater particulates from the discharge of the MBCSD effluent. Although there is a highly localized increase in organic constituents immediately adjacent to the outfall (~1m) this results from the physical presence of the outfall rather than from any accumulation of contaminants being discharged from the outfall. As a result, a balanced indigenous population of marine organisms resides throughout the region, including the area within the zone of initial dilution surrounding the MBCSD outfall.

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CHAPTER 5

Conclusions and Recommendations

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5.0 CONCLUSIONS AND RECOMMENDATIONS

The MBCSD monitoring program was designed to evaluate the performance of the wastewater treatment plant and to monitor the quality of effluent discharged to the ocean. This annual report evaluated compliance with the NPDES discharge permit and documented potential discharge impacts through quantitative analyses of an extensive data set of effluent constituents, receiving-water measurements, sediment chemistry analyses, and marine biological enumerations. Of the thousands of measurements collected as part of the monitoring program during 2010, none exceeded the discharge limitations.

5.1 TREATMENT PLANT

The MBCSD Wastewater Treatment Plant (WWTP) has been operating under the provisions of a 301(h)-modified NPDES permit since 1986, with 2010 marking the 25th year of consistently high performance by this treatment facility. In fact, many of the best measures of treatment performance have been achieved during the past seven years of operation (Table 5.1). For example, the low average effluent Total Suspended Solids (TSS) concentration in 2010 (27 mg/L) was the direct result of the treatment process's exceptional efficiency, which removed 92% of the influent solids. As a result, the 2010 solids emission was 33% less than the long-term average, only 21% of the emission allowed under the NPDES permit. The record low emissions of high-quality effluent achieved over the past seven years attest to the consistent and exemplary level of recent plant performance.

Reductions in the discharge of oil and grease (O&G) and biochemical oxygen demand (BOD) also attest to the plant's high standard of performance. As with TSS, the discharge of O&G and BOD over the past several years has been exceptionally low, while their corresponding removal rates were high compared to the average rates achieved over the entire 25 years of monitoring (Table 5.1). Reduced emissions in recent years benefited from more-accurate flow measurements and substantial reductions in inflow and infiltration (I&I) into the collection system. All of these gains can be attributed to comprehensive and proactive plant maintenance and control, and to persistent source-control efforts.

5.1.1 Overall Performance

Irrespective of comparisons with historical performance, the 2010 measurements of wastewater characteristics demonstrated that the treatment process was routinely and substantially exceeding expectations based on the original plant design, the NPDES discharge permit, and federal regulatory standards. For example, during 2010, the plant removed 17% more suspended solids than the minimum permitted, and the BOD removal rate was two and a half times greater than the minimum permitted rate of 30%. During nine months of the year, the treatment process was so efficient that effluent BOD concentrations remained at or below the 60-mg/L threshold below which removal-rate requirements are not even applicable, while effluent TSS concentrations remained well below that concentration threshold throughout the entire year. Moreover, the plant routinely achieved treatment levels that exceeded the removal requirements for full secondary treatment. For example, monthly solids-removal rates substantially surpassed the 85% full secondary criterion throughout 2010, while BOD removal rates achieved full secondary levels during six months of the year. Other effluent constituents were also correspondingly low during 2010. The discharge of settleable solids was imperceptible, and monthly averages of effluent turbidity, pH, ammonia, and coliform density remained far below the applicable permit limitations.

The benefits of past efforts to reduce rainwater inflow and groundwater infiltration (I&I), and to more accurately measure plant flow, are evident in the record of annual average flow rates listed in (Table 5.1). Specifically, the 2010 average flow rate of 1.19 MGD was comparable to the low flows measured over the past decade, which were 25% lower than in prior years. This reduction was largely due to improvements in the accuracy of flow measurements that were instituted in 2002.

The continued high overall performance of the treatment process during 2010 was the direct result of vigilant control of the process, and a proactive program of preventative maintenance. Plant personnel actively sought out and corrected potential mechanical problems with plant components before they occurred, and quickly responded to the occasional unforeseen failure. For example, when inconsistencies in the incoming power load from PG&E resulted in operational issues for the main influent pumps and caused the variable frequency drive (VFD) to shut down at the end of October 2010, quick response by plant personnel successfully limited impacts to the treatment process.

Table 5.1 Average Annual Wastewater Parameters

Year	Flow (MGD)	Suspended Solids				Biochemical Oxygen Demand			
		Influent (mg/L)	Effluent (mg/L)	Removal (percent)	Emission (MT)	Influent (mg/L)	Effluent (mg/L)	Removal (percent)	Emission (MT)
1986	1.42	332	32.8	89.8	64	235	77.0	67.2	151
1987	1.51	274	21.8	92.0	45	257	52.0	79.8	108
1988	1.51	397	29.8	90.0	62	242	43.9	81.9	92
1989	1.46	321	37.3	88.4	75	259	69.8	73.1	141
1990	1.38	345	36.0	89.6	69	261	75.7	71.0	144
1991	1.28	280	30.5	89.1	54	236	66.9	71.6	118
1992	1.41	310	43.0	86.3	84	224	59.3	73.5	116
1993	1.54	339	33.0	89.6	70	222	39.0	81.9	83
1994	1.38	310	32.0	89.4	61	249	33.0	86.4	63
1995	1.55	270	30.6	87.6	69	208	31.4	83.9	67
1996	1.55	344	33.1	89.9	70	241	35.7	85.0	73
1997	1.64	283	36.0	86.6	79	231	38.6	83.0	85
1998	1.95	236	38.8	83.9	101	216	39.1	81.5	99
1999	1.68	386	44.0	86.7	102	287	49.5	82.5	118
2000	1.77	337	37.4	87.5	91	271	50.3	81.1	125
2001	1.48	450	37.6	89.5	74	396	62.7	83.1	127
2002	1.14	374	49.2	86.0	77	386	67.5	82.4	101
2003	1.06	314	39.2	86.7	56	311	56.3	81.3	83
2004	1.09	354	28.9	91.3	44	336	53.3	83.8	81
2005	1.25	373	24.3	93.3	42	303	49.8	83.0	88
2006	1.19	335	20.5	93.2	34	291	45.3	83.8	75
2007	1.09	381	20.9	94.1	31	330	44.4	86.0	68
2008	1.10	337	20.0	94.1	30	331	38.4	88.3	58
2009	1.09	328	25.3	92.3	38	311	37.6	87.4	56
2010	1.19	383	26.6	92.1	42	350	49.4	85.2	85
Average	1.39	336	32.3	89.6	63	279	50.6	81.1	96
Limitation	2.06		70.0	75.0	199		120.0	30.0	342

Table 5.1 Average Annual Wastewater Parameters (continued)

Year	Oil and Grease			Mass Emission (MT)	Turbidity (NTU)	pH	Chronic Toxicity (TUC)	Ammonia as NH ₃ -N (mg/L)
	Influent (mg/L)	Effluent (mg/L)	Removal (percent)					
1986	64	13.8	78.4	27	26	7.7		18
1987	44	6.2	85.9	13	23	7.5		
1988	38	6.3	83.4	13	40	7.5		
1989	28	6.1	78.2	12	49	7.4		26
1990	34	8.5	75.0	16	55	7.4		26
1991	73	6.9	90.5	12	50	7.3		18
1992	33	5.3	83.9	10	56	7.3		9
1993	26	6.0	76.9	13	43	7.4	19.42 ¹	20
1994	60	4.1	93.2	8	36	7.5	4.37	27
1995	63	5.1	91.9	11	32	7.5	4.35	23
1996	52	7.9	84.8	17	34	7.7	4.83	23
1997	49	5.3	89.2	12	32	7.7	7.80	23
1998	51	5.4	89.4	15	34	7.6	7.80	19
1999	52	6.2	88.1	14	48	7.5	5.00	25
2000	74	5.5	92.6	13	39	7.5	5.60	24
2001	47	4.6	90.2	9	41	7.4	5.60	28
2002	39	4.4	88.7	7	41	7.5	4.98	31
2003	44	5.3	87.9	7	34	7.5	7.80	27
2004	47	3.7	92.0	6	26	7.5	5.60	29
2005	62	4.4	92.9	8	23	7.6	5.60	27
2006	44	4.1	90.6	7	26	7.6	4.36	28
2007	52	4.0	92.4	6	27	7.6	4.36	28
2008	84	4.4	94.8	7	30	7.5	5.56	27
2009	93	4.5	95.1	7	29	7.5	15.82 ²	32
2010	76	4.7	93.8	9	31	7.6	10.88 ²	34
Average	53	5.7	88.0	11	36	7.5	7.21	24
Limitation		25.0			75	6-9	134.00	322

¹ Screening bioassay of three marine species

² Screening bioassay of two marine species

5.1.2 Flow Rate

Historically, the most influential factor on flow rate was a metering inaccuracy that resulted in flow overtotalization. A study conducted in 2002 found that rates reported by the effluent flow meter were consistently overestimated by as much as 25%. Without this overtotalization, average flow over the 25-year record would be closer to 1.19 MGD rather than the reported 1.39 MGD. Because of overestimated flow prior to 2002, the annual mass emissions were also overestimated. Consequently, the average emissions, shown in bold at the bottom of Table 5.1, were slightly inflated. Specifically, the reported average annual TSS emission of 63 MT was actually closer to 53 MT. Similarly, the average annual BOD emission reported at 96 MT was, in reality, closer to 83 MT, and the reported 11 MT of O&G discharged on average was closer to 9 MT.

In 2002, overtotalization was largely eliminated after the more accurate influent flow meter was commissioned, and flow began to be reported based on its measurements. However, flow is still

occasionally overttotalized due to aberrant influent-flow readings, when the influent flume becomes temporarily surcharged after water backs up from the wetwell at the plant headworks. On these rare occasions, judicious use of corrected effluent flow totals, based on an adjustment determined in the flow-meter study conducted in 2002, effectively eliminates flow overttotalization.

5.1.3 Effluent Constituents

The treatment process was designed to remove organic particulates from the wastewater stream and disinfect effluent. It was not designed to eliminate chemical contaminants dissolved in wastewater. Instead, a vigorous pollution-prevention program limits introduction of chemical contaminants at the source, before they enter the collection system. The multifaceted pollution-prevention program includes public education, an onsite hazardous waste collection facility, source identification, a newly instituted pharmaceutical take-back program, and inspections of industrial users. Domestic users generate more than 80% of the sewage processed at the WWTP; non-industrial users or light industry, which generate wastewater similar to that of domestic sources but on a larger scale, contribute the remaining portion of the WWTP's influent. Without heavy industry within the service area, there is a concomitant lack of industrial pollutants within the MBCSD wastewater.

As in prior years, a few common metals and ubiquitous chemical compounds appear in low concentrations within effluent and biosolid samples collected during 2010. Of the 78 chemical compounds tested in semi-annual effluent samples, only a few were present in quantifiable amounts. Additionally, the measured concentrations of these compounds were all well below applicable NPDES discharge limits. In most cases, the concentrations were orders of magnitude lower than their respective limits. The associated mass emissions were also well below the limits identified in the discharge permit.

Quantified compounds within the effluent included three commonly occurring trace metals (copper, lead, and zinc), a radionuclide, a common phthalate compound (bis 2-ethylhexyl phthalate [DEHP]), cyanide, chloroform, selenium, a non-chlorinated phenolic compound (3,4 methylphenol), and low-level congeners of dioxin. The trace metals and selenium all occur naturally within the mineralogy of sediments along the central California coast. Additionally copper, lead, and zinc also enter the collection system through internal corrosion of household plumbing systems. Low levels of chloroform and cyanide form as byproducts of the plant's disinfection processes, while 3,4 methylphenol is commonly used as an antiseptic and disinfectant.

Both DEHP and dioxin are ubiquitous in the environment, have regularly been detected within effluent samples at low levels, and do not indicate a new or elevated source within the collection system. Additionally, some level of radioactivity in effluent samples is expected because of naturally occurring radionuclides. Nonetheless, radiation levels were still well within limits established for drinking water standards and similar to historical levels.

Largely because of the high effluent quality, bioassays conducted over the past decade consistently demonstrated the MBCSD effluent's low toxicity to marine organisms. The chronic bioassays conducted in 2010 again confirmed the benign nature of MBCSD effluent. Average toxicity levels in 2010 were an order-of-magnitude less than the permitted limits.

As with effluent samples, chemical analyses of biosolid samples quantified only very low concentrations of some commonly occurring wastewater constituents. In addition to the bulk organic compounds, the only constituents with quantifiable concentrations included 15 ubiquitous trace metals, cyanide ethylbenzene, toluene, xylene, and the same common phthalate found in effluent.

All measured concentrations were low and well below regulatory limits that would make the biosolids hazardous or unsuitable for composting and land application. Because of the high biosolids quality, which is further improved by windrow composting, the plant was able to make the final product available to the public for beneficial reuse as a high-quality soil amendment.

5.2 RECEIVING WATERS

The receiving-water environment was monitored on a quarterly basis to evaluate the oceanographic conditions near the outfall, particularly with respect to any adverse impacts from wastewater discharge. Comparison of water quality at the boundary of the zone of initial dilution (ZID) with gradient areas beyond the dilution zone documented compliance with the receiving-water objectives of the California Ocean Plan (COP) as specified in the NPDES discharge permit. Extremely sensitive electronic probes provided a detailed picture of water quality during the four surveys conducted in 2010. Precise navigation and high-resolution data on light transmittance, density, temperature, salinity, pH, and dissolved oxygen assessed spatial variations within receiving waters.

During all four surveys, small anomalies in water properties associated with the submerged wastewater plume were detected. In all cases, the water-quality fluctuations were restricted to the ZID, were generated by the upward displacement of ambient seawater and not the presence of wastewater constituents, or were insignificant compared to the larger ambient variations resulting from natural oceanographic processes. Several of these plume measurements captured the signature of wastewater while it was undergoing rapid initial mixing within the ejection jet emanating from a diffuser port. Dilution rates determined from these close-in measurements were compared with expected critical initial dilution ratios based on modeling during the outfall design. They demonstrated that the diffuser structure had dispersed the wastewater to a much greater extent than predicted by the modeling.

Because tests for compliance with the receiving-water limitations in the discharge permit only apply outside the ZID, these close-in measurements were not subject to the standards in the COP. Nevertheless, plume observations collected within the ZID were routinely below the permit limits applicable to observations collected outside this narrow 15-m mixing zone. None of the observed conditions suggested that unmixed wastewater was tangibly affecting receiving waters within or beyond the ZID. As with prior monitoring, water quality parameters measured in the 2010 surveys confirmed that the diffuser was operating efficiently and that wastewater was diluted 200-fold immediately following discharge from the diffuser ports.

5.3 SEAFLOOR SEDIMENTS

The monitoring program has evaluated physical, chemical, and biological conditions within the benthic sediments around the outfall for 25 years. Temporal fluctuations in these factors have been directly related to natural influences, the largest of which occur on seasonal and interannual time scales. The more notable faunal variations have typically involved interannual population fluxes within individual taxa. For example, substantial increases in the abundance of the Pacific sand dollar (*Dendraster excentricus*) were documented in 1989, 1991, 1999, and 2009. During these episodic recruitment events, sand dollar populations overwhelmingly dominated the infaunal community, with the residual effects of successful recruitment persisting into following years, as was the case in 2010. The marked population increases in sand dollars all coincided with the well-recognized global climate fluctuations known as El Niños. These major changes affect all of the benthic monitoring stations, including reference sites, and are related to inherent oceanographic variability rather than the discharge of effluent.

To test for outfall-related effects, a large number of biological indices and parameters were computed from an enumeration of the more than 236,000 specimens collected over 25 years of benthic monitoring. None of these parameters exhibited statistically significant spatial distributions related to the effluent discharge or long-term spatiotemporal trends indicative of an increasingly degraded benthic habitat near the outfall. Not only were the spatial differences in 2010 small compared to inherent sampling variability, but also seasonal and interannual changes in community structure from natural environmental oscillations, such as El Niño, were substantially larger. Despite large temporal fluctuations in the infaunal community, its health has remained uniformly high throughout the 25 years of monitoring. The benthic environment surrounding the outfall continues to be populated by an infaunal community dominated by pollution-sensitive suspension-feeding organisms.

Spatiotemporal analyses were also conducted on the large dataset of sediment physicochemistry spanning the 25 years since benthic monitoring began in 1986. Those analyses demonstrated that there was no buildup of sediment contaminants surrounding the outfall. In addition, trace-metal and organic concentrations collected both near and far from the outfall in 2010 remained below thresholds considered harmful to marine biota. In fact, sediment trace-metal concentrations within Estero Bay were well below concentrations found in the vast majority of samples collected offshore Southern California. This attests to the pristine nature of the ocean environment in northern Estero Bay. Nickel and chromium are the only trace metals with comparatively elevated concentrations within Estero Bay sediments. However, these metals occur naturally in the mineralogy of the region. As a result, the Estero Bay sediment metal concentrations are comparable to those in nearby benthic environments, such as Port San Luis (NOAA 1991a), and the Morro Bay Estuary (Tenera and Marine Research Specialists 1997).

These sediment-chemistry analyses, in conjunction with analyses of infaunal community structure, provide strong empirical evidence that the sediments surrounding the outfall, along with the organisms within them, have not been perceptibly impacted by the discharge, even after two-and-a-half decades of operation and monitoring.

5.4 RECOMMENDATIONS

The 25 years of monitoring data summarized in this annual report demonstrate that the MBCSD WWTP has been operating as designed and that the discharge of effluent has not adversely impacted the marine environment within Estero Bay. Occasional adjustments made to the monitoring program have substantially increased its capacity to detect minute environmental impacts, yet conclusions regarding the lack of impacts have continued to hold true into 2010.

Recent adjustments made to the monitoring program were based on recommendations in earlier annual reports and were ultimately incorporated in the current NPDES discharge permit that became effective in March 2009. Additionally, most of the recommendations in recent reports dealt with potential improvements to the monitoring program rather than with improvements to plant performance. As in recent past report, the following three recommendations pertain to proposed adjustments to the monitoring program:

- **Reduce the monitoring frequency for effluent chemical parameters.** Pursuant to the provisions within the current NPDES permit, a reduction in the monitoring frequency of effluent chemical concentrations is warranted (MBCSD 2004; MRS 2004b, 2009b). The MBCSD discharge permit allows a change in monitoring frequency to once-in-the-life of the permit for those compounds that are undetected in the first year of monitoring. During 2009 sampling, which was the first year of sampling under the current permit, there were 73 chemical constituents which met this criterion. Additionally, application of SWRCB's (2005) statistical methodology to two decades of MBCSD

effluent measurements unequivocally demonstrates that there is no reasonable potential for exceedance of permit limits for those 73 compounds, or for the remaining compounds currently monitored on an annual basis. As a result, the California Ocean Plan does not require continued annual monitoring of any of the compounds. Concentrations measured within 2009 and 2010 effluent samples, which were collected after the reasonable-potential analysis was conducted, only serve to strengthen those conclusions. The reduction in monitoring frequency is further justified by the historically high level of compliance, a proposed monitoring frequency that is consistent with other similar-sized dischargers, and an ongoing bioassay program that provides a more sensitive all-inclusive evaluation of effluent quality.

- **Reinstate analysis for trace metals, grain size, and infauna at benthic Station B1.** Although the physical environment at Station B1 varies slightly from that at the outfall stations, its 1 km distance from the outfall provides valuable insight into large-scale environmental processes within Estero Bay that are independent of the discharge. Additionally, Station B1 has been continuously sampled throughout the 25-year monitoring program. Even though benthic monitoring at this location is no longer required by the current discharge permit, voluntary collection and analysis of sediment samples was conducted in both 2009 and 2010. Continued sampling at this location is recommended to maintain historical consistency with the long-term time series analyses and provide insight into regional processes affecting Estero Bay as whole.
- **Eliminate the Cat-Litter Public-Outreach Program.** The current discharge permit requires an annual reevaluation of the implementation goals of the Cat-Litter Public-Outreach work plan. A requirement for development and submittal of a work plan was included in the current permit as a conservation measure because concerns were raised that Estero Bay was a “hot-spot” for otter mortality associated with *Toxoplasma gondii* infection. Disposal of cat litter into the MBCSD collection system was thought by some to be a contributing factor to the high exposure and infection rates found in live animals and carcasses tested from the Estero Bay area. However, shortly after final approval of the current MBCSD permit in 2009, results from a comprehensive field study (Johnson et al. 2009) were published that confirmed that disease vectors unrelated to WWTP discharge are responsible for the observed *T. gondii* exposure in otters, and that the epicenter for infection is not within Estero Bay. As such, there is little scientific rationale for the continuation of a dedicated outreach program specific to cat-litter disposal in the MBCSD collection system.

Instead, existing public-outreach efforts required under the permit should continue to incorporate efforts to keep regulatory agencies and the general public abreast of the latest scientific findings in order to reduce existing misconceptions about the MBCSD discharge’s effects on otter health and the significance of *T. gondii* within the watershed. Nevertheless, although the current MBCSD efforts at public education and outreach regarding cat litter disposal are comprehensive, and include the use of the internet, posters, newsletters, and public talks and tours, they remain uncodedified by a formal work plan, as required in the current NPDES permit. Therefore, until such time as the RWQCB revisits the validity of the concerns underlying the inclusion and necessity of this conservation measure, MBCSD should continue to work towards finalizing a cat-litter public-outreach work plan in accordance with the permit requirements.

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CHAPTER 6
Literature Cited

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6.0 LITERATURE CITED

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APPENDIX A

Wastewater Treatment Plant Specifications

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Table A.1 WWTP Specifications

Parameter	Quantity	Parameter	Quantity
Waste Loading		Tank 1	2.74
Flow (MGD)		Tank 2	2.74
Average dry-weather flow	2.06	Surface loading rate PSDWF (10 ³ L/m ² /day)	29.74
PSDWF	2.36	Detention time at PWWF (hr.)	2.2
Peak dry-weather flow	6.64	Total Treatment	
PWWF	6.60	Overall treatment efficiencies (%)	
Strength		BOD ₅	57
BOD ₅ (mg/L)	280	Suspended solids	75
Suspended solids (mg/L)	280	Expected effluent quality (mg/L)	
Grit (ft ³ /mg)	10	BOD ₅	120
Waste quantities at PSDWF		Suspended solids	70
BOD ₅ (mt/day)	2.5	Solids stabilization	
Suspended Solids (mt/day)	2.5	Anaerobic digester loading (mt/day)	
Grit (ft ³ /day)	23.6	Primary solids	1.6
Preliminary Treatment		Secondary solids	0.4
Mechanically cleaned bar screen		Assumed sludge volatile content (%)	
Number	1	Primary solids	70
Capacity (MGD)	8.2	Secondary solids	82
Channel Monster		Sludge volume (m ³ /day)	50.7
Number	1	Digester 1 (existing, fixed cover)	
Capacity (MGD)	7.0	Diameter (m)	12.2
Influent pumps (variable speed)		Side water depth (m)	4.9
Number	3	Volume (m ³)	629
Capacity each (MGD)	3.3	Digester 2 (existing, fixed cover)	
Total head (m)	9.6	Diameter (m)	12.2
Aerated grit removal tanks		Side water depth (m)	5.8
Number	1	Volume (m ³)	725
Length (m)	9.1	Digester 3 (new, floating cover)	
Width (m)	4.9	Diameter (m)	10.7
Depth (m)	2.4	Side water depth (m)	6.9
Detention time at PWWF (min)	6.3	Volume (m ³)	646
Grit Pumps		Hydraulic detention time based on net volume of digesters 2 and 3 (days)	23
Number	2	Assumed volatile solids reduction (%)	55
Capacity (gpm)	250	Expected sludge gas production (m ³ /day)	804
Primary Treatment			
Sedimentation tanks			
Number	2		
Diameter (m)			
Tank 1	15.2		
Tank 2	12.2		
Average side water depth (m)			

Parameter	Quantity
Sludge drying beds	
Number	12
Length each (m)	49.4
Width each (m)	9.8
Solids Loadings (kg ft ⁻¹ yr ⁻¹)	78.3
Assumed removal efficiency (%)	
BOD ₅	35
Suspended solids	65
Primary effluent quality (mg/L)	
BOD ₅	182
Suspended solids	98
Secondary treatment	
Biofilters (existing, in partial secondary treatment mode of operation)	
Flow distribution at PSDWF (MGD)	
Biofilter 1	0.39
Biofilter 2	0.58
Diameter (m)	
Biofilter 1	18.3
Biofilter 2	21.3
Net media surface area (m ²)	
Biofilter 1	262
Biofilter 2	350
Average media height (m)	
Biofilter 1	1.4
Biofilter 2	1.5
Media Volume (m ³)	
Biofilter 1	360
Biofilter 2	532
Specific organic loading rate (lbs BOD ₅ /day/1000 ft ³)	47
Circulated flow (MGD)	
Biofilter 1	1.37
Biofilter 2	2.04
Hydraulic loading rate (gpm/ft ² media surface)	
Biofilter 1	0.34
Biofilter 2	0.38
Circulation pumps	
Biofilter 1	
Capacity (gpm)	950
Total head (m)	3.4
Biofilter 2	
Capacity (gpm)	1420
Total head (m)	4.3

Parameter	Quantity
Stand-by (2-speed)	
Capacity (gpm)	960
	1660
Total head (m)	3.4
	4.4
Interstage pumping	
Biofilter effluent pumps (variable speed)	
Number	2
Capacity each (gpm)	2300
Total head (m)	8.2
Secondary sedimentation tanks	
Number	1
Diameter (m)	16.8
Tank surface area (m ²)	221
Tank volume (m ³)	3125
Average water depth (m)	4.6
Overflow rate at PSDWF (10 ³ L/m ² /day)	16.6
Expected secondary treatment effluent quality (mg/L)	
BOD ₅	30
Suspended Solids	30
Chlorination	
Chlorine contact tank (existing)	
Number of passes	2
Length (m)	
Pass 1	16.8
Pass 2	22.9
Width each pass (m)	4.6
Average depth (m)	2.3
Total volume (m ³)	413
Detention time at PDWF (min)	24
Chlorinators	
Pre-chlorinator	
Number	1
Initial capacity (kg/day)	227.3
Ultimate capacity (kg/day)	909.1
RAS chlorinator	
Number	1
Capacity (kg/day)	227.3
Ultimate capacity (kg/day)	90.9
Sodium Hypochlorite Post Chlorinator	
Chemical feed pumps	3
Combined Capacity (kg/day)	5450
Dechlorination	
Sodium Bisulfite System	
Chemical feed pumps	3
Combined Capacity (kg/day)	1226

APPENDIX B
Infaunal Biology

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INFAUNAL INDICES

B.1.1 Species Diversity

The Shannon diversity index (H') (Shannon and Weaver 1949) is the most common diversity index used in 301(h) programs. It measures the relative distribution of individual organisms among the species present in the sample. H' increases for broader distributions of individuals among species. If all individuals are of one species then H' is 0.00. If each individual organism is a separate species then H' is determined by the logarithm of the total number of organisms collected. For other distributions, the

diversity index is given by: $H' = - \sum_{j=1}^S \left[\left(\frac{n_j}{N} \right) \ln \left(\frac{n_j}{N} \right) \right]$; where: S = total number of species, n_j = number of individuals in the j^{th} species, N = total number of individuals, and $\ln$ = natural logarithm (base e). The value of the Shannon index usually falls between 1.5 and 3.5 and only rarely surpasses 4.5 (Margalef 1972).

Some studies have found a decrease in this index in response to pollutant stress in benthic communities. However, this index is ambiguous because it depends on how evenly the organisms are distributed among the species. Consequently, a statistically significant reduction in this index can occur in the absence of anthropogenic (human-induced) stresses.

When randomness in the sample cannot be guaranteed, then the Brillouin index (h) is a more appropriate

measure of diversity (Pielou 1977). It is calculated using the formula: $h = \frac{\ln(N!) - \sum_{j=1}^S [\ln(n_j!)]}{N}$. It gives a similar measure of diversity although it produces a slightly lower value than the Shannon index when applied to the same data. In contrast to the Shannon index, the Brillouin will vary between samples although the number of species and their proportional abundance remain the same. Because of its dependence on sample size and the increased complexity of its computation, the Brillouin index is more rarely used than the Shannon index.

B.1.2 Evenness

The Pielou evenness index (J') (Pielou 1977) measures how evenly the individual organisms are distributed among the species present in the sample. J' increases for more even distributions of individuals among species. If all individuals belong to a single species, then J' is indeterminate. If each species is represented by a single organism, then J' will be equal to 1.00. For other distributions, the evenness index is given by: $J' = \frac{H'}{\ln S}$; where: S = total number of species, and H' = Shannon-Wiener diversity index.

Because this index is derived from the Shannon-Wiener diversity index (H'), it is subject to the same limitations.

B.1.3 Species Dominance

Dominance indices increase with decreasing diversity and are heavily weighted toward the most common species in a sample. The best known of these measures is Simpson's index (C') (Simpson 1949; Wittaker 1965). It is related to other diversity and evenness indices but increases with increasing proportions of individuals associated with a few species. If all individuals are of one species, then C' is maximum and equal to the maximum dominance of 1.00. If individual organisms are evenly distributed among species

($J'=1.00$), then C' asymptotically approaches 0.00 with increasing numbers of individuals. The Simpson dominance measure is given by: $C' = \sum_{j=1}^S \left(\frac{n_j}{N} \right)^2$ but for finite communities, the unbiased form is:

$$C' = \sum_{j=1}^S \left(\frac{n_j(n_j - 1)}{N(N - 1)} \right) \text{ (Magurran 1988).}$$

An unrelated measure of dominance has been ascribed to Swartz et al. (1985). The Swartz dominance index (Sw) is defined as the minimum number of species that account for 75% of all individual organisms collected in a sample. In this dominance measure, species are first ranked by the number of individual organisms before establishing the cumulative percent equal to or exceeding 75%. This is an inverse measure because higher dominance is reflected in a lower number of species accounting for 75% of the individual organisms. Despite this, it is not subject to many of the limitations that plague the other univariate indices. It is a non-parametric measure that does not assume an underlying distribution of individuals among species.

B.1.4 Infaunal Trophic Index

The Infaunal Trophic Index (ITI) (Word 1978) compares the abundance of four soft-bottom benthic assemblages distinguished by feeding behavior. Because the sensitivity or tolerance to organic enrichment in particulate matter differs among the four groups, shifts in group dominance, as reflected in a changing infaunal index, can be indicative of changed or degraded environmental conditions. The ITI ranges between 0 and 100. When species in Group I (suspension feeders) and Group II (surface-detritus feeders) dominate, index values are above 58 and sediments are relatively clean. Lower infaunal indices occur when species in Group III (surface deposit feeders) and Group IV (sub-surface detritus feeders) dominate and sediments are high in organics. The ITI is computed from: $ITI = 100 - 33.3 \left[\frac{G_2 + 2G_3 + 3G_4}{G_1 + G_2 + G_3 + G_4} \right]$; where:

G_i = number of individual organisms within the i^{th} trophic group.

B.1.5 Species Richness

The Margalef species richness index (d) (Margalef 1951) measures the number of species in a sample relative to the number of individual organisms. d strongly increases for increasing number of species and increases only logarithmically for decreasing number of individuals. If only one species is present then d is 0.00. For other distributions, the richness index is given by: $d = \frac{S - 1}{\ln N}$. Its applicability to biological communities is dependent on whether specimens are log-normally distributed among the species in a given sample. Such an assumption is not globally applicable to benthic marine communities, and without testing each data set, the richness index is of questionable value.

Table B.1 Station Abundance by Taxa during October 2010

Taxonomic Group	Taxon	Station							Station Total	Percent of Total	Cumulative %
		B1	B2	B3	B4	B5	B6	B7			
Echinodermata	<i>Dendraster excentricus</i>	1297	921	634	187	438	138	254	3869	—	—
Bivalvia	<i>Tellina modesta</i>	58	28	37	46	111	38	42	360	11.67	11.67
Crustacea	<i>Majoxiphalus major</i>	9	35	38	52	66	49	32	281	9.11	20.78
Mollusca	<i>Alvania</i>	9	14	48	77	3	40	57	248	8.04	28.83
Crustacea	<i>Tecticeps convexus</i>	3	4	13	5	189	2	1	217	7.04	35.86
Crustacea	<i>Rhepoxynius menziesi</i>	17	16	26	30	28	27	18	162	5.25	41.12
Nemertea	<i>Carinoma mutabilis</i>	24	24	31	38	7	22	15	161	5.22	46.34
Nemertea	<i>Carinomella lactea</i>	6	10	14	27	1	47	43	148	4.80	51.13
Bivalvia	<i>Tellina bodegensis</i>	8	15	18	16	17	21	26	121	3.92	55.06
Annelida	<i>Magelona sacculata</i>	—	1	—	—	91	4	1	97	3.15	58.20
Crustacea	<i>Rhepoxynius abronius</i>	21	2	4	9	2	16	17	71	2.30	60.51
Crustacea	<i>Cancer gracilis</i>	35	16	—	3	13	1	2	70	2.27	62.78
Crustacea	<i>Americhilidium shoemakeri</i>	8	9	7	11	17	6	7	65	2.11	64.88
Bivalvia	<i>Siliqua lucida</i>	3	2	7	9	17	13	12	63	2.04	66.93
Crustacea	<i>Pacifoculodes spinipes</i>	3	8	3	12	11	12	12	61	1.98	68.90
Annelida	<i>Lumbrineris</i>	—	3	10	5	20	14	5	57	1.85	70.75
Crustacea	<i>Anchicolurus occidentalis</i>	1	2	6	1	36	5	3	54	1.75	72.50
Crustacea	<i>Leuroleberis sharpei</i>	3	1	—	1	43	3	1	52	1.69	74.19
Annelida	<i>Nephtys caecoides</i>	2	9	4	4	13	6	7	45	1.46	75.65
Annelida	<i>Armandia bioculata</i>	3	2	3	3	24	3	3	41	1.33	76.98
Crustacea	<i>Eohaustorius sencillus</i>	2	8	5	15	—	8	1	39	1.26	78.24
Crustacea	<i>Cheirimedia zotea</i>	—	—	—	14	3	11	3	31	1.01	79.25
Annelida	<i>Scoloplos armiger</i>	—	1	6	5	5	9	2	28	0.91	80.16
Annelida	<i>Chaetozone setosa</i>	—	1	8	6	5	2	3	25	0.81	80.97
Phoronida	<i>Phoronis</i>	3	1	6	2	1	9	2	24	0.78	81.74
Crustacea	<i>Gibberosus myersi</i>	2	2	4	5	5	1	3	22	0.71	82.46
Crustacea	<i>Foxiphalus xiximeus</i>	2	—	—	1	6	3	10	22	0.71	83.17
Mollusca	<i>Odostomia</i>	—	—	5	16	1	—	—	22	0.71	83.88
Crustacea	<i>Bathycopea daltonae</i>	—	3	2	5	8	—	3	21	0.68	84.57
Annelida	<i>Glycera convoluta</i>	2	2	2	4	4	3	3	20	0.65	85.21
Annelida	<i>Axiiothella rubrocincta</i>	3	1	3	6	4	2	—	19	0.62	85.83
Crustacea	<i>Isocheles pilosus</i>	—	6	1	2	10	—	—	19	0.62	86.45
Annelida	<i>Sigalion spinosa</i>	3	2	4	1	1	3	3	17	0.55	87.00
Annelida	<i>Lumbrineris californiensis</i>	2	1	1	—	4	5	4	17	0.55	87.55
Annelida	<i>Notomastus lineatus</i>	1	5	2	5	2	2	—	17	0.55	88.10
Echinodermata	<i>Amphiodia</i>	—	1	4	2	3	4	1	15	0.49	88.59
Annelida	<i>Sthenelais verruculosa</i>	1	2	1	6	—	3	1	14	0.45	89.04
Annelida	<i>Phyllodoce</i>	1	—	3	5	—	3	1	13	0.42	89.46
Annelida	<i>Polydora</i>	3	—	9	—	—	—	—	12	0.39	89.85
Annelida	<i>Onuphis iridescens</i>	1	—	—	1	8	—	2	12	0.39	90.24
Crustacea	<i>Photis brevipes</i>	—	—	—	—	—	6	5	11	0.36	90.60
Bivalvia	<i>Rocheportia tumida</i>	1	—	—	—	9	—	—	10	0.32	90.92
Other	<i>Halosydna brevisetosa</i>	—	—	—	5	—	1	4	10	0.32	91.25
Crustacea	<i>Cancer</i>	—	—	9	—	—	—	—	9	0.29	91.54
Crustacea	<i>Aoroides inermis</i>	—	—	—	2	—	2	5	9	0.29	91.83

Table B.1 Station Abundance by Taxa during October 2010

Taxonomic Group	Taxon	Station							Station Total	Percent of Total	Cumulative %
		B1	B2	B3	B4	B5	B6	B7			
Annelida	<i>Capitella capitata</i>	–	–	–	–	7	2	–	9	0.29	92.12
Echinodermata	<i>Leptosynapta</i>	6	1	1	–	–	–	–	8	0.26	92.38
Nemertea	<i>Paranemertes sp. A</i>	3	–	–	1	–	–	4	8	0.26	92.64
Annelida	<i>Phylo felix</i>	1	1	–	–	6	–	–	8	0.26	92.90
Annelida	<i>Diopatra ornata</i>	–	–	–	–	6	–	2	8	0.26	93.16
Annelida	<i>Leitoscoloplos pugettensis</i>	4	–	–	–	–	2	1	7	0.23	93.39
Mollusca	<i>Turbonilla</i>	4	–	–	–	–	–	3	7	0.23	93.61
Nemertea	Lineidae	3	–	–	–	2	2	–	7	0.23	93.84
Nemertea	<i>Cerebratulus californiensis</i>	1	2	–	2	1	1	–	7	0.23	94.07
Annelida	<i>Apoprionospio pygmaea</i>	–	–	–	–	4	2	1	7	0.23	94.29
Crustacea	<i>Crangon</i>	–	–	–	–	2	3	2	7	0.23	94.52
Crustacea	<i>Photis macinerneyi</i>	1	–	–	2	–	2	1	6	0.19	94.71
Bivalvia	<i>Clinocardium nuttallii</i>	–	1	–	1	3	–	1	6	0.19	94.91
Crustacea	<i>Mesolamprops dillonensis</i>	1	–	–	1	–	2	1	5	0.16	95.07
Annelida	<i>Ampharete labrops</i>	1	–	–	1	–	–	3	5	0.16	95.23
Crustacea	Brachyura	–	–	–	1	–	3	1	5	0.16	95.40
Annelida	<i>Microphthalmus</i>	–	–	–	–	5	–	–	5	0.16	95.56
Crustacea	Gammaridea	–	–	–	–	–	4	1	5	0.16	95.72
Nemertea	<i>Lineus bilineatus</i>	4	–	–	–	–	–	–	4	0.13	95.85
Echinodermata	<i>Amphiodia digitata</i>	1	1	–	–	1	1	–	4	0.13	95.98
Annelida	<i>Glycinde armigera</i>	1	–	1	–	2	–	–	4	0.13	96.11
Annelida	<i>Phyllochaetopterus</i>	1	–	1	–	1	1	–	4	0.13	96.24
Mollusca	<i>Nassarius fossatus</i>	–	1	2	–	–	1	–	4	0.13	96.37
Annelida	<i>Platynereis bicanaliculata</i>	–	–	1	2	–	1	–	4	0.13	96.50
Crustacea	<i>Crangon alaskensis</i>	–	–	1	–	2	1	–	4	0.13	96.63
Annelida	<i>Spiophanes bombyx</i>	–	–	–	–	4	–	–	4	0.13	96.76
Crustacea	Porcellanidae	1	–	1	–	1	–	–	3	0.10	96.85
Annelida	<i>Goniada maculata</i>	1	–	–	–	1	–	1	3	0.10	96.95
Crustacea	<i>Euphilomedes carcharodonta</i>	–	2	–	–	1	–	–	3	0.10	97.05
Annelida	<i>Chone mollis</i>	–	1	–	1	–	1	–	3	0.10	97.15
Bivalvia	<i>Cooperella subdiaphana</i>	–	–	–	2	–	1	–	3	0.10	97.24
Annelida	<i>Eupolymnia heterobranchia</i>	–	–	–	2	–	–	1	3	0.10	97.34
Annelida	<i>Tenonia priops</i>	–	–	–	1	1	–	1	3	0.10	97.44
Bivalvia	<i>Chione</i>	–	–	–	1	–	2	–	3	0.10	97.54
Bivalvia	Pectinidae	–	–	–	1	–	2	–	3	0.10	97.63
Annelida	<i>Cirriformia spirabranchia</i>	–	–	–	–	2	–	1	3	0.10	97.73
Bivalvia	<i>Pandora punctata</i>	–	–	–	–	–	3	–	3	0.10	97.83
Bivalvia	<i>Macoma acolasta</i>	–	–	–	–	–	3	–	3	0.10	97.92
Annelida	<i>Travisia gigas</i>	2	–	–	–	–	–	–	2	0.06	97.99
Annelida	<i>Aphelochaeta</i>	1	–	–	1	–	–	–	2	0.06	98.05
Crustacea	<i>Dynamene tuberculosa</i>	1	–	–	1	–	–	–	2	0.06	98.12
Crustacea	Hippolytidae	1	–	–	–	1	–	–	2	0.06	98.18
Annelida	<i>Polycirrus</i>	–	1	–	–	–	1	–	2	0.06	98.25
Crustacea	<i>Edotia sublittoralis</i>	–	–	2	–	–	–	–	2	0.06	98.31
Crustacea	<i>Synidotea bicuspidata</i>	–	–	1	–	1	–	–	2	0.06	98.38

Table B.1 Station Abundance by Taxa during October 2010

Taxonomic Group	Taxon	Station							Station Total	Percent of Total	Cumulative %
		B1	B2	B3	B4	B5	B6	B7			
Nemertea	<i>Amphiporus bimaculatus</i>	—	—	—	2	—	—	—	2	0.06	98.44
Annelida	Syllidae	—	—	—	2	—	—	—	2	0.06	98.51
Mollusca	<i>Epitonium sawinae</i>	—	—	—	1	1	—	—	2	0.06	98.57
Vertebrata	<i>Porichthys notatus</i>	—	—	—	1	1	—	—	2	0.06	98.64
Bivalvia	<i>Solen sicarius</i>	—	—	—	1	—	1	—	2	0.06	98.70
Crustacea	Majidae	—	—	—	—	2	—	—	2	0.06	98.77
Annelida	<i>Scalibregma californicum</i>	—	—	—	—	2	—	—	2	0.06	98.83
Annelida	<i>Eteone pacifica</i>	—	—	—	—	2	—	—	2	0.06	98.90
Mollusca	<i>Olivella baetica</i>	—	—	—	—	2	—	—	2	0.06	98.96
Mollusca	<i>Polinices lewisii</i>	—	—	—	—	1	—	1	2	0.06	99.03
Annelida	<i>Podarkeopsis glabra</i>	1	—	—	—	—	—	—	1	0.03	99.06
Annelida	<i>Magelona hartmanae</i>	1	—	—	—	—	—	—	1	0.03	99.09
Mollusca	<i>Olivella pedroana</i>	1	—	—	—	—	—	—	1	0.03	99.12
Annelida	<i>Harmothoe</i>	1	—	—	—	—	—	—	1	0.03	99.16
Nemertea	<i>Tubulanus</i>	1	—	—	—	—	—	—	1	0.03	99.19
Crustacea	<i>Haliophasma geminata</i>	—	1	—	—	—	—	—	1	0.03	99.22
Annelida	<i>Arabella iricolor</i>	—	1	—	—	—	—	—	1	0.03	99.25
Annelida	<i>Glycera americana</i>	—	—	1	—	—	—	—	1	0.03	99.29
Annelida	<i>Malmgrenia nigralba</i>	—	—	1	—	—	—	—	1	0.03	99.32
Mollusca	<i>Alvania compacta</i>	—	—	—	1	—	—	—	1	0.03	99.35
Annelida	<i>Exogone</i>	—	—	—	1	—	—	—	1	0.03	99.38
Crustacea	<i>Listriella goleta</i>	—	—	—	1	—	—	—	1	0.03	99.42
Annelida	<i>Mesochaetopterus</i>	—	—	—	1	—	—	—	1	0.03	99.45
Mollusca	<i>Mitrella aurantiaca</i>	—	—	—	1	—	—	—	1	0.03	99.48
Platyhelminthes	Polycladida	—	—	—	1	—	—	—	1	0.03	99.51
Crustacea	Aoridae	—	—	—	—	1	—	—	1	0.03	99.55
Mollusca	<i>Alvania compacta</i>	—	—	—	—	1	—	—	1	0.03	99.58
Annelida	<i>Megalomma pigmentum</i>	—	—	—	—	1	—	—	1	0.03	99.61
Annelida	<i>Rhynchospio arenicola</i>	—	—	—	—	1	—	—	1	0.03	99.64
Mollusca	<i>Rictaxis punctocaelatus</i>	—	—	—	—	1	—	—	1	0.03	99.68
Annelida	<i>Spiophanes duplex</i>	—	—	—	—	1	—	—	1	0.03	99.71
Annelida	<i>Typosyllis farallonensis</i>	—	—	—	—	—	1	—	1	0.03	99.74
Crustacea	<i>Diastylopsis tenuis</i>	—	—	—	—	—	1	—	1	0.03	99.77
Annelida	<i>Dispio uncinata</i>	—	—	—	—	—	1	—	1	0.03	99.81
Crustacea	<i>Exacanthomysis davisii</i>	—	—	—	—	—	1	—	1	0.03	99.84
Mollusca	<i>Hermisenda crassicornis</i>	—	—	—	—	—	1	—	1	0.03	99.87
Crustacea	<i>Ischyrocerus</i>	—	—	—	—	—	1	—	1	0.03	99.90
Crustacea	<i>Tiron biocellata</i>	—	—	—	—	—	1	—	1	0.03	99.94
Crustacea	<i>Caprella californica</i>	—	—	—	—	—	—	1	1	0.03	99.97
Pycnogonida	<i>Achelia echinata</i>	—	—	—	—	—	—	1	1	0.03	100.00
Total Number of Individuals		1581	1171	991	678	1297	593	642	6953		
Total Number of Individuals Excluding <i>D. Excentricus</i>		284	250	357	491	859	455	388	3084		

Table B.2 Replicate Sample Abundance by Taxa at Station B1 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Echinodermata	<i>Dendraster excentricus</i>	371	238	1	398	289	1297	—	—
Bivalvia	<i>Tellina modesta</i>	10	10	12	10	16	58	20.42	20.42
Crustacea	<i>Cancer gracilis</i>	15	11	—	2	7	35	12.32	32.75
Nemertea	<i>Carinoma mutabilis</i>	9	4	5	1	5	24	8.45	41.20
Crustacea	<i>Rhepoxynius abronius</i>	6	2	7	5	1	21	7.39	48.59
Crustacea	<i>Rhepoxynius menziesi</i>	3	1	3	8	2	17	5.99	54.58
Mollusca	<i>Alvania</i>	3	5	1	—	—	9	3.17	57.75
Crustacea	<i>Majoxiphalus major</i>	2	4	2	1	—	9	3.17	60.92
Bivalvia	<i>Tellina bodegensis</i>	2	1	3	1	1	8	2.82	63.73
Crustacea	<i>Americhilidium shoemakeri</i>	—	2	4	2	—	8	2.82	66.55
Echinodermata	<i>Leptosynapta</i>	1	—	—	5	—	6	2.11	68.66
Nemertea	<i>Carinomella lactea</i>	—	—	—	1	5	6	2.11	70.77
Mollusca	<i>Turbonilla</i>	—	4	—	—	—	4	1.41	72.18
Annelida	<i>Leitoscoloplos pugettensis</i>	—	—	1	2	1	4	1.41	73.59
Nemertea	<i>Lineus bilineatus</i>	—	—	—	3	1	4	1.41	75.00
Nemertea	Lineidae	3	—	—	—	—	3	1.06	76.06
Crustacea	<i>Leuroleberis sharpei</i>	2	1	—	—	—	3	1.06	77.11
Annelida	<i>Axiiothella rubrocincta</i>	1	—	2	—	—	3	1.06	78.17
Annelida	<i>Sigalion spinosa</i>	—	3	—	—	—	3	1.06	79.23
Crustacea	<i>Tecticeps convexus</i>	—	3	—	—	—	3	1.06	80.28
Phoronida	<i>Phoronis</i>	—	1	2	—	—	3	1.06	81.34
Bivalvia	<i>Siliqua lucida</i>	—	1	2	—	—	3	1.06	82.39
Annelida	<i>Polydora</i>	—	—	3	—	—	3	1.06	83.45
Crustacea	<i>Pacifoculodes spinipes</i>	—	—	3	—	—	3	1.06	84.51
Nemertea	<i>Paranemertes sp. A</i>	—	—	—	2	1	3	1.06	85.56
Annelida	<i>Armandia bioculata</i>	—	—	—	1	2	3	1.06	86.62
Crustacea	<i>Eohaustorius sencillus</i>	1	1	—	—	—	2	0.70	87.32
Annelida	<i>Nephtys caecoides</i>	1	1	—	—	—	2	0.70	88.03
Crustacea	<i>Gibberosus myersi</i>	1	—	1	—	—	2	0.70	88.73
Annelida	<i>Glycera convoluta</i>	1	—	1	—	—	2	0.70	89.44
Annelida	<i>Travisia gigas</i>	1	—	—	1	—	2	0.70	90.14
Crustacea	<i>Foxiphalus xiximeus</i>	—	—	—	—	2	2	0.70	90.85
Annelida	<i>Lumbrineris californiensis</i>	—	—	—	—	2	2	0.70	91.55
Crustacea	<i>Photis macinerneyi</i>	1	—	—	—	—	1	0.35	91.90
Nemertea	<i>Cerebratulus californiensis</i>	1	—	—	—	—	1	0.35	92.25
Mollusca	<i>Olivella pedroana</i>	1	—	—	—	—	1	0.35	92.61
Annelida	<i>Sthenelais verruculosa</i>	1	—	—	—	—	1	0.35	92.96
Echinodermata	<i>Amphiodia digitata</i>	1	—	—	—	—	1	0.35	93.31
Annelida	<i>Notomastus lineatus</i>	—	1	—	—	—	1	0.35	93.66
Crustacea	<i>Dynamene tuberculosa</i>	—	1	—	—	—	1	0.35	94.01
Annelida	<i>Phyllodoce</i>	—	—	1	—	—	1	0.35	94.37
Crustacea	<i>Anchicolurus occidentalis</i>	—	—	1	—	—	1	0.35	94.72
Annelida	<i>Glycinde armigera</i>	—	—	1	—	—	1	0.35	95.07
Crustacea	<i>Mesolamprops dillonensis</i>	—	—	1	—	—	1	0.35	95.42
Bivalvia	<i>Rocheortia tumida</i>	—	—	1	—	—	1	0.35	95.77
Annelida	<i>Magelona hartmanae</i>	—	—	1	—	—	1	0.35	96.13

Table B.2 Replicate Sample Abundance by Taxa at Station B1 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Annelida	<i>Aphelocheata</i>	–	–	1	–	–	1	0.35	96.48
Annelida	<i>Podarkeopsis glabra</i>	–	–	1	–	–	1	0.35	96.83
Nemertea	<i>Tubulanus</i>	–	–	1	–	–	1	0.35	97.18
Annelida	<i>Phylo felix</i>	–	–	–	1	–	1	0.35	97.54
Annelida	<i>Harmothoe</i>	–	–	–	1	–	1	0.35	97.89
Annelida	<i>Phyllochaetopterus</i>	–	–	–	1	–	1	0.35	98.24
Annelida	<i>Ampharete labrops</i>	–	–	–	–	1	1	0.35	98.59
Annelida	<i>Onuphis iridescens</i>	–	–	–	–	1	1	0.35	98.94
Annelida	<i>Goniada maculata</i>	–	–	–	–	1	1	0.35	99.30
Crustacea	Porcellanidae	–	–	–	–	1	1	0.35	99.65
Crustacea	Hippolytidae	–	–	–	–	1	1	0.35	100.00
Total Number of Individuals		438	295	62	446	340	1581		
Total Number of Individuals Excluding <i>D. Excentricus</i>		67	57	61	48	51	284		

Table B.3 Replicate Sample Abundance by Taxa at Station B2 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Echinodermata	<i>Dendraster excentricus</i>	34	441	399	44	3	921	–	–
Crustacea	<i>Majoxiphalus major</i>	10	2	7	5	11	35	14.00	14.00
Bivalvia	<i>Tellina modesta</i>	5	11	2	6	4	28	11.20	25.20
Nemertea	<i>Carinoma mutabilis</i>	10	1	8	5	–	24	9.60	34.80
Crustacea	<i>Rhepoxynius menziesi</i>	5	3	4	2	2	16	6.40	41.20
Crustacea	<i>Cancer gracilis</i>	–	13	1	1	1	16	6.40	47.60
Bivalvia	<i>Tellina bodegensis</i>	3	5	4	1	2	15	6.00	53.60
Mollusca	<i>Alvania</i>	9	1	–	1	3	14	5.60	59.20
Nemertea	<i>Carinomella lactea</i>	1	1	1	1	6	10	4.00	63.20
Annelida	<i>Nephtys caecoides</i>	3	–	3	3	–	9	3.60	66.80
Crustacea	<i>Americhilidium shoemakeri</i>	–	4	3	1	1	9	3.60	70.40
Crustacea	<i>Pacifoculodes spinipes</i>	4	–	1	2	1	8	3.20	73.60
Crustacea	<i>Eohaustorius sencillus</i>	1	1	5	1	–	8	3.20	76.80
Crustacea	<i>Isocheles pilosus</i>	1	1	–	4	–	6	2.40	79.20
Annelida	<i>Notomastus lineatus</i>	–	–	4	–	1	5	2.00	81.20
Crustacea	<i>Tecticeps convexus</i>	2	–	–	2	–	4	1.60	82.80
Annelida	<i>Lumbrineris</i>	1	–	2	–	–	3	1.20	84.00
Crustacea	<i>Bathycopoea daltonae</i>	1	–	–	2	–	3	1.20	85.20
Crustacea	<i>Rhepoxynius abronius</i>	2	–	–	–	–	2	0.80	86.00
Annelida	<i>Sigalion spinosa</i>	1	–	1	–	–	2	0.80	86.80

Table B.3 Replicate Sample Abundance by Taxa at Station B2 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Bivalvia	<i>Siliqua lucida</i>	1	—	—	—	1	2	0.80	87.60
Annelida	<i>Sthenelais verruculosa</i>	1	—	—	—	1	2	0.80	88.40
Annelida	<i>Glycera convoluta</i>	—	1	1	—	—	2	0.80	89.20
Crustacea	<i>Gibberosus myersi</i>	—	1	—	1	—	2	0.80	90.00
Annelida	<i>Armandia bioculata</i>	—	1	—	—	1	2	0.80	90.80
Nemertea	<i>Cerebratulus californiensis</i>	—	1	—	—	1	2	0.80	91.60
Crustacea	<i>Euphilomedes carcharodonta</i>	—	1	—	—	1	2	0.80	92.40
Crustacea	<i>Anchicolurus occidentalis</i>	—	—	—	2	—	2	0.80	93.20
Annelida	<i>Chaetozone setosa</i>	1	—	—	—	—	1	0.40	93.60
Crustacea	<i>Leuroleberis sharpei</i>	1	—	—	—	—	1	0.40	94.00
Annelida	<i>Lumbrineris californiensis</i>	1	—	—	—	—	1	0.40	94.40
Annelida	<i>Polycirrus</i>	1	—	—	—	—	1	0.40	94.80
Annelida	<i>Arabella iricolor</i>	1	—	—	—	—	1	0.40	95.20
Crustacea	<i>Haliophasma geminata</i>	1	—	—	—	—	1	0.40	95.60
Echinodermata	<i>Amphiodia digitata</i>	1	—	—	—	—	1	0.40	96.00
Annelida	<i>Scoloplos armiger</i>	—	1	—	—	—	1	0.40	96.40
Annelida	<i>Phylo felix</i>	—	1	—	—	—	1	0.40	96.80
Phoronida	<i>Phoronis</i>	—	—	1	—	—	1	0.40	97.20
Bivalvia	<i>Clinocardium nuttallii</i>	—	—	1	—	—	1	0.40	97.60
Annelida	<i>Magelona sacculata</i>	—	—	1	—	—	1	0.40	98.00
Annelida	<i>Axiiothella rubrocincta</i>	—	—	1	—	—	1	0.40	98.40
Echinodermata	<i>Leptosynapta</i>	—	—	—	1	—	1	0.40	98.80
Mollusca	<i>Nassarius fossatus</i>	—	—	—	1	—	1	0.40	99.20
Annelida	<i>Chone mollis</i>	—	—	—	—	1	1	0.40	99.60
Echinodermata	<i>Amphiodia</i>	—	—	—	—	1	1	0.40	100.00
Total Number of Individuals		102	491	450	86	42	1171		
Total Number of Individuals Excluding <i>D. Excentricus</i>		68	50	51	42	39	250		

Table B.4 Replicate Sample Abundance by Taxa at Station B3 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Echinodermata	<i>Dendraster excentricus</i>	2	66	314	118	134	634	—	—
Mollusca	<i>Alvania</i>	37	4	5	1	1	48	13.45	13.45
Crustacea	<i>Majoxiphalus major</i>	22	3	7	—	6	38	10.64	24.09
Bivalvia	<i>Tellina modesta</i>	6	7	11	7	6	37	10.36	34.45
Nemertea	<i>Carinoma mutabilis</i>	8	6	8	6	3	31	8.68	43.14
Crustacea	<i>Rhepoxynius menziesi</i>	3	5	6	12	—	26	7.28	50.42
Bivalvia	<i>Tellina bodegensis</i>	3	5	6	—	4	18	5.04	55.46
Nemertea	<i>Carinomella lactea</i>	—	—	3	2	9	14	3.92	59.38
Crustacea	<i>Tecticeps convexus</i>	—	12	—	—	1	13	3.64	63.03
Annelida	<i>Lumbrineris</i>	9	—	1	—	—	10	2.80	65.83

Table B.4 Replicate Sample Abundance by Taxa at Station B3 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Annelida	<i>Polydora</i>	5	—	4	—	—	9	2.52	68.35
Crustacea	<i>Cancer</i>	—	—	6	2	1	9	2.52	70.87
Annelida	<i>Chaetozone setosa</i>	2	—	3	1	2	8	2.24	73.11
Bivalvia	<i>Siliqua lucida</i>	4	—	—	—	3	7	1.96	75.07
Crustacea	<i>Americhilidium shoemakeri</i>	3	1	1	2	—	7	1.96	77.03
Crustacea	<i>Anchicolurus occidentalis</i>	4	—	—	1	1	6	1.68	78.71
Annelida	<i>Scoloplos armiger</i>	2	1	1	1	1	6	1.68	80.39
Phoronida	<i>Phoronis</i>	—	1	—	4	1	6	1.68	82.07
Crustacea	<i>Eohaustorius sencillus</i>	3	—	1	1	—	5	1.40	83.47
Mollusca	<i>Odostomia</i>	3	—	—	—	2	5	1.40	84.87
Annelida	<i>Sigalion spinosa</i>	3	—	—	—	1	4	1.12	85.99
Echinodermata	<i>Amphiodia</i>	2	—	1	—	1	4	1.12	87.11
Annelida	<i>Nephtys caecoides</i>	1	1	—	—	2	4	1.12	88.24
Crustacea	<i>Gibberosus myersi</i>	—	1	—	1	2	4	1.12	89.36
Crustacea	<i>Rhepoxynius abronius</i>	—	—	—	2	2	4	1.12	90.48
Annelida	<i>Phyllodoce</i>	2	—	—	—	1	3	0.84	91.32
Annelida	<i>Axiothella rubrocincta</i>	1	—	—	2	—	3	0.84	92.16
Annelida	<i>Armandia bioculata</i>	—	2	1	—	—	3	0.84	93.00
Crustacea	<i>Pacifoculodes spinipes</i>	—	—	—	—	3	3	0.84	93.84
Crustacea	<i>Edotia sublittoralis</i>	2	—	—	—	—	2	0.56	94.40
Crustacea	<i>Bathycopea daltonae</i>	2	—	—	—	—	2	0.56	94.96
Mollusca	<i>Nassarius fossatus</i>	1	—	1	—	—	2	0.56	95.52
Annelida	<i>Notomastus lineatus</i>	1	—	1	—	—	2	0.56	96.08
Annelida	<i>Glycera convoluta</i>	—	—	—	1	1	2	0.56	96.64
Crustacea	<i>Synidotea bicuspidata</i>	1	—	—	—	—	1	0.28	96.92
Annelida	<i>Platynereis bicanaliculata</i>	1	—	—	—	—	1	0.28	97.20
Annelida	<i>Sthenelais verruculosa</i>	1	—	—	—	—	1	0.28	97.48
Crustacea	<i>Isocheles pilosus</i>	1	—	—	—	—	1	0.28	97.76
Annelida	<i>Phyllochaetopterus</i>	1	—	—	—	—	1	0.28	98.04
Annelida	<i>Lumbrineris californiensis</i>	—	—	1	—	—	1	0.28	98.32
Annelida	<i>Glycera americana</i>	—	—	1	—	—	1	0.28	98.60
Annelida	<i>Glycinde armigera</i>	—	—	—	1	—	1	0.28	98.88
Crustacea	<i>Crangon alaskensis</i>	—	—	—	1	—	1	0.28	99.16
Echinodermata	<i>Leptosynapta</i>	—	—	—	—	1	1	0.28	99.44
Crustacea	Porcellanidae	—	—	—	—	1	1	0.28	99.72
Annelida	<i>Malmgrenia nigralba</i>	—	—	—	—	1	1	0.28	100.00
Total Number of Individuals		136	115	383	166	191	991		
Total Number of Individuals Excluding <i>D. Excentricus</i>		134	49	69	48	57	357		

Table B.5 Replicate Sample Abundance by Taxa at Station B4 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Echinodermata	<i>Dendraster excentricus</i>	2	39	138	5	3	187	—	—
Mollusca	<i>Alvania</i>	13	19	14	12	19	77	15.68	15.68
Crustacea	<i>Majoxiphalus major</i>	11	8	11	2	20	52	10.59	26.27
Bivalvia	<i>Tellina modesta</i>	10	16	3	10	7	46	9.37	35.64
Nemertea	<i>Carinoma mutabilis</i>	4	11	11	7	5	38	7.74	43.38
Crustacea	<i>Rhepoxynius menziesi</i>	4	9	2	7	8	30	6.11	49.49
Nemertea	<i>Carinomella lactea</i>	13	6	3	5	—	27	5.50	54.99
Mollusca	<i>Odostomia</i>	12	—	—	—	4	16	3.26	58.25
Bivalvia	<i>Tellina bodegensis</i>	3	4	—	4	5	16	3.26	61.51
Crustacea	<i>Eohaustorius sencillus</i>	—	—	2	3	10	15	3.05	64.56
Crustacea	<i>Cheirimedia zotea</i>	14	—	—	—	—	14	2.85	67.41
Crustacea	<i>Pacifoculodes spinipes</i>	3	2	4	1	2	12	2.44	69.86
Crustacea	<i>Americhilidium shoemakeri</i>	4	1	2	3	1	11	2.24	72.10
Crustacea	<i>Rhepoxynius abronius</i>	2	—	—	1	6	9	1.83	73.93
Bivalvia	<i>Siliqua lucida</i>	—	4	2	1	2	9	1.83	75.76
Annelida	<i>Sthenelais verruculosa</i>	4	1	1	—	—	6	1.22	76.99
Annelida	<i>Axiiothella rubrocincta</i>	4	—	—	1	1	6	1.22	78.21
Annelida	<i>Chaetozone setosa</i>	—	3	—	3	—	6	1.22	79.43
Annelida	<i>Phyllodoce</i>	5	—	—	—	—	5	1.02	80.45
Other	<i>Halosydna brevisetosa</i>	5	—	—	—	—	5	1.02	81.47
Crustacea	<i>Tecticeps convexus</i>	2	—	—	2	1	5	1.02	82.48
Crustacea	<i>Gibberosus myersi</i>	1	1	2	1	—	5	1.02	83.50
Annelida	<i>Notomastus lineatus</i>	1	1	1	1	1	5	1.02	84.52
Annelida	<i>Lumbrineris</i>	—	1	2	2	—	5	1.02	85.54
Annelida	<i>Scoloplos armiger</i>	—	—	1	1	3	5	1.02	86.56
Crustacea	<i>Bathycopea daltonae</i>	—	—	—	1	4	5	1.02	87.58
Annelida	<i>Glycera convoluta</i>	2	1	—	1	—	4	0.81	88.39
Annelida	<i>Nephtys caecoides</i>	1	2	—	—	1	4	0.81	89.21
Annelida	<i>Armandia bioculata</i>	1	—	1	1	—	3	0.61	89.82
Crustacea	<i>Cancer gracilis</i>	1	—	1	1	—	3	0.61	90.43
Annelida	<i>Platynereis bicanaliculata</i>	2	—	—	—	—	2	0.41	90.84
Annelida	<i>Eupolymnia heterobranchia</i>	2	—	—	—	—	2	0.41	91.24
Nemertea	<i>Amphiporus bimaculatus</i>	2	—	—	—	—	2	0.41	91.65
Crustacea	<i>Aoroides inermis</i>	2	—	—	—	—	2	0.41	92.06
Annelida	Syllidae	2	—	—	—	—	2	0.41	92.46
Crustacea	<i>Photis macinerneyi</i>	1	1	—	—	—	2	0.41	92.87
Phoronida	<i>Phoronis</i>	1	—	1	—	—	2	0.41	93.28
Nemertea	<i>Cerebratulus californiensis</i>	—	1	1	—	—	2	0.41	93.69
Echinodermata	<i>Amphiodia</i>	—	1	—	1	—	2	0.41	94.09
Crustacea	<i>Isocheles pilosus</i>	—	—	2	—	—	2	0.41	94.50
Bivalvia	<i>Cooperella subdiaphana</i>	—	—	1	—	1	2	0.41	94.91
Annelida	<i>Ampharete labrops</i>	1	—	—	—	—	1	0.20	95.11
Crustacea	<i>Foxiphalus xiximeus</i>	1	—	—	—	—	1	0.20	95.32
Annelida	<i>Tenonia priops</i>	1	—	—	—	—	1	0.20	95.52
Bivalvia	<i>Chione</i>	1	—	—	—	—	1	0.20	95.72

Table B.5 Replicate Sample Abundance by Taxa at Station B4 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Annelida	<i>Onuphis iridescens</i>	1	—	—	—	—	1	0.20	95.93
Annelida	<i>Aphelocheata</i>	1	—	—	—	—	1	0.20	96.13
Nemertea	<i>Paranemertes sp. A</i>	1	—	—	—	—	1	0.20	96.33
Mollusca	<i>Epitonium sawinae</i>	1	—	—	—	—	1	0.20	96.54
Mollusca	<i>Mitrella aurantiaca</i>	1	—	—	—	—	1	0.20	96.74
Bivalvia	Pectinidae	1	—	—	—	—	1	0.20	96.95
Platyhelminthes	Polycladida	1	—	—	—	—	1	0.20	97.15
Bivalvia	<i>Solen sicarius</i>	—	1	—	—	—	1	0.20	97.35
Crustacea	<i>Anchicolurus occidentalis</i>	—	1	—	—	—	1	0.20	97.56
Crustacea	<i>Leuroleberis sharpei</i>	—	1	—	—	—	1	0.20	97.76
Vertebrata	<i>Porichthys notatus</i>	—	1	—	—	—	1	0.20	97.96
Bivalvia	<i>Clinocardium nuttallii</i>	—	—	1	—	—	1	0.20	98.17
Annelida	<i>Exogone</i>	—	—	1	—	—	1	0.20	98.37
Annelida	<i>Mesochaetopterus</i>	—	—	1	—	—	1	0.20	98.57
Crustacea	<i>Listriella goleta</i>	—	—	—	1	—	1	0.20	98.78
Annelida	<i>Sigalion spinosa</i>	—	—	—	—	1	1	0.20	98.98
Annelida	<i>Chone mollis</i>	—	—	—	—	1	1	0.20	99.19
Crustacea	<i>Mesolamprops dillonensis</i>	—	—	—	—	1	1	0.20	99.39
Mollusca	<i>Alvania compacta</i>	—	—	—	—	1	1	0.20	99.59
Crustacea	Brachyura	—	—	—	—	1	1	0.20	99.80
Crustacea	<i>Dynamene tuberculosa</i>	—	—	—	—	1	1	0.20	100.00
Total Number of Individuals		145	136	209	78	110	678		
Total Number of Individuals Excluding <i>D. Excentricus</i>		143	97	71	73	107	491		

Table B.6 Replicate Sample Abundance by Taxa at Station B5 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Echinodermata	<i>Dendraster excentricus</i>	430	3	1	3	1	438	—	—
Crustacea	<i>Tecticeps convexus</i>	—	10	115	54	10	189	22.00	22.00
Bivalvia	<i>Tellina modesta</i>	11	31	20	12	37	111	12.92	34.92
Annelida	<i>Magelona sacculata</i>	2	—	7	54	28	91	10.59	45.52
Crustacea	<i>Majoxiphalus major</i>	6	24	20	4	12	66	7.68	53.20
Crustacea	<i>Leuroleberis sharpei</i>	4	6	8	11	14	43	5.01	58.21
Crustacea	<i>Anchicolurus occidentalis</i>	—	8	4	13	11	36	4.19	62.40
Crustacea	<i>Rhepoxynius menziesi</i>	8	7	5	6	2	28	3.26	65.66
Annelida	<i>Armandia bioculata</i>	—	1	—	20	3	24	2.79	68.45
Annelida	<i>Lumbrineris</i>	5	2	2	6	5	20	2.33	70.78
Bivalvia	<i>Tellina bodegensis</i>	4	2	7	2	2	17	1.98	72.76
Bivalvia	<i>Siliqua lucida</i>	—	9	—	6	2	17	1.98	74.74
Crustacea	<i>Americhilidium shoemakeri</i>	—	—	1	9	7	17	1.98	76.72
Crustacea	<i>Cancer gracilis</i>	13	—	—	—	—	13	1.51	78.23
Annelida	<i>Nephtys caecoides</i>	2	1	2	5	3	13	1.51	79.74

Table B.6 Replicate Sample Abundance by Taxa at Station B5 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Crustacea	<i>Pacifoculodes spinipes</i>	—	5	2	1	3	11	1.28	81.02
Crustacea	<i>Isocheles pilosus</i>	2	1	1	2	4	10	1.16	82.19
Bivalvia	<i>Rocheportia tumida</i>	—	—	—	5	4	9	1.05	83.24
Annelida	<i>Onuphis iridescens</i>	—	—	2	2	4	8	0.93	84.17
Crustacea	<i>Bathycopea daltonae</i>	—	—	1	4	3	8	0.93	85.10
Nemertea	<i>Carinoma mutabilis</i>	4	3	—	—	—	7	0.81	85.91
Annelida	<i>Capitella capitata</i>	—	—	—	7	—	7	0.81	86.73
Annelida	<i>Diopatra ornata</i>	1	—	—	4	1	6	0.70	87.43
Annelida	<i>Phylo felix</i>	—	2	1	2	1	6	0.70	88.13
Crustacea	<i>Foxiphalus xiximeus</i>	—	—	1	4	1	6	0.70	88.82
Annelida	<i>Scoloplos armiger</i>	—	3	—	—	2	5	0.58	89.41
Annelida	<i>Chaetozone setosa</i>	—	1	1	1	2	5	0.58	89.99
Annelida	<i>Microphthalmus</i>	—	—	—	5	—	5	0.58	90.57
Crustacea	<i>Gibberosus myersi</i>	—	—	—	2	3	5	0.58	91.15
Annelida	<i>Glycera convoluta</i>	1	—	—	2	1	4	0.47	91.62
Annelida	<i>Axiiothella rubrocincta</i>	1	—	—	2	1	4	0.47	92.08
Annelida	<i>Spiophanes bombyx</i>	—	—	1	3	—	4	0.47	92.55
Annelida	<i>Lumbrineris californiensis</i>	—	—	—	4	—	4	0.47	93.02
Annelida	<i>Apoprionospio pygmaea</i>	—	—	—	3	1	4	0.47	93.48
Mollusca	<i>Alvania</i>	—	—	1	2	—	3	0.35	93.83
Bivalvia	<i>Clinocardium nuttallii</i>	—	—	1	1	1	3	0.35	94.18
Echinodermata	<i>Amphiodia</i>	—	—	—	3	—	3	0.35	94.53
Crustacea	<i>Cheirimedia zotea</i>	—	—	—	2	1	3	0.35	94.88
Annelida	<i>Cirriformia spirabranca</i>	2	—	—	—	—	2	0.23	95.11
Crustacea	<i>Rhepoxynius abronius</i>	1	—	1	—	—	2	0.23	95.34
Mollusca	<i>Olivella baetica</i>	—	1	—	1	—	2	0.23	95.58
Crustacea	<i>Crangon</i>	—	—	1	1	—	2	0.23	95.81
Crustacea	<i>Crangon alaskensis</i>	—	—	1	1	—	2	0.23	96.04
Annelida	<i>Glycinde armigera</i>	—	—	—	2	—	2	0.23	96.27
Crustacea	Majidae	—	—	—	2	—	2	0.23	96.51
Annelida	<i>Scalibregma californicum</i>	—	—	—	2	—	2	0.23	96.74
Nemertea	Lineidae	—	—	—	1	1	2	0.23	96.97
Annelida	<i>Notomastus lineatus</i>	—	—	—	1	1	2	0.23	97.21
Annelida	<i>Eteone pacifica</i>	—	—	—	—	2	2	0.23	97.44
Annelida	<i>Sigalion spinosa</i>	1	—	—	—	—	1	0.12	97.56
Nemertea	<i>Carinomella lactea</i>	1	—	—	—	—	1	0.12	97.67
Crustacea	<i>Euphilomedes carcharodonta</i>	1	—	—	—	—	1	0.12	97.79
Crustacea	Porcellanidae	1	—	—	—	—	1	0.12	97.90
Echinodermata	<i>Amphiodia digitata</i>	1	—	—	—	—	1	0.12	98.02
Crustacea	Hippolytidae	1	—	—	—	—	1	0.12	98.14
Mollusca	<i>Rictaxis punctocaelatus</i>	1	—	—	—	—	1	0.12	98.25
Mollusca	<i>Odostomia</i>	—	—	1	—	—	1	0.12	98.37
Annelida	<i>Goniada maculata</i>	—	—	1	—	—	1	0.12	98.49
Mollusca	<i>Alvania compacta</i>	—	—	1	—	—	1	0.12	98.60
Phoronida	<i>Phoronis</i>	—	—	—	1	—	1	0.12	98.72

Table B.6 Replicate Sample Abundance by Taxa at Station B5 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Annelida	<i>Tenonia priops</i>	—	—	—	1	—	1	0.12	98.84
Nemertea	<i>Cerebratulus californiensis</i>	—	—	—	1	—	1	0.12	98.95
Crustacea	Aoridae	—	—	—	1	—	1	0.12	99.07
Mollusca	<i>Epitonium sawinae</i>	—	—	—	1	—	1	0.12	99.19
Annelida	<i>Megalomma pigmentum</i>	—	—	—	1	—	1	0.12	99.30
Annelida	<i>Phyllochaetopterus</i>	—	—	—	1	—	1	0.12	99.42
Vertebrata	<i>Porichthys notatus</i>	—	—	—	1	—	1	0.12	99.53
Annelida	<i>Rhynchospio arenicola</i>	—	—	—	1	—	1	0.12	99.65
Crustacea	<i>Synidotea bicuspidata</i>	—	—	—	—	1	1	0.12	99.77
Mollusca	<i>Polinices lewisii</i>	—	—	—	—	1	1	0.12	99.88
Annelida	<i>Spiophanes duplex</i>	—	—	—	—	1	1	0.12	100.00
Total Number of Individuals		504	120	210	286	177	1297		
Total Number of Individuals Excluding <i>D. Excentricus</i>		74	117	209	283	176	859		

Table B.7 Replicate Sample Abundance by Taxa at Station B6 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Echinodermata	<i>Dendraster excentricus</i>	—	127	2	4	5	138	—	—
Crustacea	<i>Majoxiphalus major</i>	7	6	13	12	11	49	10.77	10.77
Nemertea	<i>Carinomella lactea</i>	—	14	13	14	6	47	10.33	21.10
Mollusca	<i>Alvania</i>	3	4	12	12	9	40	8.79	29.89
Bivalvia	<i>Tellina modesta</i>	5	12	9	6	6	38	8.35	38.24
Crustacea	<i>Rhepoxynius menziesi</i>	6	9	3	3	6	27	5.93	44.18
Nemertea	<i>Carinoma mutabilis</i>	18	—	—	—	4	22	4.84	49.01
Bivalvia	<i>Tellina bodegensis</i>	4	8	2	4	3	21	4.62	53.63
Crustacea	<i>Rhepoxynius abronius</i>	—	3	1	7	5	16	3.52	57.14
Annelida	<i>Lumbrineris</i>	—	9	—	1	4	14	3.08	60.22
Bivalvia	<i>Siliqua lucida</i>	3	1	1	—	8	13	2.86	63.08
Crustacea	<i>Pacifoculodes spinipes</i>	—	4	7	—	1	12	2.64	65.71
Crustacea	<i>Cheirimedia zotea</i>	1	—	—	10	—	11	2.42	68.13
Phoronida	<i>Phoronis</i>	2	2	1	1	3	9	1.98	70.11
Annelida	<i>Scoloplos armiger</i>	2	1	2	1	3	9	1.98	72.09
Crustacea	<i>Eohaustorius sencillus</i>	5	1	1	—	1	8	1.76	73.85
Crustacea	<i>Americhilidium shoemakeri</i>	3	—	2	—	1	6	1.32	75.16
Annelida	<i>Nephtys caecoides</i>	2	—	—	1	3	6	1.32	76.48
Crustacea	<i>Photis brevipes</i>	—	1	—	5	—	6	1.32	77.80
Crustacea	<i>Anchicolurus occidentalis</i>	1	2	—	2	—	5	1.10	78.90

Table B.7 Replicate Sample Abundance by Taxa at Station B6 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Annelida	<i>Lumbrineris californiensis</i>	—	1	—	3	1	5	1.10	80.00
Annelida	<i>Magelona sacculata</i>	—	2	1	1	—	4	0.88	80.88
Echinodermata	<i>Amphiodia</i>	—	—	3	1	—	4	0.88	81.76
Crustacea	Gammaridea	—	—	—	4	—	4	0.88	82.64
Crustacea	<i>Crangon</i>	1	1	—	1	—	3	0.66	83.30
Annelida	<i>Sigalion spinosa</i>	1	—	1	—	1	3	0.66	83.96
Annelida	<i>Glycera convoluta</i>	1	—	1	—	1	3	0.66	84.62
Crustacea	<i>Foxiphalus xiximeus</i>	—	2	1	—	—	3	0.66	85.27
Bivalvia	<i>Pandora punctata</i>	—	2	1	—	—	3	0.66	85.93
Annelida	<i>Armandia bioculata</i>	—	2	—	1	—	3	0.66	86.59
Annelida	<i>Phyllodoce</i>	—	1	1	1	—	3	0.66	87.25
Bivalvia	<i>Macoma acolasta</i>	—	1	1	—	1	3	0.66	87.91
Annelida	<i>Sthenelais verruculosa</i>	—	1	—	2	—	3	0.66	88.57
Crustacea	Brachyura	—	1	—	1	1	3	0.66	89.23
Crustacea	<i>Leuroleberis sharpei</i>	—	—	1	2	—	3	0.66	89.89
Bivalvia	<i>Chione</i>	1	—	1	—	—	2	0.44	90.33
Annelida	<i>Chaetozone setosa</i>	1	—	—	—	1	2	0.44	90.77
Annelida	<i>Capitella capitata</i>	—	2	—	—	—	2	0.44	91.21
Crustacea	<i>Tecticeps convexus</i>	—	1	1	—	—	2	0.44	91.65
Annelida	<i>Axiothella rubrocincta</i>	—	1	1	—	—	2	0.44	92.09
Annelida	<i>Apopriospio pygmaea</i>	—	1	1	—	—	2	0.44	92.53
Bivalvia	Pectinidae	—	1	1	—	—	2	0.44	92.97
Crustacea	<i>Aoroides inermis</i>	—	—	1	1	—	2	0.44	93.41
Crustacea	<i>Photis macinerneyi</i>	—	—	—	2	—	2	0.44	93.85
Annelida	<i>Leitoscoloplos pugettensis</i>	—	—	—	2	—	2	0.44	94.29
Crustacea	<i>Mesolamprops dillonensis</i>	—	—	—	1	1	2	0.44	94.73
Nemertea	Lineidae	—	—	—	1	1	2	0.44	95.16
Annelida	<i>Notomastus lineatus</i>	—	—	—	1	1	2	0.44	95.60
Annelida	<i>Chone mollis</i>	1	—	—	—	—	1	0.22	95.82
Crustacea	<i>Crangon alaskensis</i>	1	—	—	—	—	1	0.22	96.04
Annelida	<i>Phyllochaetopterus</i>	1	—	—	—	—	1	0.22	96.26
Annelida	<i>Typosyllis farallonensis</i>	—	1	—	—	—	1	0.22	96.48
Annelida	<i>Polycirrus</i>	—	1	—	—	—	1	0.22	96.70
Other	<i>Halosydna brevisetosa</i>	—	1	—	—	—	1	0.22	96.92
Echinodermata	<i>Amphiodia digitata</i>	—	1	—	—	—	1	0.22	97.14
Annelida	<i>Platynereis bicanaliculata</i>	—	—	1	—	—	1	0.22	97.36
Mollusca	<i>Nassarius fossatus</i>	—	—	1	—	—	1	0.22	97.58
Crustacea	<i>Cancer gracilis</i>	—	—	1	—	—	1	0.22	97.80
Crustacea	<i>Exacanthomysis davisii</i>	—	—	1	—	—	1	0.22	98.02
Crustacea	<i>Ischyrocerus</i>	—	—	1	—	—	1	0.22	98.24
Nemertea	<i>Cerebratulus californiensis</i>	—	—	—	1	—	1	0.22	98.46
Bivalvia	<i>Cooperella subdiaphana</i>	—	—	—	1	—	1	0.22	98.68
Crustacea	<i>Diastylopsis tenuis</i>	—	—	—	1	—	1	0.22	98.90
Annelida	<i>Dispio uncinata</i>	—	—	—	1	—	1	0.22	99.12
Mollusca	<i>Hermisenda crassicornis</i>	—	—	—	1	—	1	0.22	99.34

Table B.7 Replicate Sample Abundance by Taxa at Station B6 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Crustacea	<i>Tiron biocellata</i>	–	–	–	1	–	1	0.22	99.56
Bivalvia	<i>Solen sicarius</i>	–	–	–	–	1	1	0.22	99.78
Crustacea	<i>Gibberosus myersi</i>	–	–	–	–	1	1	0.22	100.00
Total Number of Individuals		70	228	91	114	90	593		
Total Number of Individuals Excluding <i>D. Excentricus</i>		70	101	89	110	85	455		

Table B.8 Replicate Sample Abundance by Taxa at Station B7 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Echinodermata	<i>Dendraster excentricus</i>	19	2	–	1	232	254	–	–
Mollusca	<i>Alvania</i>	9	7	6	11	24	57	14.69	14.69
Nemertea	<i>Carinomella lactea</i>	11	13	11	3	5	43	11.08	25.77
Bivalvia	<i>Tellina modesta</i>	12	10	7	5	8	42	10.82	36.60
Crustacea	<i>Majoxiphalus major</i>	8	8	2	4	10	32	8.25	44.85
Bivalvia	<i>Tellina bodegensis</i>	5	6	3	10	2	26	6.70	51.55
Nemertea	<i>Carinoma mutabilis</i>	3	–	2	4	6	15	3.87	55.41
Crustacea	<i>Rhepoxynius abronius</i>	6	1	3	4	3	17	4.38	59.79
Crustacea	<i>Rhepoxynius menziesi</i>	3	6	4	3	2	18	4.64	64.43
Bivalvia	<i>Siliqua lucida</i>	3	5	4	–	–	12	3.09	67.53
Crustacea	<i>Pacifoculodes spinipes</i>	1	3	3	4	1	12	3.09	70.62
Annelida	<i>Nephtys caecoides</i>	2	1	3	1	–	7	1.80	72.42
Crustacea	<i>Foxiphalus xiximeus</i>	2	6	–	–	2	10	2.58	75.00
Crustacea	<i>Aoroides inermis</i>	–	4	–	–	1	5	1.29	76.29
Crustacea	<i>Americhilidium shoemakeri</i>	–	2	1	4	–	7	1.80	78.09
Annelida	<i>Lumbrineris</i>	–	2	1	1	1	5	1.29	79.38
Crustacea	<i>Photis brevipes</i>	–	2	–	–	3	5	1.29	80.67
Nemertea	<i>Paranemertes sp. A</i>	1	3	–	–	–	4	1.03	81.70
Annelida	<i>Chaetozone setosa</i>	1	1	–	1	–	3	0.77	82.47
Annelida	<i>Lumbrineris californiensis</i>	1	1	–	–	2	4	1.03	83.51
Other	<i>Halosydna brevisetosa</i>	–	4	–	–	–	4	1.03	84.54
Annelida	<i>Ampharete labrops</i>	1	1	–	–	1	3	0.77	85.31
Annelida	<i>Sigalion spinosa</i>	1	–	1	–	1	3	0.77	86.08
Crustacea	<i>Cheirimedia zotea</i>	–	3	–	–	–	3	0.77	86.86
Crustacea	<i>Anchicolurus occidentalis</i>	–	2	1	–	–	3	0.77	87.63
Crustacea	<i>Bathycopea daltonae</i>	–	1	1	1	–	3	0.77	88.40
Crustacea	<i>Cancer gracilis</i>	–	2	–	–	–	2	0.52	88.92
Annelida	<i>Armandia bioculata</i>	–	1	–	1	1	3	0.77	89.69
Annelida	<i>Glycera convoluta</i>	–	1	–	1	1	3	0.77	90.46
Mollusca	<i>Turbonilla</i>	–	1	–	–	2	3	0.77	91.24

Table B.8 Replicate Sample Abundance by Taxa at Station B7 during October 2010

Taxonomic Group	Taxon	Replicate					Total	Percent of Total	Cumulative Percent
		1	2	3	4	5			
Annelida	<i>Scoloplos armiger</i>	1	1	—	—	—	2	0.52	91.75
Crustacea	<i>Gibberosus myersi</i>	—	—	1	1	1	3	0.77	92.53
Phoronida	<i>Phoronis</i>	1	—	1	—	—	2	0.52	93.04
Annelida	<i>Diopatra ornata</i>	—	2	—	—	—	2	0.52	93.56
Crustacea	<i>Crangon</i>	—	1	1	—	—	2	0.52	94.07
Annelida	<i>Onuphis iridescens</i>	—	1	—	1	—	2	0.52	94.59
Echinodermata	<i>Amphiodia</i>	1	—	—	—	—	1	0.26	94.85
Crustacea	<i>Photis macinerneyi</i>	—	1	—	—	—	1	0.26	95.10
Annelida	<i>Phyllodoce</i>	—	1	—	—	—	1	0.26	95.36
Annelida	<i>Tenonia priops</i>	—	1	—	—	—	1	0.26	95.62
Annelida	<i>Sthenelais verruculosa</i>	—	1	—	—	—	1	0.26	95.88
Crustacea	<i>Caprella californica</i>	—	1	—	—	—	1	0.26	96.13
Annelida	<i>Eupolymnia heterobranchia</i>	—	1	—	—	—	1	0.26	96.39
Mollusca	<i>Polinices lewisii</i>	—	1	—	—	—	1	0.26	96.65
Crustacea	<i>Gammaridea</i>	—	1	—	—	—	1	0.26	96.91
Annelida	<i>Cirriformia spirabrancha</i>	—	1	—	—	—	1	0.26	97.16
Bivalvia	<i>Clinocardium nuttallii</i>	—	—	1	—	—	1	0.26	97.42
Annelida	<i>Goniada maculata</i>	—	—	1	—	—	1	0.26	97.68
Crustacea	<i>Eohaustorius sencillus</i>	—	1	—	—	—	1	0.26	97.94
Annelida	<i>Leitoscoloplos pugettensis</i>	—	1	—	—	—	1	0.26	98.20
Pycnogonida	<i>Achelia echinata</i>	—	1	—	—	—	1	0.26	98.45
Crustacea	<i>Tecticeps convexus</i>	—	—	—	1	—	1	0.26	98.71
Crustacea	<i>Mesolamprops dillonensis</i>	—	—	—	1	—	1	0.26	98.97
Crustacea	<i>Brachyura</i>	—	—	—	1	—	1	0.26	99.23
Crustacea	<i>Leuroleberis sharpei</i>	—	—	—	—	1	1	0.26	99.48
Annelida	<i>Magelona sacculata</i>	—	—	—	—	1	1	0.26	99.74
Annelida	<i>Apoprionospio pygmaea</i>	—	—	—	—	1	1	0.26	100.00
Total Number of Individuals		92	116	58	64	312	642		
Total Number of Individuals Excluding <i>D. Excentricus</i>		73	114	58	63	80	388		

Table B.9 Infaunal Indices in Sediment Samples Collected in October 2010

Parameter ^a		Total Organisms	Identified Organisms	Number of Species	Organisms per Species	Diversity (H')	Brillouin Index (h)	Dominance (C')	Dominance (S _w)	Species Richness (d)	Evenness (J')	Infaunal Index (ITI)
Station B1	Replicate 1	438	431	20	22	0.74	0.68	0.74	1	3.13	0.25	90
	Replicate 2	295	285	17	17	0.84	0.76	0.70	1	2.83	0.30	96
	Replicate 3	62	53	20	3	2.63	2.20	0.10	9	4.79	0.88	87
	Replicate 4	446	439	16	27	0.53	0.48	0.82	1	2.47	0.19	86
	Replicate 5	340	339	18	19	0.76	0.70	0.73	1	2.92	0.26	76
Station B2	Replicate 1	102	91	23	4	2.35	2.05	0.18	7	4.88	0.75	94
	Replicate 2	491	490	18	27	0.56	0.51	0.81	1	2.74	0.19	77
	Replicate 3	450	447	18	25	0.62	0.57	0.80	1	2.79	0.21	91
	Replicate 4	86	84	18	5	1.94	1.68	0.29	5	3.84	0.67	82
	Replicate 5	42	38	16	2	2.36	1.91	0.14	7	4.12	0.85	92
Station B3	Replicate 1	136	80	24	3	2.72	2.34	0.11	11	5.25	0.86	88
	Replicate 2	115	110	12	9	1.51	1.36	0.38	3	2.34	0.61	80
	Replicate 3	383	366	16	23	0.74	0.68	0.74	1	2.54	0.27	81
	Replicate 4	166	159	16	10	1.15	1.03	0.56	2	2.96	0.42	94
	Replicate 5	191	184	19	10	1.30	1.17	0.54	2	3.45	0.44	86
Station B4	Replicate 1	145	120	34	4	3.10	2.73	0.06	13	6.89	0.88	92
	Replicate 2	136	115	22	5	2.33	2.08	0.16	6	4.43	0.75	90
	Replicate 3	209	190	20	10	1.28	1.15	0.54	2	3.62	0.43	92
	Replicate 4	78	63	23	3	2.80	2.37	0.08	10	5.31	0.89	85
	Replicate 5	110	90	24	4	2.72	2.38	0.10	9	5.11	0.86	96
Station B5	Replicate 1	504	498	22	23	0.76	0.70	0.75	1	3.38	0.24	90
	Replicate 2	120	118	18	7	2.34	2.12	0.14	6	3.56	0.81	87
	Replicate 3	210	206	25	8	1.80	1.65	0.34	3	4.50	0.56	88
	Replicate 4	286	263	42	6	2.90	2.67	0.10	12	7.36	0.78	60
	Replicate 5	177	171	34	5	2.81	2.55	0.10	10	6.42	0.80	73
Station B6	Replicate 1	70	62	17	4	2.40	2.06	0.13	7	3.88	0.85	90
	Replicate 2	228	208	27	8	1.75	1.59	0.39	4	4.87	0.53	82
	Replicate 3	91	71	27	3	2.73	2.31	0.10	10	6.10	0.83	92
	Replicate 4	114	91	28	3	2.90	2.52	0.08	11	5.99	0.87	84
	Replicate 5	90	72	23	3	2.79	2.40	0.08	10	5.14	0.89	91
Station B7	Replicate 1	92	81	18	5	2.42	2.13	0.12	6	3.87	0.84	95
	Replicate 2	116	103	38	3	3.25	2.81	0.05	16	7.98	0.89	88
	Replicate 3	58	49	17	3	2.52	2.12	0.11	8	4.11	0.89	89
	Replicate 4	64	51	19	3	2.65	2.22	0.09	9	4.58	0.90	86
	Replicate 5	312	285	21	14	0.97	0.88	0.67	1	3.54	0.32	88
Mean	Station B1	316	309	18.2	17.4	1.10	0.96	0.62	2.6	3.23	0.37	87
	Station B2	234	230	18.6	12.6	1.56	1.34	0.44	4.2	3.67	0.53	87
	Station B3	198	180	17.4	11.0	1.48	1.32	0.47	3.8	3.31	0.52	86
	Station B4	136	116	24.6	5.0	2.45	2.14	0.19	8.0	5.07	0.76	91
	Station B5	259	251	28.2	9.7	2.12	1.94	0.28	6.4	5.04	0.64	80
	Station B6	119	101	24.4	4.1	2.51	2.17	0.15	8.4	5.20	0.79	88
	Station B7	128	114	22.6	5.3	2.36	2.03	0.21	8.0	4.82	0.77	89
Standard Deviation	Station B1	156	157	1.8	9.2	0.86	0.70	0.29	3.6	0.91	0.28	7.5
	Station B2	217	219	2.6	12.3	0.91	0.75	0.33	3.0	0.91	0.31	7.5
	Station B3	107	112	4.4	7.2	0.74	0.62	0.24	4.1	1.17	0.22	5.9
	Station B4	49	47	5.5	2.7	0.71	0.60	0.20	4.2	1.21	0.19	3.9
	Station B5	149	148	9.7	7.3	0.88	0.80	0.28	4.6	1.77	0.24	12.6
	Station B6	63	61	4.6	2.1	0.47	0.37	0.13	2.9	0.91	0.15	4.3
	Station B7	105	98	8.7	4.7	0.84	0.70	0.26	5.4	1.81	0.25	3.3

Table B.9 Infaunal Indices in Sediment Samples Collected in October 2010

Parameter ^a		Total Organisms	Identified Organisms	Number of Species	Organisms per Species	Diversity (H')	Brillouin Index (h)	Dominance (C')	Dominance (S _w)	Species Richness (d)	Evenness (J')	Infaunal Index (ITI)
Station Total	Station B1	1581	1547	45	34	0.91	0.87	0.71	1	5.99	0.24	87
	Station B2	1171	1150	39	29	1.09	1.04	0.64	1	5.39	0.30	89
	Station B3	991	899	36	25	1.47	1.40	0.50	3	5.15	0.41	87
	Station B4	678	578	53	11	2.80	2.65	0.13	10	8.18	0.70	92
	Station B5	1297	1256	60	21	2.54	2.47	0.16	7	8.27	0.62	73
	Station B6	593	504	54	9	2.90	2.74	0.11	10	8.52	0.73	87
	Station B7	642	569	48	12	2.41	2.28	0.22	7	7.41	0.62	89
Survey	Total	6953	6503	101	64	2.05	2.02	0.36	5	11.39	0.44	83

Table B.10 Infaunal Indices excluding *D. excentricus* in Sediment Samples Collected in October 2010

Parameter ^a		Total Organisms	Identified Organisms	Number of Species	Organisms per Species	Diversity (H')	Brillouin Index (h)	Dominance (C')	Dominance (S _w)	Species Richness (d)	Evenness (J')	Infaunal Index (ITI)
Station B1	Replicate 1	67	60	19	3.16	2.40	2.04	0.13	6	4.40	0.82	90
	Replicate 2	57	47	16	2.94	2.36	1.98	0.13	7	3.90	0.85	96
	Replicate 3	61	52	19	2.74	2.58	2.16	0.10	8	4.56	0.88	87
	Replicate 4	48	41	15	2.73	2.33	1.93	0.13	7	3.77	0.86	86
	Replicate 5	51	50	17	2.94	2.32	1.94	0.15	7	4.09	0.82	76
Station B2	Replicate 1	68	57	22	2.59	2.69	2.25	0.09	9	5.19	0.87	94
	Replicate 2	50	49	17	2.88	2.30	1.92	0.15	6	4.11	0.81	77
	Replicate 3	51	48	17	2.82	2.56	2.15	0.09	8	4.13	0.90	91
	Replicate 4	42	40	17	2.35	2.62	2.14	0.09	9	4.34	0.93	82
	Replicate 5	39	35	15	2.33	2.26	1.81	0.16	7	3.94	0.83	92
Station B3	Replicate 1	134	78	23	3.39	2.67	2.30	0.11	10	5.05	0.85	88
	Replicate 2	49	44	11	4.00	2.08	1.78	0.15	5	2.64	0.87	80
	Replicate 3	69	52	15	3.47	2.32	1.98	0.12	6	3.54	0.86	81
	Replicate 4	48	41	15	2.73	2.26	1.86	0.15	6	3.77	0.83	94
	Replicate 5	57	50	18	2.78	2.64	2.21	0.09	9	4.35	0.91	86
Station B4	Replicate 1	143	118	33	3.58	3.06	2.70	0.06	13	6.71	0.88	92
	Replicate 2	97	76	21	3.62	2.55	2.22	0.11	7	4.62	0.84	90
	Replicate 3	71	52	19	2.74	2.54	2.12	0.11	9	4.56	0.86	92
	Replicate 4	73	58	22	2.64	2.74	2.30	0.09	9	5.17	0.89	85
	Replicate 5	107	87	23	3.78	2.66	2.33	0.10	9	4.93	0.85	96
Station B5	Replicate 1	74	68	21	3.24	2.61	2.24	0.10	8	4.74	0.86	90
	Replicate 2	117	115	17	6.76	2.28	2.07	0.15	6	3.37	0.80	87
	Replicate 3	209	205	24	8.54	1.78	1.63	0.34	3	4.32	0.56	88
	Replicate 4	283	260	41	6.34	2.87	2.65	0.11	11	7.19	0.77	60
	Replicate 5	176	170	33	5.15	2.79	2.53	0.10	10	6.23	0.80	73
Station B6	Replicate 1	70	62	17	3.65	2.40	2.06	0.13	7	3.88	0.85	90
	Replicate 2	101	81	26	3.12	2.78	2.39	0.09	10	5.69	0.85	82
	Replicate 3	89	69	26	2.65	2.68	2.26	0.11	9	5.90	0.82	92
	Replicate 4	110	87	27	3.22	2.84	2.46	0.08	10	5.82	0.86	84
	Replicate 5	85	67	22	3.05	2.73	2.34	0.08	9	4.99	0.88	91
Station B7	Replicate 1	73	62	17	3.65	2.45	2.11	0.11	7	3.88	0.86	95
	Replicate 2	114	101	37	2.73	3.22	2.78	0.06	15	7.80	0.89	88
	Replicate 3	58	49	17	2.88	2.52	2.12	0.11	8	4.11	0.89	89
	Replicate 4	63	50	18	2.78	2.60	2.18	0.09	8	4.35	0.90	86
	Replicate 5	80	53	20	2.65	2.64	2.21	0.10	9	4.79	0.88	88

Table B.10 Infaunal Indices excluding *D. excentricus* in Sediment Samples Collected in October 2010

Parameter ^a		Total Organisms	Identified Organisms	Number of Species	Organisms per Species	Diversity (H')	Brillouin Index (h)	Dominance (C')	Dominance (S _w)	Species Richness (d)	Evenness (J')	Infaunal Index (ITI)
Mean	Station B1	57	50	17.2	2.9	2.40	2.01	0.13	7.0	4.14	0.85	87
	Station B2	50	46	17.6	2.6	2.49	2.06	0.12	7.8	4.34	0.87	87
	Station B3	71	53	16.4	3.3	2.39	2.03	0.13	7.2	3.87	0.86	86
	Station B4	98	78	23.6	3.3	2.71	2.33	0.09	9.4	5.20	0.86	91
	Station B5	172	164	27.2	6.0	2.47	2.22	0.16	7.6	5.17	0.76	80
	Station B6	91	73	23.6	3.1	2.68	2.30	0.10	9.0	5.26	0.85	88
	Station B7	78	63	21.8	2.9	2.69	2.28	0.09	9.4	4.99	0.89	89
Standard Deviation	Station B1	8	7	1.8	0.18	0.11	0.10	0.02	0.7	0.33	0.03	7.5
	Station B2	11	9	2.6	0.26	0.20	0.18	0.03	1.3	0.49	0.05	7.5
	Station B3	36	15	4.4	0.53	0.25	0.22	0.03	2.2	0.90	0.03	5.9
	Station B4	29	26	5.5	0.54	0.21	0.22	0.02	2.2	0.88	0.02	3.9
	Station B5	81	75	9.7	1.97	0.45	0.40	0.10	3.2	1.53	0.12	12.6
	Station B6	15	10	4.2	0.36	0.17	0.16	0.02	1.2	0.85	0.02	4.3
	Station B7	22	22	8.6	0.41	0.31	0.28	0.02	3.2	1.61	0.01	3.3
Station Total	Station B1	284	250	44	5.68	2.88	2.65	0.10	10	7.79	0.76	87
	Station B2	250	229	38	6.03	2.99	2.75	0.07	11	6.81	0.82	89
	Station B3	357	265	35	7.57	2.92	2.72	0.08	10	6.09	0.82	87
	Station B4	491	391	52	7.52	3.20	3.00	0.06	13	8.54	0.81	92
	Station B5	859	818	59	13.86	2.91	2.80	0.10	10	8.65	0.71	73
	Station B6	455	366	53	6.91	3.18	2.97	0.07	13	8.81	0.80	87
	Station B7	388	315	47	6.70	3.11	2.89	0.07	12	8.00	0.81	89
Survey	Total	3084	2634	100	26.34	3.39	3.33	0.06	15	12.57	0.74	83

SUSAN J. WILLIAMS

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Education

B.S.	Marine Biology, California State University, Long Beach
Certificate	Environmental Studies, California State University, Long Beach
M.S.	Biology, California State University, Long Beach

Credential

Instructor, California Community Colleges
Subjects: Biological Sciences, Marine Sciences, Ecology

Qualifications

Susan Williams is an environmental scientist with over thirty years experience in ecological monitoring and assessment. She has a strong background in natural history and an excellent working knowledge of such varied communities as coastal sage scrub, coastal dunes, wetlands, and marine benthos. Ms. Williams also has training in hazardous materials management, including courses and seminars in CEQA, environmental auditing, and the fate of toxins in the environment. She has an extensive background in biological survey techniques and laboratory methodology.

The postgraduate Environmental Studies Certificate provided interdisciplinary training in economics, public health issues, environmental toxicology, and assessing human impacts on terrestrial and marine environments.

Professional Employment

- 1989-present. Consultant and Contract Employee. Projects include Shoreline Recovery Study of the Exxon Valdez spill, terrestrial ecological survey of a Superfund site, and various benthic surveys, and environmental education.
- 1990-present. Interpretive Specialist, City of Ventura (Community Services). As part of the Interpretive Outreach Program, deliver classroom and field presentations on a variety of natural and cultural history topics; program development.
- 1993 - 1994. Park Ranger (Interpretive Division), Channel Islands National Park. Staff Visitor Center, present programs to school groups and general public, develop public programs (Tidepools, Island Ethnobotany).
- 1989 - 1994. Part-time Instructor, Oxnard College. Topics taught include Microbiology, Marine Biology, Biology, and Environmental Sciences.
- 1986 - 1989. Researcher, Battelle Ocean Sciences, Ventura. Laboratory supervisor, task leader for monitoring program, taxonomist, safety officer.
- 1984 - 1986. Research Scientist, Harbors Environmental Project, University of Southern California. Assessment of the marine environment of Marina Del Rey; monitoring offshore disposal of cannery waste.
- 1980 - 1986. Assistant Curator, Allan Hancock Foundation, University of Southern California. Responsible for maintaining museum collection of marine animals, processing loans, conducting independent research.

- 1979 - 1981. Research Associate, Applied Ecology Program, Institute for Marine and Coastal Studies. Investigated impacts of storms on sandy beaches, monitored benthic impacts of electrical generating stations, supervised laboratory.
- 1975 - 1978. Associate Research Scientist, Department of Biological Sciences, University of Southern California. As part of the Outer Continental Shelf Program, collected and analyzed benthic samples prior to offshore oil exploration.

Miscellaneous

Charter Member, Southern California Association of Marine Invertebrate Taxonomists

Participant, Boys & Girls Club of Ventura Career Fair

Judge, Ventura County Science Fair (2004-present). Assigned categories included Zoology, Botany, and Human Biology, junior division (grades 6-8)

Publications and Technical Reports

Ms. Williams has published 13 papers, ranging from taxonomic works and ecological analyses to articles on environmental issues for the general public.

Detailed list available upon request.

ROY K. KROPP

Senior Research Scientist
Pacific Northwest National Laboratory
Battelle Marine Sciences Laboratory
Sequim, Washington

Education

Ph.D.	Zoology, University of Maryland, 1988
M.S.	Biology, University of Guam, 1982
B.S.	Zoology, San Diego State University, 1978

Qualifications

Dr. Kropp is a specialist in benthic marine ecology, toxicology, and the systematics of crustaceans and mollusks with 21 years of experience. He has served as the principal investigator for or participated in marine environmental surveys in the tropical and boreal Pacific, off California, the Gulf of Mexico, along the Atlantic Coast of the United States, and in the Mediterranean. Currently, Dr. Kropp is the Senior Scientist for Benthic Biology for the Massachusetts Water Resources Authority Monitoring Program. Since matriculating to the Marine Sciences Laboratory from Battelle's Duxbury facility, Dr. Kropp has continued benthic ecological studies, recently completing studies of infaunal communities associated with dredged material disposal sites in Rhode Island Sound and Long Island Sound. He was the technical project manager for the preparation of the Final Environmental Impact Statement being prepared for the Providence River dredging project by the U.S. Army Corps of Engineers and is participating as a benthic ecologist on similar EISs for the designation of disposal sites in Rhode Island Sound and Long Island Sound. Dr. Kropp designed and directed a study to examine the effects of increased summer nutrient loads on nearshore seagrass beds in NW Sardinia by examining changes in plant phenology, motile epifaunal communities, and plant epiphyte loads. Dr. Kropp is a recognized authority on crustacean systematics. He was the crustacean taxonomist for the Sardinian study and served as the crustacean and mollusk taxonomist for studies conducted off California and New England. He was the crustacean taxonomist for the Gulf of Thailand and Sea of Okhotsk programs and has extensive experience in the systematics of Indo-Pacific crustaceans. Dr. Kropp is a Research Associate with the Smithsonian Institution and a Research Affiliate of the University of Guam Marine Laboratory. He has authored or coauthored many journal publications and technical reports.

Project Experience

- **Soft-Bottom Monitoring Study conducted for Massachusetts Water Resources Authority (MWRA).** Senior Scientist responsible for technical oversight of benthic monitoring tasks, including directing data analyses and report preparation for study of the response of the Boston Harbor benthos to the abatement of sludge discharge, and for the eventual diversion of effluent to Massachusetts Bay. Assisted in the design and performance of the rapid assessment technique used in the study. Co-principal Investigator of a study to determine the importance of the new outfall site as a recruitment area for juvenile lobsters.
- **Piscataqua River, New Hampshire 301(h) waiver Water Quality and Benthic Community Study.** Principal investigator for the study performed to fulfill requirements of a 301(h) waiver application. Designed the sampling scheme for the study, analyzed ecological and water-quality data, and prepared the interpretive report.
- **Rhode Island Sound and Long Island Sound Infaunal Community Analyses.** Co-Principal Investigator for two studies of infaunal communities in and near dredged material disposal sites for the U.S. Army Corps of Engineers. Performed benthic data analyses and coauthored the technical reports.
- **Effect of Water-Column Nutrients on Seagrass Epifaunal Communities in NW Sardinia, Italy.** Principle Investigator responsible for study design, staff training, study implementation, data analysis and interpretation, and preparation of interpretive report. Study examining the effects of increased summer nutrient loads (related to increased tourism) on nearshore seagrass beds by examining changes in plant phenology, motile epifaunal communities, and epiphyte loads.
- **Environmental Studies in the Gulf of Thailand, Phase I and II** Biology Task Leader for project that investigated the impacts of drilling activities on the benthos. Performed ecological data analysis, wrote biological characterization chapters of the resulting reports.

Roy K. Kropp (Continued)

Other Experience

Monitoring Studies.

Task Leader for a study to determine the abundance of ocean quahogs (*Arctica islandica*) at proposed dredged material disposal sites in Rhode Island Sound. Designed and directed the study. Analyzed quahog abundance and size-frequency data, and prepared an interpretive report.

Biology Task Leader for the Sediment Survey at the (New York) Mud Dump Site and Environs. Responsible for analysis and interpretation of infaunal data collected during 1994. Prepared sections on the benthic community for the draft final report. Contributed sections on the infaunal community and trophic relationships for the draft SEIS.

Task Leader. Statistical design of field sampling and data analysis, interpretation, and write-up for program involving lead shot remediation at Remington Gun Club site.

Biology Task Leader for Environmental Studies in the Sea of Okhotsk. Analyzed infaunal data collected from proposed drilling platform sites. Prepared an interpretive report on the infaunal communities in the study area.

Biology Task Leader for the Region VI (EPA) contaminated sediment study. Analyzed infaunal data from seven ocean dredged material disposal sites in the Gulf of Mexico. Prepared interpretive reports on the communities at each site and provided recommendations for improving the study design.

Scientist for the New York Bight Rapid Benthic Assessment project that concerned the selection of a new site for the disposal of dredge spoils. Conducted epibenthic trawls and sediment grab sampling. Analyzed trawl catches, fish stomach contents, and infauna collected in sediment grabs.

Assistant Program Manager for California OCS Phase II Monitoring Program (CAMP) that established baseline conditions in the Santa Maria Basin prior to the installation of a drilling platform. Principal Investigator studying the life histories of several key infaunal species. Conducted independent study on the incidence of repaired shell damage to gastropods and scaphopods in the study area.

Beach Replenishment Dredging Studies. Principal Investigator for three USACE sand borrow area studies. Responsible for design and ecological analysis for three projects establishing baseline conditions or investigating the effects of dredging in sand borrow areas at Broadkill Beach in Delaware Bay and off Absecon Inlet and Great Egg Harbor, New Jersey.

Toxicological Studies. Project Manager or Senior Scientist for toxicological testing of sediments from the Providence River, New Haven, and Boston Harbor/Weymouth Fore River. These tests were conducted from the New England Division, Army Corps of Engineers and involved marine species, including *Americamysis bahia* and *Ampelisca abdita*. Responsibilities included overall test planning and supervision, data analyses, and report preparation.

Project Manager for toxicological testing of sediments from Pistol Point Bar, CT. These tests were conducted from the New England Division, Army Corps of Engineers and involved freshwater species including *Hyalella azteca*, *Chironomus tentans*, and *Lumbriculus variegatus*.

Project Manager for toxicological testing of synthetic-based drilling muds from the Gulf of Mexico. These tests were conducted from the American Petroleum Institute and involved a marine species, *Leptocheirus plumulosus*.

Environmental Impact Statements. Project Manager for the preparation of the Final Environmental Impact Statement being prepared for the Providence River dredging project by the US Army Corps of Engineers. Coordinator for activities including response to public comments, re-analysis of fish trawl data to evaluate fishery value of potential disposal sites, directed the development of a statistically valid design of study on lobster populations at disposal sites, directing implementation of the study, designed a dredge survey to sample northern quahog populations in the area to be dredged and wrote the interpretive report, monitored project budgets and tracked deliverable preparation. Information will be used to assist the government in deciding the most appropriate disposal alternative.

Artificial Reef Studies. Benthic Infauna/Epifauna Task Leader for 5-year study for U.S. Army Corps of Engineers (USACE) and Environmental Protection Agency (EPA) Delaware Artificial Reef Study that investigated the feasibility of using artificial reef as compensation for shallow- and deep-water habitat loss. Performed ecological data analysis of epifaunal communities on the reefs and infaunal communities surrounding the reefs, wrote sections

Roy K. Kropp (Continued)

of the report. Designed portions of a study to examine the effects of artificial reef units on the infauna.

NOAA Hydrolab Aquanaut and field assistant for study of artificial reef colonization at Salt River Canyon, St. Croix, U.S. Virgin Islands.

Taxonomist. Crustacean taxonomist for benthic studies conducted in NW Sardinia, Italy.

Identified crustaceans and mollusks collected from Boston Harbor, Massachusetts Bay, and Cape Cod Bay for the MWRA Harbor and Outfall Monitoring Program.

Chief taxonomist for the Environmental Studies in the Gulf of Thailand, Phase I and II project. Identified the crustaceans collected during the study. Directed the establishment of a project-specific voucher collection and edited the documentation for the voucher collection.

Identified crustaceans and mollusks collected from off California for the CAMP program and the Morro Bay/Cayucos Sanitation District 301(h) monitoring program.

Specialist on benthic invertebrates for several baseline monitoring studies conducted in the western Pacific (Micronesia).

Professional Affiliations

Biological Society of Washington
Crustacean Society
Estuarine Research Federation
Pacific Science Association

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APPENDIX C

Sediment Properties: October 2010 Survey

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APPENDIX C

Properties of Sediment Samples Collected during October 2010 Offshore Survey

Table C.1 Sediment Grab-Sample Collection Record

Station	Sample	Date	Time ¹	Penetration Depth (cm)	Latitude	Longitude	Sediment Type	Sediment ² Color	Comment
1	Bio 1	10/07/2010	12:54:36	9.0	35° 23.7306' N	120° 52.6683' W	Sand	Lt. Brown	
	Bio 2	10/07/2010	12:56:46	7.5	35° 23.7344' N	120° 52.6682' W	Sand	Lt. Brown	
	Bio 3	10/07/2010	12:59:12	9.0	35° 23.7332' N	120° 52.6656' W	Sand	Lt. Brown	
	Bio 4	10/07/2010	13:01:36	11.0	35° 23.7327' N	120° 52.6663' W	Sand	Lt. Brown	
	Bio 5	10/07/2010	13:03:54	9.5	35° 23.7322' N	120° 52.6663' W	Sand	Lt. Brown	
	Chem 1	10/07/2010	13:06:08	N/A	35° 23.7322' N	120° 52.6669' W	Sand	Lt. Brown	
	Chem 2	10/07/2010	13:10:19	N/A	35° 23.7316' N	120° 52.6656' W	Sand	Lt. Brown	
	Chem 3	10/07/2010	13:13:31	N/A	35° 23.7316' N	120° 52.6663' W	Sand	Lt. Brown	
2	Bio 1	10/07/2010	12:20:59	7.5	35° 23.2873' N	120° 52.4963' W	Sand	Lt. Brown	
	Bio 2	10/07/2010	12:23:20	10.0	35° 23.2856' N	120° 52.4937' W	Sand	Lt. Brown	
	Bio 3	10/07/2010	12:25:42	8.0	35° 23.2856' N	120° 52.4937' W	Sand	Lt. Brown	
	Bio 4	10/07/2010	12:27:57	7.5	35° 23.2850' N	120° 52.4924' W	Sand	Lt. Brown	
	Bio 5	10/07/2010	12:30:13	8.0	35° 23.2845' N	120° 52.4931' W	Sand	Lt. Brown	
	Chem 1	10/07/2010	12:32:25	N/A	35° 23.2840' N	120° 52.4918' W	Sand	Lt. Brown	
	Chem 2	10/07/2010	12:35:58	N/A	35° 23.2834' N	120° 52.4918' W	Sand	Lt. Brown	
	Chem 3	10/07/2010	12:39:14	N/A	35° 23.2829' N	120° 52.4918' W	Sand	Lt. Brown	
3	Bio 1	10/07/2010	11:45:16	7.0	35° 23.2326' N	120° 52.4911' W	Sand	Lt. Brown	
	Bio 2	10/07/2010	11:47:31	8.0	35° 23.2320' N	120° 52.4911' W	Sand	Lt. Brown	
	Bio 3	10/07/2010	11:49:51	10.0	35° 23.2342' N	120° 52.4924' W	Sand	Lt. Brown	Many sand dollars
	Bio 4	10/07/2010	11:56:44	7.5	35° 23.2370' N	120° 52.4956' W	Sand	Lt. Brown	
	Bio 5	10/07/2010	12:00:18	8.0	35° 23.2369' N	120° 52.4923' W	Sand	Lt. Brown	
	Chem 1	10/07/2010	11:32:48	N/A	35° 23.2370' N	120° 52.4996' W	Sand	Lt. Brown	
	Chem 2	10/07/2010	11:36:04	N/A	35° 23.2332' N	120° 52.4944' W	Sand	Lt. Brown	
	Chem 3	10/07/2010	11:38:57	N/A	35° 23.2309' N	120° 52.4918' W	Sand	Lt. Brown	
4	Bio 1	10/07/2010	10:54:01	9.0	35° 23.2159' N	120° 52.4982' W	Sand	Lt. Brown	
	Bio 2	10/07/2010	10:56:26	8.0	35° 23.2154' N	120° 52.4995' W	Sand	Lt. Brown	
	Bio 3	10/07/2010	10:58:40	9.0	35° 23.2154' N	120° 52.4982' W	Sand	Lt. Brown	
	Bio 4	10/07/2010	11:11:50	9.5	35° 23.2143' N	120° 52.5002' W	Sand	Lt. Brown	
	Bio 5	10/07/2010	11:24:09	9.0	35° 23.2154' N	120° 52.4995' W	Sand	Lt. Brown	
	Chem 1	10/07/2010	11:01:19	N/A	35° 23.2154' N	120° 52.4995' W	Sand	Lt. Brown	
	Chem 2	10/07/2010	11:04:37	N/A	35° 23.2165' N	120° 52.4988' W	Sand	Lt. Brown	
	Chem 3	10/07/2010	11:07:59	N/A	35° 23.2148' N	120° 52.4982' W	Sand	Lt. Brown	
5	Bio 1	10/07/2010	10:08:46	10.0	35° 23.1900' N	120° 52.5002' W	Sand	Lt. Brown	Many sand dollars
	Bio 2	10/07/2010	10:12:26	7.5	35° 23.1904' N	120° 52.4955' W	Sand	Lt. Brown	
	Bio 3	10/07/2010	10:15:01	8.5	35° 23.1904' N	120° 52.4955' W	Sand	Lt. Brown	Swimming isopods
	Bio 4	10/07/2010	10:17:14	10.5	35° 23.1910' N	120° 52.4949' W	Sand	Lt. Brown	Shell hash
	Bio 5	10/07/2010	10:19:35	9.0	35° 23.1904' N	120° 52.4955' W	Sand	Lt. Brown	Shell hash
	Chem 1	10/07/2010	10:29:27	N/A	35° 23.1893' N	120° 52.4942' W	Sand	Lt. Brown	
	Chem 2	10/07/2010	10:36:57	N/A	35° 23.1888' N	120° 52.4923' W	Sand	Lt. Brown	
	Chem 3	10/07/2010	10:40:26	N/A	35° 23.1860' N	120° 52.4917' W	Sand	Lt. Brown	

¹ Time when the sediment grab was collected (trip time of the grab)

² No odors emanating from the sediment samples were noted at any station

Table C.1 Sediment Grab-Sample Collection Record

Station	Sample	Date	Time ¹	Penetration Depth (cm)	Latitude	Longitude	Sediment Type	Sediment ² Color	Comment
6	Bio 1	10/07/2010	8:59:48	9.0	35° 23.1706' N	120° 52.5046' W	Sand	Lt. Brown	
	Bio 2	10/07/2010	9:05:30	8.5	35° 23.1706' N	120° 52.5027' W	Sand	Lt. Brown	
	Bio 3	10/07/2010	9:07:45	7.0	35° 23.1711' N	120° 52.5046' W	Sand	Lt. Brown	
	Bio 4	10/07/2010	9:12:22	8.5	35° 23.1717' N	120° 52.5073' W	Sand	Lt. Brown	
	Bio 5	10/07/2010	9:14:48	8.0	35° 23.1723' N	120° 52.5079' W	Sand	Lt. Brown	
	Chem 1	10/07/2010	9:17:11	N/A	35° 23.1717' N	120° 52.5079' W	Sand	Lt. Brown	
	Chem 2	10/07/2010	9:22:24	N/A	35° 23.1706' N	120° 52.5033' W	Sand	Lt. Brown	
	Chem 3	10/07/2010	9:25:55	N/A	35° 23.1711' N	120° 52.5053' W	Sand	Lt. Brown	
7	Bio 1	10/07/2010	9:38:05	8.0	35° 23.1243' N	120° 52.5151' W	Sand	Lt. Brown	
	Bio 2	10/07/2010	9:40:22	8.0	35° 23.1263' N	120° 52.5084' W	Sand	Lt. Brown	
	Bio 3	10/07/2010	9:42:44	8.0	35° 23.1263' N	120° 52.5091' W	Sand	Lt. Brown	
	Bio 4	10/07/2010	9:44:55	7.0	35° 23.1263' N	120° 52.5091' W	Sand	Lt. Brown	
	Bio 5	10/07/2010	9:47:25	7.5	35° 23.1263' N	120° 52.5084' W	Sand	Lt. Brown	
	Chem 1	10/07/2010	9:49:39	N/A	35° 23.1263' N	120° 52.5078' W	Sand	Lt. Brown	
	Chem 2	10/07/2010	9:54:21	N/A	35° 23.1258' N	120° 52.5091' W	Sand	Lt. Brown	
	Chem 3	10/07/2010	9:59:37	N/A	35° 23.1252' N	120° 52.5091' W	Sand	Lt. Brown	

Table C.2 Grain-Size Class Distribution in October 2010 Sediment Samples

Phi	-2 to -1	-1 to 0	0 to 1	1 to 2	2 to 3	3 to 4	4 to 9	>9
Size (µm)	2000	1000	500	250	125	62.5	62.5 to 2	<2
Class	Gravel	Vry Crs Snd	Crs Sand	Med Snd	Fine Snd	Vry Fine Snd	Silt	Clay
Station B1	0.000%	0.033%	0.697%	2.108%	70.319%	25.667%	0.767%	0.409%
Station B2	0.000%	0.026%	0.690%	2.747%	80.486%	15.575%	0.312%	0.163%
Station B3	0.000%	0.405%	0.580%	2.697%	81.059%	14.721%	0.382%	0.156%
Station B4	0.000%	0.063%	0.453%	2.655%	82.871%	13.741%	0.182%	0.035%
Station B4(d)	0.000%	0.092%	0.745%	3.144%	81.991%	13.738%	0.225%	0.066%
Station B5	0.000%	0.159%	0.532%	3.875%	83.732%	11.393%	0.158%	0.151%
Station B5(d)	0.000%	0.099%	0.416%	3.662%	87.039%	8.545%	0.188%	0.052%
Station B6	0.000%	0.009%	0.218%	1.283%	77.577%	20.157%	0.627%	0.129%
Station B7	0.000%	0.046%	0.851%	2.583%	80.281%	15.755%	0.364%	0.120%

Table C.3 Grain-Size Weight Distribution in October 2010 Sediment Samples

Phi Size (µm) Class	Dry Weight (grams)			Percentage Summary		
	<-1 to 4	>4	Total	-2 to -1	-1 to 4	4 to >9
	2000 to 62.5	<62.5		2000	1000 to 62.5	<62.5
	Coarse	Fine		Gravel	Sand	Mud
Station B1	108.176	1.288	109.464	0.000%	98.823%	1.177%
Station B2	102.051	0.487	102.538	0.000%	99.525%	0.475%
Station B3	104.175	0.563	104.738	0.000%	99.462%	0.538%
Station B4	109.743	0.239	109.982	0.000%	99.783%	0.217%
Station B4(d)	106.309	0.310	106.619	0.000%	99.709%	0.291%
Station B5	100.960	0.313	101.273	0.000%	99.691%	0.309%
Station B5(d)	105.876	0.255	106.131	0.000%	99.760%	0.240%
Station B6	101.351	0.772	102.123	0.000%	99.244%	0.756%
Station B7	109.270	0.532	109.802	0.000%	99.515%	0.485%

Table C.4 Grain-Size Statistics for October 2010 Sediment Samples

Station	Percent Coarser than Listed Diameter (µm)								
	Mean (φ)	σ (φ)	Skewness (φ)	Mean (µm)	5%	16%	50%	84%	95%
B1	2.79	0.395	0.10	145	224	186	147	111	86
B2	2.68	0.345	0.06	156	233	195	158	125	100
B3	2.66	0.346	0.06	158	235	196	159	126	100
B4	2.66	0.324	0.04	158	230	195	159	128	105
B4(d)	2.65	0.339	0.03	159	238	198	160	128	104
B5	2.61	0.337	0.03	164	245	203	164	132	107
B5(d)	2.58	0.309	0.02	167	242	204	168	137	114
B6	2.75	0.336	0.13	149	211	183	150	118	93
B7	2.68	0.345	0.06	156	232	194	157	125	100

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APPENDIX D
Outfall Inspection Report

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OUTFALL/DIFFUSOR ANNUAL REPORT

NAME OF DISCHARGER m8csd
NPDES PERMIT # CA0047881

NAME OF DIVER/INSPECTOR Craig Porter / Porter Diving
FIRM & ADDRESS 15730 Morro rd

TELEPHONE # (805) 966-0566

OUTFALL LENGTH 5160' FT. DEPTH OF WATER 50' FT.

DESIGN OF DIFFUSOR (physical dimensions, shape, include sketch)

OF PORTS 34 # PORTS OPEN 28 DIFFUSOR LEVEL? 1'-6"

END OF DIFUSSOR OPEN? CLOSED? ✓

OUTFALL MARKED BY BOUYS? YES ✓ NO TYPE SPAR

DIFFUSORS OPERATING AS DESIGNED? YES ✓ NO

BREAKS IN OUTFALL LINE NOTED? YES NO ✓ IF YES, DESCRIBE

DESCRIBE PROBLEMS NOTED N/A

CORRECTIVE ACTION NEEDED N/A (SPARS Removed for Replacement Today)

PHYSICAL DESCRIPTION OF ENVIRONMENT AROUND OUTFALL (ie. fish noted, debris, sediments, etc.) starfish, ANEMONES, small Fish

VIDEO to BE taken this month when SPAR Bouys are re-installed

DIRECTION OF PLUME IN RELATIONSHIP TO SHORELINE N.E.

PICTURES TAKEN? YES NO (INCLUDE COPIES IF TAKEN)

SIGNATURE OF DIVER/INSPECTOR Craig Porter

9-20-2010

DATE

SIGNATURE OF DISCHARGER Bruce Keen

9-20-2010

TITLE

RHS/DIFF. DISC C

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APPENDIX E

Sediment Chemistry: October 2010 Survey Methods, Results, and QA/QC

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Methods

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**Table E.1 Summary of Analytical Methods Used for
Physicochemical Determinations of Sediment**

Parameter	Method	Description	Reference
Biochemical Oxygen Demand 5-Day	5210B	Dissolved Oxygen Probe	6
Total Kjeldahl Nitrogen (TKN)	351.2	Block Digestion/Colorimetry	1
Total Volatile Solids	160.4	Dry ashing/Gravimetry	1
Moisture	160.3	Evaporation/Gravimetry	1
Sediment Grain Size	MRS, 1998	Sieve/Pipette without salt	2,3,4
Aluminum	6010	ICP	5
Arsenic	7060	GFAAS	5
Cadmium	6010	ICP	5
Chromium	6010	ICP	5
Copper	6010	ICP	5
Iron	6010	ICP	5
Lead	7421	CVAAS	5
Mercury	7471	CVAAS	5
Nickel	6010	ICP	5
Silver	272.2	GFAAS	1
Zinc	6010	ICP	5
Oil and Grease	1664	Extraction/Gravimetry	7

CVAAS = Cold Vapor Atomic Absorption Spectrometry

ICP/MS = Inductively Coupled Plasma/Mass Spectrometry

GC = Gas Chromatography

GC/MS = Gas Chromatography/Mass Spectrometry

GFAAS = Graphite Furnace Atomic Absorption Spectrometry

References:

1. U.S. Environmental Protection Agency. 1983. Methods for chemical analysis of water and wastes. EPA-600/4-79-020.
2. Plumb, R.H., Jr. 1981. Procedures for Handling and chemical analysis of sediment and water samples. U.S. Army Corps of Engineer Waterway Experiment Stations, Vicksburg, Miss.
3. Marine Research Specialists. 1998. City of Morro Bay and Cayucos Sanitary District, Offshore Monitoring and Reporting Program, Semiannual Benthic Sampling, October 1997. Prepared for the City of Morro Bay, Morro Bay, CA
4. Coats, D.A., Imamura, E., Fukuyama, A.K., Skalski, J.R., Kimura, S., and J. Steinbeck. 1998. Monitoring of Biological Recovery of Prince William Sound Intertidal Sites Impacted by the *Exxon Valdez* Oil Spill. 1997 Biological Monitoring Survey. NOAA Technical Memorandum NOS ORCA NOS OR&R 1.
5. U.S. Environmental Protection Agency. 1986. Test methods for evaluating solid wastes physical/chemical methods. EPA SW-846. 3rd ed., revised.
6. American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1998. Standard methods for the examination of water and wastewater (20th Ed.). Washington, DC.
7. U.S. Environmental Protection Agency. 1999. Method 1664 Revision A: N-Hexane Extractable Material (HEM; Oil and Grease) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM; Non-polar Material) by Extraction and Gravimetry. February 1999. EPA-821-R-98-002.

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Analytical Results

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Laboratories, Inc.

Environmental Testing Laboratory Since 1949



Date of Report: 11/09/2010

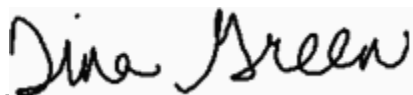
Doug C 

Marine Research Specialists
3140 Telegraph Road, Suite A
Suite A
Ventura, CA 93003-3238

RE: Annual Benthic Sediment Sampling for MBTP
BC Work Order: 1014100
Invoice ID: B089725

Enclosed are the results of analyses for samples received by the laboratory on 10/7/2010. If you have any questions concerning this report, please feel free to contact me.

Sincerely,



Contact Person: Tina Green
Client Services Manager



Authorized Signature

Certifications: CA ELAP #1186; NV #CA00014

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.
All results listed in this report are for the exclusive use of the submitting party. BC Laboratories, Inc. assumes no responsibility for report alteration, separation, detachment or third party interpretation.

4100 Atlas Court Bakersfield, CA 93308 (661) 327-4911 FAX (661) 327-1918 www.bclabs.com



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Chain of Custody Form

Report To: Marine Research Specialists		Project #:	Analysis Requested																																										
Client:		Project Name: MBCSD Benthic																																											
Attn: Doug Coats		Global ID #:	Comments: 11 Metals (EPA 6010B/6020/7471A): As, Cd, Ch, Cu, Pb, Ni, Ag, Zn, Al, Fe, and Hg <table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th colspan="5">Sample Matrix</th> <th colspan="2">Are there any tests with holding times less than or equal to 48 hours?</th> </tr> <tr> <th>Solid</th> <th>Dissolved</th> <th>Drinking Water</th> <th>Clean water</th> <th>Waste Water</th> <th>Other</th> <th>Yes ☒ No ☐</th> </tr> </thead> <tbody> <tr> <td>✓</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td rowspan="5"></td> </tr> <tr><td>✓</td><td></td><td></td><td></td><td></td></tr> <tr><td>✓</td><td></td><td></td><td></td><td></td></tr> <tr><td>✓</td><td></td><td></td><td></td><td></td></tr> <tr><td>✓</td><td></td><td></td><td></td><td></td></tr> </tbody> </table>		Sample Matrix					Are there any tests with holding times less than or equal to 48 hours?		Solid	Dissolved	Drinking Water	Clean water	Waste Water	Other	Yes ☒ No ☐	✓							✓					✓					✓					✓				
Sample Matrix					Are there any tests with holding times less than or equal to 48 hours?																																								
Solid	Dissolved	Drinking Water			Clean water	Waste Water	Other	Yes ☒ No ☐																																					
✓																																													
✓																																													
✓																																													
✓																																													
✓																																													
Street Address: 3140 Telegraph Rd. Suite A		Sampler(s):																																											
City, State, Zip: Ventura, CA 93003																																													
Phone: 805-644-1180																																													
Email Address: doug.coats@mrsenv.com																																													
Work Order# 104100																																													

Sample #	Description	Date Sampled	Time Sampled	Metals TLC (see comments)	Moisture	TKN - EPA 351.2	BOD - SM17-5210B	TVS - SM-2540G	Oil and Grease - 1664/HEM						
* B1	Composite Offshore Benthic Sediment	10/7/10	13:10	✓	✓	✓	✓	✓				✓			
2 B2	Composite Offshore Benthic Sediment	10/7/10	12:36	✓	✓	✓	✓	✓	✓			✓			
3 B3	Composite Offshore Benthic Sediment	10/7/10	11:36	✓	✓	✓	✓	✓	✓			✓			
4 B4	Composite Offshore Benthic Sediment	10/7/10	11:05	✓	✓	✓	✓	✓	✓			✓			
5 B5	Composite Offshore Benthic Sediment	10/7/10	10:37	✓	✓	✓	✓	✓	✓			✓			
6 B6	Composite Offshore Benthic Sediment	10/7/10	09:54	✓	✓	✓	✓	✓	✓			✓			
7 B7	Composite Offshore Benthic Sediment	10/7/10	09:22	✓	✓	✓	✓	✓	✓			✓			

☐ SHORT FOLDING TIME

Cr⁶⁺ NO₂-N NO₃-N OP SS

DO Cl₂ SMD MBAC COT

KEY DISTRIBUTION

Can 10/7/10 RT AS

SUB-DUT []

Billing ☒ Same as above	EDF Required? ☐ Yes ☒ No	Special Reporting ☐ QC ☐ EDF ☐ Raw Data
Client: _____ Address: _____ City: _____ State: _____ Zip: _____ Attn: _____ PO#: _____	Send Copy to State of CA? ☐ Yes ☒ No	

Sample Disposal			Special Reporting		
☐ Return to Client ☒ Dispose by lab ☐ Archive Months _____			☐ QC ☐ EDF ☐ Raw Data		
1. Relinquished By	Date	Time	1. Relinquished By	Date	Time
Bon Rm	10/7/10	17:00	Jen M	10/20/10	17:00
2. Relinquished By	Date	Time	2. Relinquished By	Date	Time
Jen M	10-7-10	2050	Jen M	10/7/10	2050
3. Relinquished By	Date	Time	3. Relinquished By	Date	Time



Laboratories, Inc.

Environmental Testing Laboratory Since 1949

Chain of Custody and Cooler Receipt Form for 1014100 Page 2 of 2

BC LABORATORIES INC.		SAMPLE RECEIPT FORM		Rev. No. 12	06/24/08	Page 1 Of 1
Submission #: <u>1014100</u>						
SHIPPING INFORMATION Federal Express ☐ UPS ☐ Hand Delivery ☐ BC Lab Field Service ☒ Other ☐ (Specify) _____				SHIPPING CONTAINER Ice Chest ☒ None ☐ Box ☐ Other ☐ (Specify) _____		
Refrigerant: Ice ☒ Blue Ice ☐ None ☐ Other ☐ Comments: _____						
Custody Seals Ice Chest ☐ Containers ☐ None ☒ Comments: _____ Intact? Yes ☐ No ☐ Intact? Yes ☐ No ☐						
All samples received? Yes ☒ No ☐ All samples containers intact? Yes ☒ No ☐ Description(s) match COC? Yes ☒ No ☐						
COC Received ☒ YES ☐ NO		Emissivity: <u>0.95</u> Container: <u>32oz Jar</u> Thermometer ID: <u>#163</u>		Date/Time: <u>10/7/10</u> <u>2130</u>		Analyst Init: <u>BE</u>
		Temperature: A <u>0-1</u> °C / C <u>0.7</u> °C				

SAMPLE CONTAINERS	SAMPLE NUMBERS									
	1	2	3	4	5	6	7	8	9	10
QT GENERAL MINERAL / GENERAL PHYSICAL										
PT PE UNPRESERVED										
QT INORGANIC CHEMICAL METALS										
PT INORGANIC CHEMICAL METALS										
PT CYANIDE										
PT NITROGEN FORMS										
PT TOTAL SULFIDE										
2oz. NITRATE / NITRITE										
PT TOTAL ORGANIC CARBON										
PT TOX										
PT CHEMICAL OXYGEN DEMAND										
PIA PHENOLICS										
40ml VOA VIAL TRAVEL BLANK										
40ml VOA VIAL										
QT EPA 413.1, 413.2, 413.1										
PT ODOR										
RADIOLOGICAL										
BACTERIOLOGICAL										
40 ml VOA VIAL- 504										
QT EPA 508/608/5080										
QT EPA 515.1/5150										
QT EPA 525										
QT EPA 525 TRAVEL BLANK										
100ml EPA 547										
100ml EPA 531.1										
QT EPA 548										
QT EPA 549										
QT EPA 632										
QT EPA 8015M										
QT AMBER										
8 OZ. JAR										
32 OZ. JAR	A	A	A	A	A	A	A			
SOIL SLEEVE										
FCB VIAL										
PLASTIC BAG										
FERROUS IRON										
ENCORE										

Comments: _____
Sample Numbering Completed By: CW Date/Time: 10-8-10 18:05
A = Actual / C = Corrected
(H:\DOCS\WP\10LAB_DOCS\FORMS\5ANREC2.WPD)

Marine Research Specialists
3140 Telegraph Road, Suite A
Suite A
Ventura, CA 93003-3238

Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Laboratory / Client Sample Cross Reference

Laboratory	Client Sample Information			
1014100-01	COC Number:	---	Receive Date:	10/07/2010 20:50
	Project Number:	---	Sampling Date:	10/07/2010 13:10
	Sampling Location:	---	Sample Depth:	---
	Sampling Point:	B1 Composite Offshore Benthic Sediment	Sample Matrix:	Solids
	Sampled By:	---		
1014100-02	COC Number:	---	Receive Date:	10/07/2010 20:50
	Project Number:	---	Sampling Date:	10/07/2010 12:36
	Sampling Location:	---	Sample Depth:	---
	Sampling Point:	B2 Composite Offshore Benthic Sediment	Sample Matrix:	Solids
	Sampled By:	---		
1014100-03	COC Number:	---	Receive Date:	10/07/2010 20:50
	Project Number:	---	Sampling Date:	10/07/2010 11:36
	Sampling Location:	---	Sample Depth:	---
	Sampling Point:	B3 Benthic Offshore Benthic Sediment	Sample Matrix:	Solids
	Sampled By:	---		
1014100-04	COC Number:	---	Receive Date:	10/07/2010 20:50
	Project Number:	---	Sampling Date:	10/07/2010 11:05
	Sampling Location:	---	Sample Depth:	---
	Sampling Point:	B4 Composite Offshore Benthic Sediment	Sample Matrix:	Solids
	Sampled By:	---		
1014100-05	COC Number:	---	Receive Date:	10/07/2010 20:50
	Project Number:	---	Sampling Date:	10/07/2010 10:37
	Sampling Location:	---	Sample Depth:	---
	Sampling Point:	B5 Composite Offshore Benthic Sediment	Sample Matrix:	Solids
	Sampled By:	---		
1014100-06	COC Number:	---	Receive Date:	10/07/2010 20:50
	Project Number:	---	Sampling Date:	10/07/2010 09:54
	Sampling Location:	---	Sample Depth:	---
	Sampling Point:	B6 Composite Offshore Benthic Sediment	Sample Matrix:	Solids
	Sampled By:	---		
1014100-07	COC Number:	---	Receive Date:	10/07/2010 20:50
	Project Number:	---	Sampling Date:	10/07/2010 09:22
	Sampling Location:	---	Sample Depth:	---
	Sampling Point:	B7 Composite Offshore Benthic Sediment	Sample Matrix:	Solids
	Sampled By:	---		

Marine Research Specialists
3140 Telegraph Road, Suite A
Suite A
Ventura, CA 93003-3238

Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Chemical Analysis

BCL Sample ID:	1014100-01	Client Sample Name:	B1 Composite Offshore Benthic Sediment, 10/7/2010 1:10:00PM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Moisture	0	23.1	%	0.05	0.05	Calc	ND		1
Total Kjeldahl Nitrogen	190	150	mg/kg	40	15	EPA-351.2	ND		2
Volatile Solids	1.55	1.19	%	0.200	0.200	SM-2540G	ND		3
Biochemical Oxygen Demand	40	30	mg O/kg	7.5	7.5	SM17-5210B			4
Solids	100	76.9	%	0.05	0.05	SM-2540G			5

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	Calc	10/13/10	10/20/10 21:42	TMS	Calc	1	BTJ0771
2	EPA-351.2	11/02/10	11/02/10 10:02	SDU	SC-1	1	BTK0155
3	SM-2540G	10/25/10	10/25/10 10:30	NW1	MANUAL	1.060	BTK0254
4	SM17-5210B	10/08/10	10/08/10 11:25	HPR	YSI-57	0.250	BTJ0902
5	SM-2540G	10/18/10	10/19/10 17:32	RCP	MANUAL	1	BTJ1288

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Total Concentrations (TTLc)

BCL Sample ID:	1014100-01	Client Sample Name:	B1 Composite Offshore Benthic Sediment, 10/7/2010 1:10:00PM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Arsenic	3.0	2.3	mg/kg	0.36	0.27	EPA-6020	0.28		1
Cadmium	ND	ND	mg/kg	0.40	0.040	EPA-6010B	ND		2
Chromium	63	48	mg/kg	0.40	0.048	EPA-6010B	ND		2
Copper	3.7	2.9	mg/kg	0.81	0.097	EPA-6010B	ND		2
Lead	2.4	1.9	mg/kg	0.18	0.034	EPA-6020	ND		1
Mercury	ND	ND	mg/kg	0.16	0.012	EPA-7471A	ND		3
Nickel	44	34	mg/kg	0.40	0.047	EPA-6010B	ND		2
Silver	0.029	0.023	mg/kg	0.18	0.019	EPA-6020	ND	J	1
Zinc	18	14	mg/kg	2.0	0.20	EPA-6010B	0.41		2
Aluminum	6400	4900	mg/kg	4.0	1.0	EPA-6010B	ND		2
Iron	10000	7900	mg/kg	4.0	3.0	EPA-6010B	ND		2

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-6020	10/14/10	10/15/10 17:15	PPS	PE-EL1	0.719	BTJ0961
2	EPA-6010B	10/13/10	10/14/10 11:01	ARD	PE-OP1	0.806	BTJ0827
3	EPA-7471A	10/12/10	10/12/10 14:13	MEV	CETAC1	0.977	BTJ0663



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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

EPA Method 1664

BCL Sample ID:	1014100-02	Client Sample Name:	B2 Composite Offshore Benthic Sediment, 10/7/2010 12:36:00PM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Oil and Grease	ND	ND	mg/kg	50	13	EPA-1664HEM	ND		1

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-1664HEM	10/18/10	10/18/10 11:00	JAK	MAN-SV	1	BTJ1163

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Chemical Analysis

BCL Sample ID:	1014100-02	Client Sample Name:	B2 Composite Offshore Benthic Sediment, 10/7/2010 12:36:00PM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Moisture	0	23.6	%	0.05	0.05	Calc	ND		1
Total Kjeldahl Nitrogen	170	130	mg/kg	40	15	EPA-351.2	ND		2
Volatile Solids	1.51	1.15	%	0.200	0.200	SM-2540G	ND		3
Biochemical Oxygen Demand	50	38	mg O/kg	15	15	SM17-5210B			4
Solids	100	76.4	%	0.05	0.05	SM-2540G			5

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	Calc	10/13/10	10/20/10 21:42	TMS	Calc	1	BTJ0771
2	EPA-351.2	10/28/10	11/04/10 13:40	SDU	SC-1	1	BTJ1450
3	SM-2540G	10/25/10	10/25/10 10:30	NW1	MANUAL	1.090	BTK0254
4	SM17-5210B	10/08/10	10/08/10 11:25	HPR	YSI-57	0.500	BTJ0902
5	SM-2540G	10/18/10	10/19/10 17:32	RCP	MANUAL	1	BTJ1288

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Total Concentrations (TTLIC)

BCL Sample ID: 1014100-02		Client Sample Name: B2 Composite Offshore Benthic Sediment, 10/7/2010 12:36:00PM							
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Arsenic	3.8	2.9	mg/kg	0.40	0.30	EPA-6020	0.31		1
Cadmium	ND	ND	mg/kg	0.34	0.034	EPA-6010B	ND		2
Chromium	50	38	mg/kg	0.34	0.041	EPA-6010B	ND		2
Copper	4.1	3.2	mg/kg	0.69	0.083	EPA-6010B	ND		2
Lead	2.3	1.7	mg/kg	0.20	0.038	EPA-6020	ND		1
Mercury	0.018	0.014	mg/kg	0.16	0.012	EPA-7471A	ND	J	3
Nickel	53	40	mg/kg	0.34	0.040	EPA-6010B	ND		2
Silver	0.030	0.023	mg/kg	0.20	0.022	EPA-6020	ND	J	1
Zinc	17	13	mg/kg	1.7	0.17	EPA-6010B	0.35		2
Aluminum	5900	4500	mg/kg	3.4	0.90	EPA-6010B	ND		2
Iron	9800	7500	mg/kg	3.4	2.6	EPA-6010B	ND		2

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-6020	10/14/10	10/15/10 17:18	PPS	PE-EL1	0.800	BTJ0961
2	EPA-6010B	10/13/10	10/14/10 11:03	ARD	PE-OP1	0.690	BTJ0827
3	EPA-7471A	10/12/10	10/12/10 14:15	MEV	CETAC1	0.919	BTJ0663



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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

EPA Method 1664

BCL Sample ID:	1014100-03	Client Sample Name:	B3 Benthic Offshore Benthic Sediment, 10/7/2010 11:36:00AM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Oil and Grease	36	27	mg/kg	50	13	EPA-1664HEM	ND	J	1

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-1664HEM	10/18/10	10/18/10 11:00	JAK	MAN-SV	1	BTJ1163

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Chemical Analysis

BCL Sample ID:	1014100-03	Client Sample Name:	B3 Benthic Offshore Benthic Sediment, 10/7/2010 11:36:00AM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Moisture	0	25.8	%	0.05	0.05	Calc	ND		1
Total Kjeldahl Nitrogen	170	130	mg/kg	40	15	EPA-351.2	ND		2
Volatile Solids	1.45	1.08	%	0.200	0.200	SM-2540G	ND		3
Biochemical Oxygen Demand	58	43	mg O/kg	7.5	7.5	SM17-5210B			4
Solids	100	74.2	%	0.05	0.05	SM-2540G			5

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	Calc	10/13/10	10/20/10 21:42	TMS	Calc	1	BTJ0771
2	EPA-351.2	10/28/10	11/04/10 13:41	SDU	SC-1	1	BTJ1450
3	SM-2540G	10/25/10	10/25/10 10:30	NW1	MANUAL	1.097	BTJ0254
4	SM17-5210B	10/08/10	10/08/10 11:25	HPR	YSI-57	0.250	BTJ0902
5	SM-2540G	10/18/10	10/19/10 17:32	RCP	MANUAL	1	BTJ1288

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Total Concentrations (TTLIC)

BCL Sample ID: 1014100-03		Client Sample Name: B3 Benthic Offshore Benthic Sediment, 10/7/2010 11:36:00AM							
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Arsenic	3.7	2.8	mg/kg	0.44	0.33	EPA-6020	0.34		1
Cadmium	ND	ND	mg/kg	0.38	0.038	EPA-6010B	ND		2
Chromium	47	35	mg/kg	0.38	0.045	EPA-6010B	ND		2
Copper	3.8	2.8	mg/kg	0.76	0.091	EPA-6010B	ND		2
Lead	2.2	1.6	mg/kg	0.22	0.042	EPA-6020	ND		1
Mercury	0.021	0.016	mg/kg	0.16	0.012	EPA-7471A	ND	J	3
Nickel	50	37	mg/kg	0.38	0.044	EPA-6010B	ND		2
Silver	0.032	0.024	mg/kg	0.22	0.024	EPA-6020	ND	J	1
Zinc	17	12	mg/kg	1.9	0.19	EPA-6010B	0.38		2
Aluminum	5600	4100	mg/kg	3.8	0.98	EPA-6010B	ND		2
Iron	9300	6900	mg/kg	3.8	2.8	EPA-6010B	ND		2

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-6020	10/14/10	10/15/10 17:21	PPS	PE-EL1	0.885	BTJ0961
2	EPA-6010B	10/13/10	10/14/10 11:05	ARD	PE-OP1	0.758	BTJ0827
3	EPA-7471A	10/12/10	10/12/10 14:17	MEV	CETAC1	0.947	BTJ0663



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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

EPA Method 1664

BCL Sample ID:	1014100-04	Client Sample Name:	B4 Composite Offshore Benthic Sediment, 10/7/2010 11:05:00AM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Oil and Grease	32	24	mg/kg	50	13	EPA-1664HEM	ND	J	1

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-1664HEM	10/18/10	10/18/10 11:00	JAK	MAN-SV	1	BTJ1163

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Chemical Analysis

BCL Sample ID:	1014100-04	Client Sample Name:	B4 Composite Offshore Benthic Sediment, 10/7/2010 11:05:00AM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Moisture	0	24.5	%	0.05	0.05	Calc	ND		1
Total Kjeldahl Nitrogen	130	99	mg/kg	40	15	EPA-351.2	ND		2
Volatile Solids	1.32	1.00	%	0.222	0.222	SM-2540G	ND		3
Biochemical Oxygen Demand	32	24	mg O/kg	10	10	SM17-5210B			4
Solids	100	75.5	%	0.05	0.05	SM-2540G			5

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	Calc	10/13/10	10/20/10 21:42	TMS	Calc	1	BTJ0771
2	EPA-351.2	11/02/10	11/02/10 10:10	SDU	SC-1	1	BTK0155
3	SM-2540G	10/25/10	10/25/10 10:30	NW1	MANUAL	1.108	BTK0254
4	SM17-5210B	10/08/10	10/08/10 11:25	HPR	YSI-57	0.333	BTJ0902
5	SM-2540G	10/18/10	10/19/10 17:32	RCP	MANUAL	1	BTJ1288

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Total Concentrations (TTLc)

BCL Sample ID:	1014100-04	Client Sample Name:	B4 Composite Offshore Benthic Sediment, 10/7/2010 11:05:00AM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Arsenic	3.7	2.8	mg/kg	0.50	0.37	EPA-6020	ND		1
Cadmium	ND	ND	mg/kg	0.33	0.033	EPA-6010B	ND		2
Chromium	43	32	mg/kg	0.33	0.039	EPA-6010B	ND		2
Copper	3.4	2.5	mg/kg	0.66	0.079	EPA-6010B	ND		2
Lead	2.1	1.5	mg/kg	0.25	0.047	EPA-6020	ND		1
Mercury	0.024	0.018	mg/kg	0.16	0.012	EPA-7471A	ND	J	3
Nickel	43	33	mg/kg	0.33	0.038	EPA-6010B	ND		2
Silver	ND	ND	mg/kg	0.25	0.027	EPA-6020	ND		1
Zinc	15	11	mg/kg	1.6	0.16	EPA-6010B	0.33		2
Aluminum	5200	3900	mg/kg	3.3	0.86	EPA-6010B	ND		2
Iron	8700	6500	mg/kg	3.3	2.4	EPA-6010B	ND		2

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-6020	10/14/10	10/15/10 17:23	PPS	PE-EL1	0.917	BTJ0961
2	EPA-6010B	10/13/10	10/14/10 11:08	ARD	PE-OP1	0.658	BTJ0827
3	EPA-7471A	10/12/10	10/12/10 14:20	MEV	CETAC1	0.977	BTJ0663



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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

EPA Method 1664

BCL Sample ID:	1014100-05	Client Sample Name:	B5 Composite Offshore Benthic Sediment, 10/7/2010 10:37:00AM							
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #	
Oil and Grease	38	29	mg/kg	50	13	EPA-1664HEM	ND	J	1	

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-1664HEM	10/18/10	10/18/10 11:00	JAK	MAN-SV	1	BTJ1163

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Chemical Analysis

BCL Sample ID:	1014100-05	Client Sample Name:	B5 Composite Offshore Benthic Sediment, 10/7/2010 10:37:00AM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Moisture	0	22.7	%	0.05	0.05	Calc	ND		1
Total Kjeldahl Nitrogen	98	76	mg/kg	40	15	EPA-351.2	ND		2
Volatile Solids	1.36	1.05	%	0.222	0.222	SM-2540G	ND		3
Biochemical Oxygen Demand	30	23	mg O/kg	7.5	7.5	SM17-5210B			4
Solids	100	77.3	%	0.05	0.05	SM-2540G			5

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	Calc	10/13/10	10/20/10 21:42	TMS	Calc	1	BTJ0771
2	EPA-351.2	11/02/10	11/02/10 10:11	SDU	SC-1	1	BTK0155
3	SM-2540G	10/25/10	10/25/10 10:30	NW1	MANUAL	1.108	BTK0254
4	SM17-5210B	10/08/10	10/08/10 11:25	HPR	YSI-57	0.250	BTJ0902
5	SM-2540G	10/18/10	10/19/10 17:32	RCP	MANUAL	1	BTJ1288

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Total Concentrations (TTLc)

BCL Sample ID:	1014100-05	Client Sample Name:	B5 Composite Offshore Benthic Sediment, 10/7/2010 10:37:00AM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Arsenic	3.7	2.9	mg/kg	0.50	0.37	EPA-6020	ND		1
Cadmium	ND	ND	mg/kg	0.34	0.034	EPA-6010B	ND		2
Chromium	43	33	mg/kg	0.34	0.041	EPA-6010B	ND		2
Copper	3.3	2.6	mg/kg	0.68	0.081	EPA-6010B	ND		2
Lead	2.0	1.6	mg/kg	0.25	0.047	EPA-6020	ND		1
Mercury	ND	ND	mg/kg	0.16	0.012	EPA-7471A	ND		3
Nickel	43	33	mg/kg	0.34	0.039	EPA-6010B	ND		2
Silver	ND	ND	mg/kg	0.25	0.027	EPA-6020	ND		1
Zinc	15	12	mg/kg	1.7	0.17	EPA-6010B	0.34		2
Aluminum	5300	4100	mg/kg	3.4	0.88	EPA-6010B	ND		2
Iron	8800	6800	mg/kg	3.4	2.5	EPA-6010B	ND		2

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-6020	10/14/10	10/15/10 17:26	PPS	PE-EL1	0.917	BTJ0961
2	EPA-6010B	10/13/10	10/14/10 11:10	ARD	PE-OP1	0.676	BTJ0827
3	EPA-7471A	10/12/10	10/12/10 14:22	MEV	CETAC1	0.962	BTJ0663



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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

EPA Method 1664

BCL Sample ID:	1014100-06	Client Sample Name:	B6 Composite Offshore Benthic Sediment, 10/7/2010 9:54:00AM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Oil and Grease	22	17	mg/kg	50	13	EPA-1664HEM	ND	J	1

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-1664HEM	10/18/10	10/18/10 11:00	JAK	MAN-SV	1	BTJ1163

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Chemical Analysis

BCL Sample ID:	1014100-06	Client Sample Name:	B6 Composite Offshore Benthic Sediment, 10/7/2010 9:54:00AM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Moisture	0	21.7	%	0.05	0.05	Calc	ND		1
Total Kjeldahl Nitrogen	130	98	mg/kg	40	15	EPA-351.2	ND		2
Volatile Solids	1.41	1.10	%	0.235	0.235	SM-2540G	ND		3
Biochemical Oxygen Demand	38	29	mg O/kg	10	10	SM17-5210B			4
Solids	100	78.3	%	0.05	0.05	SM-2540G			5

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	Calc	10/13/10	10/20/10 21:42	TMS	Calc	1	BTJ0771
2	EPA-351.2	10/28/10	11/04/10 13:45	SDU	SC-1	1	BTJ1450
3	SM-2540G	10/25/10	10/25/10 10:30	NW1	MANUAL	1.175	BTK0254
4	SM17-5210B	10/08/10	10/08/10 11:25	HPR	YSI-57	0.333	BTJ0902
5	SM-2540G	10/18/10	10/19/10 17:32	RCP	MANUAL	1	BTJ1288

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Total Concentrations (TTLc)

BCL Sample ID:	1014100-06	Client Sample Name:	B6 Composite Offshore Benthic Sediment, 10/7/2010 9:54:00AM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Arsenic	3.5	2.7	mg/kg	0.50	0.37	EPA-6020	0.37		1
Cadmium	ND	ND	mg/kg	0.31	0.031	EPA-6010B	ND		2
Chromium	52	41	mg/kg	0.31	0.037	EPA-6010B	ND		2
Copper	3.7	2.9	mg/kg	0.62	0.074	EPA-6010B	ND		2
Lead	2.3	1.8	mg/kg	0.25	0.047	EPA-6020	ND		1
Mercury	0.028	0.022	mg/kg	0.16	0.012	EPA-7471A	ND	J	3
Nickel	44	35	mg/kg	0.31	0.036	EPA-6010B	ND		2
Silver	ND	ND	mg/kg	0.25	0.027	EPA-6020	ND		1
Zinc	17	13	mg/kg	1.5	0.15	EPA-6010B	0.31		2
Aluminum	6000	4700	mg/kg	3.1	0.80	EPA-6010B	ND		2
Iron	9800	7700	mg/kg	3.1	2.3	EPA-6010B	ND		2

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-6020	10/14/10	10/15/10 17:29	PPS	PE-EL1	0.943	BTJ0961
2	EPA-6010B	10/13/10	10/14/10 11:12	ARD	PE-OP1	0.617	BTJ0827
3	EPA-7471A	10/12/10	10/12/10 14:24	MEV	CETAC1	0.977	BTJ0663



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Environmental Testing Laboratory Since 1949



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Ventura, CA 93003-3238

Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

EPA Method 1664

BCL Sample ID:	1014100-07	Client Sample Name:	B7 Composite Offshore Benthic Sediment, 10/7/2010 9:22:00AM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Oil and Grease	57	44	mg/kg	50	13	EPA-1664HEM	ND	J	1

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-1664HEM	10/18/10	10/18/10 11:00	JAK	MAN-SV	1	BTJ1163

Marine Research Specialists
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Ventura, CA 93003-3238

Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Chemical Analysis

BCL Sample ID:	1014100-07	Client Sample Name:	B7 Composite Offshore Benthic Sediment, 10/7/2010 9:22:00AM						
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Moisture	0	22.5	%	0.05	0.05	Calc	ND		1
Total Kjeldahl Nitrogen	120	96	mg/kg	40	15	EPA-351.2	ND		2
Volatile Solids	1.46	1.13	%	0.230	0.230	SM-2540G	ND		3
Biochemical Oxygen Demand	34	27	mg O/kg	10	10	SM17-5210B			4
Solids	100	77.5	%	0.05	0.05	SM-2540G			5

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	Calc	10/13/10	10/20/10 21:42	TMS	Calc	1	BTJ0771
2	EPA-351.2	10/28/10	11/04/10 13:47	SDU	SC-1	1	BTJ1450
3	SM-2540G	10/25/10	10/25/10 10:30	NW1	MANUAL	1.149	BTK0254
4	SM17-5210B	10/08/10	10/08/10 11:25	HPR	YSI-57	0.333	BTJ0902
5	SM-2540G	10/18/10	10/19/10 17:32	RCP	MANUAL	1	BTJ1288

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Total Concentrations (TTLIC)

BCL Sample ID: 1014100-07		Client Sample Name: B7 Composite Offshore Benthic Sediment, 10/7/2010 9:22:00AM							
Constituent	Dry Basis Result	As Recvd Result	Units	PQL	MDL	Method	MB Bias	Lab Quals	Run #
Arsenic	3.8	3.0	mg/kg	0.50	0.37	EPA-6020	0.37		1
Cadmium	ND	ND	mg/kg	0.43	0.043	EPA-6010B	ND		2
Chromium	48	37	mg/kg	0.43	0.051	EPA-6010B	ND		2
Copper	3.5	2.7	mg/kg	0.85	0.10	EPA-6010B	ND		2
Lead	2.3	1.8	mg/kg	0.25	0.047	EPA-6020	ND		1
Mercury	0.019	0.015	mg/kg	0.16	0.012	EPA-7471A	ND	J	3
Nickel	44	34	mg/kg	0.43	0.050	EPA-6010B	ND		2
Silver	ND	ND	mg/kg	0.25	0.027	EPA-6020	ND		1
Zinc	17	13	mg/kg	2.1	0.21	EPA-6010B	0.43		2
Aluminum	5600	4300	mg/kg	4.3	1.1	EPA-6010B	ND		2
Iron	9500	7300	mg/kg	4.3	3.2	EPA-6010B	ND		2

Run #	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID
1	EPA-6020	10/14/10	10/15/10 17:32	PPS	PE-EL1	0.952	BTJ0961
2	EPA-6010B	10/13/10	10/14/10 11:14	ARD	PE-OP1	0.855	BTJ0827
3	EPA-7471A	10/12/10	10/12/10 14:26	MEV	CETAC1	0.977	BTJ0663



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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

EPA Method 1664

Quality Control Report - Method Blank Analysis

Constituent	QC Sample ID	MB Result	Units	PQL	MDL	Lab Quals
QC Batch ID: BTJ1163						
Oil and Grease	BTJ1163-BLK1	ND	mg/kg	50	13	



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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

EPA Method 1664

Quality Control Report - Laboratory Control Sample

								<u>Control Limits</u>		
Constituent	QC Sample ID	Type	Result	Spike Level	Units	Percent Recovery	RPD	Percent Recovery	RPD	Lab Quals
Oil and Grease	QC Batch ID: BTJ1163									
	BTJ1163-BS1	LCS	656.00	802.00	mg/kg	81.8		59 - 117		



11/11/11

Project Manager: Doug Coats



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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Chemical Analysis

Quality Control Report - Method Blank Analysis

Constituent	QC Sample ID	MB Result	Units	PQL	MDL	Lab Quals
QC Batch ID: BTJ0771						
Moisture	BTJ0771-BLK1	ND	%	0.05	0.05	
QC Batch ID: BTJ0902						
Biochemical Oxygen Demand	BTJ0902-BLK1	ND	mg O/kg	0.98	0.98	
QC Batch ID: BTJ1450						
Total Kjeldahl Nitrogen	BTJ1450-BLK1	ND	mg/kg	40	15	
QC Batch ID: BTK0155						
Total Kjeldahl Nitrogen	BTK0155-BLK1	ND	mg/kg	40	15	
QC Batch ID: BTK0254						
Volatile Solids	BTK0254-BLK1	ND	%	0.200	0.200	



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Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Chemical Analysis

Quality Control Report - Laboratory Control Sample

Constituent	QC Sample ID	Type	Result	Spike Level	Units	Percent Recovery	RPD	Control Limits		Lab
								Percent Recovery	RPD	Quals
QC Batch ID: BTJ0902										
Biochemical Oxygen Demand	BTJ0902-BS1	LCS	199.27	198.00	mg O/kg	101		85 - 115		
QC Batch ID: BTJ1450										
Total Kjeldahl Nitrogen	BTJ1450-BS1	LCS	361.50	400.00	mg/kg	90.4		85 - 115		
QC Batch ID: BTK0155										
Total Kjeldahl Nitrogen	BTK0155-BS1	LCS	403.66	400.00	mg/kg	101		85 - 115		

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Chemical Analysis

Quality Control Report - Precision & Accuracy

									Control Limits		
Constituent	Type	Source Sample ID	Source Result	Result	Spike Added	Units	RPD	Percent Recovery	RPD	Percent Recovery	Lab Quals
QC Batch ID: BTJ0902		Used client sample: Y - Description: B1 Composite Offshore Benthic Sediment, 10/07/2010 13:10									
Biochemical Oxygen Demand	DUP	1014100-01	30.424	31.517		mg O/kg	3.5		20		
QC Batch ID: BTJ1288		Used client sample: Y - Description: B1 Composite Offshore Benthic Sediment, 10/07/2010 13:10									
Solids	DUP	1014100-01	76.880	76.680		%	0.3		20		
QC Batch ID: BTJ1450		Used client sample: Y - Description: B1 Composite Offshore Benthic Sediment, 10/07/2010 13:10									
Total Kjeldahl Nitrogen	DUP	014100-01RE´	169.94	140.92		mg/kg	18.7		20		
	MS	014100-01RE´	169.94	520.38	400.00	mg/kg		87.6		80 - 120	
	MSD	014100-01RE´	169.94	555.98	400.00	mg/kg	9.7	96.5	20	80 - 120	
QC Batch ID: BTK0155		Used client sample: Y - Description: B1 Composite Offshore Benthic Sediment, 10/07/2010 13:10									
Total Kjeldahl Nitrogen	DUP	014100-01RE¿	146.32	147.04		mg/kg	0.5		20		
	MS	014100-01RE¿	146.32	539.78	400.00	mg/kg		98.4		80 - 120	
	MSD	014100-01RE¿	146.32	544.74	400.00	mg/kg	1.3	99.6	20	80 - 120	
QC Batch ID: BTK0254		Used client sample: Y - Description: B1 Composite Offshore Benthic Sediment, 10/07/2010 13:10									
Volatile Solids	DUP	014100-01RE´	1.1902	1.1896		%	0.1		20		



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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Total Concentrations (TTLC)

Quality Control Report - Method Blank Analysis

Constituent	QC Sample ID	MB Result	Units	PQL	MDL	Lab Quals
QC Batch ID: BTJ0663						
Mercury	BTJ0663-BLK1	ND	mg/kg	0.16	0.012	
QC Batch ID: BTJ0827						
Cadmium	BTJ0827-BLK1	ND	mg/kg	0.50	0.050	
Chromium	BTJ0827-BLK1	ND	mg/kg	0.50	0.060	
Copper	BTJ0827-BLK1	ND	mg/kg	1.0	0.12	
Nickel	BTJ0827-BLK1	ND	mg/kg	0.50	0.058	
Zinc	BTJ0827-BLK1	0.50534	mg/kg	2.5	0.25	J
Aluminum	BTJ0827-BLK1	ND	mg/kg	5.0	1.3	
Iron	BTJ0827-BLK1	ND	mg/kg	5.0	3.7	
QC Batch ID: BTJ0961						
Arsenic	BTJ0961-BLK1	0.38875	mg/kg	0.50	0.37	J
Lead	BTJ0961-BLK1	ND	mg/kg	0.25	0.047	
Silver	BTJ0961-BLK1	ND	mg/kg	0.25	0.027	

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Total Concentrations (TTLC)

Quality Control Report - Laboratory Control Sample

Constituent	QC Sample ID	Type	Result	Spike Level	Units	Percent Recovery	RPD	Control Limits		Lab
								Percent Recovery	RPD	
QC Batch ID: BTJ0663										
Mercury	BTJ0663-BS1	LCS	1.3903	1.5000	mg/kg	92.7		75 - 125		
QC Batch ID: BTJ0827										
Cadmium	BTJ0827-BS1	LCS	10.360	10.000	mg/kg	104		75 - 125		
Chromium	BTJ0827-BS1	LCS	105.24	100.00	mg/kg	105		75 - 125		
Copper	BTJ0827-BS1	LCS	102.35	100.00	mg/kg	102		75 - 125		
Nickel	BTJ0827-BS1	LCS	107.40	100.00	mg/kg	107		75 - 125		
Zinc	BTJ0827-BS1	LCS	103.67	100.00	mg/kg	104		75 - 125		
Aluminum	BTJ0827-BS1	LCS	528.45	500.00	mg/kg	106		75 - 125		
Iron	BTJ0827-BS1	LCS	518.67	500.00	mg/kg	104		75 - 125		
QC Batch ID: BTJ0961										
Arsenic	BTJ0961-BS1	LCS	23.979	25.000	mg/kg	95.9		75 - 125		
Lead	BTJ0961-BS1	LCS	24.615	25.000	mg/kg	98.5		75 - 125		
Silver	BTJ0961-BS1	LCS	10.106	10.000	mg/kg	101		75 - 125		

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Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Total Concentrations (TTLC)

Quality Control Report - Precision & Accuracy

									Control Limits		
Constituent	Type	Source Sample ID	Source Result	Result	Spike Added	Units	RPD	Percent Recovery	RPD	Percent Recovery	Lab Quals
QC Batch ID: BTJ0663		Used client sample: N									
Mercury	DUP	1014105-01	0.083433	0.075224		mg/kg	10.3		20		J
	MS	1014105-01	0.083433	0.75179	0.74627	mg/kg		89.6		85 - 115	
	MSD	1014105-01	0.083433	0.82866	0.74627	mg/kg	10.9	99.9	20	85 - 115	
QC Batch ID: BTJ0827		Used client sample: N									
Cadmium	DUP	014214-07RE	ND	ND		mg/kg			20		
	MS	014214-07RE	ND	9.6212	10.000	mg/kg		96.2		75 - 125	
	MSD	014214-07RE	ND	9.5737	10.000	mg/kg	0.5	95.7	20	75 - 125	
Chromium	DUP	014214-07RE	135.17	134.93		mg/kg	0.2		20		
	MS	014214-07RE	135.17	222.04	100.00	mg/kg		86.9		75 - 125	
	MSD	014214-07RE	135.17	227.47	100.00	mg/kg	6.1	92.3	20	75 - 125	
Copper	DUP	014214-07RE	11.945	12.075		mg/kg	1.1		20		
	MS	014214-07RE	11.945	112.29	100.00	mg/kg		100		75 - 125	
	MSD	014214-07RE	11.945	112.55	100.00	mg/kg	0.3	101	20	75 - 125	
Nickel	DUP	014214-07RE	10.333	10.103		mg/kg	2.3		20		
	MS	014214-07RE	10.333	105.11	100.00	mg/kg		94.8		75 - 125	
	MSD	014214-07RE	10.333	104.28	100.00	mg/kg	0.9	94.0	20	75 - 125	
Zinc	DUP	014214-07RE	38.900	37.570		mg/kg	3.5		20		
	MS	014214-07RE	38.900	127.60	100.00	mg/kg		88.7		75 - 125	
	MSD	014214-07RE	38.900	132.09	100.00	mg/kg	4.9	93.2	20	75 - 125	
Aluminum	DUP	014214-07RE	9223.2	9102.6		mg/kg	1.3		20		
	MS	014214-07RE	9223.2	9921.1	500.00	mg/kg		140		75 - 125	A03
	MSD	014214-07RE	9223.2	10309	500.00	mg/kg	43.5	217	20	75 - 125	A03,Q02
Iron	DUP	014214-07RE	16184	15913		mg/kg	1.7		20		
	MS	014214-07RE	16184	15889	500.00	mg/kg		-59.0		75 - 125	A03
	MSD	014214-07RE	16184	17167	500.00	mg/kg	372	197	20	75 - 125	A03,Q02
QC Batch ID: BTJ0961		Used client sample: N									
Arsenic	DUP	1014183-06	3.4412	3.4918		mg/kg	1.5		20		
	MS	1014183-06	3.4412	27.486	25.000	mg/kg		96.2		75 - 125	
	MSD	1014183-06	3.4412	28.390	25.000	mg/kg	3.7	99.8	20	75 - 125	
Lead	DUP	1014183-06	14.350	14.199		mg/kg	1.1		20		
	MS	1014183-06	14.350	37.159	25.000	mg/kg		91.2		75 - 125	
	MSD	1014183-06	14.350	37.592	25.000	mg/kg	1.9	93.0	20	75 - 125	
Silver	DUP	1014183-06	0.12500	0.11350		mg/kg	9.6		20		J
	MS	1014183-06	0.12500	9.8638	10.000	mg/kg		97.4		75 - 125	
	MSD	1014183-06	0.12500	10.262	10.000	mg/kg	4.0	101	20	75 - 125	



Marine Research Specialists
3140 Telegraph Road, Suite A
Suite A
Ventura, CA 93003-3238

Reported: 11/09/2010 12:40
Project: Annual Benthic Sediment Sampling for MBTP
Project Number: [none]
Project Manager: Doug Coats

Notes And Definitions

J	Estimated Value (CLP Flag)
MDL	Method Detection Limit
ND	Analyte Not Detected at or above the reporting limit
PQL	Practical Quantitation Limit
RPD	Relative Percent Difference
A03	The sample concentration is more than 4 times the spike level.
Q02	Matrix spike precision is not within the control limits.



Report To: Marine Research Specialists Client: _____		Project #: _____		Analysis Requested										Comments: 11 Metals (EPA 6010B/6020/7471A): As, Cd, Ch, Cu, Pb, Ni, Ag, Zn, Al, Fe, and Hg											
Attn: Doug Coats		Project Name: MBCSD Benthic																							
Street Address: 3140 Telegraph Rd. Suite A		Global ID #:																							
City, State, Zip: Ventura, CA 93003		Sampler(s):																							
Phone: 805-644-1180																									
Email Address: doug.coats@mrsenv.com				Sample Matrix <table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td>Soil</td> <td>Sludge</td> <td>Drinking Water</td> <td>Ground water</td> <td>Waste Water</td> <td>Other</td> </tr> <tr> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> <td> </td> </tr> </table>										Soil	Sludge	Drinking Water	Ground water	Waste Water	Other						
Soil	Sludge	Drinking Water	Ground water											Waste Water	Other										
Work Order# 1014100																									
				Are there any tests with holding times less than or equal to 48 hours? ☒ Yes ☐ No																					
				Notes																					
				SHORT HOLDING TIME Cr ⁶ NO ₂ NO ₃ OP SS DO Cl ₂ <u>205</u> MBAS COT																					
				CHECK BY: CAM DISTRIBUTION: RTU, SLE SUB-OUT																					
				Sample Disposal ☐ Return to Client ☒ Disposal by lab ☐ Archive Months _____																					
				Special Reporting ☐ QC ☐ EDF ☐ Raw Data																					
				Client: _____ Address: _____ City: _____ State _____ Zip _____ Attn: _____ PO#: _____																					
				EDF Required? ☐ Yes ☒ No Send Copy to State of CA? ☐ Yes ☒ No																					
				1. Relinquished By: <u>Bon Rhu</u> Date: <u>10/7/10</u> Time: <u>17:00</u> 2. Relinquished By: <u>Jen M</u> Date: <u>10-7-10</u> Time: <u>2050</u> 3. Relinquished By: _____ Date: _____ Time: _____																					
				1. Relinquished By: <u>Jen M</u> Date: <u>10/7/10</u> Time: <u>1700</u> 2. Relinquished By: _____ Date: _____ Time: _____ 3. Relinquished By: _____ Date: _____ Time: _____																					

#1014100

**Attachment (Page 2 of 2) to Chain of Custody Form
Morro Bay Benthic Sediment Sampling
Thursday, 7 October 2010**

The following analyses should be conducted on the **composited** soil matrix using procedures and a QC Level similar to the analyses conducted in 2009 on BC Laboratory Sample Number **09-14065**. Prior to analysis, macrofauna and large remnants greater than 0.25 inches should be removed, taking care to avoid contamination. **Additionally, prior to analysis, homogenize the composite sample in the laboratory to ensure uniform distribution of multiple subsamples in sample container(s).** All results should be reported on an as-received (raw) basis and where appropriate, on a **dry-weight basis**. The required analyses are:

Constituent		Samples	Method
Moisture		7	160.3 or BC
Total Volatile Solids		7	160.4 or SM-2540G
Biochemical Oxygen Demand		7	405.1 or SM17-5210B
Total Kjeldahl Nitrogen		7	351.2
Oil and Grease		6	413.2 or EPA-1664/HEM
Metals (11)			
	Aluminum	7	SW-6010
	Iron	7	SW-6010
	Arsenic	7	SW-7060
	Cadmium	7	SW-6010
	Total Chromium	7	SW-6010
	Copper	7	SW-6010
	Lead	7	SW-7421
	Mercury	7	SW-7471
	Nickel	7	SW-6010
	Silver	7	EPA-272.2
	Zinc	7	SW-6010

Questions can be directed to Bonnie Luke at Marine Research Specialists at (805) 289-3926.

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APPENDIX F
Laboratory Quality Assurance and Quality Control Plans

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APPENDIX F

Quality Assurance/Quality Control

Government organizations and respected contract research facilities now require specific Quality Assurance Programs and Plans for all scientific research efforts. Marine Research Specialists (MRS), without exception, abides by these requirements and has integrated Quality Assurance procedures in their normal course of scientific investigations. We pride ourselves on excellence and objectivity in research, and we support that pride with Quality Assurance and Quality Control procedures, which are documented by SOP's. These procedures have been developed through the years in support of major environmental programs for clients such as the U.S. Environmental Protection Agency, U.S. Department of Commerce (NOAA), and the U.S. Department of the Interior (Minerals Management Service).

The quality assurance procedures for work undertaken in this program meet all MRS requirements for assuring the reliability of monitoring and measurement data. This level of QA/QC is also applicable to all subcontractors working on this monitoring program under the direction of MRS. The procedures form an integrated program for assuring complete, accurate, precise, and representative data under defined requirements. Our general quality assurance requirements are discussed below.

Program Management. The basis of any sound QA/QC program resides with the Program Manager. She ensures that monitoring program activities, client-approved changes in scope, and progress are well documented throughout the duration of the monitoring program. She also ensures that specific QA/QC documentation such as field observation logs, sampling logs (separate logs are maintained for water, sediment and infauna samples), and sample transfer forms are properly and accurately recorded and maintained. It is important to note that each and all samples maintain unique sample codes throughout the sample collection, analyses, and reporting phases of the monitoring program.

The Program Manager, Ms. Bonnie Luke, also conducts QA/QC reviews of our subcontractors, BC Laboratories and Aquatic Testing Laboratories, to ensure that their QA/QC procedures, described on the following pages are adhered to. They are promptly notified of any deviation and the need for corrective action.

Field Sampling. All field sampling equipment is calibrated according to manufacturer's specifications. Logs are maintained for the Sea-Bird SBE-19 Seacat CTD Profiler with the number of casts and cast locations recorded. Calibration results are also recorded into the log. Periodically, the CTD is returned to the manufacturer for a complete bench testing and calibration. The CTD was factory calibrated and fully tested at the Sea Bird Testing Facility in November 1999 and again in October 2001.

The Van Veen sediment grab sampler and subsamplers are cleaned with noncontaminating solvents between all collections of sediment chemistry samples. The solvents include methanol for the removal of organics and de-ionized water and HCl for the removal of metals. The grab sampler and sediment subsamplers such as scoops, are coated with noncontaminating Dykor® to limit contamination of chemistry samples from the sampling equipment. Similarly, all sediment sample containers are pre-cleaned and acid washed accorded to USEPA specifications. The grab sampler was recoated with Dykor® in September 1999.

Laboratory Analysis. QA/QC procedures are also used in the laboratory for grain-size analysis and sorting benthic infauna samples. A minimum of 10 percent of all samples sorted by any one technician are resorted by another technician. The level of sorting error must not exceed five percent (i.e. the sample residue that is resorted by another technician must not contain more than five percent of the total number of organisms contained in the original sample). Additionally, all samples sorted by a technician who is in

the process of being trained are subject to quality control inspection. A technician is considered a trained sorter if they pass quality control inspection in five consecutive samples. Ms. Bonnie Luke is currently the lead technician for MRS for both grain-size analysis and benthic sample sorting.

Independent QA/QC Audit. In addition to the QA/QC auditing performed by the Program Manager, an independent semi-random audit on project performance is conducted by Dr. Douglas A. Coats. Dr. Coats reviews all reports for completeness, thoroughness, accurateness, and errors. He also performs periodic unannounced audits on monitoring program status and additionally, calls or meets independently with the Public Works Department's project officer for an evaluation of our performance.

Subcontracted Laboratories. The following Quality Assurance guidelines and methods for subcontractor laboratories are excerpts from the full Quality Assurance Manuals of BC Laboratories and Aquatic Testing Laboratories. The full QA documents are too voluminous to provide in complete form in this annual report but are on file at MRS. BC Laboratories of Bakersfield California, performed the chemical analyses for treatment plant effluent and sludge and the offshore sediments. Aquatic Testing Laboratories of Ventura analyzed the effluent for acute and chronic toxicity levels.

2010

Morro Bay / Cayucos Wastewater Treatment Plant

LABORATORY QUALITY ASSURANCE MANUAL Updated 3-16-10

Bruce Keogh, Lab Director_____ **Date:**_____
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INTRODUCTION

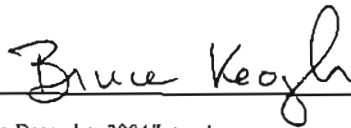
The Morro Bay – Cayucos Wastewater Treatment Plant Laboratory provides analytical services for the Morro Bay – Cayucos Wastewater Treatment Plant located at 160 Atascadero Road, the mailing address is 955 Shasta, Morro Bay, CA.

The laboratory analyzes samples of wastewater effluent, influent, and sludges on a daily, weekly, or monthly basis for physical parameters. Microbiological samples are analyzed daily, weekly, and monthly.

The laboratory only analyzes samples from the Morro Bay – Cayucos Wastewater Treatment Plant. The laboratory does not accept samples for analysis from outside sources.

There are currently two positions in the laboratory, the Laboratory Director and the laboratory analyst.

Bruce Keogh, Lab Director



Date: 1-31-05

MONITORING AND REPORTING PROGRAM NO. 98-15
FOR
CITY OF MORRO BAY AND CAYUCOS SANITARY DISTRICT
WASTEWATER TREATMENT PLANT
SAN LUIS OBISPO COUNTY

The monitoring program for a discharger receiving a 301(h) modified National Pollutant Discharge Elimination System (NPDES) permit is intended to: a) document short and long-term effects of the discharge on receiving waters, sediments, biota, and on beneficial uses of the receiving water; b) determine compliance with NPDES permit items and conditions; and c) assess the effectiveness of industrial pretreatment and toxics control programs.

The Regional Water Quality Control Board (Regional Board) and U.S. Environmental Protection Agency, Region IX (EPA) may revise the monitoring program presented herein, within the specified order and permit period. The program will be reviewed at annual intervals to assess its effectiveness at meeting the objectives stated above. If predictable relationships among effluent, water quality and biological monitoring variables can be clearly demonstrated, it may be appropriate to decrease certain elements of the monitoring program. Conversely, the monitoring program may be intensified if it appears that the above objectives cannot be achieved through the existing monitoring program.

INFLUENT MONITORING

Representative samples of influent to the treatment plant shall be collected (upstream of any in-plant return flows) and analyzed as follows:

<u>Constituent</u>	<u>Units</u>	<u>Sample Type</u>	<u>Minimum Frequency</u> <u>Sampling/Analysis</u>
BOD ₅ (20°C)	mg/l	24-hr Composite	Weekly
Suspended Solids	mg/l	24-hr Composite	Weekly

Influent flow metering shall be required if the Executive Officer determines such monitoring is necessary to identify sources of noncompliance with this Order.

EFFLUENT MONITORING

Representative effluent samples shall be collected (downstream of any inplant return flows or disinfection units) and analyzed as follows:

<u>Constituent</u>	<u>Units</u>	<u>Sample Type</u>	<u>Minimum Frequency</u> <u>Sampling/Analysis</u>
Daily Flow	MG	Metered	Daily
Maximum Daily Flow	MGD	Metered	Daily
Mean Daily Flow	MGD	Calculated	Monthly
Total Chlorine Residual	mg/l	Grab	Daily
Chlorine Used	lbs/day	Recorded	Daily
Total Coliform	MPN	Grab	5 days/week ¹
Temperature	°C	Grab	5 days/week)
Turbidity	NTU	Grab	5 days/week)
BOD ₅ (20°C)	mg/l	24-hr Composite	Weekly ¹
Suspended Solids	mg/l	24-hr Composite	Weekly ¹
pH	pH units	Grab	Weekly ¹
Settleable Solids	ml/l	Grab	Weekly
Grease and Oil	mg/l	Grab	Weekly
Acute Toxicity	TUa	Grab	Quarterly (Jan/Apr/July/Oct)
Chronic toxicity	TUc	24-hr Composite	Semi-annually (Jan/July)
Ammonia (as N)	mg/l	Grab	Monthly
Phenolic Compounds (non-chlorinated)	mg/l	Grab	Semi-annually
Chlorinated Phenolics	mg/l	Grab	Semi-annually

If results of monitoring a constituent appear to violate effluent limitations based on a weekly, monthly, 30-day, or six-month period, but compliance or non-compliance cannot be validated because sampling is too infrequent, the frequency of sampling shall be increased to validate the test within the next monitoring period. The increased frequency shall be maintained until the Executive Officer agrees the original monitoring frequency may be resumed, as stated in B.2 of the Standard Provisions and Reporting Requirements.

FOOTNOTES:

1. Sampling shall be arranged so that each day of the 7-day week is represented, at least once, each month, or every two (2) months for weekly sampling. For samples collected 5 times per month, at least one (1) sample shall be taken weekly, and sampling should be arranged so that each day of the 7-day week is represented, at least once, every two (2) months.
2. Dischargers may at their option meet this limitation as total chromium limitation.
3. ENDOSULFAN shall mean the sum of endosulfan-alpha and -beta and endosulfan sulfate.
4. HCH shall mean the sum of the alpha, beta, gamma (lindane), and delta isomers of hexachlorocyclohexane.
5. DICHLOOROBENZENES shall mean the sum of 1,2- and 1,3-dichlorobenzene.
6. CHLORDANE shall mean the sum of chlordane-alpha, chlordane-gamma, chlordene-alpha, chlordene-gamma, nonachlor-alpha, nonachlor-gamma, and oxychlordane.
7. DDT shall mean the sum of 4,4-DDT, 2,4-DDT, 2,4-DDE, 4,4-DDD, and 2,4-DDD.
8. HALOMETHANES shall mean the sum of bromoform, bromomethane (methyl bromide), chloromethane (methyl chloride), chlorodibromomethane, and dichlorobromomethane.
9. HEPTACHLOR shall mean the sum of heptachlor and heptachlor epoxide.
10. PAHs (polynuclear aromatic hydrocarbons) shall mean the sum of acenaphthylene, anthracene, 1,2-benzanthracene, 3,4-benzofluoranthene, benzo[k]fluoranthene, 1,12-benzoperylene, benzo[a]pyrene, chrysene, dibenzo[ah]anthracene, fluorene, indeno[1,2,3-cd]pyrene, phenanthrene, and pyrene.
11. PCBs (polychlorinated biphenyls) shall mean the sum of chlorinated biphenyls whose analytical characteristics resemble those of Aroclor-1016, Aroclor-1221, Aroclor-1232, Aroclor-1242, Aroclor-1248, Aroclor-1254 and Aroclor-1260.
12. TCDD EQUIVALENTS shall mean the sum of the concentrations of chlorinated dibenzodioxins (2,3,7,8-CDDs) and chlorinated dibenzofurans (2,3,7,8-CDFs) multiplied by their respective toxicity factors, as shown below:

Isomer Group	Toxicity Equivalent Factor
2,3,7,8-tetra CDD	1.0
2,3,7,8-penta CDD	0.5
2,3,7,8-hexa CDDs	0.1
2,3,7,8-hepta CDD	0.01
octa CDD	0.001
2,3,7,8-tetra CDF	0.1

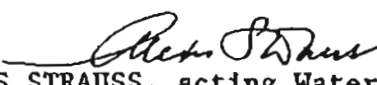
Isomer Group	Toxicity Equivalent Factor
1,2,3,7,8-penta CDF	0.05
2,3,4,7,8-penta CDF	0.5
2,3,7,8-hexa CDFs	0.1
2,3,7,8-hepta CDFs	0.01
octa CDF	0.001

13. Mass emission based on detectable concentrations.
14. Mass emission based on Table B effluent limit concentrations listed in the Order No. 98-15.

This certifies that the foregoing is a full, true and correct copy of an order adopted by the California Regional Water Quality Control Board, Central Coast Region, on December 11, 1998, and of a NPDES permit issued by the U.S. Environmental Protection Agency, Region IX, on 26 January, 1999



ROGER W. BRIGGS, Executive Officer
California Regional Water Quality Control Board
Central Coast Region



ALEXIS STRAUSS, acting Water Division Director for
FELICIA MARCUS, Regional Administrator
U.S. Environmental Protection Agency
Region IX

Quality Assurance Objectives

The role of the analytical laboratory is to provide qualitative and quantitative data to be used in decision making. To be valuable, the data must accurately describe the characteristics or the concentration of constituents in the sample submitted to the laboratory. In many cases, an approximate answer or incorrect result is worse than no answer at all, because it will lead to faulty interpretations.

Decisions made using data from water and wastewater are far reaching. Water quality standards are set to establish satisfactory conditions for a given water use. The laboratory data define whether that condition is being met, and whether the water can be used for its intended purpose. If the laboratory results indicate a violation of the standard, action is required on the part of pollution control authorities. With the present emphasis on legal action and social pressures to abate pollution, the analyst should be aware of his or her responsibility to provide laboratory results that are a reliable description of the sample. Furthermore, the analyst must be aware of his or her professional competence, the procedures he or she has used, and the reported values may be used and challenged in court. To satisfactorily meet this challenge, the laboratory data must be backed up by an adequate program to document the proper control and application of all of the factors which affect the result.

In wastewater analyses, the laboratory data define the treatment plant influent, the status of the steps in the treatment process, and the final load imposed upon the water resources. Decisions on process changes, plant modification, and even the construction of a new facility is based upon the results of laboratory analysis.

Research investigations in water pollution control rest upon a firm base of laboratory data. The final result sought can usually be described in numerical terms. The progress of the research and the alternative pathways available are generally evaluated on the basis of laboratory data. The value of the research effort will depend on the validity of laboratory results.

Because of the importance of laboratory analyses and the resulting actions that they produce, a program to ensure the reliability of the data is essential. It is recognized that all analysts practice quality control to varying degrees, depending somewhat upon their training, professional pride, and awareness of the importance of the work they are doing. An established, routine control program applied to every analytical test is important in assuring the reliability of the final results.

The Quality Control Program in the laboratory has two primary functions. First, the program should monitor the reliability or truth of the results reported. It should continually provide an answer to "How good or true are the results submitted?" This phase may be a "measurement of quality." The second function is the control of the quality in order to meet the program requirements for reliability. For example, the processing of spiked samples is the measurement of quality, while the use of analytical grade reagents is a control measure. Just as each analytical method has a rigid protocol, so the quality control associated with that test must also involve definite required steps to monitor and assure that the result is correct. Ideally, all of the variables, which can affect the final answer should be considered, evaluated, and controlled.

Bruce Keogh, Lab Director

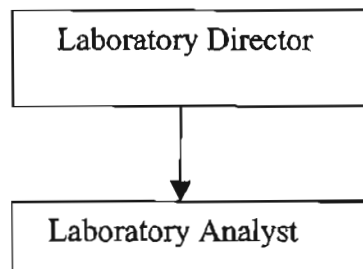
Bruce Keogh Date: 1-31-05

Lab/C/MyDocuments/Lab QC Docs/Lab QA Updates December 2004/qualityassuranceobjectives.doc

PROGRAM ORGANIZATION AND RESPONSIBILITY

The responsibility for the Quality Control Program lies with the Laboratory Director who collects, interprets, and reviews all the data from various quality control measures taken in the laboratory. It is the responsibility of this Quality Control official to make sure that each analyst in the laboratory is performing their duties of quality control measures and proper documentation of sample collection, preservation and analyses. It is therefore requested that all laboratory employees read this Quality Assurance Manual and become familiar with all the quality control terminology, methodology, and procedures. Without exception, the final responsibility for the reliability of the analytical results rest with the Laboratory Director.

The Morro Bay – Cayucos Wastewater Treatment Plant Laboratory is organized as follows:



Responsibilities for each position in the Morro Bay – Cayucos Wastewater Treatment Plant Laboratory are as follows:

Laboratory Director

The managerial, administrative, and supervisory level position for the laboratory is responsible for the planning, implementation, and supervision of the laboratory testing and water quality control programs to comply with local, State, and Federal standards. Supervisory duties include making assignments of work, setting priorities, training and inspecting work, selection of employees, preparing performance evaluations and recommending recognition and disciplining of subordinates.

Laboratory Analyst

The chemist level position for the laboratory is responsible for the physical, chemical, and biological testing of water, wastewater, and sludges. Additional responsibilities include sampling and cleaning and preparing laboratory glassware. Analyses include pH, turbidity, total chlorine residual, suspended solids, BOD, oil & grease, volatile acids, alkalinity, and total and fecal coliforms. Assisting in the training and supervision of other laboratory analysts, assigning, instructing, monitoring, and correcting work.

Bruce Keogh, Lab Director Bruce Keogh Date: 1-31-05
Lab/C/My Documents/Lab QC Docs/Lab QA Update December 2004/Program Organization and Responsibility

LABORATORY GENERAL PROCEDURES

There are some standard operating procedures that all laboratories have to ensure that procedures are performed the same way by each analyst and are a form of Quality Control.

Glassware

1. After dumping sample, rinse with water and apply FL70 detergent located at sink. Scrub or brush unit until all of sample has been removed from glassware. Glassware should then be rinsed at least three times with hot water. After rinsing with tap water, rinse again with DI water. Dry glassware is ready for use. **Note:** If there is a change in the formulation used, or a change in the method of washing a glassware inhibitory residue test must be performed.
2. Broken, cracked, or chipped glassware is to be discarded.

Sample Custody

1. Sample bottles are labeled either prior to sampling by the lab or during sampling by the sampler.
2. Chain of Custody sheets, filled out completely, must accompany all samples sent to other laboratories for analysis.
3. A copy of Chain of Custody sheets are kept in a separate file in the laboratory file cabinet.

Quality Control

1. Use volumetric glassware and pipettes for all analyses.
2. Label all reagents with name, date, and expiration.
3. Record all temperatures of lab equipment on a daily basis.
4. Keep the laboratory benchtops, floors, and instruments neat and clean.
5. Double check your calculations or have them checked by another analyst.
6. Standards should reflect a high and low value, with the sample close to the middle standard.
7. Rerun any questionable sample results to verify your analyses.

Safety Practices

1. Be familiar with the Material Safety Data Sheets (MSDS) for any chemical you are working with.
2. Do not pipette liquids by mouth.
3. Wear safety glasses when working with strong acids or bases.
4. Wear a lab coat or apron when working in the lab.
5. Use the fume hood to vent hazardous materials.
6. Wipe up any spills on the floors or counter tops immediately.
7. If a large chemical spill occurs use the chemical spill kit.
8. Know where the fire blanket, extinguishers, and showers are located.
9. No eating, drinking, or smoking is allowed in the lab.

10. Wear gloves and then wash hands after working with sewage, sludge, coliform bacteria, or any chemical.
11. Clean up your glassware from your work area when done & wipe counters.
12. Return any chemicals used to the chemical storage area.
13. Try to predict any safety hazards you will encounter before performing a task.
14. Inform the supervisor of any accident or injury immediately.

Bruce Keogh, Lab Director Bruce Keogh Date: 1-31-05
Lab/C/My Documents/Lab QC Docs/Lab QA update December 2004/Laboratory General Procedures

PREVENTATIVE MAINTENANCE

Since instrumentation is heavily relied upon in the laboratory it must be kept clean and well maintained. A computerized work order program, Datastream MP2 Access, is used to schedule and record all preventative maintenance procedures performed on turbidimeters, dissolved oxygen meters, composite samplers, ovens, autoclave, waterbaths, analytical balances, and pH meters. Calibration records of all instruments are also kept in the appropriate folders in the laboratory file cabinet.

Distilled Water: Distilled water is used in the laboratory for dilutions and final rinsing of glassware. We currently use bottled, distilled water from Arrowhead. The water quality is tested and assured from the distributor, a copy of the results are located in the laboratory file cabinet.

Analytical Balances: The laboratory balances are cleaned and serviced annually by a balance technician.

Temperature Logs: Temperature logs are kept on all ovens, incubators, refrigerators, and water baths. Temperatures are recorded twice daily or when in use. Thermometers are compared annually against a certified National Bureau of Standards thermometer and recorded on the temperature logs. Thermometers are also labeled with any corrective factor.

Composite Samplers: Composite samplers have tubing for the sample line and the peristaltic pump. This tubing needs to be cleaned every two weeks due to algae growth. The tubing must be replaced when cracked or worn. Dessicant, inside the control box of the sampler needs to be changed whenever indicator turns pink.

Turbidimeter: The Hach 2100N Turbidimeter needs to be cleaned and serviced per the manufacturers recommendations.

Bruce Keogh, Lab Director Bruce Keogh **Date:** 1-31-05

SYSTEM AUDITS

The laboratory participates annually in the National Pollutant Discharge Elimination System (NPDES) DMR-QA Laboratory Performance Evaluation sponsored by the U.S. Environmental Protection Agency. The samples are purchased from a list of accredited providers and the samples are analyzed along with the lab's regular samples and the results are reported. The accredited provider submits a report to the laboratory and the USEPA that notes whether sample results were acceptable or unacceptable. Any sample result receiving a not acceptable report requires a letter of corrective action be submitted to the State coordinator for USEPA within the specified time period.

The laboratory applies for certification with the California State Department of Health Services every two years as part of their Environmental Laboratory Accreditation Program (ELAP). The laboratory participates in Water Pollution Laboratory Performance Evaluation Studies (WP) for chemistry and microbiological samples on an annual basis. The samples are purchased from a list of accredited providers and the samples are analyzed along with the lab's regular samples and the results are reported. The accredited provider submits a report to the laboratory and to ELAP that notes whether sample results were acceptable or unacceptable. Any sample result receiving a not acceptable report requires a letter of corrective action be submitted to ELAP within the specified time period.

An additional requirement for the State Department of Health Services ELAP certification is a site visit and inspection of the laboratory every two years. The results of the visit and any deficiencies noted are sent back to the lab to be corrected.

Bruce Keogh, Lab Director Bruce Keogh Date: 1-31-05

Lab/C/My Documents/Lab QC Docs/ Lab QA Updates December 2004/System Audits

SAMPLING POINTS AND TECHNIQUES

Sampling is a very important part of analysis. It should always be done with great consistency at the same point and the same technique should always be employed to insure a representative sample. Because of the importance of this subject sample, it is necessary to have outlined procedure and set points for obtaining various samples for analysis.

Sample containers can greatly affect the constituent to be determined. Cations can absorb readily on some plastics and glassware. Metal or aluminum foil cap liners can interfere with metals analyses. How the sample containers are washed and cleaned are also a significant factor in quality control.

All samples should be refrigerated while they are being transported to the laboratory. If the samples cannot be analyzed immediately they should be refrigerated and analyzed as soon as possible. The following page contains our guidelines for sample containers, preservative used and the holding times for most of the samples we pull for analysis by the Morro Bay – Cayucos Wastewater Treatment Plant laboratory or a contract laboratory.

It is essential to ensure sample integrity from collection to data reporting. This includes the ability to trace possession and handling of the sample from the time of collection through analysis and final disposition. This is referred to as chain of custody and is important in the event of litigation involving the analytical results. Where litigation is not involved, chain of custody procedures are useful for routine control of sample flow. Samples that come into the laboratory on a daily basis do not need a chain of custody, but are logged into the laboratory workbook.

A sample is considered to be under a person's custody if it is in the individual's physical possession, in the individual's sight, secured in a tamper proof way by that individual, or is secured in an area restricted to authorized personnel.

All composite samples of final effluent should be collected from the Sigma 900 refrigerated automatic composite sampler currently located on top of the chlorine contact chamber. The sampler should be pre-set according to manufacturer instructions located in the filing cabinet in the laboratory. The effluent grab samples are obtained from the air relief structure, located downstream from the chlorine contact chamber.

If bacteriological samples are needed from the plant final effluent then samples should be collected at the discharge end of the chlorine contact chamber, using sterile sample bottles containing sodium thiosulfate which de-chlorinates the sample.

Influent samples are taken at the headworks and again a Sigma 900 refrigerated automatic composite sampler is employed for obtaining composite samples.

Digester sludge samples are obtained at the valve manifold for each digester. They are all marked and samples can be obtained from any elevation desired. Close

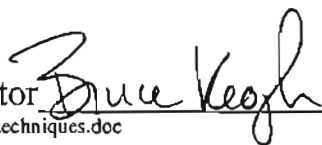
attention should be given to flushing the line by opening the valve and letting the old sludge in the line to run for at least two minutes. Then grab the sample.

Grab samples of mixed liquor suspended solids and return activated sludge are obtained at the south end of the solids contact channel and in the return sludge box respectively on the top of the secondary clarifier.

Samples of primary clarifiers are obtained by holding a beaker or container close to the weirs, where the primary process water is being discharged over the weirs. Samples of trickling filters are collected at the wet well next to them.

Bruce Keogh, Lab Director

Mydocuments/LabQCdocs/samplepoints&techniques.doc

 Date: 1-31-05

Sludge Monitoring

- Maintain a record of the volume of solids generated and disposal sites used.

A. SURF ZONE MONITORING

Station Locations

(see attached Station Location Map)

Shore Stations

Description

A1	Surf, 1700 meters (5600') upcoast of Station C
A	Surf, 610 meters (2000') upcoast of Station C
B	Surf, 305 meters (1000') upcoast of Station C
C	Surf, at point closest to outfall diffuser
D	Surf, 305 meters (1000') downcoast of Station C
E	Surf, 610 meters (2000') downcoast of Station C
F	Surf, 1520 meters (5000') downcoast of Station C

Grab samples shall be taken at all shore stations weekly during summer months (May-October) and monthly during winter months (November-April). Samples shall be analyzed for fecal and total coliform organisms.

Monitoring shall include observations of wind (direction and speed), weather (e.g., cloudy, sunny, rainy), waves, longshore currents (e.g., direction), and tidal conditions (e.g., high, slack, or low tide). Observations of water discoloration, floating oil and grease, turbidity, odor and materials of sewage origin in the water or on the beach shall be recorded. The water temperature (°C) shall also be recorded. The sample shall be collected as far seaward within the surf zone as possible.

CITY OF MORRO BAY WWTP
CHAIN OF CUSTODY

Project Name:	Date:
Project Mngr:	Page _____ Of _____
City of Morro Bay	Special Instruction's:
160 Atascadero Rd.	
Morro Bay, Ca. 93442	
Phone # 805-772-6273	

Sample I.D.	Date	Time	Analysis Requested	Remark's

Relinquished/ Received By:	Date	Time	Firm/City	Signature:

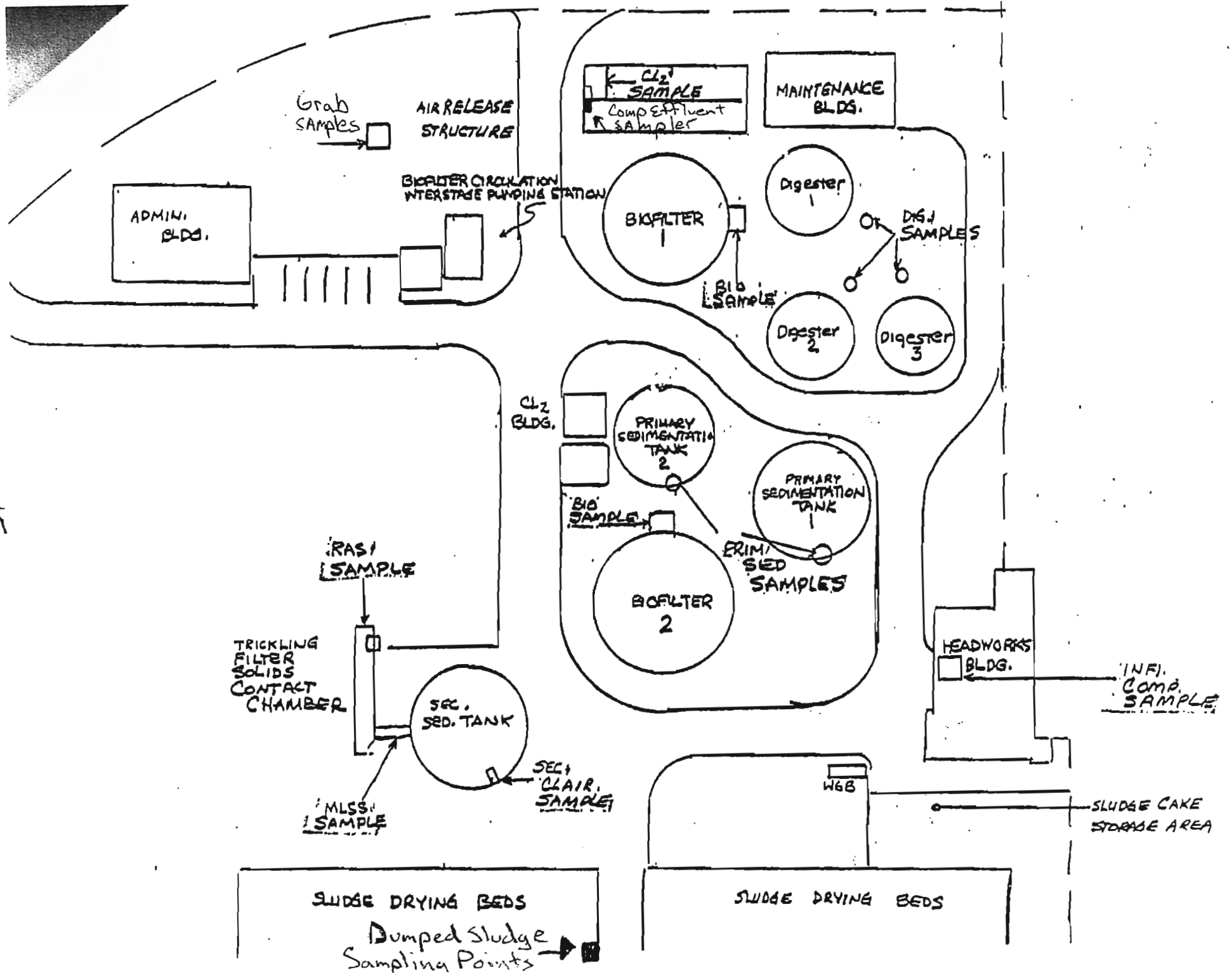
SAMPLING AND PRESERVATION
OF SAMPLES ACCORDING TO MEASUREMENT (1)

4A

Measurement	Container	Preservative	Holding Time (6)
Acidity	P,G (2)	Cool, 4°C	24 Hours
Alkalinity	P,G	Cool, 4°C	24 Hours
BOD	P,G	Cool, 4°C	6 Hours (3)
COD	P,G	H ₂ SO ₄ to pH 2	7 Days
Chloride	P,G	None Req.	7 Days
Chlorine Resid.	P,G	Det. on site	No Holding
Color	P,G	Cool, 4°C	24 Hours
Dissolved Oxygen			
Probe	G only	Det. on site	No Holding
Winkler	G only	Fix on site	No Holding
Hardness	P,G	Cool, 4°C	7 Days
MBAS	P,G	Cool, 4°C	24 Hours
Nitrogen			
Ammonia	P,G	Cool, 4°C H ₂ SO ₄ to pH 2	24 Hours (4)
Kjeldahl	P,G	Cool, 4°C H ₂ SO ₄ to pH 2	24 Hours (4)
Nitrate	P,G	Cool, 4°C H ₂ SO ₄ to pH 2	24 Hours (4)
Nitrite	P,G	Cool, 4°C H ₂ SO ₄ to pH 2	24 Hours (4)
Oil & Grease	G only	Cool, 4°C H ₂ SO ₄ to pH 2	24 Hours
Organic Carbon	P,G	Cool, 4°C H ₂ SO ₄ to pH 2	24 Hours
pH	P,G	Cool, 4°C Det. on site	6 Hours (3)

Measurement	Container	Preservative	Holding Time (6)
Residue			
Filterable	P,G	Cool, 4°C	7 Days
Non-filterable	P,G	Cool, 4°C	7 Days
Total	P,G	Cool, 4°C	7 Days
Volatile	P,G	Cool, 4°C	7 Days
Settleable-Matter	P,G	None Req.	24 Hours
Specific-Conductance	P,G	Cool, 4°C	24 Hours (5)
Sulfide	P,G	2 ml. zinc acetate	24 Hours
Temperature	P,G	Det. on site	No Holding
Threshold Odor	G only	Cool, 4°C	24 Hours
Turbidity	P,G	Cool, 4°C	7 Days

1. A general discussion on sampling water and industrial wastewater may be found in ASTM, part 23, p. 72-91 (1973)
2. Plastic or Glass
3. If samples cannot be returned to the laboratory in less than 6 hours and holding time exceeds this limit, the final reported data should indicate the actual holding time.
4. Mercuric chloride may be used as an alternate preservative at a concentration of 40 mg/l, especially if a longer holding time is required.
5. If the sample is stabilized by cooling, it should be warmed to 25°C for reading, or temperature correction made and result reported at 25°C.
6. It has been shown that samples properly preserved may be held for extended periods beyond the recommended holding time.

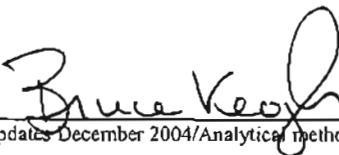


ANALYTICAL METHODS

The following methods are used by the Morro Bay – Cayucos Wastewater Treatment Plant Laboratory and taken from Standard Methods for the Examination of Water and Wastewater, 18th Edition.

<u>Analysis</u>	<u>Method No.</u>
pH.....	SM4500-H+B
Turbidity.....	SM2130B
Total Chlorine Residual.....	SM4500-Cl G
Total Suspended Solids.....	SMSM2540D
BOD.....	SMSM5210B
Oil & Grease.....	SM5520B
Total Coliform.....	SM9221B
Fecal Coliform.....	SM9221E
Volatile Acid	SM5560C
Alkalinity	SM2320A
Settleable Solids	SM2540F

Bruce Keogh, Lab Director



Date: 1-31-05

Lab/C/My Documents/Lab QC Docs/Lab QA Updates December 2004/Analytical methods

CALIBRATION PROCEDURES AND FREQUENCY

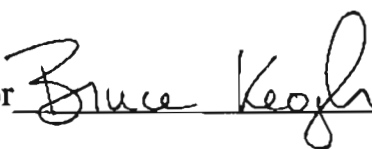
All laboratory instruments are to be calibrated prior to or during use. Instruments require calibration, standardization and informed observation to work accurately.

The pH meter is calibrated daily during lab open up using pH 4, 7, and 10 buffers. Refer to the standard operating procedures (SOP) for pH.

The turbidimeter is checked daily against secondary standards, and calibrated quarterly using primary standards. Refer to the standard operating procedures (SOP) for the turbidimeter.

The analytical balances are calibrated annually by an independent company (Wine Country Balance, Sonoma, CA). Refer to the standard operating procedures (SOP) for the balances.

Bruce Keogh, Lab Director



Date: 1-31-05

Lab/C/My Documents/Lab QC Docs/ Lab QA Updates December 2004/Calibration Procedures and Frequency

Data Reduction, Validation, and Reporting

Significant Figures:

A significant figure is a digit that denotes the amount of the quantity in the particular decimal place in which it stands. Reported analytical values should contain only significant figures. A value is made up of significant figures when it contains all digits known to be true and on the last digit in doubt. For example, if a value is reported as 18.8 mg/L, the 18 must be firm while the 0.8 is somewhat uncertain, but presumably better than one of the values 0.7 or 0.9 would be.

The number zero may or may not be a significant figure depending on the situation. Final zeros after a decimal point are always meant to be significant figures. Zeros before a decimal point with non-zero digits preceding them are significant. With no preceding non-zero digit, a zero before the decimal point is not significant. If there are no non-zero digits preceding a decimal point, the zeros after the decimal point but preceding other non-zero digits are not significant. These zeros only indicate the position of the decimal point.

Rounding Off:

Round off by dropping digits that are not significant. If the digit 6, 7, 8, or 9 is dropped, increase the preceding digit by one unit. If the digit 1, 2, 3, or 4 is dropped, do not alter the preceding digit. If the digit 5 is dropped, increase the preceding digit by one if it is an odd number, or keep it unchanged if it is an even number.

Calculations:

As a practical operating rule, round off the result of a calculation in which several numbers are multiplied or divided to as few significant figures as are present in the factor with the fewest significant figures. When numbers are added or subtracted, the number that has the fewest decimal places, not necessarily the fewest significant figures, puts the limit on the number of places that justifiably may be carried in the sum or difference.

Data Reduction, Validation, and Reporting Cont

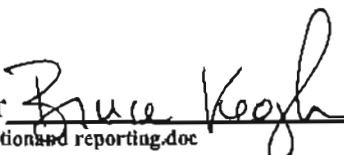
Data Validation:

The data is reviewed and checked by the analyst. The analyst will review all raw data and calculations to insure that the QC criteria has been met. The raw data, sample run sheet, and all other paperwork associated with the job are kept in the individual analyses notebooks for supervisor review. If the data is acceptable, then a report will be generated by the Laboratory supervisor.

The review of the data will include the following checks.

- a. Were the correct samples analyzed for the correct analyses as documented on the chain of custody form?
- b. Was the instrument properly calibrated?
- c. Was the holding time of the samples prior to analysis within acceptable limits?
- d. Are results calculated correctly after dilutions?

If there is a question to the validity of the analyses, then the sample is re-run by the analyst to verify. If the results are still in question after the second analyses, then they are declared invalid and the sampler is contacted to provide a second sample to the laboratory. All final reports are reviewed and signed by the Laboratory supervisor. All NPDES and EPA reports to the Regional Water Quality Control Board are also reviewed and signed by the Lab Manager. All lab data sheets and recorder charts are kept and stored at the wastewater treatment plant.

Bruce Keogh, Lab Director  Date: 1-31-05
Mydocuments/LabQCdocs/datareductionvalidationand reporting.doc

Maintenance of Laboratory Supplies

Standard Methods 18th Edition, Page 9-3 to 9-5 section 9020 B

Monitoring Pure Water Quality:

At this time, laboratory distilled water (DI water) is purchased from an independent company (Arrowhead). Copies of analysis of purchased water are requested from the company. Copies of the monthly and annual analytical results are on file in the laboratory file cabinet. To perform analysis for quality of purified water used in bacteriological testing, refer to Standard Methods 18th Edition, Page 1-32,33 section 1080 A, B, & C.

Bruce Keogh, Lab Director

Mydocuments/LabQCdocs/maintenanceoflabsupplies.doc



Date: 1-31-05



ARROWHEAD DISTILLED WATER

QUALITY OF PURIFIED WATER USED IN MICROBIOLOGY TESTING

The Arrowhead distilled water described below meets all reagent grade water requirements by the California Department of Health Services as listed in Standard Methods for the Examination of Water and Wastewater, 19th Edition, 1995.

ANNUAL SUITABILITY - 2003

Production Location: Los Angeles

Production Date: March 11, 2003

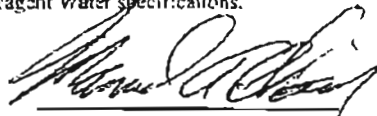
<u>TEST DESCRIPTION</u>	<u>TEST RESULT</u>
Conductivity	1.4 μ mhos/cm
pH	5.60
Total Organic Carbon	< 0.5 mg/L
Heavy Metals:	
Cadmium, Cd	< 0.001 mg/L
Chromium, Cr	< 0.002 mg/L
Copper, Cu	< 0.005 mg/L
Nickel, Ni	< 0.002 mg/L
Lead, Pb	< 0.001 mg/L
Zinc, Zn	< 0.025 mg/L
Ammonia/Organic Nitrogen	Passes USP Standard
Total Chlorine Residual	< 0.01 mg/L
Total Dissolved Solids	< 1.0 mg/L
Heterotrophic Plate Count (HPC)	< 1 cfu/ml
Water Bacteriological Quality Test	Growth ratio = 0.96
Oxidizable Substances	Passes USP Standard
Carbon Dioxide	Passes USP Standard

Arrowhead Distilled Water Specifications:

Total dissolved solids (TDS): < 2 mg/L; Total residual chlorine: ND (< 0.01 mg/L); Ammonia, N: ND (< 0.1 mg/L); pH: 5.0 - 7.0; Heterotrophic Plate Count (HPC): < 100 cfu/ml; Conductivity: < 4.0 μ mhos/cm; Bacterial growth ratio: 0.8-3.0; Heavy metals: < 0.050 mg/L; Total organic carbon: < 1.0 mg/L.

ND = None Detected.

Arrowhead Distilled Water also meets all USP Purified Water and ASTM Type IV Reagent Water specifications.


Quality Assurance Manager

Quality Assurance Laboratory, Los Angeles, CA 90021. Phone (213) 763-1350. Fax (213) 749-3777

Glassware Cleaning
Standard Methods 18th Edition, Page 9-3 Section B-3

Procedure:

1. After dumping sample, rinse with water and apply FL70 detergent located at sink.
2. Scrub or brush unit until all of sample has been removed from glassware.
3. Glassware should then be rinsed three times with hot water.
4. After rinsing with tap water, rinse again with DI water.
5. Dry glassware is ready for use.

Note: A **glassware inhibitory residue test** will be performed on initial use of washing compound, when there is a change in formulation used, or a change in the method of washing of reusable culture tubes, pipettes, flasks, graduated cylinders, beakers, blenders, funnels, etc.

A glassware inhibitory residue test was last performed on _____;
by _____
Lab name

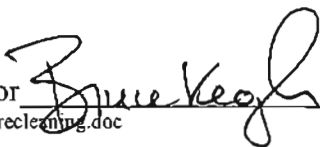
pH Spot Check:

Because some cleaning solutions are difficult to remove completely, spot check batches of clean glassware for pH reaction, especially if soaked in alkali or acid.

Procedure:

On a monthly basis, test clean glassware by adding a few drops of 0.04% bromthymol blue (BTB) or other pH indicator and observe the color reaction. BTB should be blue – green (in the neutral range). Record results on pH check form.

Bruce Keogh, Lab Director
Mydocuments/LabQCdocs/glasswarecleaning.doc



Date: 1-31-05

PH Spot Check

[illegible]

Mydocuments/labQCdocs/phspotcheck.doc

Lab Equipment and Instrumentation

Standard Methods 18th Edition, Page 9 -3, Section 9020 B

Analytical Balance & Top Load Balance

1. Balance must have a readability of 0.1g
2. Balance must be checked daily for accuracy using ASTM class I weights. Note: a minimum of 3 traceable weights that bracket our lab's weighing needs are to be used.
3. Data recording on daily scale record sheet located on the refrigerator.
4. All reference weights will be re-certified if damaged or corroded.
5. Service contract for internal maintenance control on the analytical and top load balance is completed annually by Wine Country Balance, Sonoma, CA.

Portable Balance

The portable top load balance (Sartorius 500.0g) will be checked at least monthly and before use, using ASTM 1, 10 and 100g weights (minimum of three traceable weights that bracket our labs weighing needs) and recorded on the portable balance calibration sheet.

Incubators

1. Our incubator is of sufficient size for our workload.
2. Our incubator unit has an internal temperature monitoring device and maintains a temperature of $35^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$.
3. Any temperature corrections must be noted on the daily incubator record sheet located on the side of our unit and on the thermometers.
4. Temperatures must be recorded twice each day of use, with readings at least 4 hours apart.

Scale Calibration (s)

Class I Weights Used #1 _____ #2 _____ #3 _____ #4 _____

[illegible]

EQUIPMENT TEMPERATURE RECORD
(C)

Month . Year .

Equipment_____. Certified Thermometer_____. +/-_____.

[illegible]

Autoclave

Standard Methods 18th Edition, Page 9-4, Section 9020 b

1. Our autoclave is sufficient for our workload and pressure cookers are not being used.
2. Our autoclave has an internal heat source, temperature gauge with sensor in exhaust, pressure gauges, and an operational safety valve.
3. Our autoclave maintains sterilization temperature during cycle and completes the entire cycle within 45 minutes when 12 to 15 minute sterilization period is used.
4. For quality control, the automatic timing device is checked quarterly for accuracy with another accurate timing device. Results are recorded on the Control Test Data sheet in the lab data book and corrections are to be noted on log sheet and autoclave time temperature sheet.
5. For quality control, a maximum temperature registering device is used weekly to check the sterilization temperature of $121^{\circ} \pm 2^{\circ} \text{C}$. Results are recorded on the Control Test data sheet in the lab data book.
6. A heat indicating tape is used to identify items that have been sterilized.
7. Routine maintenance of the autoclave includes cleaning of drain screen and visual inspection of the door seals on a weekly basis.
8. Spore ampules are used monthly as bioindicators to confirm sterilization. Results are recorded on the Control Test data sheet in the lab data book.
9. Contaminated test materials must be autoclaved at 121°C for at least 30 minutes.

Autoclave records must include:

- Date
- Contents
- Time in and out
- Total exposure/cycle time
- Sterilization time
- Sterilization temperature
- Initial of technician

Bruce Keogh, Lab Director
Mydocuments/LabQCdocs/autoclave.doc

Bruce Keogh Date: 1-31-05

AUTOCLAVE RECORD SHEET

[illegible]

MYDOCUMENTS/LAB/AUTOCLAVESHEET.DOC

LAB OPEN UP

I. Procedures to open Lab:

- A. Check Temp of Bac T Incubator. ($35^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$)
- B. Check Oven Temp. ($103-105^{\circ}\text{C}$)
- C. Check BOD Incubator Temp. ($20^{\circ}\text{C} \pm 1.0^{\circ}\text{C}$)
- D. Check Refrigerator Temp. ($< 5.0^{\circ}\text{C}$)
- E. Check the Calibration of Turbidimeter. (see chart)
- F. Calibrate the PH. meter. (see Instructions)
- G. Check the H₂O Bath Temp. ($44.5^{\circ}\text{C} \pm 0.2^{\circ}\text{C}$)

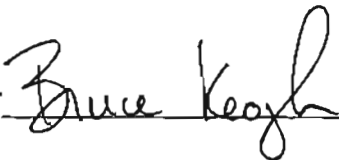
II. Other Open-up Duties:

- A. Read Plant Bac T Test.
 - 1. Monday ~ Friday
 - 2. Saturday – Sunday (Once a month sliding schedule)
- B. Set-up daily glassware
 - 1. Two 250 ml. Graduated cylinders. (Comp Eff Susp Solids Test)
 - 2. One 25 ml. Graduated cylinder. (MLSS)
 - 3. One 250 ml. Graduated cylinder. (Secondary Susp Solids Test.)
 - 4. One 250 ml. Beaker. (Inf PH. Test)
 - 5. One 250 ml. Beaker. (Eff PH. Test)
 - 6. One Imhoff Cone. (Settleable Solids Test)
 - 7. Turbidity Tube. (NTU Test)
 - 8. Glass Vial. (CL₂ Test)

III. Weigh Suspended Solids Filters:

- 1. Two Comp EFF.
- 2. One MLSS.
- 3. One secondary Effluent
- 4. One RAS

Bruce Keogh, Lab Director
Mydocumnets/LabQCdocs/labopenup.doc



Date: 1-31-05

**General scheme of laboratory testing
for detection of COLIFORM group in water**

Standard Methods 18th Edition, Page 9-45 to 9-53 Section 9221 A - E

Presumptive Test

Inoculation of lactose broth

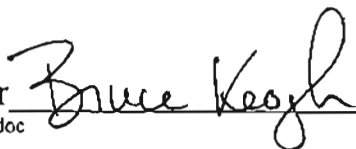
Gas produced = presumed evidence of coliforms Examination continued	No Gas = coliform not present
CONFIRMED TEST – Transfer made from lactose broth tubes to the following:	
BGLB or Brilliant green lactose broth (this medium inhibits the growth of lactose fermenters other than coliforms; thus gas formation in the BGLB medium constitutes a confirmed test: i.e. coliforms present.	Eosin-methylene agar (EMB). Coli-aerogenes organisms produce characteristic colonies; <u>Escherichia</u> : small colonies, dark, almost black centers, with greenish metallic sheen. <u>Enterobacter</u> : large, pinkish colonies, dark centers, rarely show metallic sheen. Presence of typical colonies constitutes a confirmed test: i.e. coliforms present.
Completed Test	
The most typical colonies are selected from EMB plate. (if BGLB used in confirm test, it is first streaked to EMB) and inoculated into :	
Lactose broth (coliforms produce gas).	Agar slant (gram stain prepared from growth; coliforms are gram-negative, nonsporulating bacilli (rod shaped).

Fermentation of lactose broth and demonstration of gram-negative, nonsporulating bacilli constitutes a positive completed test demonstrating the presence of some member of coliform group in the volume of sample examined.

Note: Completed test must be run quarterly, and results are to be logged in Lab log sheet.

Bruce Keogh, Lab Director

Mydocuments/LabQCdocs/coliformgrouptest.doc



Date: 1-31-05

Coliform

Standard Methods 18th Edition, Page 9-45 to 9-53 Section 9221 A – E

Equipment

Pipettes – 10ml, 5ml, and 1ml
Durham tube (glass vials)
Test tubes with aluminum caps
Wire loop
35° C incubator
44.5° C incubator
Broths (LTB, BGB, EC)

Procedure

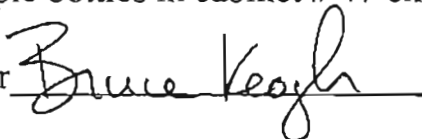
1. Make up and sterilize as on label of broth. Note: make up 1 liter of broth for approx. 80 tubes.
2. Put 10ml of broth in a test tube containing inverted durham tube using the automatic dispenser.
3. Put aluminum caps on.
4. Sterilize using autoclave.

Sterilize capped test tubes containing the media for not more than 15 minutes. The autoclave is preset to maintain a temperature of 121° C at 15 lbs. of pressure. All that is required to operate the autoclave is to fill the chamber with DI water to the marked point, close the door and set the timer for the desired length of time. Make sure that when sterilizing the test tube containing broth media, the exhaust selector switch is in slow (liquid mode). To sterilize pipettes, after rinsing with DI water and drying, place them in the stainless steel cylindrical storage case by the oven. Close the top and place them in the autoclave. Sterilize for 30 minutes at 121°C and 15lbs of pressure.

The sample bottles are also sterilized in the same manner as for pipettes except for samples containing residual chlorine. 1ml = 2 drops of 1% sodium thiosulfate is placed in the jar prior to sterilization. At least one bottle from each batch or lot of bottles shall be tested for sterility with TSB media incubated at 35°C for 24 hours and checked for growth. The results will be recorded on a bottle sterility data sheet.

Store sterilized sample bottles in cabinet # 47 on the east wall.

Bruce Keogh, Lab Director
Mydocuments/LabQCdocs/coliformgroup1est

 Date: 1-31-05

Confirmed Test and EC
Brilliant Green Bile (BGB)

Standard Methods 18th Edition, Page 9-45 to 9-53 Section 9221 A – E

LTB broths plus the sample with dilution indicated are positioned in the tray (in the big incubator) as shown below:

10.0 ml LTB II	O	O	O	O	O
1.0 ml LTB	O	O	O	O	O
0.1 ml LTB	O	O	O	O	O

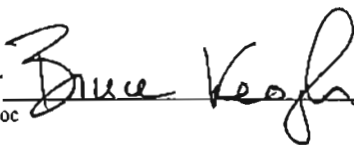
Any positive (gas production) LTB tube either at 24 hrs or 48 hrs is transferred to BGB. The BGB tubes replace the LTB tubes in the same spot.

Example:

1. Burn loop in bunsen burner flame till glowing orange.
2. Air cool 10-15 seconds.
3. Dip loop in a positive LTB tube about 3mls under surface and rotate tube. Pull out loop full of culture and transfer to BGB or BGLB. (try not to pick up scum off the surface of culture).
4. Repeat 1, 2, & 3.
5. Repeat 4 but transfer to EC broth for ocean sampling.

For technique please refer to Standard Methods 18th edition page 9 – 45 sections 9221 a – e.

Bruce Keogh, Lab Director
Mydocuments/LabQCdocs/coliformgroup1cst.doc



Date: 1-31-05

Media QC Positive/Negative Control

Standard Methods 18th Edition Page 9-3 Section 9020-9050 C

Rehydrate Culti – Loops: *E-coli*, *Enterobacter aerogenes*, *Staphylococcus aureus* using blood agar (TSA with sheep blood).

Procedure:

The film in each loop is made of a gelatin formulation. To rehydrate the film, the loop must come in contact with both warmth and moisture. To open: cut open the end of the foil packet as indicated on the label.

A: DIRECT STREAK METHOD

1. Warm appropriate plated media to 35° C.
2. Remove red sheath from the loop (*E-coli*, *E-aerogenes*, *staph*).
3. Lay the loop flat on the warm agar surface for 10 – 15 seconds, pressing gently onto the surface of the media. Rehydration of the loop will appear as a clear “bead of moisture” upon lifting the loop from the agar surface. Note: The black film does not have to completely dissolve from the loop for growth of the organism to occur.

After Incubation of 24 to 48 hours at 35°C the *E-aerogenes*, *S.Aureus*, *E-Coli* plates will be ready for use as positive/negative controls.

Using a steril inoculation loop transfer the appropriate bacteria to the prepared broths.

LTB/BGB: *E-Aerogenes* as a positive control

Staph aureus as a negative control

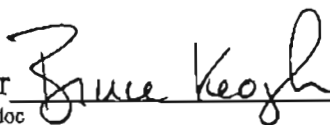
EC: *E-Coli* as a positive control

E-Aerogenes as a negative control

Once the bacteria are transferred, LTB and BGB broth will be incubated at 35° C $\pm$ 0.5° C for 24 to 48 hours. Log results in lab book. EC broth will be incubated at 44.5° C $\pm$ 0.2° C for 24 hours only. Log results in lab book.

Bruce Keogh, Lab Director

Mydocuments/LabQCdocs/MediaQCPosNeg.doc



Date: 1-31-05

Morro Bay / Cayucos Wastewater Treatment Plant
Quality Controls

AutoClave Bacillus Stearothermophilus			Bact-T Bottle/Pipette Steril Check Media Type (TSB)			
Date	Pos Control	Neg Control	Date	Bottles by numbers	Pipettes Pos/Neg	Bottles Pos/Neg

Completed Test					Autoclave Timer/Temp		
Date	Growth Yes/No	LTB Pos/Neg	BGB Pos/Neg	EC Pos/Neg	Date	Temp	Time Corrections

Mydocuments/lab/controlchecks.doc

Water Bath Quality Control (EC Broth)

[illegible]

Ocean samples are examined as follows:

Standard Methods 18th Edition, Page 9-45 to 9-53 Section 9221 A – E

1. 5 double strength tubes of broth inoculated with 10.0ml of sample.
(double strength = double in concentration).
2. 5 single strength tubes of broth inoculated with 1.0ml of sample.
3. 5 single strength tubes of broth inoculated with .1ml of sample.

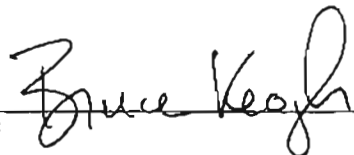
These tubes are then incubated in 35° C incubator by the east wall and checked at the end of 24 hours and 48 hours. The results are entered in the laboratory log book. At the end of 24 hours, transfer with transfer loop the positive tubes (gas production constitutes a positive result) to BLGB broth and E.C. broth at the same time. Incubate BGLB medium in 35° C.

Production of gas at the end of 24 hrs or 48 hrs constitutes a confirmed test, i.e. coliforms are present. Incubate the E.C. broth in water bath at 45° C for 24 hrs. Gas production constitutes a positive test, i.e. fecal coliform is present. If, at the end of 24 hrs, the E.C. broth yields a negative result (no gas production), it constitutes a negative test, i.e fecal coliform is not present. The E.C. tubes are then discarded.

Positive (*Escherichia Coli*) and negative (*Enterobacter aerogenes*) controls must be run whenever sample tubes are placed in the water bath for determination of fecal Coliform. Results are to be recorded on the water bath positive / negative control data sheet and beach survey form.

Please note that the transfer loop is sterilized by heat (a bunsen burner); it is placed in the flame and needs to glow bright orange then taken out and air cooled before using it for transfer. If a sizzling sound is produced when dipping the loop in the medium, that is an indication that the loop has not been given enough time to cool.

Bruce Keogh, Lab Director
Mydocuments/LabQCdocs/coliformgroupstest.doc

 Date: 1-31-05

CITY OF MORRO BAY BEACH SURVEY

PLACE: Morro Strand Beach

DATE:

SAMPLER:

WEATHER:

☐ CLEAR☐ CLOUDY☐ FOG☐ RAIN

INCH: _____

TEMPERATURE:

AIR _____

WATER _____

TIDE:

☐ Ebb☐ Flood☐ Slack

WIND: Direction _____

Intensity _____

BEACH USE: Swimmers _____

Spectators _____

STATION NUMBER:

A1

A

B

C

D

E

F

M/CRK

TIME SAMPLE COLLECTED:

R E C F I V I N G	N o n S D e e w b a r g i e s	Marine Growth							
		Storm\Shipping							
		Garbage\Refuse							
		Tars\Oils							
		TOTAL COLIFORM							
W A T E R S	S e D w e a b g r e i s	Soap\Grease balls							
		Rubber Goods							
		Fecal Material							
		FECAL COLIFORM							
B E A C H A R E A	N o n D S e b w r a i g s e	Marine Growth							
		Storm\Shipping							
		Garbage\Refuse							
		Tars\Oils							
	S e D w e a b g r e i s								
		Soap\Grease balls							
		Rubber Goods							
		Fecal Material							

PLANT OPERATION:

☐ Good☐ Fair☐ Poor☐ Unknown

BYPASSING WHEN SAMPLING:

☐ Yes☐ No☐ Unknown

PREVIOUS DAY

AT TIME OF SAMPLING

Flow _____ MGD Gal NaOCL used _____

Flow _____ MGD Dosage Lbs \ day _____

Calculated NaOCL Dosage _____ mg/L

Residual NaOCL in effluent _____ mg/I

Suspended Solids

Standard Methods 18th Edition Page 2-56, Section 2540 D

Background:

Total suspended solid (nonfilterable residue) is the material retained on a standard glass fiber filter after filtration of a well-mixed sample.

Equipment:

Vacuum source (on the bench top).

- Buchner Funnel and 1000 ml. vacuum flask (by the north sink).
- Filter paper (glass microfibril) 9 cm (located in drawer).
- Oven 103°-105° C (north wall).
- Analytical Balance (north wall).
- Desicator (by oven).

Procedure:

The filtration is achieved by vacuum. The filter paper (located in drawer) is first washed with distilled water (three 20 ml. portions) and place in the 103°-105°C oven for one hour to dry, and then transferred to the desicator to cool for 15-30 mins. (Use forceps for handling the filter paper). Weigh the filter paper and record in the lab log book. Measure the desired volume of sample with a graduated cylinder and pass through the filter (vacuum filtration). This is achieved with the use of a Hirsh Funnel. When washing the filter paper, a Buchner Funnel is employed.

Dry the filter paper in the oven (103°-105° C) for one hour or more and cool in the desicator for 30 mins. Weigh as before and record the values in the lab log book. Composite influent and effluent samples must be averaged between the two samples (of the same kind) when weighed. A second weighing should be done on all samples tested. If a deviation of 5% or more from the previous weight is noted, than a third weighing is necessary. The weight measurements are done by the analytical balance and weights are recorded to the nearest .1 mg. i.e. 1.2345 gr.

Calculation:

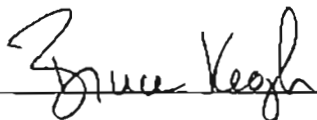
Mg. total nonfilterable residue $PPM = \frac{(a-b) \times 1000}{\text{Sample volume, ml.}}$

A= weight of filter paper + residue in mg. and

B= weight of filter paper, mg.

Note: 1.00 gr. = 1000mg

Bruce Keogh, Lab Director
Mydocuments/LabQCdocs/suspendedsolids.doc

 Date: 1-31-05

Suspended Solids Record

40

Biochemical Oxygen Demand (BOD)

Standard Methods 18th Edition, Page 5-1 to 5-6, Sections 5010 ABC, 5020, and 5210 A-B

Background:

Biochemical Oxygen Demand (BOD) is an empirical test that is used to determine the relative oxygen requirements of wastewater effluents and polluted waters. The test measures the oxygen required for the biochemical degradation (degradation by living organisms) of organic materials (pollutants that can be used as food for living organisms).

There are also some inorganic materials that would oxidize and therefore increase the oxygen consumption. These materials are mostly sulfides (S^{2-}) and ferrous iron (Fe^{+2}). A reduced form of nitrogen, like ammonia, would also use the oxygen to become oxidized (nitrogenous demand).

Nitrogenous demand can be prevented by the use of an inhibitor such as 2-chloro-6 (trichloromethyl) pyridine (TCMP).

Equipment:

Dissolved oxygen meter YSI 5100 (on the bench top)

BOD bottles (cabinet under incubator)

Plastic caps (located in drawer)

Glass bottle caps (cabinet under incubator)

Reagents:

BOD nutrient buffer pillows (Hach, BOD nutrient buffer pillows)

Locations:

Compositor at headworks (influent) and upper chlorine contact chamber area (effluent).

Procedure:

Please note that these procedures are only applicable at Morro Bay/Cayucos WWTP lab.

A) Preparations of dilution water:

Use one BOD nutrient buffer pillow for three liters of water, usually six liters of dilution water is made. Aerate the dilution water by shaking the bottle for about five minutes or use filtered air.

Mydocuments/labQCdocs/BOD&DOMeter.doc

BOD Cont.

Standard Methods 18th Edition, Page 5-1 to 5-6, Sections 5010 ABC, 5020, and 5210 A-B

B) Dilution Techniques:

Note: Composite influent and effluent samples both need to be at a pH range between 6.5 and 7.5. This is accomplished by placing the samples on our pH meter and titrating the sample with either sulfuric acid concentrate to reduce the pH to 7.5, if pH is lower than 6.5, titrate with sodium hydroxide to increase pH to proper range.

Use two dilutions for each sample in duplicate (two of each) and a blank for each set of analyses. Composite final effluent samples usually require 20 and 10 ml. of sample per BOD bottle. Raw samples require 3 and 1 ml. per BOD bottle. Use a pipette for all measurements.

After all the samples are measured and put in BOD bottles fill the bottles with dilution water to the top and make sure that there are no air bubbles trapped in the bottles. The air bubbles can be withdrawn by tapping the side of the bottle with a glass or metal rod.

Bruce Keogh, Lab Director
Mydocuments/labQCdocs/BOD&DOmeter.doc



Date: 1-31-05

YSI Dissolved Oxygen Electrode:

BOD TEST

How to Run

1. First you'll need to calibrate the BOD unit.
2. Turn the unit on (see the diagram).
3. Let the unit warm up at least 15 minutes.
4. The meter will have four choices at the bottom.
5. After the 15 minutes warm up choose the Calibrate button (see the diagram).
6. Four new choices will appear (see diagram).
7. Choose the AUTO CAL. Button (D.O. Calibration Saved will appear briefly).
8. Next push the mode button. This will change the screen to the operation ready mode (see the diagram).
9. Now you're ready to start your reads. Place the probe into Blank bottle # 122, wait 45 sec. Then read. Log the reading on BOD sheet.
10. Now do the rest of the BOD bottles the same way. In this order. Bottles # 137, # 130, # 110, # 127, # 123, # 104, # 126, # 135, # 98.
11. After your last bottle. Turn the unit off then rinse the probe CAREFULLY no higher the 1" from the bottom. Replace probe into holder.

Note: The oxygen content of all samples bottles (other than the blanks) should be at least 1 mg/L. Furthermore, a depletion of 2 mg/L of DO is desirable and the DO uptake in the blanks should not be more than 0.2 mg/L and preferably not more than 0.1 mg/L.

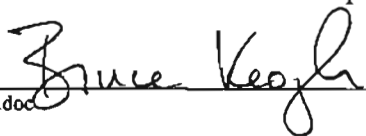
To prevent loss of oxygen during incubation, the DO must be reduced to saturation at 20° C by bringing the sample to about 20° C in partially filled bottle while agitating by vigorous shaking or by aerating with clean, filtered compressed air. During the BOD setup, initial DO should not be over 9.0mg/L.

Calculations:

By subtracting final DO from initial DO, the depletion of oxygen is obtained, and since there are duplicate bottles, this depletion is averaged.

$$\text{BOD mg/L} = \frac{\text{In} - \text{Out} \times 300\text{ml}}{\text{Ml of sample}}$$

Bruce Keogh, Lab Director



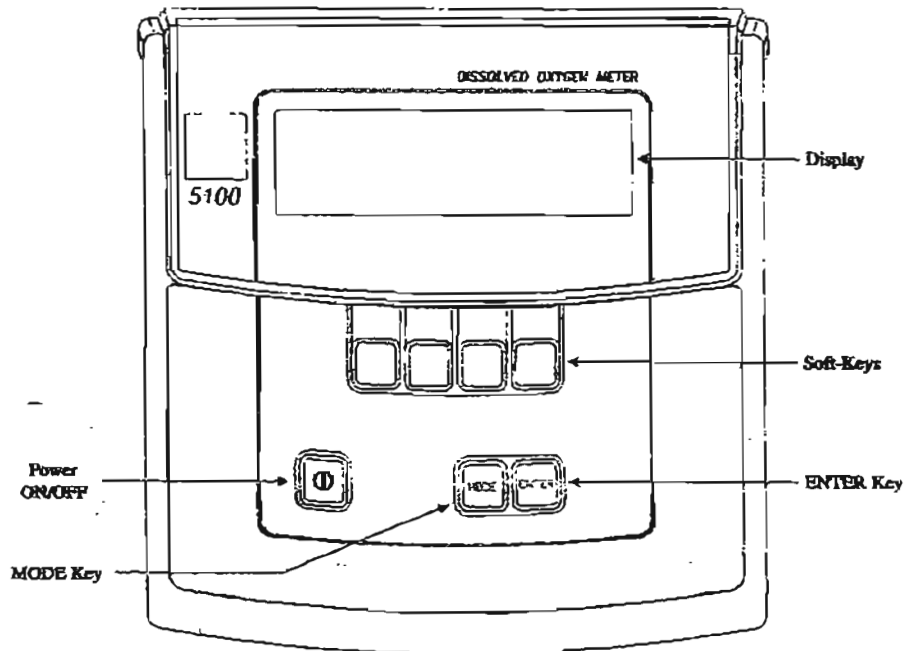
Date 1-31-05

Mydocuments/LabQCdocs/BOD&Dometer.doc

4. Controls

4.1 Front Panel

The front panel of the instrument contains the display and keypad as shown below. The front panel display and controls of the 5000 and 5100 are identical.



8.15 [*] mg/L		Main	
24.38°C		11:33 ^{AM}	
STORE	REVIEW	SEND	CALIBRATE

98.0 %	8.15 mg/L	Calibrate	
0.0 %	740 mmHg		
24.38°C	11:33 ^{AM}		
AUTO CAL	DO CAL	SETUP	DIAGNOSTICS

MORRO BAY / CAYUCOS WASTEWATER TREATMENT PLANT

BOD Record (mg/L, 5 Day, 20 °C)

[illegible]¹Time at start of incubation

²Include Time Sampler
On and period of
collection

5/5

pH

Please refer to Standard Methods 18th Edition Page 4-65 section 4500 A-B

Equipment: Orion model 310 pH meter

Procedure:

Before making measurements with a pH meter, one must make sure that the meter is calibrated. Each day of use, the pH will be calibrated with 2 buffers (4&7 or 7&10). The buffers must be dated and buffer type documented on our daily logs each time a calibration is made or changed. Accuracy and scale graduations must be within ± 0.1 units and the electrode must be maintained as per manufacturer's instructions. The calibration procedure is in the LAB TEST PROCEDURES BOOK located on shelf above computers.

In general, three types of buffer are used (pH 7.00, pH 4.00, and pH 10 buffer, located in chemical cabinet). Fill one 50 ml beaker with pH 7.00 buffer and one with 10.0 pH buffer. Place the 7.00 buffer on the stirrer and stir. Insert the pH probe into the beaker then press the mode button to turn unit on. Next press the CAL. Button to start the calibration process. The meter will flash SLP (at this point the up arrow may need to be pressed to bring the slope to 7-10 range) then briefly a percentage number. After the slope is seen on the meter push the YES button to accept this range. The meter will show a reading *at or near 7.00*. Log this reading on pH Calibration sheet located on BOD incubator. The meter will then lock onto the 7.00 reading and the ready light will be displayed. At this point, press the YES button locking in the 7.00 pH part of the CAL. Remove probe from 7.00 pH buffer beaker and replace with 10.0 pH buffer (on stirrer). Be sure to wipe the electrode with a clean Kim Wipe to remove 7.00 pH buffer. Insert probe into pH 10.00 and stir. Leave electrode in 10.0 pH buffer until the unit reads exactly 10.01 and the ready light is visible. Hit the Yes button, and a new SLP percentage will show (approx. 98%). The pH meter is now ready for use.

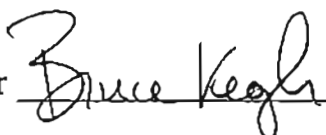
pH meter Cont.

Please refer to Standard Methods 18th Edition Page 4-65 section 4500 A-B

NOTES:

1. Make sure the electrode is thoroughly rinsed with DI water after each use or between measurements of different samples.
2. Do not touch or damage the electrode tip. It is very sensitive and great care should be taken when analysis is performed.
3. Record all reading in lab log book and initial the entries.
4. When testing a lower pH range, for instance, during a grease and oil test, the pH meter must be recalibrated to the 4-7 range by simply pressing the down arrow during initial calibration.
5. Always stir the sample during use of the pH meter.
6. For additional info refer to pH instruction handbook located above the computer desk. Also refer to Standard Method Handbook 18th ed.
Page # 4 – 65 section 4500 A-B.

Bruce Keogh, Lab Director
Mydocuments/LabQCdocs/PH.doc

 Date: 1-31-05

PH. CALIBRATION

[illegible]

Determination of Residual Chlorine in Wastewater
(Simplified Field Test)

Refer to Standard Methods 18th Edition, page 4-45 section: 4500-ci

Equipment:

1. LaMotte 1200 Colorimeter
2. 10ml graduated cylinder
3. Sample bottle
4. DI water
5. DPD pillows (reagents)

Procedure:

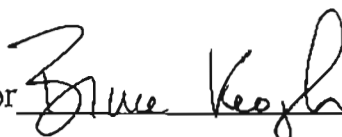
To get an accurate reading a dilution may be necessary for this test. Collect a sample of the wastewater or water to be tested in a clean sample bottle. Add 2.5 ml of sample to your 10ml grad. cylinder. Then fill the rest of the cylinder with DI water up to 10ml.

NOTE: This is your diluted sample used for the test at a ratio of 4:1. In general, this dilution factor will change depending on the strength of CL₂ in your sample as the residual meter does not exceed 9.9mg/l.

In the next step, pour your 10ml sample into the 10m. cylinder designed to fit into the meter. Upon insertion, close the hatch and turn the meter on. Then, hold the "zero" button down until "BLA" appears. The meter is now zeroed. Remove sample and pour reagent (currently using DPD pillow) into sample. Allow reagent to dissolve completely, insert the sample into the machine and press read. The resulting display will show the CL₂ concentration. This number would then be multiplied by 4 to counteract the dilution factor. Example: Meter reads .80mg/l so times by 4 = 3.2mg/l. Log all results in lab book.

For further information please look in the Lamonte 1200 colorimeter handbook located in the meter storage box or for more general info, Standard Methods 18th edition may be utilized page 4-45 section: 4500-ci.

Bruce Keogh, Lab Director
Mydocuments/LabQCdocs/chlorineresid.doc

 Date: 1-31-05

Turbidimeter

Standard Methods 18th edition page 2-8,9 sections 2130a-b.

Calibrating:

When data is used is used for USEPA reporting, recalibrate at least every 90 days or as stipulated by the regulating authority. Refer to section 3.2 “calibration” in the Hach 2100N Turbidimeter instrument manual. Furthermore, the turbidimeter will be calibrated using a primary or secondary standard before each use. A quarterly crosscheck should be made using a primary standard. Also, our turbidimeter is on a quarterly work order for calibration and we are using primaries for this check.

Calibration Procedure for the The Hach 2100N Turbidimeter:

1. Fill a clean sample cell to the line (approx 30 ml) with dilution water.
2. Wipe the cell clean and apply a thin film of silicone oil.
3. Place the sample cell into the cell holder and close the cell cover.
4. Press the CAL key. The SO annunciator lights. The NTU value of the dilution water used in the previous water used in the pervious calibration is displayed.
5. Press ENTER key. The instrument display counts down from 60 to 0, and then makes a measurement. This result is stored and used to compensate for the turbidity of the dilution water.
6. The instrument automatically increments to the next standard, displays the expected NTU value, and the S1 annunciator lights. Remove the sample cell from the cell holder.
7. Fill a clean sample cell to the line with well mixed, 20 NTU Formazin standard. Wipe the cell clean and apply a thin film of silicone oil to the surface. Place it into the cell holder, and close the cell cover. Press ENTER key. The instrument display counts down from 60 to 0, and then makes a measurement. The display automatically increments to the next standard, the display shows 200.0 NTU, and the S2 annunciator lights. Remove the sample cell from the instrument.
8. Fill a clean sample cell to the line with well mixed 200 NTU Formazin standard, and complete the same steps used in # 7. This time the S3 light will show.
9. Fill a clean sample cell to the line with well mixed 1000 NTU Formazin standard, and complete the same steps used in # 7. This time the S4 light will show.

Turbidimeter Calibration Cont.

10. Fill a clean sample cell to the line with well mixed 4000 NTU Formazin standard, and complete the same steps used in # 7. This time the S0 light will show, and the previously measured value of the dilution water is displayed.
11. Press the CAL key. The instrument makes calculations based on the new calibration data, stores the new calibration and returns the instrument to the measurement mode.

Reviewing the calibration sequence

Press the CAL key and then use the UP ARROW key to scroll through the standard to review calibration data currently in effect. Press the UNITS/EXIT key to return to the operating mode without altering the current calibration data.

Note: Reassign new values to the Gelex standards each time the instrument is calibrated with Formazin. Formazin is the primary standard and Gelex is the secondary standard. Formazin is known to cause cancer so use extreme caution when handling.

Error Codes are located on the Hach 2100N Turbidimeter Quick reference guide located in the drawer under the meter itself.

Hach 2100N Turbidimeter Test Procedure:

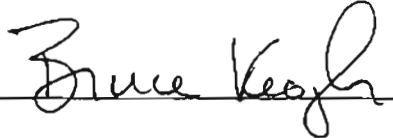
1. Collect a representative sample in a clean container. Fill the sample cell to the line. Take care to handle the sample cell by the top. Cap the sample cell. Our turbidimeter is designed to stay on 24hrs a day. If machine is ever turned off refer to Quick Reference Guide, step 1 in procedures.

Turbidimeter sample procedures cont.

2. Hold the sample by the cap, and wipe to remove water spots and finger prints with a clean Kim Wipe.
3. Apply a thin bead of silicone oil from the top to the bottom of the cell, just enough to coat the cell with a thin layer of oil. Using the oiling cloth provided, spread the oil uniformly. Then, wipe off the excess. The cell should appear nearly dry with little or no visible oil.
4. Place the sample cell in the instrument cell compartment and close the cell cover.
5. Select manual or automatic ranging by pressing the RANGE key.
6. Select the appropriate SIGNAL AVERAGING setting (on or off) by pressing the SIGNAL AVERAGE key.
7. Select the appropriate RATIO setting (on or off) by pressing RATIO key. NOTE: Values greater than 40 NTU require ratio on.
8. Select the appropriate measurement unit by pressing the UNITS/EXIT key (NTU is our standard).
9. Read and record the results in the lab book.

For any other references please look in the HACH 2100N Turbidimeter manual or Quick reference guide or Standard Methods 18th edition page 2-8,9 sections 2130a-b.

Bruce Keogh, Lab Director
Mydocuments/LabQCdocs/turbidimeter.doc

 Date: 1-31-05

Turbidity Meter Calibration

Standards Used #1_____, #2_____.

#3 _____, #4 _____.

[illegible]

Settleable Solids

Refer to Standard Methods 18th Edition, Page 2-57 section 2540 – F.

Description:

Settleable solids of sewage is the volume of suspended matter that settles to the bottom of a tank or compartment designed for the collection of the settleable material. The determination for settleable solids is made by allowing one liter of the sewage to stand for one hour in an Imhoff cone, and reading directly from the graduations of the cone the volume of the suspended matter that settled to the bottom. The result represents the settleable solids, in milliliters per liter.

Purpose:

The determination of settleable solids in sewage is valuable as showing how much suspended matter can be or has been removed by sedimentation. To measure visibly the efficiency of a sedimentation process, tests for settleable solids are made on the influent and effluent of the settling basin or compartment. The difference between the settleable solids of the influent and effluent gives the settleable solids removed. The percent of the solids removed may now be calculated by dividing the volume of the solids removed by the volume of the settleable solids of the influent and multiplying by 100.

Equipment:

Imhoff Cones.

Rack for holding Imhoff cones.

Glass stirring rod or wire.

Settleable Solids Cont.

Test Procedure:

1. Thoroughly mix the sewage sample by shaking and immediately fill an Imhoff cone to the Liter mark.
2. Record the time that the cone is filled. Time = _____.
3. Allow the waste sample to settle for 45 minutes.
4. Gently spin the cone to facilitate settling of material adhering to the side of the cone.
5. After one hour, record the number of milliliters of settleable solids in the Imhoff cone. Make allowance for voids among the settled material.
6. Record the settleable solids as ml/L or milliliters per Liter

	Sample
Settleable solids, Influent = _____ ml/L	10.0
Settleable solids, Effluent = _____ ml/L	0.5
Settleable solids, Removal = _____ ml/L	9.5

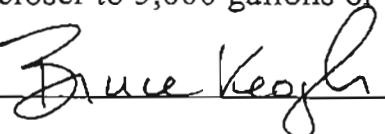
Example:

If one liter of raw sewage or influent contains 10.0 ml of settleable solids, it should be possible to remove most of this in the primary settling system. If the effluent contains 0.5 ml per liter, it is possible to calculate the efficiency of removal by using this formula:

$$\begin{aligned}\% \text{ Efficiency} &= \frac{(\text{ml influent}) - (\text{ml effluent})}{(\text{ml influent})} \times 100 \\ &= \frac{10.0 - 0.5}{10.0} \times 100 = 95\% \text{ removal}\end{aligned}$$

It should also be possible to check the maximum volume of sludge to be pumped out of settling tanks. For example, if one liter, equaling 1,000 ml of sewage, contains 10.0 ml of settleable solids, 1,000,000 gallons of sewage should not contain over 10,000 gallons of sludge. Generally, sludge compacts by a factor of two or three and therefore this volume will be smaller by half or more. Instead of pumping 10,000 gallons, then, the volume would probably be closer to 5,000 gallons or less.

Bruce Keogh, Lab Director
Mydocuments/LabQCdocs/settleablesolids.doc

 Date: 1-31-05

Grease and Oil

Refer to Standard Methods 18th Edition, page 2-51 section 2530 –c

Background:

“Grease and Oil” is any material recovered as a substance soluble in trichlorotrifluoroethane (freon). Thus, in the determination of oil and grease on absolute quantity of a specific substance is not measured. The significance of this test arises from the fact that certain constituents measured by the oil and grease analysis may influence wastewater treatment systems. If present in excessive amounts, they may interfere with aerobic and anaerobic biological processes (digester and trickling filter) and can lead to decreased wastewater treatment efficiency. When discharged in wastewater or treated effluents, they may cause surface films and shoreline deposits leading to environmental degradations.

NOTE: The effluent grab sample should be collected in a glass beaker (2000ml) at the air relief structure. Sample volume should be exactly 1000ml. The influent grab sample is taken directly from the main influent channel located in the lower headworks.

Method:

Partition-Gravimetric Method

Apparatus:

1. Separatory funnel, 1 Liter with teflon stoplock
2. Distilling flask
3. Water bath
4. Filter paper, 11cm diameter, Whatman # 40

Reagents:

1. Hydrochloric acid, Hcl 1+1
2. Trichlorotrifluoroethane
3. Sodium sulfate

Procedure:

Collect exactly 1 Liter (1000ml) of sample in your 2000ml beaker. Mark the sample level for later determination of sample volume. Acidify to pH 2.0 or lower (about 5ml of Hcl 1+1). Transfer to separatory funnel. Carefully rinse sample container with 30ml of trichlorotrifluoroethane and add solvent washing to separatory funnel. Shake vigorously for 2 minutes venting immediately and frequently to allow gas build up to be released. Place funnel in holder and allow the layers to separate for 10 mins.

Grease and Oil Cont.

Refer to Standard Methods 18th Edition, page 2-51 section 2530 -c

Procedure continued:

Adding two scoops of sodium sulfate to the filter paper assists in filter efficiency. Then, drain solvent layer through a funnel containing solvent-moistened filter paper into a clean, tared (pre weighed) distilling flask.

As mentioned above, if a clear solvent layer cannot be obtained (which is the case at this treatment plant), add 2 scoops of sodium sulfate to the filter paper cone and slowly drain emulsified solvent onto the crystals. Add more sodium sulfate if necessary.

Extract twice more with 30 ml of solvent each time, but first rinse sample container with each solvent portion. Combine extracts in tarred distilling flask and wash filter paper with an additional 10 to 20 ml solvent.

Evaporate freon from distilling flask in a water bath at 70° C for 15 minutes. Draw air through it with an applied vacuum for the final minute. Cool in a desicator for 30 minutes and weigh.

A blank shall be run on 90ml of trichlorotrifluoroethane (FREON) for each new bottle of trichlorotrifluoroethane opened. The results will be recorded, and a corrective factor will be used for each test conducted.

Calculations:

$$\text{Mg oil and grease/L} = \frac{(A-B) \text{ in mg} \times 1000}{\text{Ml sample}}$$

A = total gain in weight for the sample

B = total gain in weight for the blank

Enter all data collected and calculations in lab log book.

Grease and Oil Cont.

Refer to Standard Methods 18th Edition, page 2-51 section 2530 -c

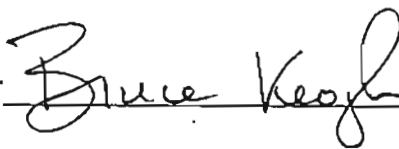
CAUTION !!!

Trichlorotrifluoroethane (FREON) is extremely flammable so handle with care and keep fire or sparks away from are while performing the analysis.

NOTES:

1. DO NOT use a bunsen burner for water bath.
2. Vent the seperatory funnel properly.
3. Avoid breathing the vapor of the solvent (freon).
4. Avoid getting solvent on the skin.
5. For additional information please refer to Standard Methods 18th edition book page 5-25.

Bruce Keogh, Lab Director
Mydocuments/LabQCdocs/grease&oil.doc

 Date: 1-31-05

CAUTION:

Trichlorotrifluoroethane (freon) is extremely flammable handle with great care and keep fire or sparks away from work area while performing the analysis.

DO NOT Use a bunsen burner for water bath.

—Vent the separatory funnel properly.

— Avoid breathing the vapor of the solvent.

— Avoid getting the solvent on the skin.

— For additional information, refer to Standard Method 15th. edition, page 460.

Top open
for draining

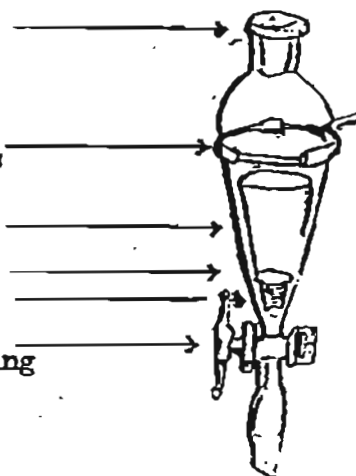
ring with
rubber cushions

top layer

interface

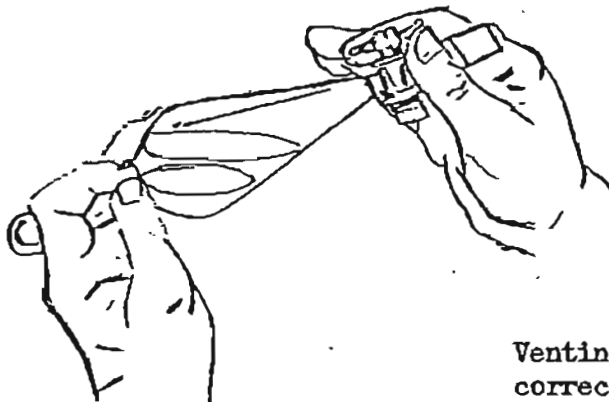
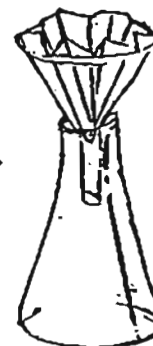
bottom layer

stopcock
open for draining



fluted filter
paper

Erlenmeyer
flask
(other kind of flask
can also be used)



Venting position, showing correct way of holding funnel for shaking and venting.

GREASE & OIL

NAME	DATE	TIME	SAMPLE DESCRIBE LOCATION	ANALYTICAL DATA	REMARK
				FLASK EXTRACT _____ GRMS FLASK TARE WT _____ GRMS NET WEIGHT _____ GRMS	
				FLASK EXTRACT _____ GRMS FLASK TARE WT _____ GRMS NET WEIGHT _____ GRMS	
				FLASK EXTRACT _____ GRMS FLASK TARE WT _____ GRMS NET WEIGHT _____ GRMS	
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				FLASK EXTRACT _____ GRMS FLASK TARE WT _____ GRMS NET WEIGHT _____ GRMS	
				FLASK EXTRACT _____ GRMS FLASK TARE WT _____ GRMS NET WEIGHT _____ GRMS	

COMMENTS:

VOLATILE ACIDS TEST

DISTILLATION METHOD

Standard Methods 18th Edition, Page 5-42 Sections 5560 A-C

General Discussion:

Digestion is the process wherein anaerobic organisms, concentrated in a digester tank, decompose the waste organic materials in sludge into simple more stable and non-offensive compounds.

The groups of bacteria work to digest sludge. First, saprophytic bacteria will break down the large organic molecules present in the form of proteins, fats and carbohydrates into simpler organic acids, containing six atoms of carbon or less. Second, methane producing bacteria will further break down these acids, called volatile acids, into methane and carbon dioxide. When the rate of the acids produced equals the rate of acid breakdown with methane production, alkaline digestion progresses satisfactorily. When the process of digestion is upset, the volatile acid level rises rapidly. This condition is usually caused by the sudden inactivity of the methane producing bacteria and the continued production of volatile acids by the saprophytic bacteria. When this occurs, the volatile acid level tends to climb by accumulation. Methane bacteria are much more sensitive to environmental changes in a digester. Sudden variations in digester temperature, pH, feed rate, or the introduction of undesirable waste material easily affect them, curtailing their normal functions.

Purpose:

The volatile acids test measures the acid content in sludge. This test measures the organic fatty acids produced during digestion which are water soluble and can be distilled, such as formic, acetic, propionic, butyric, valeric, and caproic acids. This information is valuable in maintaining digester control. Volatile acid levels below 300 ppm are desirable. Values greater than 1000 ppm are probably indicative of a serious problem. If the acids increase and continue to build up, this test will usually correct this condition, although other factor such as digester temperature, gas production and raw sludge solids concentration should also be checked.

Volatile Acids Test Cont.

Standard Methods 18th Edition, Page 5-42 Sections 5560 A-C

The straight distillation method will be described. This method is simple and requires little equipment. However, because of the continuously changing conditions in the distillation flask it may give slightly high results. Digested sludge liquor is separated from the solids by centrifugation; a measured volume of the supernatant liquor is then acidified to convert the buffered acids into an acid form. These acids are then distilled and titrated with 0.1 normal sodium hydroxide from which the acid content may be determined. If a centrifuge is not available, the liquor may be separated from the solids by filtering the sludge through coarse paper, such as a paper towel place in a funnel.

Equipment:

Glassware needed:

Graduated Cylinder 100 ml. (2)

Erlenmeyer flask 1000 ml.

Pipette 1 ml. 1/100

Flask 225 ml.

Filter w/ 90mm SS filter

Filter Flask w/ hose

Glass beads

Chemicals needed:

H₂SO₄ Sulfuric Acid Conc.

Phenol Indicator

Sodium Hydroxide

Celite Filter Aid

Procedure:

1. Place about 200 ml of sludge into a centrifuge bottle and centrifuge for about 15 minutes, or filter sample through coarse paper.
2. Measure 100 ml of the supernatant sludge liquor or filtrate into the distillation flask.
3. Add 5 ml concentrated sulfuric acid.
4. Add 150ml DI water to make a total volume of 250ml
5. Connect the flask to distillation apparatus.
6. Collect 100 ml of the distilled material in an Erlenmeyer flask which has been previously marked at the 100 ml level.
7. Titrate distillate with 0.1 N Sodium Hydroxide (NaOH).
 - a) Add several drops of phenolphthalein indicator.
 - b) While stirring, add from a buret standard (0.1 N) sodium hydroxide until the pink color of the indicator solution first appears.

Volatile acid test Cont.

Standard Methods 18th Edition, Page 5-42 Sections 5560 A-C

Note: This color should disappear on standing for several mins.

ml of NaOH used = _____

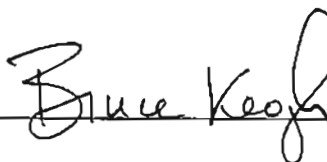
8. Calculation of the volatile acids = If 100 ml of sludge sample is taken, then Volatile acid in mg/L = (ml of standard NaOH used) x 86.5.
9. Record results of test. Volatile acids = _____ mg/L.
10. Sample calculation:
ml of Standard NaOH used = 2.0ml
Volatile acids, mg/L = (ml Std. NaOH used) x 86.5
Volatile acids, mg/L = 2.0 x 86.5 = 173 ppm

Precautions:

1. The sludge sample must be representative of the digester. The sample line should be allowed to run for a few minutes before the sample is taken. The sample temperature should be as warm as the digester itself.
2. The sample for the volatile acids test should not be taken immediately after charging the digester with raw sludge. Should this be done, the raw sludge may short circuit to the withdrawal point and result in the withdrawal of raw sludge rather than digested sludge. Therefore, after the raw sludge has been fed into the tank, the tank should be well mixed by re-circulation or other means before a sample is taken.
3. If a digester is performing well with low volatile acids and then if one sample should unexpectedly and suddenly give a high value, say over 1000 ppm of volatile acids, do not become alarmed. The high result may be caused by a poor, non-representative sample of raw sludge instead of digested sludge. Resample and retest. The second test will probably give a more normal value.
However, continued high values of volatile acids will usually mean that corrective measures should be taken, such as reducing the feed rate, reseeding from another digester, maintaining optimum temperatures, or cleaning the tank of grit and scum.
4. Be sure that the cooling water is running through the condenser.
5. Be sure that the H₂SO₄ has been added before distillation begins. If the solution is alkaline, the volatile acids exist as ammonium salts and will not distill over.

6. Be certain to distill only 200 ml of condensate. Additional distilling beyond 200ml may cause serious errors and very high results, instead of correct answers, for the excess sulfuric acid may start to fume and distill over.

Bruce Keogh, Lab Director
Mydocuments/LabQCdocs/volatile acid.doc

 Date: 1-31-05

Alkalinity

Standard Methods 18th Edition, Page 2-25 Sections 2320 A-B

Equipment:

Graduated cylinder 50ml

Beaker 80ml

5ml Pipette

H₂SO₄ solution

PH meter

D.I water

For sampling points and techniques please refer to page _____.

Procedure:

Note: The pH meter must be recalibrated to the proper range of 4-7 for this particular test. Refer to pH page for step by step instructions.

1. Take the 50ml graduated cylinder and add 45ml D.I. water.
2. Pour the 45ml D.I. water into 80ml beaker.
3. Take 5ml pipette and add 5ml of digester supernatant which has been separated from the sludge sample during the volatile acid test (both tests are run at the same time). This will bring the total amount of sample in the beaker to 50ml (5ml of supernatant and 45ml D.I. water).
4. Grab another clean 5 ml pipette and fill with sulfuric acid solution to 5 ml. Place sample on stirrer and insert pH probe. While stirring, titrate the sample using your sulfuric acid solution until the pH meter reaches 4.30 pH, which usually requires multiple fillings of the pipette.
5. When 4.30 PH is reached, add up the total ml of sulfuric acid solution applied to reach 4.30 pH. Multiply the sulfuric acid used in ml by 200 and this is the alkalinity.
6. Log results in laboratory log sheet.

Bruce Keogh, Lab Director



Date: 1-31-08

Mydocuments/LabQCdocs/alkalinityvolatilematter,moisture.doc

VOLATILE ACID & ALKALINITY

DATE	PH.	VA.	ALK.	RATIO.
DIGESTER #	TEMP.			
DATE	PH.	VA.	ALK.	RATIO.
DIGESTER #	TEMP.			
DATE	PH.	VA.	ALK.	RATIO.
DIGESTER #	TEMP.			
DATE	PH.	VA.	ALK.	RATIO.
DIGESTER #	TEMP.			
DATE	PH.	VA.	ALK.	RATIO.
DIGESTER #	TEMP.			
DATE	PH.	VA.	ALK.	RATIO.
DIGESTER #	TEMP.			
DATE	PH.	VA.	ALK.	RATIO.
DIGESTER #	TEMP.			
DATE	PH.	VA.	ALK.	RATIO.
DIGESTER #	TEMP.			
DATE	PH.	VA.	ALK.	RATIO.
DIGESTER #	TEMP.			
DATE	PH.	VA.	ALK.	RATIO.
DIGESTER #	TEMP.			

COMMENTS:

Volatile Matter / Moisture

Refer to Standard Methods 18th Edition Page 2-57 Section 2540 B,E

General Discussion:

A well mixed sample is evaporated in a weighed dish and dried to a constant weight in an oven at 103° to 105° C. The increase in weight over that of the empty dish represents the total solids. The results may not represent the weight of actual dissolved and suspended solids in wastewater samples.

Equipment:

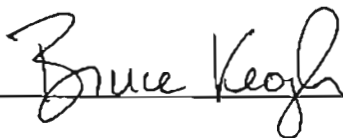
Porcelain dish
Furnace
Desiccator
Drying oven
Analytical balance

Procedure:

Remove a crucible from the oven and allow it to cool to scale temperature in desiccator. Weigh the empty crucible to establish a tare weight and log on sheet. Pour a representative sample into pre weighed, fully cooled crucible approximately one third full and weigh immediately. Log weight on Sludge Moisture / Volatile Solids log sheet and place the crucible in the oven (103°-105°C). Allow crucible to stay in the oven overnight, thus removing any moisture from the sample. Remove and cool to scale temperature in desiccator. Sample is now ready to be placed in the muffle furnace at 500° ±50°C for 15 to 20 minutes thus burning off all volatile matter leaving only inorganic material. Remove carefully (HOT) and place in desiccator until it is cooled to scale temperature. Weigh and record results in log sheet. Perform calculations on log sheet to determine percent moisture and percent volatile solids.

Refer to Standard Methods 18th Edition Page 2-57 Section 2540 B,E

Bruce Keogh, Lab Director
Mydocument/labQCdocs/volatilematter.doc

 Date: 1-31-05

SLUDGE MOISTURE

DATE/ DIGESTER #			
WT OF DISH & WET SLDG			
WEIGHT OF DISH			
WT OF WET SLUDGE			
WT OF DISH & WET SLDG			
WT OF DISH & DRY SLDG			
LOSS IN WEIGHT			
MOISTURE (LOSS IN - WT MULTIPLIED BY 100 / WT OF WET SLUDGE			
SOLIDS (100- MOISTURE)			

VOLATILE CONTENT

WT OF DISH & DRY SOLIDS			
WT OF DISH			
WT OF DRY SOLIDS			
WT OF DISH & DRY SOLIDS			
WT OF DISH & ASH			
LOSS IN WEIGHT			
VOLATILE MATTER (LOSS- N WT MULTIPLIED BY 100 WT OF DRY SOLIDS			

COMMENTS:

1 OBJECTIVES

The primary objectives of the BC Laboratories, Inc. (BCL) Quality Assurance Program Plan (QAPP) are to provide QA/QC guidelines to 1) assure the data produced is of known quality, 2) ensure our organization is capable of providing results which are of value to our customers, 3) ensure the system can consistently perform under adverse conditions, and to 4) comply with quality goals and objectives as set forth in government and industry standards.

1.1 POLICY STATEMENT

B C Laboratories Inc. is an organization committed to providing legally defensible data that is technically valid and in accordance with professional standards, project goals, and government regulations. The management and staff at B C Laboratories, Inc. are committed to use all available resources to supply accurate, precise, timely and fully documented results. BCL's goal is to provide analytical results and services which are of value to our customers.

1.2 COMPONENTS OF THE QUALITY PROGRAM

Our overall program can be broken down into five essential parts: 1) *Preclusion*, 2) *Assessment*, 3) *Validation*, 4) *Corrective Action*, and 5) *Improvement*.

PRECLUSION: This is comprised of an orderly program of positive actions taken before and during analyses to ensure that analytical systems are functioning properly. Components include quality control planning, training, documented and approved methodologies, calibration of instrumentation, instrument maintenance, comprehensive standardization, control charting, internal and external monitoring.

ASSESSMENT: This includes all components of determining analytical performance. Components include matrix duplicates, matrix spikes, matrix spike duplicates, post spikes, blank spikes, blank spike duplicates, laboratory control samples, calibration checks, calibration blanks, method blanks and surrogate additions. Inclusion of all or some of these components and their frequencies are method dependent. B C Laboratories' standard operating procedures (SOP's) contain all pertinent information concerning respective QC criteria needed for assessment and approval of data. The adequacy of the QC program is measured through internal and external auditing and client feedback on customer surveys.

VALIDATION: This consists of all the steps taken to ensure that generated analytical data is complete and correct. Steps include maintenance of sample tracking and data processing systems, technical review of raw data and final results review and approval by management staff.

CORRECTIVE ACTION: The actions rendered to determine the causes of quality defects and restore proper function of the analytical system. This includes troubleshooting techniques, re-evaluations of analyses and/or methodologies, dilution, calculation checks and continued training of analysts.

IMPROVEMENT: Actions taken to improve standard quality baselines. Steps include assessing windows of improved performance, total quality management training of personnel, and research / development.

1.3 OTHER SOURCES FOR QUALITY GUIDELINES

Since BCL's scope of work is very diversified, pertinent Standard Operating Procedures (SOP's) are used at the bench level to provide guidance and direction. Specific project plans are developed to narrow the scope of work, and thus provide QA/QC protocols on a limited scale and provide for possible modifications to standard practice.

1.4 REVISION PRACTICES

The QA Officer is responsible for the maintenance of the QAPP. Review of this plan should take place by each department supervisor and President before the end of each calendar year. All revisions and additions are submitted to the word processing specialist for entry, then each revision is reviewed by pertinent personnel. Once final approval is granted, the revision number is sequentially increased by one and the date of approval is recorded. All revised sections are distributed to persons who have controlled copies of the QAPP.

QUALITY OBJECTIVES

3.0 QUALITY OBJECTIVES

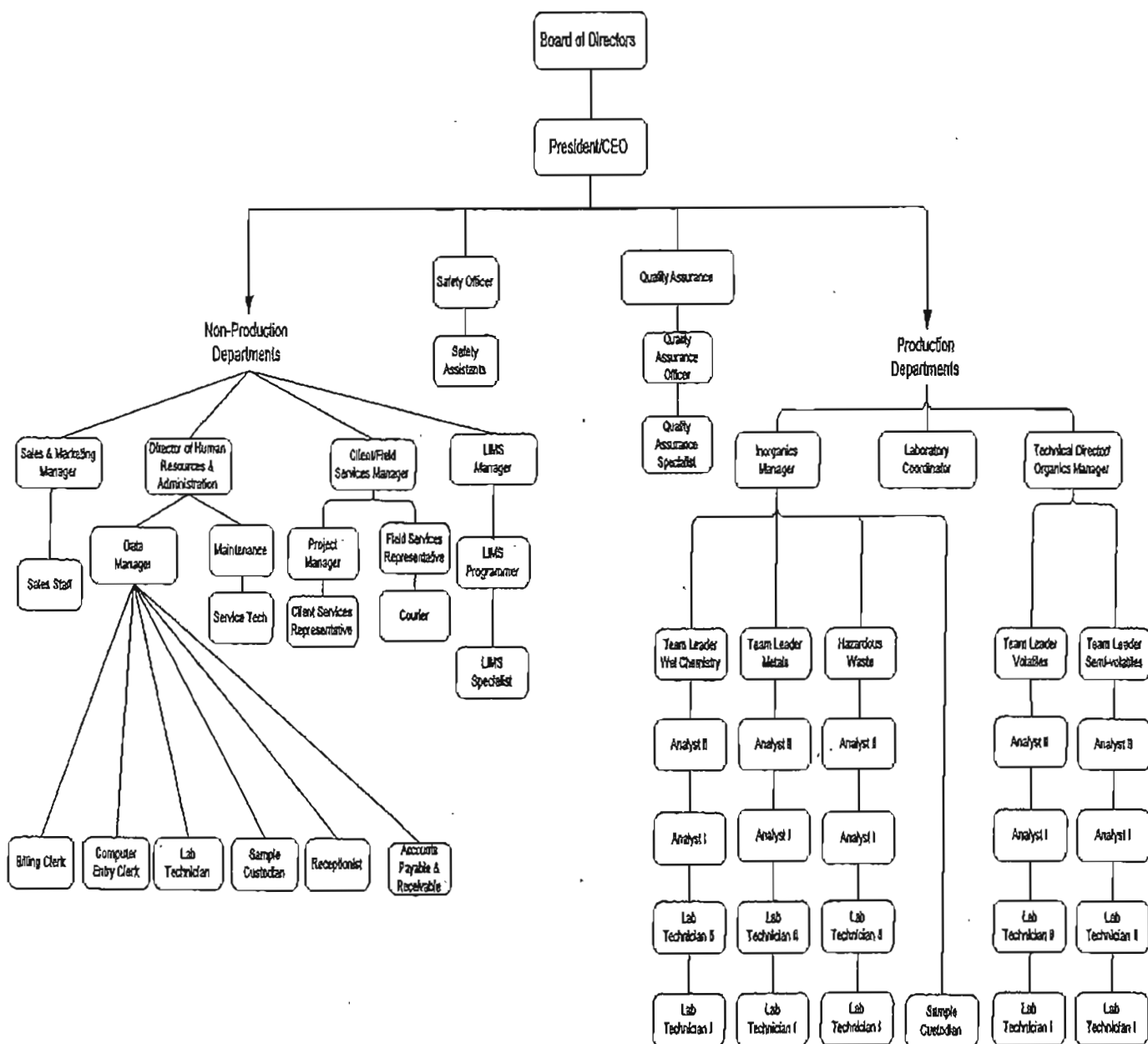
Quality assurance objectives are set to provide the metrics necessary to assess and ensure the quality of generated data. Laboratory QA objectives will be accomplished by applying EPA method acceptance criteria and laboratory internal controls for QC parameters including preparation blanks, surrogates, spikes, duplicates and laboratory control samples. Participation in various audit studies, internal and external will be used to verify the adequacy of the quality objectives. Laboratory data quality will be quantitatively assessed through accuracy, precision and respective method limitations. Qualitative assessment will be conducted through comparability, representativeness and completeness studies.

Specific Parameters:

- ❖ Accuracy - Defined as the degree to which the analytical measurement reflects the true value present. Surrogate, ICV, CCV, RLS, LCS and matrix spike recoveries will be used to measure accuracy. See section 13.4 for the algorithm used to measure accuracy.
- ❖ Precision - Defined as the measure of mutual agreement among individual measurements of the same pollutant in a sample, secured under the same analytical protocols. Laboratory precision will be expressed as relative percent difference (RPD). The goals for precision are related to the proximity of the sample to the detection limit. At or less than five (5) times the PQL, the precision goal will be expressed in absolute concentration (quantitation limit) terms. See section 13.4 for the algorithm used to compute the relative percent difference.
- ❖ Representativeness - Dependent upon the sampling plan. Assessment of site and collection representativeness is done by subcontracted or laboratory field service personnel. Procedures to ensure representativeness will be determined prior to the initiation of individual projects.
- ❖ Comparability - Defined as the extent to which samples can be verified or duplicated by another independent laboratory or compared against results previously found. Comparability will be assessed through parallel studies, round robin programs and internal and external audit results. Acceptable levels of comparability will be addressed in specific project plans.
- ❖ Completeness - Defined as the percentage of valid data obtained, as judged by objectives, compared to the total amount of data collected. QC parameters that shall be assessed for quantitative determinations of completeness shall include initial calibrations, continuing calibrations, surrogate percent recovery, RPD's of duplicates, percent recovery and RPD for matrix spike recoveries, percent recovery for laboratory control samples, and holding times. The requirement for the quantitative assessment of completeness is 90%.
- ❖ Sensitivity - Established practical quantitation limits (PQL's) and method detection limits based on procedures outlined in Appendix B of 40 CFR Part 136, have been documented for analytes of interest. (See Appendix B). Please note that these detection limits are established under ideal conditions, i.e., matrices used for detection limit studies are "clean" soils and deionized laboratory water. MDL studies must be performed annually for each matrix type - water and soil. MDL's and PQL's must meet standards set in SW-846, EPA 500 series methods, EPA 600 series methods and standard methods 18th edition. Special provisions may be necessary in cases of project specific goals, which exceed the aforementioned standards. MDL/PQL derivation procedures are addressed in the QA Protocols Manual.

FIGURE 2

BC Laboratories, Inc.
Laboratory Organizational Chart
Company Structure



SAMPLING PROCEDURES

4.0 SAMPLING PROCEDURES

Proper collection, preservation and storage of samples is needed to ensure sample integrity and representativeness. Samples are collected by trained, experienced field personnel according to guidelines established by Standard Methods for the Examination of Water and Wastewater, Test Methods for Evaluating Solid Waste (SW-846), and 40 CFR Part 136. The Field Services Standard Operating Procedures (SOP) Index, displays the scope of capabilities of our Field Services Department. All protocols for proper sample collection and handling are addressed in respective Field Service SOP's.

4.1 DOCUMENTATION

Proper documentation, including use of Sampling Logs, Field Logs and Chain-of-Custody forms are maintained throughout sampling procedures. Field measurements are recorded in Ink in bound Field Logs with entries signed by respective field service personnel. Field sample information is entered directly into the LIMS upon receipt by a representative of the Sample Control Department. A chain of custody form must be properly completed to track samples in from the field.

4.2 SAMPLE CONTAINERS

All samples collected have proper containers and preservatives with which they are associated. Containers are monitored for artifacts on a quarterly basis or whenever new containers are used.

Table 1 displays Information on proper containers, preservatives and holding times.

4.2.1 SAMPLE BOTTLE / CONTAINER PROCESSING

Preservatives are routinely analyzed before usage. Documentation exists to trace the preservative used for each sample submitted in a laboratory supplied containers.

1. Containers are prepared.
2. Preservatives are made as needed.
 - A. Reagent - grade chemicals are used.
 - B. Once the preservative is made, it is given a batch ID.
 - C. The preservative is tested before use by testing an aliquot brought up to volume in a proper sample container.
 - D. The preservative test is logged into the LIMS.
 - E. The preservative is analyzed for constituents of concern.
 - F. If all constituents of concern are not detected, the preservative can be used. If detections are found, the process must be reinitiated.
3. A reagent log is kept on file to record chemicals used.
4. Analytical records are kept by the Sample / Data Control Supervisor.

4.2.2 TRIP BLANKS

Trip blanks are used to identify the presence of volatile compound contamination attributable to transfer across a sample container septum during shipping and storage of samples. A trip blank is a sample of analyte-free matrix that is transported from the laboratory to the field with sample containers, then stored during sampling and finally transported back to the laboratory with the samples. The trip blank is then treated as an environmental sample in the laboratory with the following exceptions:

1. Analyze trip blanks only when detections are found in associated samples.
2. Analyze according to specific project protocols.

4.2.1.1 Trip blank Preparation

Trip blank matrix is prepared in the laboratory by purifying deionized water. Deionization of laboratory water can be broken into two major steps, macro and micro polishing. Tap water is passed through large resin beds then polished by being passed through a second set of micro resin beds and a carbon cartridge. After purification, the water is collected into a large glass bottle, which is fitted with a carbon filter. A sample, labeled with the batch

SAMPLING PROCEDURES

number and date, is then taken in a 40 ml VOA and analyzed for volatiles by GC/MS. If any analyte concentrations are found above 1 $\mu\text{g/L}$, the process is re-initiated.

4.2.1.2 Monitoring

Every week the stored trip blank water must be analyzed to assure integrity. A sample is taken and labeled with the date and the batch number followed with a letter from the alphabet, which corresponds to the number of samplings after the initial sampling.

Example: Batch 215 initialized and sampled on 06/23/97.
The following weeks' sample is labeled - Batch 215A 05/30/97.

If any target analytes are quantified above 2.0 $\mu\text{g/L}$, a new trip blank batch should be processed.

4.2.3 EQUIPMENT BLANK

A sample of deionized water, which is poured over or through field sampling equipment. This water is processed as an environmental sample in the laboratory for the use of verifying whether or not the decontamination of field equipment was adequate.

4.3 HOLDING TIMES

Samples should be analyzed as soon as possible after collection. The times listed in Table 1 are the maximum time limits that the samples may be held before requested analyses are initiated. Analyses conducted beyond proper sample holding times are to be considered minimum values. Samples may be held for longer periods if the permittee, or monitoring laboratory has data on file to show that the specific types of samples under study are stable for a longer time, and has received a variance from the person in authority. A permittee, or monitoring laboratory is obligated to hold samples for shorter times if knowledge exists showing necessity of maintenance of sample stability. Our goal is to meet every holding time.

4.4 SAMPLE / CONTAINER ORDERING

Completing a bottle order is the responsibility of Client Service personnel. An order is completed by entering all pertinent information from the client into the LIMS. The bottle order form is generated and submitted to the bottle preparation technician. The bottle preparation technician completes the tasks listed on the bottle preparation form and acknowledges completion with the ordering party. Sample containers are now available for client pick up, shipping or courier submittal. A copy of the bottle order form is included for each respective bottle order and should be submitted back to the laboratory after field activities. An example of a Bottle Order Form is given in Figure 3. The bottle ordering process flow chart is located in Appendix E.

SAMPLE CUSTODIAN

5.0 SAMPLE CUSTODY

All samples must remain under custody from the time of sample collection to the time of sample disposal. A sample is considered under custody if:

- 1) It is in one's or a team's possession verified by some form of documentation, or
- 2) it was in one's possession and he/she locked it or placed it in a sealed container to prevent tampering, or
- 3) It is within the laboratory grounds.

5.1 CHAIN-OF-CUSTODY PROCEDURES

- 5.1.1 Samples will be collected, transported, and received under Chain-Of-Custody (COC) protocols consistent with procedures established by the EPA for litigation-related practices. The Chain-of-Custody record will validate the transfer of samples among client personnel, BCL Field Personnel, and/or BCL Sample Control Personnel.
- 5.1.2 Upon receipt at the laboratory, the Sample Custodian is the primary person who will assume sample custody. If the Sample Custodian is not available, any person from the Sample Control Department will be able to handle initial or secondary custody procedures.
- 5.1.3 The COC record is the documentation supporting the integrity of a sample from data collection to data reporting. COC procedures must be followed for all samples from which analytical results may be obtained and introduced as evidence in litigation.

5.2 COOLER RECEIPT FORM

- 5.2.1 Cooler Receipt Forms will be used to document the condition and availability of samples on arrival at the laboratory. The temperature of the air inside sample coolers and/or the temperature of samples is recorded on the Cooler Receipt Form. Sample shipping, type numbers, condition, and containment is also recorded on this form.

5.3 SAMPLE LABELS AND CUSTODY SEALS

- 5.3.1 If sample containers originated from the laboratory, the sample labels will include fields for the following information:
 - 5.3.1.1 Laboratory Name (defaulted)
 - 5.3.1.2 Sample ID
 - 5.3.1.3 Sampler ID
 - 5.3.1.4 Date and Time of sampling
 - 5.3.1.5 Method (defaulted)
 - 5.3.1.6 Preservative if applicable (defaulted)
 - 5.3.1.7 Preservative batch number if applicable (entered by lab personnel prior to shipping to client)
- 5.3.2 Some sample labels are color coded to indicate preservative types:
 - 5.3.2.1 Yellow - Sulfuric acid
 - 5.3.2.2 Red - Nitric acid
 - 5.3.2.3 Green - Sodium Hydroxide
 - 5.3.2.4 Blue - HCl
 - 5.3.2.5 Brown - Zinc Acetate

FIGURE 4

BC Laboratories, Inc. - 4100 Atlas Cl - Bakersfield, CA 93308 - 661.327.4911 - Fax: 661.327.1918 - www.bclabs.com

SAMPLING PROCEDURES

TABLE 1

GENERAL/INORGANIC CHEMISTRY

ANALYSIS	CONTAINER	PRESERVATIVE	CONTAINER	HOLDING TIME (FROM SAMPLING DATE)	
	WATER	WATER (2-8°C)	SOIL	WATER	SOIL
ALKALINITY	PT. PE	UNPRESERVED	N/A	14 DAYS	N/A
AMMONIA (NH ₃)	PT. PE	H ₂ SO ₄	8 OZ. JAR	28 DAYS	28 DAYS
BOD	QT. PE (HEADSPACE FREE)	UNPRESERVED	N/A	24 HR./ 48 HR.	N/A
BORON	PT. PE	UNPRESERVED	8 OZ. JAR	28 DAYS	28 DAYS
BROMIDE	PT. PE	UNPRESERVED	8 OZ. JAR	28 DAYS	28 DAYS
CHLORIDE	PT. PE	UNPRESERVED	8 OZ. JAR	28 DAYS	28 DAYS
COD	PT. PE	H ₂ SO ₄	8 OZ. JAR	28 DAYS	28 DAYS
COLOR	PT. AMBER GLASS	UNPRESERVED	N/A	48 HR.	N/A
CYANIDE (TOTAL AND/OR REACTIVE)	PT. PE	NaOH	8 OZ. JAR	14 DAYS	NO SPECIFIED TIME
EC (ELECTRICAL CONDUCTIVITY)	PT. PE	UNPRESERVED	8 OZ. JAR	28 DAYS	28 DAYS
FLASHPOINT	PT. AMBER GLASS (GLASS ONLY)	UNPRESERVED	8 OZ. JAR	28 DAYS	28 DAYS
FLUORIDE	PT. PE	UNPRESERVED	8 OZ. JAR	28 DAYS	28 DAYS
GROSS ALPHA/BETA	1 L. PLASTIC	UNPRESERVED	8 OZ. JAR	6 MOS.	6 MOS.
URANIUM	1 L. PLASTIC	UNPRESERVED	8 OZ. JAR	6 MOS.	6 MOS.
HARDNESS	PT. PE	UNPRESERVED	N/A	28 DAYS	N/A
HEXAVALENT CHROMIUM (Cr + 6)	PT. PE	UNPRESERVED	8 OZ. JAR	24 HR.	30 DAYS TIL EXT/24 HR IN EXTRACT FORM
IODIDE	PT. PE	UNPRESERVED	8 OZ. JAR	24 HR.	28 DAYS
NITRATE/NITRITE (NO ₃ /NO ₂)	2 OZ. PE	H ₂ SO ₄	8 OZ. JAR	28 DAYS	28 DAYS
NITRITE/NO ₂	PT. PE	UNPRESERVED	8 OZ. JAR	48 HR.	28 DAYS
NO ₂ AS NO ₃	2 OZ. PE	UNPRESERVED	8 OZ. JAR	48 HR.	28 DAYS
ODOR	PT. AMBER	UNPRESERVED	N/A	24 HR.	N/A
OIL & GREASE	1 L. AMBER GLASS (GLASS ONLY)	HCl	8 OZ. JAR	28 DAYS	28 DAYS
418.1 (TPH BY IR)	1 L. AMBER GLASS (GLASS ONLY)	HCl	8 OZ. JAR	28 DAYS	28 DAYS
PH	PT. PE	UNPRESERVED	8 OZ. JAR	IMMEDIATELY	IMMEDIATELY
PHENOLICS	4 OZ. AMBER GLASS (GLASS ONLY)	H ₂ SO ₄	8 OZ. JAR	28 DAYS	28 DAYS
PHOSPHORUS • TOTAL (P)	PT. PE	H ₂ SO ₄	8 OZ. JAR	28 DAYS	28 DAYS
PHOSPHORUS • ORTHO (PO ₄)	PT. PE	UNPRESERVED	8 OZ. JAR	48 HR.	28 DAYS
SILICA	PT. PE (PLASTIC ONLY)	UNPRESERVED	8 OZ. JAR	28 DAYS	28 DAYS
TDS	QT. PE	UNPRESERVED	N/A	7 DAYS	N/A
TSS	QT. PE	UNPRESERVED	N/A	7 DAYS	N/A
SS	QT. PE	UNPRESERVED	N/A	48 HR.	N/A
TOTAL SOLIDS	QT. PE	UNPRESERVED	N/A	7 DAYS	N/A
SPECIFIC GRAVITY	PT. PE	UNPRESERVED	8 OZ. JAR	28 DAYS	28 DAYS
SULFATE	PT. PE	UNPRESERVED	8 OZ. JAR	28 DAYS	28 DAYS
SULFIDE, TOTAL	PT. PE	Zn ACETATE	8 OZ. JAR	7 DAYS	N/A
SURFACTANTS (MBAS)	QT. PE	UNPRESERVED	N/A	48 HR.	N/A
TOTAL COLIFORM	8 OZ. GLASS OR MARGENE	SODIUM THIOSULFATE	N/A	24 HR.	N/A
TKN (KJELDAHL NITROGEN)	PT. PE	H ₂ SO ₄	8 OZ. JAR	28 DAYS	28 DAYS
TOTAL ORGANIC CARBON (TOC)	4 OZ. AMBER GLASS (GLASS ONLY)	H ₂ SO ₄	8 OZ. JAR	28 DAYS	28 DAYS
TOTAL ORGANIC HALIDE (TOX)	PT. AMBER	H ₂ SO ₄	8 OZ. JAR	7 DAYS	NO SPECIFIED TIME
TURBIDITY	PT. AMBER GLASS	UNPRESERVED	N/A	48 HR.	N/A

SAMPLING PROCEDURES

TABLE 1 (CONTINUED)

ORGANIC CHEMISTRY

ANALYSIS	CONTAINER	PRESERVATIVE	CONTAINER	HOLDING TIME		HOLDING TIME	
	WATER	WATER	SOIL	WATER		SOIL	
				EXTRACT	ANALYSIS	EXTRACT	ANALYSIS
• 601	2X VOA (HEADSPACE FREE)	HCl	8 OZ. JAR	14 DAYS	14 DAYS	N/A	14 DAYS
• 602, 8021	2X VOA (HEADSPACE FREE)	HCl	8 OZ. JAR	14 DAYS	14 DAYS	N/A	14 DAYS
• BTEX	2X VOA (HEADSPACE FREE)	HCl	8 OZ. JAR	14 DAYS	14 DAYS	N/A	14 DAYS
• GASOLINE RANGE	2X VOA (HEADSPACE FREE)	HCl	8 OZ. JAR	14 DAYS	14 DAYS	N/A	14 DAYS
• DIESEL RANGE	1 L. AMBER GLASS W/TEFLON	UNPRESERVED	8 OZ. JAR	14 DAYS	40 DAYS	14 DAYS	40 DAYS
8240, 824.2/824/8260	2X VOA (HEADSPACE FREE)	HCl	8 OZ. JAR	14 DAYS	14 DAYS	N/A	14 DAYS
504	3X VOA	UNPRESERVED	3X VOA	28 DAYS	1 DAY	N/A	N/A
531.1	4 OZ. AMBER GLASS	MONOCHLOROACETIC	8 OZ. JAR	FROZEN IN LAB, 28	N/A	N/A	N/A
547	4 OZ. AMBER GLASS	SODIUM THIOSULFATE	8 OZ. JAR	14 DAY	N/A	N/A	N/A
548	QT. AMBER GLASS	NONE	8 OZ. JAR	7 DAYS	14 DAYS	N/A	N/A
549	QT. AMBER PLASTIC	NONE	8 OZ. JAR	7 DAYS	21 DAYS	N/A	N/A
8080A, 608, 608, 8081, 8082	1 L GLASS AMBER W/TEFLON	UNPRESERVED	8 OZ. JAR	7 DAYS	40 DAYS/14**	14 DAYS	40 DAYS
8140/ 8141	1 L GLASS AMBER W/TEFLON	UNPRESERVED	8 OZ. JAR	7 DAYS	40 DAYS	14 DAYS	40 DAYS
8150, 616, 616.1, 8161	1 L GLASS AMBER W/TEFLON	UNPRESERVED	8 OZ. JAR	7 DAYS	40 DAYS	14 DAYS	40 DAYS
525.2/ 507	2X 1 L GLASS AMBER	SODIUM SULFITE & HCl	8 OZ. JAR	*** 14 DAYS	30 DAYS	14 DAYS	N/A
525, 8270C	2X 1 L GLASS AMBER	UNPRESERVED	8 OZ. JAR	7 DAYS	40 DAYS	14 DAYS	40 DAYS
MODIFIED 632, 832	1 L GLASS AMBER W/TEFLON	UNPRESERVED	8 OZ. JAR	7 DAYS	40 DAYS	14 DAYS	40 DAYS
TCLP • VOLATILES	2X VOA (HEADSPACE FREE)	HCl	8 OZ. JAR			14 DAYS	7 DAYS
• SEMI-VOLATILES	1 L AMBER GLASS (EACH TEST)	NONE	8 OZ. JAR			14 DAYS UNTIL TCLP LEACHING	

METALS

ANALYSIS	CONTAINER	PRESERVATIVE	HOLDING TIME (FROM SAMPLING DATE)
WATER			
METALS (1 OR MORE METALS) • TOTAL	QT. PE	HNO ₃	6 MO. (28 DAYS-Hg)
• DISSOLVED • FILTERED IN FIELD	PT. PE	HNO ₃	8 MO. (28 DAYS-Hg)
• NOT FILTERED	QT. PE	UNPRESERVED	6 MO. (28 DAYS-Hg)
• ORGANIC LEAD	QT. AMBER GLASS	CHILL TO 2-8° C	14 DAYS UNTIL ANALYSIS
• HEXAVALENT CHROMIUM (Cr + 6)	PT. PE	UNPRESERVED	24 HOURS

SOIL

METALS (1 OR MORE METALS) • TOTAL	8 OZ. JAR	CHILL TO 2-6° C	6 MO. (28 DAYS-Hg)
• SOLUBLE	8 OZ. JAR	CHILL TO 2-6° C	8 MO. (28 DAYS-Hg)
• EP TOXICITY	8 OZ. JAR	CHILL TO 2-8° C	8 MO. (28 DAYS-Hg)
• WET	8 OZ. JAR	CHILL TO 2-8° C	8 MO. (28 DAYS-Hg)
• TCLP (SEE ALSO ORGANIC CHEMISTRY)	8 OZ. JAR	CHILL TO 2-8° C	8 MO. (28 DAYS-Hg)
• SPLP	8 OZ. JAR	CHILL TO 2-8° C	6 MO. (28 DAYS-Hg)
• HEXAVALENT CHROMIUM (Cr + 6)	8 OZ. JAR	CHILL TO 2-8° C	30 DAYS UNTIL EXTRACTION/24 HR. IN EXTRACT FORM
• ORGANIC LEAD	8 OZ. JAR	CHILL TO 2-8° C	14 DAYS UNTIL ANALYSIS

6.0 FACILITY

The facility was specially designed to alleviate those undesirable factors, which would affect quality in a detrimental way. Emphasis was placed on 1) minimizing cross contamination potentials, 2) providing extensive bench space and considerable refrigerated sample storage areas to ensure effective sample handling processes, 3) maximizing sample and data flow processes, and 4) ensuring a safe working environment.

Laboratory features:

- 1) (2) Walk-in and (4) large wall reach-in refrigerators
- 2) (6) Fire proof data storage rooms
- 3) chemical storage rooms
- 4) Two-story storage area
- 5) Hazardous Waste drum storage facility
- 6) (8) safety shower/eye stations
- 7) (3) hood rooms (24 hoods)
- 8) Conference room with reference library
- 9) Bottle preparation room
- 10) Automated sample submission doors
- 11) Sample split room
- 12) (3) Compressed Gas storage rooms
- 13) Kern Securities fire and security systems
- 14) On site maintenance department
- 15) Separate volatiles rooms: GC, GC/MS
- 16) (6) RAD Lab

The laboratory was built on a large lot which is company owned to accommodate expansion. Figure 6 displays the laboratory floor plan.

6.1 ORGANICS LABORATORY

6.1.1 Separate semi-volatiles and volatiles laboratories.

6.1.2 Semi-Volatiles

6.1.2.1 Separate HPLC, and GC/MS Laboratories

6.1.2.2 Gases piped in from gas storage room.

6.1.2.3 1,600 sq. ft. of working area.

6.1.3 Volatiles

6.1.3.1 Located in the NW corner of the facility (Extractions located in the SE corner).

6.1.3.2 Two separate laboratories, GC-GC/MS.

6.1.3.3 Maintained under positive pressure.

6.1.3.4 Special carbon filters are integrated into the ventilation systems.

6.1.3.5 2,500 sq. ft. of working space.

6.1.4 Extractions

6.1.4.1 Laboratory equipped with 10 ventilated hoods.

6.1.4.2 400 cubic ft. refrigerator.

6.1.4.3 750 sq. ft. of working space.

6.2 WET CHEMISTRY LABORATORY

- 6.2.1 3,200 sq. ft. of laboratory space.
- 6.2.2 560 cubic ft. of refrigerator space.
- 6.2.3 Preparation area segregated from analytical laboratory.
- 6.2.4 Six (6) laboratory hoods.

6.3 METALS LABORATORY

- 6.3.1 Separate preparation areas (soil / water).
- 6.3.2 Two analytical laboratories (ICP, ICP-MS / GFAA-AA, CV)
- 6.3.3 Gases piped in from gas storage room.
- 6.3.4 2,200 sq. ft. of working space.
- 6.3.5 500 cubic ft. refrigerator.
- 6.3.6 Seven (7) laboratory hoods.

6.4 LOG-IN DEPARTMENT

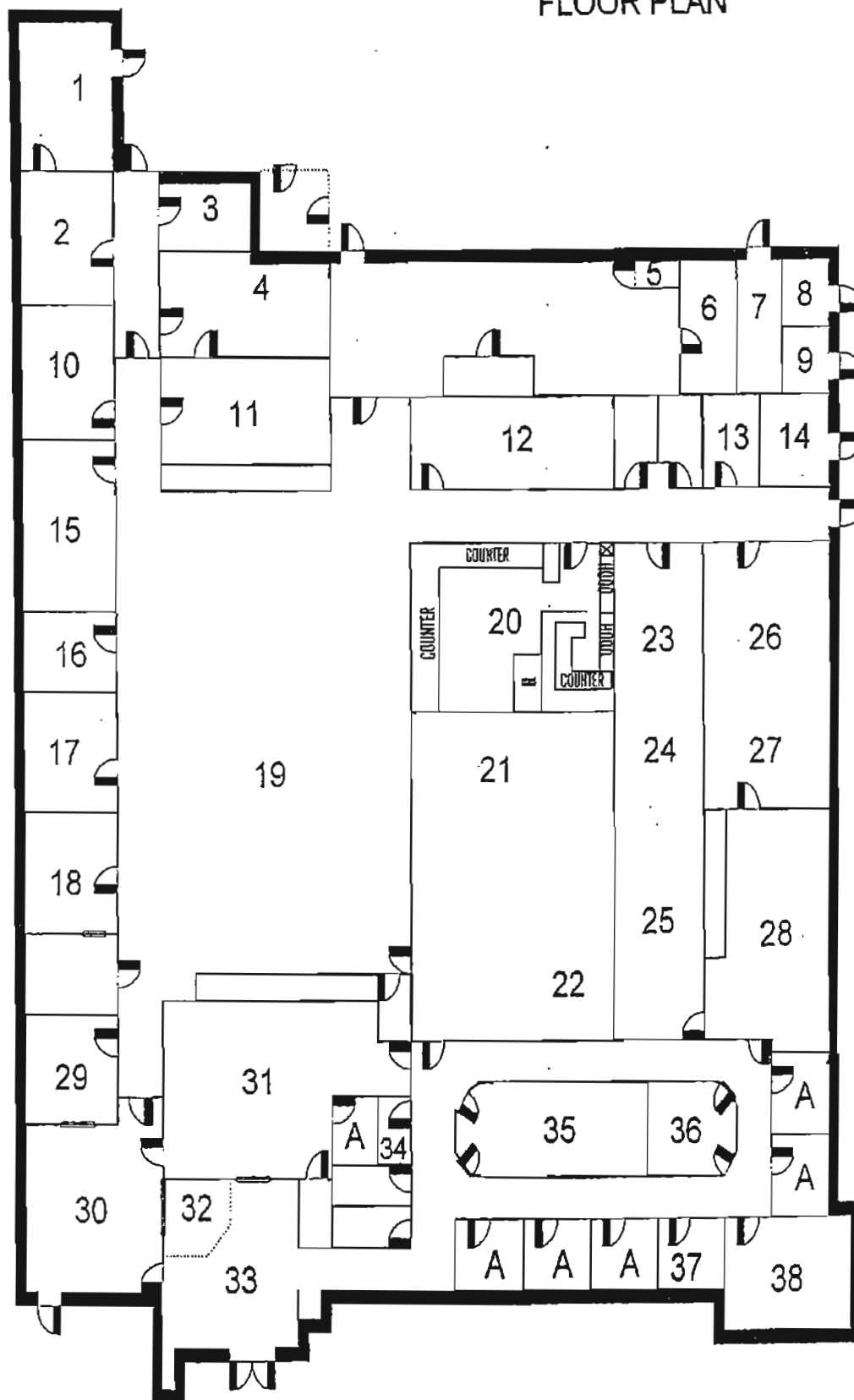
- 6.4.1 1,000 sq. ft. of working space.
- 6.4.2 100 cubic ft. of refrigerator space.
- 6.4.3 One (1) laboratory hood.

6.5 RECORD KEEPING

- 6.5.1 Five (5) Sea - Trains for data and equipment storage.
- 6.5.2 Fireproofed data storage room for temporary storage of data.

6.6 WASTE DISPOSAL AREA

- 6.6.1 Built from the ground up to be a waste disposal storage unit.
- 6.6.2 Secondary containment for individual waste containers.



1	GC Volatiles
2	GC/MS Volatiles
3	Sample Splitting
4	GC/MS Volatiles
5	Compressed Air Dryer
6	Maintenance Office
7	Gas Storage
8	Gas Storage
9	Gas Storage
10	ICP Lab
11	GC/MS Volatiles
12	Metals Digestion (Solids)
13	Solvent Storage
14	Electrical Room
15	Atomic Absorption Lab
16	Bottle Prep
17	Metals Digestion (Water)
18	Bacteriology
19	Wet Chemistry Department
20	RAD LAB
21	Metals / Misc. Department
22	QA/QC Department
23	GC/MS Semi-Volatiles Lab
24	TPH Lab
25	Pesticides / PCB's Lab
26	GC Lab
27	HPLC Lab
28	Organic Extracolon
29	Data Control Department
30	Sample Receiving Dept
31	Client Services/Log-In Dept
32	Reception
33	Lobby
34	Computer Room
35	Break Room
36	Conference Room
37	President's Office
38	Chairman of the Board
A	Administrative Office
H	Hazardous Waste Storage

Figure 8

PERSONNEL / TRAINING

7.0 PERSONNEL

BC Laboratories, Inc. is staffed by qualified, experienced and well-educated personnel. Brief résumés on key personnel are located in our Statement of Qualifications manual. Job descriptions have been finalized for all laboratory positions. Please refer to the Job Description manual for further details. Each position requires specific qualifications to be met. The training program is structured to ensure that curricula addresses specific needs of employees and the organization.

7.1 QUALIFICATIONS

Technical positions require minimum educational standards and experience to be met. These minimum requirements are documented in BC Laboratories, Inc. Job Description Manual. Each analyst must perform an initial demonstration of competency (IDC) before analyses solely generated by the concerned analyst can be reported to clients. These IDC's will follow guidance as listed in SW-846, Method for the Determination of Metals in Environmental Samples, Methods for the Determination of Organic Compounds in Drinking Water, and Standard Methods, 19th edition.

Training is conducted by persons with a solid background in respective subject matter. Module training is presented by individuals who are technically competent and qualified in instructional techniques.

7.2 INTERNAL TRAINING PROGRAM

Basic skills and training knowledge are conducted through in-house programs and/or subcontract programs. The In-house program includes an initial orientation, on the job training and a training module program, which covers various aspects of laboratory operations.

In House Training Modules (offered as needed and/or every other year). See the QAPM.

Module	Topics	Duration	Trainers
1 SECONDARY	Basic Laboratory Operations Math and Science Basics Introduction to Quality Control Introduction to Laboratory Analyses Physical Properties	To Be Determined	Danette Bohm Marna Atencio
2 PRIMARY	Laboratory Math I Units of Measurement Significant Figures and Rounding Percents Exponential Numbers	13,21-I, 22-I, 23-I 21-O, 22-O, 23-O, 24-O	Danette Bohm Richard Penner
3 SECONDARY	Laboratory Math II Dilutions Percent Solutions Molar Solutions Normal Solutions	To Be Determined	Danette Bohm Richard Penner
4 PRIMARY	Laboratory Math III Basic Statistical Concepts SPC and Normal Distribution Control Charts	13,20-I, 21-I, 22-I, 23-I, 24-I, 20-O, 21-O, 22-O, 23-O, 24-O	Danette Bohm Richard Penner
5 PRIMARY	Sample Containers, Preservation, Holding Times Container types per respective analyses Preservatives Holding Times Restrictions References	9,10,13,14,17,21-I,22-I, 32	Karen Bonanno
6 SECONDARY	Quality Assurance, Quality Control Concepts Parameters Basic Tasks Measurement and Assessment Documentation and Audits Corrective Logic	7, 8, 9, 12, 13, 14, 21-I, 21-O, 29, 30, 32	Danette Bohm

7.3 ON THE JOB TRAINING

After the orientation is completed, the trainee will be directed to his/her respective department supervisor. The department supervisor will initiate on the job training procedures. (See the Training Procedures in the QAPM).

7.4 INITIAL DEMONSTRATION OF COMPETENCY

Each analyst must perform an initial demonstration of competency (IDC) before analyses solely generated by the concerned analyst can be reported to clients. These IDC's will follow guidance as listed in SW-846, Methods for the Determination of Metals in Environment Samples, Methods for the Determination of Organic Compounds in Drinking Water, and Standard Methods, 19th edition.

7.5 EXTERNAL TRAINING PROGRAM

External training is conducted through manufacturer's instrument training programs, various independent seminars, California State University at Bakersfield (CSUB), and Bakersfield College. External training is addressed under the Educational Assistance section of the Employee Policy Manual.

Each supervisor is encouraged to attend at least one outside services seminar or training session, which would enhance his/her job performance or knowledge. In order to attend, supervisors must be granted an approval by the General Manager.

7.6 SAFETY

Safety training begins with the new employee orientation. Quarterly safety meetings are held to provide for continuing training regarding safety-related updates and to ensure safe working conditions by providing reiterated safety practice and policy information. All employees,

unless absence is approved by the Safety Officer, are required to attend quarterly meetings. Meeting schedules can be found posted in the lunchroom or in the Injury and Illness Prevention Plan.

7.7 PERFORMANCE EVALUATIONS

To monitor employee progress and efficiency, department supervisors evaluate each specialist annually. These annual screenings are conducted on a one-on-one basis with supervisors rating employee performance on various job-related subjects. During these interviews, goals are set to provide for deficiencies, or to help employees further their training and skills. Evaluation forms used are exclusive for each laboratory department. (See Appendix C to see an example of an evaluation form.)

7.8 EMPLOYMENT

BC Laboratories, Inc. offers a comprehensive benefit package for each employee to ensure a productive and efficient work force. All agreements and particulars are addressed in the BC Laboratories, Inc. Employee Policy Manual.

8.0 RECORDS

Documentation is the heart of every viable QA/QC Program. Without adequate documentation the ability to defend generated data is impossible. The purpose of documentation for viable QA/QC programs is to provide the ability to defend and recreate steps taken associated with each sample from sampling to final submittal and disposal. Documentation falls into two categories: 1) documents providing assurance of data quality objectives, and 2) documents providing information pertaining to contingent processes to support activities concerning sample and sample data handling. Necessary documentation includes:

8.1 SAMPLE CONTROL RECORDS

- 8.1.1 Chain of Custody - A record verifying the custody of samples and requested and associated analyses. The COC will be generated by the person(s) in the field. Completion of this record is addressed in the LOG-IN SOP.
- 8.1.2 Internal Sample Tracking Records
 - 8.1.2.1 Refrigerator Logs - Logs which track internal sample custody used in the Organics's, Wet Chemistry, and Metals Departments.
 - 8.1.2.2 Sample Split Log - Record of sample preparation of solid matrices prior to analytical manipulations.
 - 8.1.2.3 Water Tracking Log - Used to track internal sample custody in the Metals Department.
 - 8.1.2.4 Disposal Log - Tracks sample route from temporary storage to disposal.
 - 8.1.2.5 Archive Refrigerator Log - Record of internal sample tracking for archived samples.
 - 8.1.2.6 Internal Chain of Custody Ledger - Record of initial sample tracking record.
- 8.1.3 Sample Receipt Form - Record of samples submitted and their disposition, condition, and number.
- 8.1.4 Sample Control Approval Form - Provides a review of the log-in process on a submission basis. Also used to verify sample condition.
- 8.1.5 Preservative Reagent Log - Record of preservative preparation.

8.2 ANALYTICAL / INSTRUMENT RECORDS

- 8.2.1 Bench Worksheets (Analytical Data Forms) - Used to record analytical results and support information.
- 8.2.2 Extraction Log - Record of sample extraction.
- 8.2.3 Digestion Log - Record of sample digestion.
- 8.2.4 Filtration Log - Used to document sample filtration.
- 8.2.5 Analysis Logs (Run Log) - Record of the sample analytical sequence on respective instrumentation. Can include other QC information.
- 8.2.6 Maintenance Log - Used to document routine maintenance and subcontract repair of instrumentation.
- 8.2.7 Standards Log - Record of standards preparation.
- 8.2.8 Reagent Log - Record of reagent preparation and use.
- 8.2.9 Raw data - Printouts, charts, and chromatograms produced by instrumentation. Also will include handwritten records for instrumentation without printing capabilities.
- 8.2.10 LIMS printouts - Records of instrument processing and laboratory corrective activities.
- 8.2.11 QC Sheets - Used to document QC and batching capability.

8.3 QA/QC RECORDS

- 8.3.1 Technical Review Sheets - Formatted sheets which guide reviewers to parameters of interest. Record of technical review.
- 8.3.2 Balance Monitoring Log - Used to document analytical and top-loading balance calibration on a daily basis.
- 8.3.3 Refrigerator Monitoring Log - Used to document refrigerator temperatures on a daily basis.
- 8.3.4 Oven Monitoring Log - Used to monitor oven temperatures on a work basis.
- 8.3.5 Thermometer Calibration Check Log - Record of thermometer external checks against a NIST reference thermometer.
- 8.3.6 Waterbath Logs - Record of waterbath temperature during analysis.
- 8.3.7 Auto-diluter Calibration Record - Gravimetric checks of auto-diluter volume deliveries.
- 8.3.8 Data Custody Ledger - Record of custody of data.
- 8.3.9 Spreadsheets - Used to track
 - 8.3.9.1 SIF's
 - 8.3.9.2 Altered Completed Forms
 - 8.3.9.3 Logbooks
 - 8.3.9.4 Instruments
 - 8.3.9.5 Support Instruments
 - 8.3.9.6 Audits
 - 8.3.9.7 Sample Custody
 - 8.3.9.8 Capacity
 - 8.3.9.9 Data Custody
 - 8.3.9.10 IDC - Initial Demonstration of Competency Forms

8.4 SUPPORT DOCUMENTATION

- 8.4.1 Phone Records - Record of phone correspondence between laboratory personnel and clients.
- 8.4.2 Sample Tracking Logs - Record of sample tracking via project coordinators.
- 8.4.3 Archived Files Request Log - Used to document requests for archived files.
- 8.4.4 Subcontract COC Log - Record of sample tracking of submissions to a subcontractor.
- 8.4.5 Shipping Logs (Federal Express / UPS / DHL) - Used to track shipping of samples and/or data supplies.
- 8.4.6 Requisition Form - Procurement record.
- 8.4.7 Altered Completed Files Form - Record of modifications made to records which have been filed.
- 8.4.8 Maintenance Request Form - Record of scheduled maintenance.

INSTRUMENTATION

9.0 INSTRUMENTATION

9.1 Wet Chemistry

9.1.1 Ion Chromatographs

Instrument	ID	Analysis	Year in Service	Method
Dionex Model 2000i AI450 Data Station GPM Pump CDM-1A Conductivity Detector	IC1	Chloride, Nitrate, Sulfate Bromide, Fluoride	1991	EPA-300.0
Dionex Model 2000i AI450 Data Station GPM Pump CDM-2 Conductivity Detector	IC2	Chloride, Nitrate, Sulfate Bromide, Fluoride	1994	EPA-300.0
Dionex Model DX500 A550 Autosampler LC20 CE CD20 Conductivity Detector IP25 Isocratic Pump Peak Net Software	IC1A/IC2A	Chloride, Nitrate, Sulfate Bromide, Fluoride	2000	EPA-300.0

9.1.2 Auto Analyzer Systems

Instrument	ID	Analysis	Year in Service	Method
Alpkem Rapid Flow Analyzer Total Kjeldahl Nitrogen Semi-automated, block digester	RFA-1	Total Kjeldahl Nitrogen	1989	EPA-351.2
Alpkem Rapid Flow Analyzer Nitrate/Nitrite, Cadmium reduction	RFA-3	Nitrate/Nitrite	1989	EPA-353.2
Technicon AAI Auto Analyzer Cyanide Automated Distillation/Colorimetric	AAII-1	Cyanide	1985-current	EPA-335.3 EPA-335.4
Technicon AAI Auto Analyzer Hexavalent Chromium Diphenylcarbazide	AAII-2	Hexavalent Chromium	1985-current	SW-7196
Technicon AAI Auto Analyzer Phenol Automated distillation/Colorimetric	AAII-3	Phenol	1985-current	EPA-420.2
Technicon AAI Auto Analyzer ortho-Phosphate Molybdenum blue	AAII-4	ortho-Phosphate	1985-current	EPA-365.1 EPA-365.2
Technicon AAI-5 Auto Analyzer NH ₃ -N Automated Colorimetric	AAII-5	NH ₃ -N	1977-current	EPA-350.1

INSTRUMENTATION

9.1.3 Other Instruments

Instrument	ID	Analysis	Year in Service	Method
Spectronic 20 Genesys	Spec 05	COD MBAS Sulfide	2001	EPA-410.4 EPA-425.1 EPA-376.2
Altex 70	APH-70	pH in soil samples	1990	SW-9040
Beckman 360 pH/Temp/mv Meter	pH08	pH in water samples	2000	EPA-150.1
Orion Research 420A pH Meter	04202	pH in soil samples	1991	SW-9040 SW-9045
YSI Model 3100 Conductivity Meter	CND-3	Electrical Conductivity	1985	EPA-120.1 SW-9050
Hach Model 2100N Turbidimeter	T2100	Turbidity	1991	EPA-180.1
YSI Model 57 Oxygen Meter	YSI-57	BOD Dissolved O ₂	1990	EPA-405.1 EPA-360.1
Brinkman Digital Buret	BDB	Alkalinity (HCO ₃ , CO ₃ , OH)	1995	EPA-310.1
Dohrmann Model DC80	DCA-1	TOC Analysis	1988	EPA-415.1 SW-9060

9.2 Metals

9.2.1 Inductively Coupled Argon Plasma / Mass Spectrometer

Instrument	ID	Analysis	Year in Service	Method
Perkin Elmer Elan 6100	PE-EL 1	16 Routine metals; Additional metals available upon request	2001	EPA-200.8

9.2.2 Inductively Coupled Argon Plasma

Instrument	ID	Analysis	Year in Service	Method
TJA Model 61E Trace Simultaneous Instrument	TJA61E	28 metals	1995	EPA-200.7 SW-6010A
TJA Model 36 Simultaneous Instrument	TJA36E	28 metals	1990	EPA-200.7 SW-6010A
Perkin Elmer Optima 4300	PE-OP1	30 Metals	2001	EPA-200.7 SW-6010A

9.2.3 Graphite Furnace Atomic Absorption Spectrophotometers

INSTRUMENTATION

Instrument	ID	Analysis	Year in Service	Method
Varian SpectrAA 40Z Zeeman Background	V802	Antimony Arsenic Beryllium Cadmium Copper Chromium Lead Nickel Selenium Silver Tin Thallium	1989, 1990	EPA-200.9/7000A EPA-200.9/7000A EPA-200.9/7000A EPA-200.9/7000A EPA-220.2/7000 EPA-218.2/7000 EPA-200.9/7000A EPA-249.2/7000 EPA-200.9/7000A EPA-200.9/7000A EPA-282.2/7000 EPA-200.9/7000A
Varian Spectra 300/400Z Zeeman Background	V005	Beryllium Cadmium Copper Chromium Nickel Silver Tin Thallium	1996	EPA-200.9/7000A EPA-200.9/7000A EPA-220.2/7000 EPA-218.2/7000 EPA-249.2/7000 EPA-200.9/7000A EPA-282.2/7000 EPA-200.9/7000A
Perkin Elmer SIMAA 600 Zeeman Background AA Winlab Software	PE-1	Arsenic Selenium Lead Antimony Silver	2000	EPA-200.9/7000A

9.2.4 Mercury Analyzers

Instrument	ID	Analysis	Year in Service	Method
Leeman LDC Mercury Analyzer	LDC1	Mercury	1993, 1995	SW-7470/245.1 & 245.5 SW-7471
Thermo Separation Products Mercury Monitor 3200	TSP1	Mercury	1995	SW-7470/245.1 & 245.5 SW-7471

9.3 ORGANICS

9.3.1 GC/MS - Semi Volatiles

Instrument	ID	Analysis	Year in Service	Method
HP 5972 HP 5673 Autosampler HP Chemstation with Enviroquant	MS-B1	Semi-Volatiles	1994	EPA-625 EPA-8270C
HP 5972 HP 7673 Autosampler HP Chemstation with Enviroquant	MS-B2	Semi-Volatiles	1994	EPA-625 EPA-8270C

INSTRUMENTATION

Varian Saturn Varian 8100 Autosampler Varian Enviropro	MS-B3	Synthetic Organic Compounds EPA-507	1995	EPA-525.5 EPA-507

9.3.2 GC/MS - Volatiles

Instrument	ID	Analysis	Varian Service	Method
HP 5970 Tekmar 3000 Concentrator Tekmar Precept II HP Chemstation with Enviroquant	MS-V1	Volatiles	1991	EPA-524.2 EPA-601 EPA-624 EPA-8240B EPA-8260B
HP 5970 Tekmar 3000 Concentrator Tekmar Precept II HP Chemstation with Enviroquant Tekmar Sample Heater	MS-V2	Volatiles	1991	EPA-524.2 EPA-601 EPA-624 EPA-8240B EPA-8260B
HP 5971 Takmar 3000 Concentrator Tekmar Precept II HP Chemstation with Enviroquant	MS-V3	Volatiles	1993	EPA-524.2 EPA-624 EPA-8240B EPA-8260B
HP 5971 Tekmar 3000 Concentrator Tekmar Precept II HP Chemstation with Enviroquant	MS-V4	Volatiles	1993	EPA-524.2 EPA-624 EPA-8240B EPA-8260B
HP 5973 Tekmar 3000 Concentrator Precept II Autosampler HP Chemstation with Enviroquant	MS-V5	Volatiles	2000	EPA-524.2 EPA-601 EPA-624 EPA-8240B EPA-8260B
HP 5972 Tekmar Precept II Tekmar 3000 Concentrator HP Chemstation with Enviroquant	MS-V6	Volatiles	2000	EPA-524.2 EPA-601 EPA-624 EPA-8240B EPA-8260B

INSTRUMENTATION

HP 5971 Tekmar 3000 Concentrator Tekmar Solatek 72 HP Chemstation with Enviroquant	MS-V7	Volatiles	2001	EPA-524.2 EPA-601 EPA-624 EPA-8240B EPA-8260B
HP 5971 Tekmar 3000 Concentrator Tekmar Precept II HP Chemstation with Enviroquant	MS-V8	Volatiles	2001	EPA-524.2 EPA-601 EPA-624 EPA-8240B EPA-8260B
HP 5972 Tekmar 3000 Concentrator Tekmar Solatek 72 HP Chemstation with Enviroquant	MS-V9	Volatiles	2001	EPA-524.2 EPA-601 EPA-624 EPA-8240B EPA-8260B

9.3.3 Gas Chromatography

Instrument	ID	Analyte	Year in Service	Method
Varian 3400 HP 3100 Autosampler HP Chemstation with GC-Enviroquant	GC-1	Organochlorine pesticides and PCB's	1994	EPA-508 EPA-608 EPA-8080 EPA-8081
Perkin Elmer Autosystem Autosystem Autosampler HP Chemstation with GC-Enviroquant	GC-2	Diesel Fuel Fingerprint Carbon Ranges	1991	8015M
Varian 3400 Dual ECD Varian 8100 Autosampler HP Chemstation with GC-Enviroquant	GC-3	Organochlorine Pesticides and PCB's	1989	EPA-508 EPA-608 EPA-8080 EPA-8081
Varian 3400 Dual ECD Varian 8100 Autosampler HP Chemstation with GC-Enviroquant	GC-4	DBCP and EDB	1989	EPA-504.1
Tekmar 2000 and 2032	MS-D1	DOE Room	2001	8260
Tekmar 2000 and 2032	MS-D2	DOE Room	2001	8260

INSTRUMENTATION

HP 5890 Series II Dual FID Tekmar 2000 and 2016 HP Chemstation with GC-Enviroquant	GC-5	Gas	1992	8015M
HP 5890 Series II HP 7673 Autosampler HP Chemstation with GC-Enviroquant	GC-6	PCB's only	1989	EPA-8082
Dual TSD HP 5890 Series II HP 7673 Autosampler HP Chemstation with GC-Enviroquant	GC-7	Organophosphorus pesticides	1990	EPA-614 EPA-8140 EPA-8141
Varian 3400 Dual ECD Varian 8100 Autosampler HP Chemstation with GC-Enviroquant	GC-8	Chlorinated herbicides	1990	EPA-515.1 EPA-615 EPA-8150 EPA-8151
HP 5890 Series II Dual FID HP 7673 Dual Tower Autosampler HP Chemstation with GC-Enviroquant	GC-12	Diesel	1992	8015M
Perkin Elmer Autosystem Autosystem Autosampler HP Chemstation with GC-Enviroquant	GC-13	Diesel Fuel Fingerprint Carbon Ranges	1993	8015M

9.3.4 Gas Chromatography - Volatiles

Instrument	ID	Analysis	Year in Service	Method
Varian 3400 with PID and FID Tekmar 2000 Concentrator Tekmar 2016 Autosampler HP Chemstation with GC-Enviroquant	GC-V1	BTEX, MTBE, TPH (gas)	1989	EPA-8020, 8021 8015M
Varian 3400 with PID and FID Tekmar 2000 Concentrator Tekmar 2016 Autosampler Tekmar 2032 Autosampler HP Chemstation with GC-Enviroquant	GC-V2	BTEX, MTBE, TPH (gas)	1992	EPA-8020, 8021 8015M
Varian 3400 with PID and FID Tekmar Precept II Tekmar 3000 HP Chemstation with GC-Enviroquant	GC-V4	BTEX, MTBE, TPH (gas)	1992	EPA-8020, 8021 8015M

BC LABORATORIES, INC.
INSTRUMENTATION

Varian 3400 with PID and FID Tekmar 2000 Concentrator Tekmar 2016 Autosampler HP Chemstation with GC-Enviroquant	GC-V5	BTEX, MTBE, TPH (gas)	1991	EPA-8020, 8021 8015M
Varian 3400 with PID and FID Tekmar 2000 Concentrator Tekmar 2016 Autosampler Tekmar 2032 Autosampler HP Chemstation with GC-Enviroquant	GC-V6	BTEX, MTBE, TPH (gas)	1991	EPA-8020, 8021 8015M
HP 5890 Series II with PID and FID Tekmar 3000 Concentrator Tekmar 2016 Autosampler Tekmar 2032 Autosampler HP Chemstation with GC-Enviroquant	GC-V7	BTEX, MTBE, TPH (gas)	1998	EPA-8020, 8021 8015M
HP 5890 Series II with PID and FID Tekmar 3000 Concentrator Tekmar Precept II Autosampler HP Chemstation with GC-Enviroquant	GC-V8	BTEX, MTBE, TPH (gas)	1998	EPA-8020, 8021 8015M 5035

9.3.5 HPLCs

Instrument	ID	Analyte	Year in Service	Method
HP 1050 Model 79856A Quaternary Eluent Pump Autosampler Multiwavelength UV Detector HP Chemstation with GC-Enviroquant	LC-14	Polynuclear Aromatic Hydrocarbons Carbamate and Urea- containing Pesticides	1994	EPA-610 EPA-8310 EPA-632

9.3.6 Other Instruments

Instrument	ID	Analyte	Year in Service	Method
Foxboro Miran IFF (IR)	IR-1	TPH	1992	EPA-413.2 EPA-418.1
Foxboro Miran IFF (IR)	IR-2	TPH	1992	EPA-413.2 EPA-418.1

9.4 Microbiology

INSTRUMENTATION

Instrument	ID	Analysis	Year In Service
Incubator - ASP Model	IS-81	5.5.5 or 10 Tube	1989-1995
Incubator - VWR Model	1565	5.5.5 or 10 Tube	1989-1995
Incubator - ASP Model	IS-41	Autoclave QC only	1989-1995
Autoclave Marketforge Sterilmatic (2)		1600 Tubes of media (3200)	1990
Waterbath - PS Coliform Incubator Bath		10 (10 tubes/samples)	1992
Waterbath - Precision Scientific Large		20 (10 tubes/samples)	1990
Waterbath - Precision Scientific Small	#1, #2, #3	10 (10 tubes/samples)	1990
Quebec Colony Counter Capacity/100 Potential Capacity/200			1980
Dissection Microscope	Bausch & Lomb		1986
IDEX Spectrolina	EA-160		1996

9.5 Sampling Equipment

9.5.1 Well Sampling

Instrument	ID	Year In Service
ISCO	2700	1994
Grundfos Rediflo	BMI	1992
Grundfos Rediflo	MPI	1992
Solinst Water Depth Finder		1994
Generac 3500 XL Generator	3500	1994
Generac G1600 Generator	G1600	1994
Lamotte Turbidity Meter	2008	1994

9.5.2 Air Sampling

Instrument	ID	Year In Service
SKC Air Sampling Pump	Model 224-PCXR7	1992
Air Test Meters S-275 STD with Pressure Pot (2)		1992
Sensidyne pump	Gastec No. 800	1993

INSTRUMENTATION

9.5.3 Instrumentation

Instrument	Model	Year in Service
Omega pH H60 and pH Conductivity Meter		1994
Myron Company pH & Conductivity Meter		1994
HNU Photolionizer	Model HW - 101	1994

9.6 Support Equipment and Supplies

9.6.1 Laboratory Information & Management System (LIMS)

Instrument	Year in Service
Novell Network Using Advanced Revelations	1990-1998
Pentium 60 40 GB hard drive 32 MB RAM Compaq DLT 15/30 GB Tape backup	1990-1998
Pentium 200 W/9.1 GC hard drive 128 MB RAM Mountain File Safe 1400 8 GB Tape backup	1990-1998
HP Laser Jet Printers (7)	1990-1998
PC's - 386 (13)	1990-1998
PC's - 486 (41)	1990-1998
PC's - Pentium (28)	1990-2000

9.6.2 Laboratory Water System

Instrument	Year in Service
Ionics Deionized Water System	1990-2000
Ionics Nanopure Water System	1990-2000

9.6.3 Glassware

Instrument	Year in Service
Class A for Reagent and Standard Preparation	1990-2000
Various Calibrated Units	1990-2000

BC LABORATORIES, INC.**INSTRUMENTATION**

Instrument	Year in Service
Northstar Walk-In	1987
Rancho Reach-In (4)	1990
Traulsen Reach-In (2)	1987-1995
GE Cold Spot: Nor lake (1), Whirlpool (1), Baxter (1)	1987-1995
GE Freezer (1) Montgomery Ward	

9.6.5 Ovens

Instrument	Year in Service
Precision Scientific (2)	1987-1994
Fisher (4)	1987-1994
VWR (3)	1987-1994
Manitowoc VWR (4)	

9.6.6 Misc Equipment

Instrument	Year in Service
Balance Analytical - Mettler H6 (2)	1987-1993
Balance Analytical - Mettler B5	1987-1993
Top-Loading OHAUS 1500, E4000d, TS400D, E120	1988-1994
Top-Loading DTL 4100S	1988-1994
Top-Loading Mettler PE3600, PL300	1988-1994
Top-Loading Mettler PB 3002-5, BD202	2000
Top-Loading Denver Model A160	2000

9.7 Safety

BC LABORATORIES, INC.

INSTRUMENTATION

Instrument	Qty
Laboratory Hoods	26
Fire Extinguishers	35
Halon	
Combined Class ABC	
Eye/Safety Showers	7
Spill Stations	3
First Aid Kits	5
Fire Blanket	1

11.0 ANALYTICAL PROCEDURES

BC Laboratories, Inc. conducts approved methodologies which have been promulgated by Federal and State legislators, and ASTM and in-house methods for non-regulated analyses.

References

Drinking Waters - 40 CFR Parts 131, 143 Methods for the Determination of Metals in Environmental Samples (EPA/600/R-94/111, May 1994), Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600/R-93/August 1993), Methods for the Determination of Organic Compounds in Drinking Water (EPA/600/4-88/039, EPA/600/4-90/020), Methods for the Chemical Analyses of Water and Wastewater (EPA-600 4-79-020), and Standard Methods for the Examination of Water and Wastewater, 18th Edition (1992), Standard Methods for the Examination of Water and Wastewater, 19th Edition.

Waste waters - 40 CFR Part 136, Standard Methods for the Examination of Water and Wastewater, Methods for the Chemical Analyses of Water and Wastewater, Methods for the Determination of Metals in Environmental Samples (EPA/600/R-94/111, May 1994), Methods for the Organic Chemical Analysis of Municipal and Industrial Wastewater.

Soils, sludges, wastewater, hazardous waste, and solids - SW-846 Federal Register Test Methods for Evaluating Solid Waste Physical/Chemical Methods, Third Edition, Update I, II, & III.

Fuels - LUFT Manual, State Water Resources Control Board and the SB 1764 (1994) Advisory Committee.

Each method has been outlined in respective laboratory standard operating procedures (SOP's). Information such as procedural steps for conducting analysis, standard and reagent preparation, documentation, safety, and quality control are included in each analytical SOP. Refer to Appendix A for listing of SOP's, Table 5-7 list methods conducted on-site.

11.1 SOP CREATION

Department Supervisor's, the Technical Director, and/or the QA Officer will determine the person(s) responsible for SOP creation, and then delegate the task. The template below will be used as guidance for analytical SOP's:

SOP TEMPLATE

- 1.0 SCOPE AND APPLICATION
- 2.0 SUMMARY OF METHOD
- 3.0 INTERFERENCE AND THEIR CORRECTIVE ACTION
- 4.0 APPARATUS AND MATERIALS
 - 4.1 APPARATUS
 - 4.2 INSTRUMENT PARAMETERS
- 5.0 REAGENTS AND STANDARD SOLUTIONS
 - 5.1 REAGENTS - NAME AND SOURCE
 - 5.2 SOLUTIONS - DILUTION SCHEMES
 - 5.3 WORKING STANDARDS
 - 5.4 SPIKES
- 6.0 SAMPLE COLLECTION, PRESERVATION AND HANDLING
- 7.0 PROCEDURE

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- 8.0 QUALITY CONTROL
 - 8.1 DETERMINATION OF IDL, MDL, AND PQL
 - 8.2 METHOD BLANKS
 - 8.3 QC SETS - DUPLICATES & SPIKES
 - 8.4 CONTROL CHARTS
 - 8.5 LOG BOOKS
- 9.0 CALCULATIONS
- 10.0 FORMS
 - 10.1 QC SHEET
 - 10.2 OTHER FORMS
- 11.0 METHOD PERFORMANCE
- 12.0 GENERAL MAINTENANCE
- 13.0 WASTE MANAGEMENT
- 14.0 POLLUTION PREVENTION
- 15.0 SAFETY
- 16.0 REFERENCES

Non-analytical SOP's do not follow a standard format, however these documents should contain sufficient detail to ensure processes can be carried out completely and competently. When completed by the responsible party, the SOP is entered into the LIMS via the word processor. SOP identification will be by method number, technique, and a laboratory/department sequential numbering identification (i.e., BCMET01, BCMET02 ...etc.). The word processing specialist will return the SOP to the author for corrections. When corrections are completed, the SOP will be reviewed by the Department Supervisor. When the supervisor review and correction phase is complete, the QA Officer will conduct a final review and approval. Further details of SOP creation can be found in the SOP QA/QC Protocols.

11.2 CONTROL OF SOP'S AND LOGBOOKS

In order to receive a copy of an SOP, a request must be made to the QA officer, Department Supervisor, or General Manager. One of these persons will inform the word processor specialist to generate the requested SOP. Records pertaining to SOP retrieval will be kept by the word processor.

Record: SOP Number.
 Date of regeneration.
 Person receiving the document.
 Purpose.
 Number of Copies.
 Total Number of copies (History).

The SOP will be generated with an approval by the word processing specialist. Logbooks requests are honored by the Word Processing Specialist. Logbook request sheets are located on a clip near the word processing station. Once a logbook is created, the Word Processing Specialists records the following information:

Logbook ID

ANALYTICAL PROCEDURES

Logbook number
Number of copies
Person receiving the logbook
Date of generation

The Word Processing Specialist will then review the logbook and acknowledge final approval by initialing and dating the logbook cover.

11.3 DEPARTURE FROM SOP

In cases where it is necessary to depart from standard practice, approval must be granted by the department supervisor and the Quality Assurance Officer. Departures for standard procedures must be documented on all affecting final reports.

11.3.1 Documentation - Document nonstandard practice on affecting worksheet(s). Client notification must be made and documented before departure can be granted. Affected final reports must have a comment which alludes to the modification of method.

11.3.2 Approvals from the client must be verified in order to close the deviation of standard practice.

11.4 ASSESSMENT AND HANDLING OF NEW/ADDITIONAL WORK

11.4.1 Summary

Project information must be legible and obtained in a timely fashion to allow necessary modifications to be made prior to projects initiation. Information is obtained from QAPPs, SAPs, CDAPs, or subsets of the aforementioned formats, or from projects initiation forms completed by laboratory interviewers. The information is translated into the appropriate language then discussed through supervisor meetings.

Discussion topics:

- * Confirmation of amount of new/additional work
- * Baseline capacities
- * Potential capacities
- * Labor
- * Instrumentation
- * Certification/Methods
- * Materials
- * Implementation
- * Monitoring
- * Responsibilities
- * Deliverables

Once discussed, accommodations addressing pertinent concerns are made in each department. The Project Manager verifies that all project specific work requirements are secured; especially all non-routine tasks. Project Initiation Forms are then completed and distributed to affecting department supervisors, and if possible, to pertinent clients before initiation of sampling. Performance monitoring will be conducted by the QA/QC Department to measure compliance with project specifications and customer satisfaction.

The LIMS will act as the tool used to confirm analytical capabilities.

11.4.2 Responsibilities

Sales and Marketing

1. Obtain project deliverables information
2. Confirm the amount of work and compare to the capability/capacity of the laboratory
3. Confirm type of work (DOD, DOE, RCRA, CERLA, etc)
4. Monitor project quotes
5. Establish probabilities of project awards

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6. Identify project initiation date
7. Obtain project method specifications
8. Obtain quality goals
9. Act as liaison between laboratory and client until award is granted
10. Submit all pertinent information to Client Services Department

Project Coordinator

1. Obtain project information from Sales and Marketing or client.
2. Translate project information.
3. Assign projects to project managers.
4. Provide guidance in project handling.
5. Provide guidance on completing Project Checklist Form.

Project Manager

1. Gather project information into a Project Initiation Form.
2. Distribute project initiation forms.
3. Modify project initiation forms as needed.

President

1. Facilitate brainstorm sessions.
2. Allocate resources.
3. Approve laboratory system modifications.
4. Approve instrumentation purchases.
5. Approve labor allowances.
6. Secure and allocate resources.
7. Approve purchases of materials and instruments.

Department Manager

1. Assess department capacities.
2. Review and approve prospective work.
3. Coordinate with project coordinator.
4. Initiate IDCs or IDPs for new analysts and/or methods.

QA Officer

1. Monitor performance.
2. Provide method guidance.

LIMS Manager

1. Write programs to handle project specific requirements.
2. Update, increase, and modify LIMS capabilities.

11.4.3 Procedure

Sales and Marketing representative produces bid packages then rates the probability of an award by obtaining information through contracts and/or correspondence with bid proprietors. When awards are confirmed, a request for project information is made, if not already available in RFPs or RFQs, by a representative of Sales and Marketing or the Project Coordinator. The Project Coordinator gathers all project information then translates this information into BC Laboratories' language. Translation will be discussed during weekly supervisor meetings and on a one-to-one basis. A project Quotation Form, which is completed through the LIMS or by hand, is created then distributed to all pertinent personnel.

11.5 CAPACITY

Capacities are functions based by method, # of instruments, # of analysts, # of work shifts, potential # of samples analyzed per 8 hour shifts, sample matrix, and baseline levels of continuous work.

Daily capacity is figured by finding the number of samples which can be analyzed (excluding CCV's, Curve Stds, blanks, LCS's and MS's) on one instrument by one analyst during an eight hour work shift. Actual capacity will vary based on

ANALYTICAL PROCEDURES

time of year, workload, analyst vacations, instrument configuration for multiple analyte analysis, instrument performance, and analyst performance. To adjust this daily capacity, take the average amount of samples analyzed per year and divide by the number of work days in a year, then subtract this number from the daily capacity. This will give us available capacity.

Quarterly capacity will be assessed more accurately detail available capacity during high workload periods. This can be found by finding the average daily workload during quarterly monitoring periods.

Projected workload is based on number of analyses and turnaround time.

$$\text{Projected workload} = \frac{\text{Number of analyses}}{\text{Turnaround Time (days)}}$$

In order to verify if additional workload can be handled, find the daily capacity and/or the quarterly capacity, projected workload (analyses per day) and place in the following algorithm:

Available capacity - projected workload

If this number is positive, the additional workload can be approved. If negative, available capacity must be increased through more instrumentation, more labor, and/or modified system changes.

11.6 METHOD QUALIFICATION

Each new method must be pre-qualified prior to use. Prequalification entails meeting reporting and performance criteria outlined in the ELAP manual "Data Package Guidelines". Further details can be found in the QA Protocols Manual.

11.7 USE OF NON-STANDARD METHODS

In order to utilize methods which are non-referenceable or deviate significantly from referenced methods, we are required to obtain client and/or regulatory agency approval. If regulatory approval is needed, the QA Officer will initiate the process of obtaining method exceptions. Approvals by our clients must be documented in writing on a record which is recognized by our system. All data associated with non-standard methods should be flagged on affected final reports.

11.8 USE OF DIFFERENT METHOD VERSIONS

In cases of combined analytical methods, the most stringent requirements for each of the various calibration and quality control steps must be incorporated in the merged procedure. All instruments are set up to accommodate the most stringent QC requirements for like methods so reporting can be a function of sample matrix or project method reporting protocol. Sample results reported under particular methods must be referenced correctly on final reports either in the heading or in a comments section.

TABLE 5 METAL METHODOLOGIES

Aluminum	EPA 200.7, 6010B			EPA 200.8
Antimony	EPA 200.7, 6010B		EPA 204.2, SW7041, 200.9	EPA 200.8
Arsenic	EPA 200.7, 6010B		EPA 206.2, SW7060, 200.9	EPA 200.8
Barium	EPA 200.7, 6010B			EPA 200.8
Beryllium	EPA 200.7, 6010B		EPA 210.2, SW7091, 200.9	EPA 200.8
Boron	EPA 200.7, 6010B			EPA 200.8
Cadmium	EPA 200.7, 6010B		EPA 213.2, SW7131, 200.9	EPA 200.8
Calcium	EPA 200.7, 6010B			EPA 200.8
Cobalt	EPA 200.7, 6010B		EPA 219.2, 200.9	EPA 200.8
Copper	EPA 200.7, 6010B		EPA 220.2, 200.9	EPA 200.8
Chromium	EPA 200.7, 6010B		EPA 218.2, SW7191, 200.9	EPA 200.8
Iron	EPA 200.7, 6010B			EPA 200.8
Lead	EPA 200.7, 6010B		EPA 239.2, SW7421, 200.9	EPA 200.8
Lithium	EPA 200.7, 6010B			EPA 200.8
Magnesium	EPA 200.7, 6010B			EPA 200.8
Manganese	EPA 200.7, 6010B			EPA 200.8
Mercury		EPA 245.1, O, SW7471		EPA 200.8
Molybdenum	EPA 200.7, 6010B			EPA 200.8
Nickel	EPA 200.7, 6010B		EPA 249.2, EPA 200.9	EPA 200.8
Potassium	EPA 200.7, 6010B			EPA 200.8
Selenium	EPA 200.7, 6010B		EPA 270.2, SW7740, EPA 200.9	EPA 200.8
Silica	EPA 200.7, 6010B			EPA 200.8
Silver	EPA 200.7, 6010B		EPA 272.2, EPA 200.9	EPA 200.8
Sodium	EPA 200.7, 6010B			EPA 200.8
Strontium	EPA 200.7, 6010B			EPA 200.8
Tin	EPA 200.7, 6010B		EPA 282.2	EPA 200.8
Titanium	EPA 200.7, 6010B			EPA 200.8
Thallium	EPA 200.7, 6010B		EPA 279.2, SW7841, EPA 200.9	EPA 200.8
Vanadium	EPA 200.7, 6010B			EPA 200.8
Zinc	EPA 200.7, 6010B			EPA 200.8

TABLE 6 ORGANIC METHODOLOGIES

Purgeables (GC)	EPA 601, EPA 602	EPA 8020, EPA 8021A, EPA 8021B
Purgeables (GC / MS)	EPA 524.2, EPA 624, EPA 8240B, EPA 8260B, EPA 601/602 by GC/MS	EPA 8240B, EPA 8260B
EOB / DBCP	EPA 504	EPA 504M
Pesticides, Herbicides (GC)	EPA 608, EPA 614, EPA 619 EPA 515, EPA 508	EPA 8080A, EPA 8081A, EPA 8082, EPA 8141A, EPA 8140, EPA 525.2, EPA 8150B, EPA 8151A, 8081A
Gasoline Residue	LUFT Manual 8015M	LUFT Manual 8015M
Diesel Residue	LUFT Manual 8015M	LUFT Manual 8015M
PCB's	Modified 608, State Method	Modified 8080, State Method
Phenols	EPA 525.2	EPA 8270C
Title 22	State Method	
Priority Pollutants (GC/MS)	EPA 625, EPA 525.2, EPA 548.1	EPA 8270C
Oil and Grease	EPA 413.1, EPA 413.2, 1664	EPA 413.1, EPA 413.2, EPA 9071M
TPH	EPA 418.1	EPA 418.1
Pesticides, Herbicides (HPLC), Carbamates	EPA 632, EPA 531, EPA 547, EPA 549	632M
PAH's	EPA610	EPA 8310
Explosives	EPA8330	EPA8330

TABLE 7 INORGANIC METHODOLOGIES

Alkalinity	EPA 310.1, SM2320B	EPA AVAC, 1.005
Chloride	SM407C, EPA 300.0, SM 4500 CLC	SM 4500CL D, EPA 300.0
Chromium VI	SW 7196A, SM 3500Cr D	SW7196A
Corrosivity	EPA 150.1	SW9040
Conductivity	EPA 120.1	SW9050
Cyanide	EPA 335.3, EPA 335.2, EPA 335.4	SW9012, SW9010
Flashpoint	SW1010	SW1010
Fluoride	EPA 340.2	EPA 340.2
Nitrogen Forms	EPA 350.1, EPA 353.2, EPA 300.0, EPA 351.2	EPA 350.1, EPA 353.2, EPA 300.0, EPA 351.2
Bacteriologicals	SM 9221B, 9221E, 9223B	SM 9221B, 9221E
D.O.	EPA 360.1	N/A
Bromide	EPA 300.0	N/A
Chlorate	EPA 300.0	N/A
Chlorine Residue	SM 4500 CL-B, F	
Color	EPA 110.2, 9215B (Hpc)	N/A
Organic Lead	LUFT Manual	LUFT Manual
pH	EPA 150.1, SW9040	SW9045, SW9040
Phenols	EPA 420.2, 5530D	SW9066
Phosphorous	EPA 365.1, EPA 365.4	SM424G, SM424C
Sulfur Forms	EPA 376.1, EPA 376.2, SW 9030	SW9030, SW 7.3.4.2
Sulfate	EPA 300.0	
BOD	EPA 405.1	
COD	EPA 410.2, EPA 410.4	
TOC	EPA 415.1	SW 9060
Residue	EPA 160.1 - EPA 160.5	
MBAS	EPA 425.1	
Odor	EPA 140.1	
Turbidity	EPA 180.1	

2.0 SUMMARY

It is the responsibility of the analyst to conduct initial data reduction procedures by using calculations referenced in State and Federally recognized methodologies and within respective SOP's. The tools used to reduce data include Excel spreadsheets, Dionex AI-450 software, HP Chemstation software, calculators, Enable database software, LIMS processing programs and instrument programs.

Validation and verification processes include analyst reviews, technical reviews, supervisor reviews, project management reviews, QA department reviews, data processing checks, and final approvals. See the appropriate flowcharts in Appendix D.

Results are entered onto laboratory bench worksheets, then introduced into the LIMS via data entry specialists. At present, a parallel data processing system is in place for QA/QC purposes only. The incorporation of this new reporting system will eventually replace the hand entry process.

12.1 REDUCTION

12.1.1 Organics Department

12.1.1.1 GC/HPLC

Data is processed via HP Chem software reduced by hand if necessary and recorded onto worksheets. The reduced data is electronically transferred to the LIMS. The LIMS performs statistical calculations (% recoveries % RPD, % found, etc) and sample calculations in test solutions sample weights, extract volume and sample dilution.

12.1.1.2 GC/MS

All data is processed and reduced on manufacturer's software. Sample analyses are processed via data systems enviroquant and Varian's enviropro. Results are then recorded onto worksheets. The reduced data is electronically transferred to the LIMS. The LIMS performs statistical calculations (% recoveries % RPD, % found, etc) and sample calculations in test solutions sample weights, extract volume and sample dilution.

12.1.1.3 TRPH

Data is recorded onto QC bench sheets, reduced by hand, then recorded onto worksheets. Calibration factors are used in the linear regression model which is used to reduce data. The reduced data is electronically transferred to the LIMS. The LIMS performs statistical calculations (% recoveries % RPD, % found, etc) and sample calculations in test solutions sample weights, extract volume and sample dilution.

12.1.2 Metals Department

12.1.2.1 ICP, ICP/MS, GFAA, AA

Instrument data is reduced on manufacturer's software. All dilutions are accounted for on laboratory worksheets. The reduced data is electronically transferred to the LIMS. The LIMS performs statistical calculations (% recoveries % RPD, % found, etc) and sample calculations in test solutions sample weights, extract volume and sample dilution.

12.1.2.2 Hg by cold vapor

The method of least squares, using chart line versus concentration, is used as the linear regression model. Results are reduced onto a QC bench sheet then entered onto worksheet. The reduced data is electronically transferred to the LIMS. The LIMS performs statistical calculations (% recoveries % RPD, % found, etc) and sample calculations in test solutions sample weights, extract volume and sample dilution.

12.1.3 General Chemistries

12.1.3.1 IC

Data is reduced via the use of manufacturer's software. Values are recorded onto a QC bench sheet then transferred to worksheets. The reduced data is electronically transferred to the LIMS.

DATA REDUCTION, VALIDATION, AND REPORTING

The LIMS performs statistical calculations (% recoveries % RPD, % found, etc) and sample calculations in test solutions sample weights, extract volume and sample dilution.

12.1.3.2

Meters, titrimetric and gravimetric tests.

Data is recorded onto QC benchsheets then transferred to worksheet. The reduced data is electronically transferred to the LIMS. The LIMS performs statistical calculations (% recoveries % RPD, % found, etc) and sample calculations in test solutions sample weights, extract volume and sample dilution.

12.1.3.3

Optical Analyses

The method of least squares, using chart line versus concentration, is used as the linear regression model. Results are reduced on QC log sheets then transferred onto worksheets. The reduced data is electronically transferred to the LIMS. The LIMS performs statistical calculations (% recoveries % RPD, % found, etc) and sample calculations in test solutions sample weights, extract volume and sample dilution.

BC LABORATORIES, INC.

PQL/MDL DETERMINATIONS

Analyst:
 Analyte:
 Method:
 Run Date:
 Instrument ID:
 Matrix:
 Units:
 Prep Date:
 MDL Study No:

Analyst:
 Analyte:
 Method:
 Run Date:
 Instrument ID:
 Matrix:
 Units:
 Prep Date:
 MDL Study No:

Analyst:
 Analyte:
 Method:
 Run Date:
 Instrument ID:
 Matrix:
 Units:
 Prep Date:
 MDL Study No:

/ / - - -
 DATE INSTR ID SEQ MATRIX
 NO (W,S)

/ / - - -
 DATE INSTR ID SEQ MATRIX
 NO (W,S)

/ / - - -
 DATE INSTR ID SEQ MATRIX
 NO (W,S)

MDL Std. ID	Response	Conc.	MDL Std. ID	Response	Conc.	MDL Std. ID	Response	Conc.
1			1			1		
2			2			2		
3			3			3		
4			4			4		
5			5			5		
6			6			6		
7			7			7		

MDL Std Concentration:

 $\bar{x} =$ $s =$ $3.29(s) =$
 $t_{(n-1, .99)s} =$ MDL =

 $10s =$ PQL =

MDL Std Concentration:

 $\bar{x} =$ $s =$ $3.29(s) =$
 $t_{(n-1, .99)s} =$ MDL =

 $10s =$ PQL =

MDL Std Concentration:

 $\bar{x} =$ $s =$ $3.29(s) =$
 $t_{(n-1, .99)s} =$ MDL =

 $10s =$ PQL =
Standard Curve $r =$ $r^2 =$ Standard Curve $r =$ $r^2 =$ Standard Curve $r =$ $r^2 =$

1st Order	2nd Order	3rd Order	1st Order	2nd Order	3rd Order	1st Order	2nd Order	3rd Order
Stand. ID	Conc.	Response	Stand. ID	Conc.	Response	Stand. ID	Conc.	Response

MDL/PQL DETERMINATIONS

Analyte:	Study No:	Std Concentration Used:	
Dates: Run No. 1		$\bar{x} =$	$s =$ 3.29(s) =
Run No. 2		$t_{(n-1, .99)} =$	$t_{(n-1, .99)} =$
Run No. 3		10s =	
Analyst:		Blank Response Data:	
Instrument:		$\bar{x} =$	$s =$ 3.29(s) =
Method:		3s =	
Matrix:		10s =	
Units:		STANDARD CURVE	
		Standard ID	Conc.
Instrument Parameters:			Response
Standard Calibration Setting:			
Flowcell Length:		1st Order	2nd Order
Program Method ID:			3rd Order
Date of Preparation:		Correlation Coefficient:	
		PQL:	MDL:

Run No. 1			Run No. 2		
MDL STD. ID	RESPONSE	CONC.	MDL STD. ID	RESPONSE	CONC.
1.			1.		
2.			2.		
3.			3.		
4.			4.		
5.			5.		
6.			6.		
7.			7.		
8.			8.		
Run No. 3			Blank Determination		
MDL STD. ID	RESPONSE	CONC.	BLANK ID	RESPONSE	CONC.
1.			1.		
2.			2.		
3.			3.		
4.			4.		
5.			5.		
6.			6.		
7.			7.		
8.			8.		

PERFORMANCE AND SYSTEMS AUDITS

TABLE 8
LEVEL OF QC EFFORT

TEST	MATRIX	FREQUENCY	CRITERIA	CHEMISTRY
Duplicate	Water	10% or 1 per batch, whichever is greater	<10% RPD above 5 times PQL, If <5 times PQL, $\leq$ PQL.	Inorganic
	Soil/ Wastewater	5% for solid and wastewater matrices	<20% RPD above 5 times PQL, If <5 times PQL, $\leq 2 \times$ PQL.	
Matrix Spike, Matrix Spike Dupl.	Water	10% or 1 per batch, whichever is greater	Within defaulted Control Limits	Inorganic except TSS, TDS, Color, Odor, Turbidity, pH, Conductivity
	Soil/other	5% or 1 per batch, whichever is greater	Within defaulted Control Limits	Solid Matrix Metals, Solid Matrix Inorganics
		5% or 1 per batch, whichever is greater	Within Control Limits	Organic
LCS	NA	1 per batch	90 - 110% Recovery or Within Control Limits	Wet Chemistry
		1 per batch	85 - 115% Recovery or Within Control Limits	Metals, Wet Chemistry (Prepared Samples)
		1 per batch	Within Control Limits	Organic
ICV / CCV	NA	10%	90 - 110% Recovery, for CCV 95 - 105% Recovery, for ICV (See SOPs)	Inorganic, except Hg on solids 200.7, 7470, GFAA for waters
		Every 12 hours	See SOP	GC/MS
		10%	$\pm 15\%$ diff	8000 Series except for GC/MS and 500/600 series
CCB	NA	Run after ICV and each CCV	<PQL	Inorganic, Organic
Preparation Blank	NA	1 per batch or 20 (whichever more frequent)	<PQL	Inorganic, Organic
Initial Calibration	NA	Before each sample run and/or when CCV unacceptable	>0.995 Corr. Coeff.	Inorganic
		When CCV unacceptable, when target compounds out	<20% RSD or regression model	Organic except GC/MS
			<15% RSD/If >15% RSD-use linear regression	GC/MS

PERFORMANCE AND SYSTEMS AUDITS

14.0 PERFORMANCE AUDITS

In order to validate BC Laboratories, Inc. method performance accuracy and comparability to standards of the environmental laboratory industry, a program of external and internal performance evaluations must be incorporated into the Quality Program. Comparability studies are through external PE sample analyses, while internal assessments are conducted to validate and maintain control of the analytical system.

14.1 EXTERNAL PERFORMANCE EVALUATION SAMPLES

BC Laboratories, Inc. is involved in 1) the ERA Water Supply and Water Pollution performance evaluation studies, 2) the NPDES DMR PE studies, 3) a program of PE samples for soil matrices through ERA, 4) an internal PE sample assessment through purchased standards from ERA, 5) SLAP, the Shell Laboratory Audit Program, and 6) ELAP Microbiology Evaluation Study.

All performance sample studies are completed (i.e., we participate in every WS, WP and DMR PE Study). This is not a necessity since one compliant analyte result per PE study will validate that parameter for one year. Each PE sample is analyzed to validate continuous control of the analytical system.

14.1.1 Scope of Analytical Parameters

- 14.1.1.1 Water Supply - TAL metals, minerals, Anions, Cations, EPA 507/8140, EPA 508/8080, EPA 525/8270, EPA 531.1, EPA 515.1/8150, EPA 8010/8020, EPA 8240/8260, EPA 300.0, Physical testing, residue EPA 160.1, EPA 335.3/9012, EPA 9040, alkalinity.
- 14.1.1.2 Water Pollution - TAL metals, alkalinity, EPA 9040, Cations, Anions, Demand, PCB's, EPA 8080, EPA 8010/8020, EPA 8240/8260, EPA 413.1, EPA 335.3/9012, EPA 420.2, Residue EPA 160.1, residual chlorine.
- 14.1.1.3 DMR - TAL metals, EPA 9040, EPA 160.2, EPA 413.1, nitrogen forms (350.1, 353.2, 300.0, 351.1), EPA 365.4, EPA 365.1, Demand, EPA 335.3/9012, EPA 420.2, residual chlorine.
- 14.1.1.4 SLAP - EPA 8020, EPA 8270, TAL metals, EPA 415.1, Demand, EPA 351.1, EPA 413.1
- 14.1.1.5 ELAP Microbiology Study - Bacteriological Analyses
- 14.1.1.6 Internal Performance Evaluation - Parameters under investigation
- 14.1.1.7 Soil Series - 8015M purgeable and extractable, 8080, 8150, 8260, 8270, TRPH, metals.

14.2 SYSTEMS AUDIT

14.2.1 Internal

Systems audits will be conducted on a annual basis and will cover 1) parameters outlined on the Internal Assessment Schedule (Figure 7), 2) clerical procedures, 3) invoicing, 4) conformance to methodology and SOP procedural outline, and 5) other tasks with performance objectives. A completed Systems Audit Report will be submitted to the General Manager annually. Topics of concern which arise during the year will be addressed at the weekly Supervisor's Meetings.

14.2.2 External

External based audits are conducted by representatives of the state of California, and other private or government entities.

14.3 ACTION

The QA Officer is responsible for completing annual systems audits and initiating subsequent corrective actions as needed. If corrective action is required, the QA Officer has the authority to delegate responsibilities and to initiate progressive discipline if tasks are not completed sufficiently to restore acceptable performance of the analytical system. Corrective action documentation will illustrate tasks, responsibilities, time frames, and will validate restoration of the process to a controlled status. Corrective action documentation and Quality Improvement Forms are stored in the QA/QC Department and in pertinent files.

ANALYTICAL QUALITY CONTROL REQUIREMENTS

13.0 QC PARAMETERS

Required QC parameters will vary according to method, specific project requirements, and/or sample matrices encountered. Table 5 illustrates generalized criteria. QC parameter requirements in specific SOP's supercede those listed in Table 5.

QC Parameters for Wet Chemistry testing

Sample/Sample Duplicate
Matrix Spike/Matrix Spike Duplicate
Laboratory Control Sample-Water or Solid
Method Blank

Exceptions:

pH, EC, TDS, Flashpoint

Sample/Sample Duplicate
Laboratory Control Sample

TSS, Settleable Solids

Sample/Sample Duplicate

QC Parameters for Metals testing

Sample/Sample Duplicate
Matrix Spike/Matrix Spike Duplicate
Laboratory Control Sample-Water or Solid
Method Blank
Post Spike

QC Parameters for Organics testing

Matrix Spike/Matrix Spike Duplicate
Laboratory Control Sample
Method Blank
Surrogate

Exceptions:

Oil and Grease, Total Recoverable Petroleum Hydrocarbons
Soil

Sample/Sample Duplicate
Matrix Spike/Matrix Spike Duplicate
Laboratory Control Sample
Method Blank

Water
Matrix Spike/Matrix Spike Duplicate
Laboratory Control Sample
Method Blank

13.1 BATCHING

A group of samples of similar matrix that behave similarly with respect to the procedures being employed. The number of samples in a batch may never exceed 20, (consult SOP to verify maximum batch size). All samples in a batch must be processed as a unit with the same method sequence and the same lots of reagents and standards. The manipulations common to each sample in a batch must be performed simultaneously or in a continuous sequence without significant interruption. If an analytical sequence contains more than one distinct step, such as a preparation procedure, quality control samples required by the method for the batch must be assigned and prepared in the initial step. This group of samples is called a preparation batch, and must contain all quality control

ANALYTICAL QUALITY CONTROL REQUIREMENTS

samples required by the method, including (PB/MB, Dup, MS, MSD, LCS, other). A preparation batch must not contain more than twenty field samples. Laboratory QC samples processed in the preparation batch are not counted in the maximum batch size of 20. If the instrumental analysis of the samples in one preparation batch is not performed in a continuous sequence, the method blank from the preparation batch must be analyzed with each set of samples from the same preparation batch. If re-analyses are required (e.g. to perform dilutions) it is not necessary to include the method blank in the reanalysis.

13.2 LABELING CONVENTIONS

Unique batch identifiers are needed to properly coordinate referencing of QC parameters to associated samples. Preparation sets which are processed into the LIMS are labeled by preparation code, date and set number. All prepared samples within the batch are associated automatically by the LIMS. If preparation tasks are not processed into the LIMS, preparation batches are labeled on individual preparation logs. QC parameters are labeled by a combination of 1) QC parameters type, 2) Method code, 3) Sample number, 4) date and 5) extension.

13.3 QC PARAMETER CONTROL LIMITS

Control limits are calculated from recoveries of laboratory control samples and/or matrix spikes. A minimum of twenty observations should be used to calculate control limits. 500 and 600 series methods mandate calculation of control limits with the statistical use of the word "control" in mind.

Control Limits = Mean Recovery $\pm 3 s$
 s is the standard deviation of the recoveries

The SW-846 series calculation for control limits are as follows:

Control Limits (Matrix Spikes) = Mean Recovery $\pm 3 s$
 s is the standard deviation of the recoveries

Control Limit (for surrogates) = Mean Recovery $\pm 3 s$
 s is the standard deviation of the recoveries

In order to monitor trends in the analytical process, the latest thirty to forty observations are used to calculate laboratory control sample control limits. New control limits are compared to previously calculated limits to track possible trends. Comparisons are made on the means, UCL, LCL and numbers of outliers.

When calculating control limits for matrix spikes, the database will be continually added to until major modifications occur to a method.

There exists many variables that would cause new control limits to be initiated.

Variables:	1.	New Analyst
	2.	New Preparation Tech
	3.	Method Modification
	4.	Instrument Modification
	5.	Reagent and/or standard vendor change

Control limits are calculated by QA Department personnel and analysts using statistical software packages NWA Quality Analyst, Statistica and Excel.

13.4 CALCULATIONS

Precision

Precision is defined as the measure of mutual agreement among individual measurements of the same pollutant in a sample secured under the same analytical protocols. Field and lab precision will be expressed as relative percent difference where:

$$RPD = \frac{|x1 - x2|}{\bar{X}} \times 100$$

ANALYTICAL QUALITY CONTROL REQUIREMENTS

- $|d|$ = Absolute value of the difference between duplicates X1 and X2
X = Mean value of duplicate results, X1 and X2

The goals for precision are related to the proximity of the sample value to the detection limit. At or less than five times the practical quantitation limit, the precision goal will be expressed in absolute concentration (quantitation limit terms).

Accuracy

Accuracy is defined as the degree to which the analytical measurement reflects the true value present. Overall accuracy will be estimated by recovery performance of spiking events, internal standards and control samples. Accuracy will be measured as percent recovery where:

$$\% \text{ RECOVERY} = \frac{X - B}{T} \times 100$$

- X = measured concentration in sample after spiking
B = background concentration in sample
T = concentration of spike added to sample

If the sample concentration is below the MDL, zero(0) will be used in the calculation. In all other cases, the sample concentration must be used to calculate percent recovery. When the sample concentration is greater than four(4) times the spike level, the percent recovery result will be expressed as "High Mean". Percent recovery for selected inorganic method soil matrix samples may use the average of the sample and sample duplicate in the percent recovery equation.

13.5 COMPLETENESS

Completeness shall be evaluated qualitatively and quantitatively if necessary to meet specific project requirements. The qualitative evaluation of completeness shall be determined as a function of all events contributing to the sampling event including items such as correct handling of chain of custody forms, etc. The quantitative description of completeness shall be defined as the percentage of Contract controlled QC parameters that are acceptable.

QC parameters that shall be assessed for quantitative determinations of completeness shall include Initial calibrations, continuing calibrations, surrogate percent recovery for organics analyses, analysis of laboratory duplicates for Relative Percent Difference (RPD), analysis of Matrix Spike/Matrix Spike Duplicate analyses for percent recovery and RPD, and analysis of Laboratory Control Samples for percent recovery, and holding times. The requirement for the quantitative assessment of completeness shall be 90%. The 90% standard shall be applied to the entire list of parameters described above such that a minimum of 90% of the data for each analytical method is associated with acceptable quality control criteria as described above and in other sections of this document. The quantitative assessment of completeness shall be calculated for each analytical method as the ratio of acceptable sample results to all sample results. For multi-analyte methods (organics analyses) each analysis of the aggregate of analytes shall be considered a single sample result. The requirement for holding times shall be 100%. If any sample exceeds the holding time specified by EPA SW 846 (or other guidance documents for other analyses), that sample should be resampled and reanalyzed, unless redirected by the client.

13.6 CORRECTIVE ACTION

Corrective Action will be initiated for instances of QC parameter noncompliance. The extent and steps of corrective action procedures will vary according to project requirements or individual client protocols.

PREVENTATIVE MAINTENANCE

16.0 SCOPE

Preventive maintenance is an orderly program of positive actions (equipment cleaning, lubricating, reconditioning, adjustment and/or testing) done to prevent the failure of measurement systems or support equipment. The goal is to ensure the analytical system is in control and to prevent any nonconformance from occurring before tasks are initiated. Use of preventive maintenance schedules for each analytical measurement system and support equipment type aids in the foretelling of possible problems. Documentation of preventive procedures is through Preventive Maintenance Logs.

Preventive Maintenance Logs are maintained for all instrumentation and equipment. These logs are stored near respective instrumentation and are maintained by responsible analysts or technicians. Figure 8 displays an example of a preventive maintenance schedule.

Service contracts are maintained for all major instrumentation including:

Varian AAs and GFAAs
TJA36
Dionex ICs
Varian GC/MS
Varian GCs
Perkin Elmer GCs

All service calls will be documented in respective Preventive Maintenance Logs.

16.1 GENERAL PROCEDURES

Preventive maintenance will be performed by qualified personnel. Records of repairs, adjustments, and calibrations will be maintained and available for inspection. Periodic checks of Preventive Maintenance Logs and schedules will be performed by department supervisors. Documentation of these checks will consist of approval initials on pertinent logs.

If an instrument is not working properly and cannot be restored by laboratory personnel, a service call to the manufacturer will be made. Approval of a service call must be made by the concerned department supervisor or General Manager before initiation. Documentation of each service call will be maintained in respective Preventive Maintenance Logs.

16.2 TAGGING OUT

In cases when instrumentation or equipment is not operational, they must be labeled out of service, do not use. A sign with the aforementioned label will be affixed to non-operational instruments or equipment by department supervisors or the QA Officer. Responsibility of the removal of warning signs is designated to either department supervisors or the QA Officer.

16.3 GENERAL PREVENTIVE MAINTENANCE CHECKS

EQUIPMENT MONITORING			
Equipment	Check	Frequency	Frequency
Top-loading balances	Verify accuracy with weights calibrated against certified class-S weights	± 0.02 g	Daily or with each use
Analytical balances	Verify accuracy with certified class-S weight using different weight each day over range of weights routinely determined. Calibration by outside source quarterly.	± 0.0005 g	Daily or with each use
Thermometers	Verify accuracy against NIST-certified thermometer, or if purchased with certificate of traceability, check for mercury separation daily.	$\pm 1.0^{\circ}\text{C}$	Annually
Temporary storage refrigerators	Verify temperature within range.	$4^{\circ}\text{C} \pm 2^{\circ}\text{C}$	Daily
Long-term storage refrigerators	Verify temperature within range.	$4^{\circ}\text{C} \pm 2^{\circ}\text{C}$	Daily
Freezers	Verify temperature within range.	$< -10^{\circ}\text{C}$	Daily

17.0 DEFINITIONS

17.0.1 Corrective Action (CA)

A process by which a critical error is corrected in such a way as to prevent future errors of the same nature or type. Some examples of when to initiate corrective action:

- Calculation errors.
- Client Request.
- Out of control trend
- Significant QA/QC anomalies
- Unacceptable PE results.
- Poor curve linearity.
- Dilution error (if sample is diluted).
- Equipment malfunction.
- Improper methodology for sample matrix.
- Contamination.
- Incorrect report formatting.
- Clerical discrepancies.
- Invoicing problems.
- Field service problems.
- Inherent or chronic problems with methodology.

17.0.2 Quality Improvement (QI)

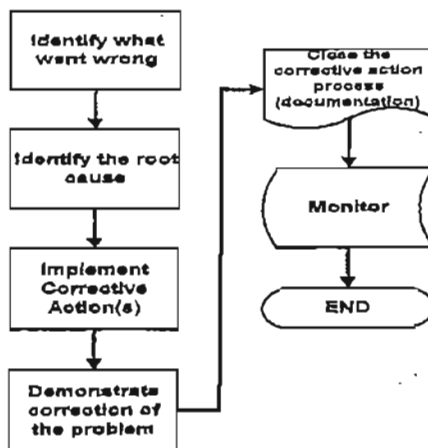
A term used to describe a preemptive positive action or process modification, which increases the level of quality and customer satisfaction.

17.1 PROCESS

Corrective steps for reporting and correcting problems for non-conforming measurements, equipment, or instruments:

1. Assign responsibility for investigating the problem
2. Determine the cause of the problem
3. Determine corrective action to eliminate the problem
4. Assign responsibility for implementing the corrective action
5. Verify that the corrective action has eliminated the problem
6. Create a historical file for future problem solvers
7. Document the corrective action process.
8. Trend corrective action.

PROCESS



Please refer to Appendix D for background on initiation of analytically based corrective action.

PREVENTATIVE MAINTENANCE

Figure 8

MAINTENANCE LOG

		MONTH _____ YEAR _____																														
DAY		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
INITIALS																																
DAILY																																
Clean Platens																																
Empty Waste Containers																																
Wipe Spills																																
Dispose of Sample Cups																																
WEEKLY																																
Wipe Pump Rollers																																
Clean Manifolds - KemWash																																
MONTHLY																																
Clean Wash Reservoir																																
160-200 HRS																																
Change Pump Tubing																																
400 HRS																																
Clean Pump Roller Cage																																
Clean Pump Fan																																
Lubricate Pump Gears																																
6 MONTHS																																
Replace Wash Res. Tubing																																
Replace Cart. Drain Tubing																																
Replace Transmission Tubing																																

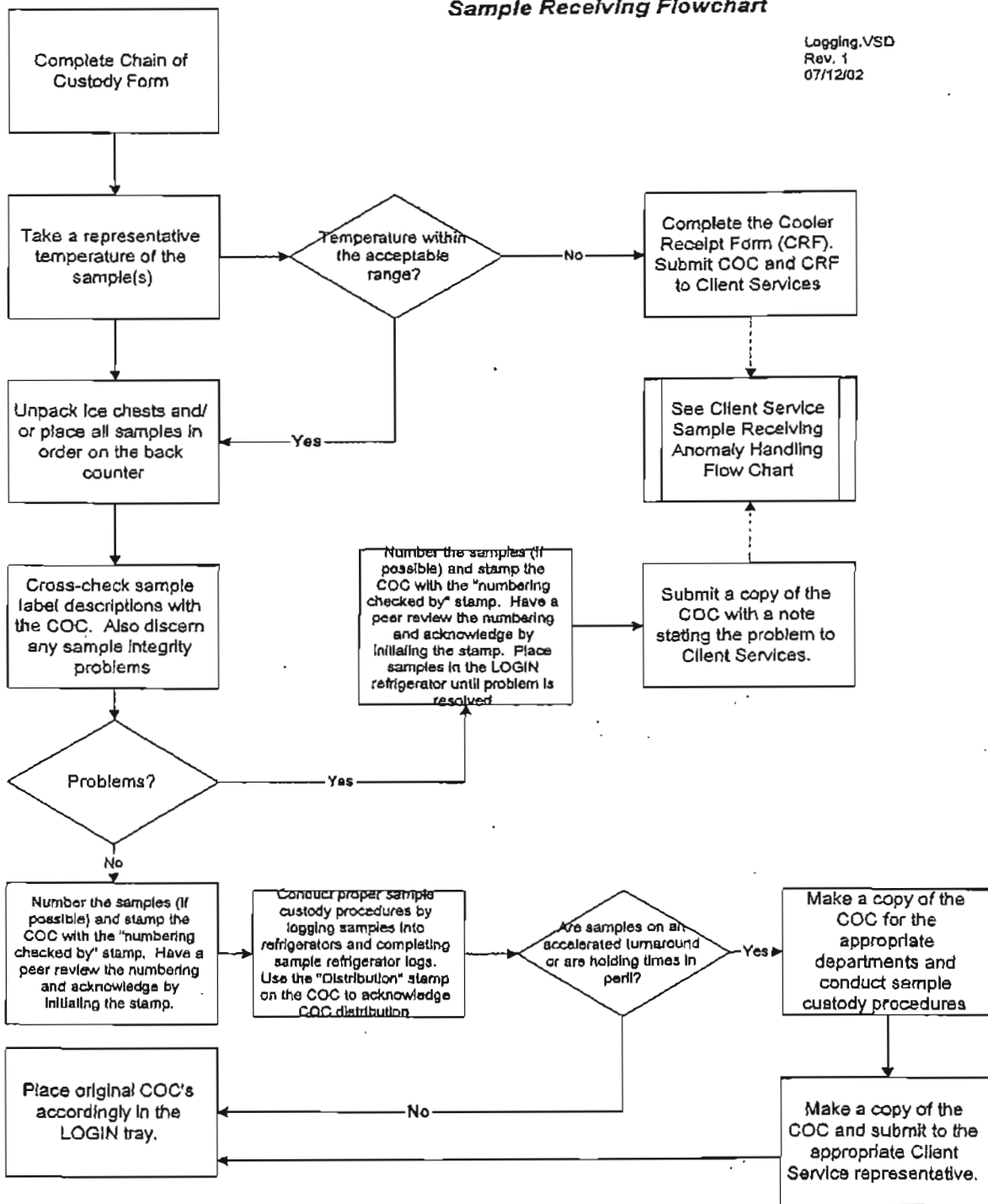
18.0 QUALITY ASSURANCE REPORTS

Quality Assurance reports, prepared by the Quality Assurance Officer, are issued on a quarterly basis. The purpose of these quarterly updates is to give an indication of overall laboratory performance and quality of work. These reports contain information pertaining to the overall performance of the laboratory. Annual internal audit reports are also completed to measure laboratory performance during the previous three month spans.

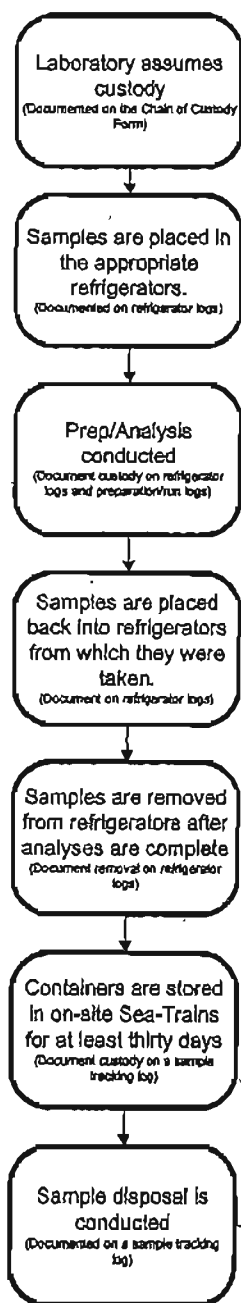
Information is gathered from internal and external audit results, control charts, monitoring programs and supervisor/analyst interviews. Situations such as equipment malfunctions, new or updated QC techniques, revised analytical procedures, corrective action activities, and any significant QC or performance evaluations will also be addressed in the report. Copies of these reports are available upon request.

The QA Officer maintains a direct line of communication with upper management to relay quality related information, therefore eliminating conflict of interest influence from concerned parties.

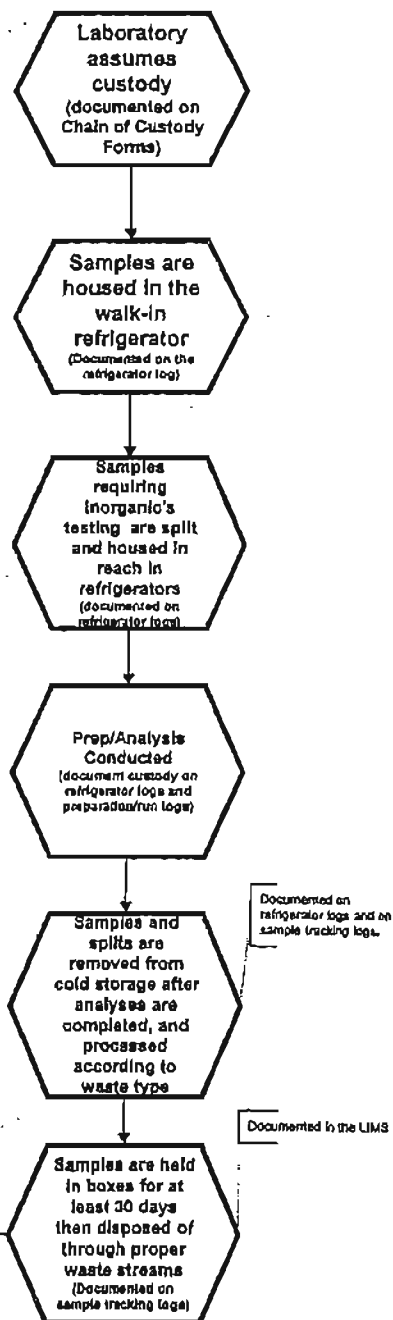
Sample Receiving Flowchart

Logging.VSD
Rev. 1
07/12/02

Sample Tracking Aqueous Matrices



Sample Tracking Non-Aqueous Matrices



Documented on refrigerator logs and on sample tracking logs.

Documented in the LIMS

14.6 Working Standards

Internal audit standards are purchased from: ERA, 5540 Marshall Street, Arvada, CO 80002, 303-431-8454, 1-800-ERA-0122.

Catalog descriptions: WW-11: Wastewater, PP-41: PP/CLP Organic-water PW-31: Potablewater.

Optional purchases are made from: Ultra Scientific, 250 Smith Street, North Kingstown, RI 02852, 401-294-9400, Fax: 401-295-2330.

14.7 Sample Collection, Preservation and Handling

Audit samples should be prepared as soon as possible. If this is not practical, store samples or ampuls according to specifications included in respective preparation method instructions.

Preserve audit solutions according to method preparation instructions, and/or laboratory guidelines.

Handle concentrated ampul solutions with care. Read associated MSDS sheets for more information on safe handling of each material.

When analyses are completed, discard samples and remaining ampul contents according to laboratory waste disposal protocols.

14.8 Procedure

14.8.1 Internal Audits (conducted by the QA/QC Dept.)

Purchase audit samples from ERA on an as needed basis. When the audit samples arrive, prepare and process them immediately. If this cannot be done, store the samples inside the walk-in refrigerator. Follow preparation procedures and fill out chain-of-custody forms under fictitious client identifications. Document these sample identifications and notify the billing department of the audit samples so they are not billed. The most anonymous method of submitting samples is to pack the sample batch into an ice chest. Then leave it overnight in the walk-in refrigerator. The samples will be logged in the following morning. When analyses are completed, retrieve data from the billing department or client services. Process the results in report form as part of the quarterly report to upper management. List sample IDs, methods used, results, units, control limits and analytes. Process an unacceptable results section that includes: sample IDs, methods, analytes, reasons for discrepancies, and corrective action.

14.8.2 External Audits

Examine all aspects of sample condition when the audit arrives. If any discrepancies are found, contact the responsible parties for further instruction or action. After examination of samples and instructions, initiate the analytical process. Review all pertinent raw data after respective supervisor validations. If any discrepancies are found, allow the responsible supervisor to correct the problem. When all data is acceptable and complete, hand in the data package to the Data Control Department. Review of data

transferal is conducted by the Data Control Supervisor. When this checkpoint is cleared, the QA Officer reviews the results and clears the audit.

14.9 Forms

- Preparation Forms
- Sample Constituency Forms
- Analyte Concentrations Reports
- Chain-of-Custody

14.10 Safety

Follow any precautions listed in the MSDS associated for each sample. Always wear a labcoat, gloves and safety glasses.

AQUATIC TESTING LABORATORIES

1. INTRODUCTION

Aquatic Testing Laboratories (ATL) is dedicated to providing the highest quality aquatic toxicity testing available to its clients. This document describes ATL's Quality Assurance policies and procedures as they relate to biological monitoring for environmental pollutants.

Purpose of Document

This Quality Assurance Program Plan (QAPP) is intended to ensure that precision, accuracy, completeness, comparability, and representativeness of data are known and documented.

The QAPP presents an overview of the essential elements of ATL's QA program. This plan has been modeled along EPA guidelines as outlined in "Interim Guideline and Specifications for Preparing Quality Assurance Program Plans," QAMS-004/80, December 29, 1980; "Interim Guideline and Specifications for Preparing Quality Assurance Project Plans," QAMS-005/80, February 1983; "Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms," EPA/600/4-89/001; and "Manual for the Evaluation of Laboratories Performing Aquatic Toxicity Tests," EPA/600/4-90/031. All of these documents have been issued by the Office of Monitoring Systems and Quality Assurance, Office of Research and Development, U.S. Environmental Protection Agency (U.S. EPA). Primary guidance was obtained from "Enseco Incorporate Quality Assurance Program Plan for Environmental Biology," Revision 3.1, July, 1988, written by Enseco Inc. with additional guidance provided from the Environmental Laboratory Accreditation Program, (State of California Department of Health Services and Department of Fish and Game).

QA Objectives

This QA Program Plan is designed to control and monitor the quality of data generated at MRS and by subcontractors. The described QA program is geared toward generating data that comply with federal regulatory requirements specified under the National Pollutant Discharge Elimination System (NPDES) as well as the State of California Department of Health Services Environmental Laboratory Accreditation Program (DOHS ELAP) and other state equivalents. Although the QC requirements of these various programs are not completely consistent, each of the programs base data quality judgements on two types of information:

- 1) Data that indicate the overall qualifications of the laboratory to perform environmental analyses;
- 2) Data that measure the laboratory's daily performance using a specific method.

The operational elements that are involved in making each of these assessments are described in TABLE 2.1 along with the pertinent section number from this document in which each is discussed.

TABLE 2.1
DATA QUALITY ASSESSMENT

Evaluation Criteria	Operational Elements	QA Plan
LABORATORY QUALIFICATION	Facilities/Equipment/Staff	SOQ*
	Written SOP's for all laboratory procedures	27
	Sample custody	8
	Calibration procedures	10
	Testing procedures	11
	Data validation	15
	Documented QA program	1-28
	Laboratory certifications	21
LABORATORY PERFORMANCE	Calibration data	10
	Check samples	21
	Reference toxicant data	19
	Control charts	19

* SOQ (Statement Of Qualifications) described in a separate document.

2. DEFINITIONS

Definition of Terms

Protocol: the actual plan for scientific testing. A protocol may refer to several SOP's to complete the plan.

Quality Assurance (QA): the total integrated program for assuring the reliability of data generated in the laboratory.

Quality Assurance Program Plan (QAPP): an assemblage of management policies, objectives, principles, and general procedures outlining the techniques by which the laboratory produces data of known and accepted quality.

Quality Assurance Project Plan (QAPjP): an assemblage of detailed SOP's describing how the laboratory will generate data that meet the data quality objective of a specific project.

Quality Control (QC): the routine application of specific, well documented procedures to ensure the generation of data of known and accepted quality, thus fulfilling the objectives of the QA program.

Quality Control Manual: an assemblage of detailed SOP's describing the laboratory implementation of the QAPP.

Standard Operating Procedure (SOP): a detailed, written description of a procedure designed to systematize and standardize the performance of the procedure.

3. ORGANIZATION, RESPONSIBILITIES AND AUTHORITIES

Executing an effective QA program demands the commitment and attention of both management and staff. The QA effort at ATL is managed by the Laboratory Director who serves as the QA Officer and as such, has the responsibility of overseeing and regulating all laboratory functions. The QA program operates independently of all areas, generating analytical data to ensure complete objectivity in the evaluation of laboratory operations.

QA Officer Responsibilities

The QA officer is responsible for:

- * Developing and implementing a QA program that ensures that all data generated are scientifically sound, legally defensible, and of known precision and accuracy;
- * Monitoring the QA Plan to ensure compliance with QA objectives;
- * Ensuring that all employees are complying with the QA Plan;
- * Developing and implementing new QA procedures to improve data quality;
- * Conducting in-house audits and inspections of all laboratories on a regular basis and applying corrective actions as needed to ensure compliance with the QA Plan;
- * Maintaining copies of all SOP'S;
- * Assist in the writing of SOP's;
- * Distributing current SOP's to the laboratory staff;
- * Monitoring laboratory performance in the areas of holding times, turn-around times, and meeting contractual obligations;
- * Performing statistical analyses of QC data and establishing data bases that accurately reflect the performance of the laboratory;
- * Maintaining reference toxicant control charts on all testing done at ATL;

- * Maintain records and archives of all QA/QC data, PE results, audit comments, and client inquiries concerning data quality;
- * Conducting seminars on QA issues for both clients and laboratory staff; and
- * Promoting sound QA practices within the environmental regulatory and analytical communities.

QA Officer Authority

The QA officer has the final authority on all issues dealing with data quality and has the authority to require that procedures be amended or discontinued, or analyses suspended or repeated. He also has the authority to suspend or terminate employees on the grounds of dishonesty, incompetence, or repeated non-compliance with QA procedures.

Laboratory Personnel Responsibilities

All laboratory personnel involved in the generation and reporting of data have a responsibility to understand and follow the ATL QA Plan. Laboratory personnel are responsible for:

- * Have a working knowledge of the ATL QA Plan;
- * Ensuring that all work is generated in compliance with the QA Plan;
- * Performing all work according to written SOP's;
- * Ensuring that all documentation related to their work is complete and accurate; and
- * Providing management with immediate notification of quality problems.

Laboratory Personnel Authority

Laboratory personnel have the authority to accept or reject data based on compliance with well-defined QC acceptance criteria. The acceptance of data that fall outside QC criteria must be approved by laboratory management. The authority of the laboratory personnel flows from the Laboratory Director.

4. SAMPLING PROCEDURES

The generation of quality data begins with the collection of the effluent, water or sediment sample. Therefore the integrity of the sample collection process is of concern to the laboratory. Samples must be collected in such a way that no foreign material is introduced into the sample and no material of interest escapes from the sample prior to analysis. To ensure sample integrity, the following must be considered:

- * Samples must be collected in appropriate containers. In general, glass containers are used for soils and solids, while plastic "cubitainers" are used for effluents and surface waters;
- * The sample containers must be properly cleaned to ensure that the sample is not contaminated during the collection process;
- * Appropriate volumes of sample must be collected to ensure that the required testing may be completed and QC samples may be analyzed;
- * Samples must be cooled to the appropriate holding temperature (4°C) prior to shipping;
- * Samples must be properly shipped to the laboratory, in the appropriate time frame, to ensure that holding times can be met.

ATL can assist in the sample collection process by providing consultation and assistance to clients designing sampling programs and also by making available to the client a set of appropriate sample containers that are properly cleaned for use in sample collection.

The maximum holding times recommended by ATL, appropriate containers, and minimum sample volumes required for routine testing are given in Appendix I. These holding times are in general agreement with EPA and the State of California recommended holding times, as stated in the National Pollutant Discharge Elimination System (NPDES) and the California Environmental Laboratory Accreditation Program (ELAP) programs. Other holding times can be honored if special arrangements are made with the laboratory.

5. SAMPLE CUSTODY

Upon receipt by ATL, samples proceed through an orderly processing sequence specifically designed to ensure continuous integrity of both the sample and its documentation.

All samples are received by ATL's sample control personnel and are carefully checked for label identification, and completed, accurate chain-of-custody records. Photographs may be used to document the condition of samples. Each sample is then assigned a unique laboratory identification number. The date received, the condition upon receipt, the new laboratory identification number, as well as the client and the client's sample identification are recorded in the sample control log book. A sample file is then generated in which all documentation, including testing results, are kept. The sample itself is labeled with the laboratory identification number and stored in a secured refrigerated storage facility with temperature maintained at 4°C until analysis. Any unused sample is returned to refrigerated storage until all analyses are complete. Samples are then either returned to the client, properly disposed of, or at the request of the client, stored for an extended length of time.

An example of ATL's chain-of-custody record form is given in Figure 5.1.

CHAIN OF CUSTODY

Client: _____

Address: _____

Project Manager: _____

Phone: _____

Purchase Order/Quote No.: _____

Aquatic
Testing
Laboratories



"dedicated to providing quality aquatic toxicity testing"

2810 Bunsen Ave., Unit A
Ventura, CA 93003
(805) 650-0546 FAX (805) 650-0756

SAMPLE ID/DESCRIPTION	SAMPLE DATE	SAMPLE TIME	SAMPLE TYPE*	NUMBER OF CONTAINERS	TESTING REQUESTED	REMARKS

Special Instructions: _____

* L - Liquid, S - Solid, SS - Semi-Solid, WW - Waste Water, RW - Receiving Water

CUSTODY TRANSFERS

RELINQUISHED BY (SIGNED)	RECEIVED BY (SIGNED)	DATE	TIME
Sampler:			

Shipping Company: _____ Airbill No.: _____

Received for Laboratory by: _____ Date: _____ Time: _____

Received Chilled: Yes No Seals Intact: Yes No None

Figure 5.1 Sample Chain Of Custody Form

6. CALIBRATION PROCEDURES AND FREQUENCY

Standard/Reagent Preparation

A critical element in the generation of quality data is the purity/quality and traceability of the standard solutions and reagents used in the analytical and/or biological operations. ATL continually monitors the quality of reagents and standard solutions through a series of well-documented procedures.

To ensure the highest purity possible, all primary reference standards and standard solutions are obtained from the EPA laboratory in Cincinnati, Ohio, or other reliable commercial sources. All standards and standard solutions are recorded into a log book that identifies the supplier, lot number, purity/concentration, receipt/preparation date, preparer's name, method of preparation, expiration date, and all other pertinent information.

Care is exercised in the proper storage and handling of standard solutions, and all containers are labeled as to compound, concentration, solvent, expiration date, and preparation data (initials of preparer/date of preparation).

Instrument Calibration and Tuning

Calibration of instrumentation is required to ensure that the analytical system is operating correctly and functioning at the proper sensitivity. Instruments used for routine measurements of chemical and physical parameters such as pH, DO, temperature, conductivity, salinity, alkalinity, and hardness, must be calibrated and standardized according to the instrument manufacturer's procedures prior to any uninterrupted use.

Dissolved oxygen probes can be calibrated daily by use of the moist air technique, however, comparison to the Winkler titrimetric method must be performed at least once per week.

Wet chemical methods used to measure hardness and alkalinity must be standardized according to EPA Methods 130.2 and 310.1.

7. TESTING PROCEDURES

Test Organisms

The fish and invertebrates used in toxicity testing should appear healthy, behave normally, feed well, and have low mortality in cultures, holding tanks, and test controls. Test organisms should be disease-free and should be positively identified to species.

The sensitivity (quality) of test organisms obtained from an outside of the laboratory source is to be tested by conducting a reference toxicant test on organisms from each batch received by the laboratory. The sensitivity of test organisms obtained from an in-lab breeding culture is to be tested by conducting a reference toxicant test on the cultured organisms on a monthly basis. Reference toxicant tests may be performed concurrently with an effluent toxicity test.

Facilities, Equipment, and Test Chambers

Laboratory and bioassay temperature control equipment must be adequate to maintain recommended test water temperatures. Surfaces that come in contact with the sample, such as test chambers, must be made of recommended materials. See individual testing SOP's and protocols for recommended materials and testing regimes.

Dilution Water

The dilution water used in toxicity tests will depend on the objectives of the study and client requirements. Hazardous waste testing utilize synthetic, soft (hardness: 40-48 mg/l CaCO_3) water. EPA NPDES toxicity test utilizes synthetic, moderately hard water or 20% diluted mineral water (DMW). Some tests will required the use of client-supplied dilution water.

The dilution water used for internal quality assurance tests with organisms, food, and reference toxicants should be water routinely used with success in the laboratory.

Testing Conditions

Water temperature must be maintained within the limits specified for each test. Dissolved oxygen (DO) concentration and pH in fish and invertebrate test chambers should be checked daily throughout the test period, as described in the test SOP.

Food Quality

The quality of the food for fish and invertebrates is an important factor in toxicity tests. Suitable fish food flakes, brine shrimp cysts, and other foods must be obtained as described in the test SOP's and protocols. The suitability of each new supply of food must be determined in a side-by-side test, using two treatments with four replicates per treatment. In this test, the response of control test organisms fed with the new food is compared with the response of organisms fed a reference food or a previously used, satisfactory food.

Test Methods

Most tests performed by ATL are driven by regulatory concerns. Therefore, methods used at ATL predominately originate from regulatory agencies. Generally the methods used are those specified by the U.S. EPA and other federal agencies, state agencies, and professional organizations, as provided in the following references:

- * American Society for Testing Materials (ASTM). 1989. Standard Guide for Conducting Static Acute Toxicity Tests Starting with Embryos of Four Species of Saltwater Bivalve Molluscs. Procedure E 724-89. ASTM, Philadelphia, PA.
- * California Department of Health Services. 1988. Static Acute Bioassay Procedures for Hazardous Waste Samples. Prepared by J.M. Polisini and R.G. Miller. California Department of Fish and Game Water Pollution Control Laboratory.
- * California State Water Resources Control Board (CSWRCB). 1989. Experimental Evaluation of Effluent Toxicity Testing Protocols with Giant Kelp, Mysids, Red Abalone, and Topsmelt. CSWRCB, Sacramento, CA.

- * Dinnel, P., J.M. Link and Q.J. Stober. 1987. Improved Methodology for a Sea Urchin Sperm Cell Bioassay for Marine Waters. Arch. Environ. Contam. Toxicol. 16:23-32.
- * Kopperdahl, F. 1976. Guidelines for Performing Static Acute Toxicity Fish Bioassays in Municipal and Industrial Wastes. Calif. Dept. of Fish and Game.
- * Machuzak, M.J. and T.K. Mikel, Jr. 1988. Drilling Fluid Bioassays Using Pacific Ocean Mysid Shrimp, *Acanthomysis sculpta*, a Preliminary Introduction. ASTM STP 971. ASTM, Philadelphia, PA.
- * U.S.ACE/HD. 1990. Dredged Material Bioassay/Bioaccumulation Testing Manual for Hawaii. U.S. Army Corps of Engineers, Honolulu District, Fort Shafter, Hawaii.
- * U.S.ACE/NYD. 1984. Guidance for Performing Tests on Dredged Material to be Disposed of in Ocean Waters. U.S. Army Corps of Engineers, Regulatory Branch, Water Compliance Section, New York, NY.
- * U.S.EPA. 1985. Methods for Measuring the Acute Toxicity of Effluents to Freshwater and Marine Organisms. EPA/600/4-85/013.
- * U.S.EPA. 1985. Proposed Regulations for Offshore, Oil and Gas Extraction Point Source Category. Appendix 3. Drilling Fluids Toxicity Tests. Federal Register, Vol. 50, No. 165. Washington DC.
- * U.S.EPA. 1988. Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms. EPA/600/4-87/028.
- * U.S.EPA. 1989. Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. EPA/600/4-89/001.
- * U.S.EPA/CE. 1977. Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters. Environmental Effects Laboratory, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.
- * U.S.EPA/CE. 1990. Draft Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters. EPA-503-8-90/002. Office of Marine and Estuarine Protection, Washington, DC 20460.

9. INTERNAL QC CHECKS

The QA/QC program monitors data quality with internal QC checks which are used to determine if all laboratory operations are "in control," (i.e., operating within acceptable QC guidelines), during data generation.

Responsibility for internal QC checks rests with the QA Officer and with the individual analyst. These QC checks include instrument calibration checks, chemical monitoring of dilution waters, specific test validity requirements, and a reference toxicant monitoring program which includes the generation of test control charts.

Instrument QC Checks

All analytical instruments will be calibrated prior to use as set forth in ATL SOP's. Whenever calibration cannot be achieved or measurement of a calibration standard is not within specified limits, the instrument will be considered malfunctioning and will be reported to the Laboratory Director. Any malfunctioning instrument will not be used until appropriate maintenance or repairs are performed and documented.

Chemical Monitoring Of Dilution Waters

In order to establish and continuously monitor the acceptability of the dilution waters utilized in toxicity tests, the dilution waters will be monitored continuously, for deionized water, or at least twice per year for field collected seawater. Dilution waters are to be analyzed to the parameters listed in the appropriate SOP. Results of such analyses are to be maintained in appropriate dilution log books.

Test Validity Requirements

Due to the wide range of test guidelines utilized in toxicity testing, the requirements to determine the validity of any test conducted will be stated in the appropriate SOP. Generally, all acute toxicity tests will be required to meet the following criteria for acceptability:

- * No more than a total of 10 percent of the control organisms may appear to be diseased, stressed, or die in a test.

- * Appropriate testing conditions, (i.e., temperature, light/dark cycles), are maintained during the course of testing.

Reference Toxicant Monitoring Program

The QA Officer will obtain reference toxicants from the EPA Environmental Monitoring and Support Laboratory in Cincinnati, Ohio, (Telephone No.: (513) 569-7325), or from another reputable commercial supplier. Generally, sodium dodecylsulfate (SDS) will be the reference toxicant of choice, however, in some instances or for certain species other reference toxicants may be utilized.

Reference toxicant tests will be performed on each new batch of test organisms received at the laboratory or on a monthly basis for organisms cultured in-house. Appropriate reference toxicant testing will be conducted concurrently with sample testing when required by test methodology or by the client.

Control Charts

Control charts are to be established and continuously maintained for each organism and test conducted at ATL. Control charts should monitor appropriate test endpoints such as LC50 and NOEC values obtained from the reference toxicant testing program. The control chart is used to evaluate the cumulative trend of the statistics from a series of tests. For point estimation techniques, the mean and upper and lower control limits (± 2 times the mean toxicity value standard deviation) are re-calculated with each successive point, until the statistics stabilize. Outliers, which are values which fall outside the upper and lower control limits, and trends of increasing or decreasing sensitivity are readily identified. Note: at the 0.05 probability level, one in 20 tests would be expected to fall outside of the control limits by chance alone. For hypothesis testing results, the same concentrations of reference toxicants are used for each toxicity test. The NOEC from each successive test is entered on the control chart, and the values should fall within one concentration interval above or below the central tendency.

Control charts are to be established based on five successfully completed reference toxicant tests with control limits recalculated with each successive valid reference toxicant test data endpoint. Control charts are used to monitor test organism sensitivity for both commercially obtained and in-house cultured test organisms. If a control chart data point falls outside the established control limits, corrective action must be taken to determine the cause of the discrepancy.

Laboratory Performance QC Program

Laboratory Performance QC is provided as a standard part of every analysis. The main elements of Laboratory Performance QC are:

- * Organism survival and reproduction;
- * The analysis of reference toxicants
- * The generation of daily calibration data.

Satisfactory laboratory performance is demonstrated by performing at least one acceptable reference toxicant test per month for each of the toxicity test methods commonly used in the laboratory. Reference toxicant tests are to be conducted concurrently with less frequently performed tests. If the toxicity value from a given test with the reference toxicant does not fall in the expected range for the test organisms when using the standard dilution water, the sensitivity of the organisms and the overall credibility of the test system are suspect. In this case, the test procedure should be examined for defects and should be repeated with a different batch of test organisms.

Please refer to section 6 of this manual for a discussion of calibration procedures.

10. PERFORMANCE AND SYSTEM AUDITS

ATL participates in a variety of federal and state certification programs, (i.e., EPA's DMR study and California's ELAP program), that subject the laboratory to stringent system and performance audits on a regular basis. A system audit is a review of laboratory operations conducted to verify that the laboratory has the necessary facilities, equipment, staff and procedures in place to generate acceptable data. A performance audit verifies the ability of the laboratory to correctly identify toxicity in blind check samples submitted by the auditing agency. The purpose of these audits is to identify those laboratories that are capable of generating scientifically sound data. A list of current ATL certifications is available upon request.

In addition to external audits conducted by certifying agencies or by clients, the QA Officer periodically conducts system and performance audits of the laboratory to verify that only quality, scientifically sound, data are being generated.