City of San Diego
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Water & Wastewater

Application For Renewal of NPDES CA0107409 and 301(h) Modified Secondary Treatment Requirements

POINT LOMA OCEAN OUTFALL

Volume X
Appendices P thru V

January 2015

THE CITY OF SAN DIEGO PUBLIC UTILITIES DEPARTMENT

Application for Renewal of NPDES CA0107409

301(h) Modified Secondary Treatment Requirements for Biochemical Oxygen Demand and Total Suspended Solids

POINT LOMA OCEAN OUTFALL &
POINT LOMA WASTEWATER TREATMENT PLANT

Submitted pursuant to
Sections 301(h) and 301(j)(5) of the Clean Water Act

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APPLICATION FOR RENEWAL OF NPDES CA0107409
301(h) MODIFIED SECONDARY TREATMENT REQUIREMENTS

Point Loma Ocean Outfall
Point Loma Wastewater Treatment Plant

VOLUME X
APPENDICES P thru V

Appendix P	**Oceanography**
Appendix Q	**Initial Dilution Simulation Models**
Appendix R	**Re-Entrainment**
Appendix S	**Dissolved Oxygen Demand**
Appendix T	**Analysis of Ammonia**
Appendix U	**2012 California Ocean Plan**
Appendix V	**Correspondence**

LIST OF VOLUMES

THE CITY OF SAN DIEGO • STATE OF CALIFORNIA
SEMPER VIGILANS

Appendix P
OCEANOGRAPHY

Renewal of NPDES CA0107409

APPENDIX P

OCEANOGRAPHY

Summary of Physical Oceanographic Conditions in the Vicinity of the Point Loma Ocean Outfall

THE CITY OF SAN DIEGO · STATE OF CALIFORNIA

SEMPER VIGILANS

January 2015

APPENDIX P

OCEANOGRAPHY

Table of Contents

List of Figures

List of Figures
(Continued)

List of Tables

List of Abbreviations

°C	degrees Centigrade
CalCOFI	California Cooperative Fisheries Investigation
California Ocean Plan	2012 *Water Quality Control Plan, Ocean Waters of California*
cm	centimeters
cm/sec	centimeters per second
CTD	conductivity, temperature, depth
EPA	United States Environmental Protection Agency
km	kilometers
m	meters
m^3/sec	cubic meters per second
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
PLOO	Point Loma Ocean Outfall
PVD	progressive vector diagram
rms	root mean square
SC Bight	Southern California Bight
SCCWRP	Southern California Coastal Water Research Project

APPENDIX P
OCEANOGRAPHY

Oceanographic information presented in this appendix was originally presented in the City's 1995 301(h) application, which included a summary of comprehensive oceanographic studies of Point Loma coastal waters performed in support of design of the extended Point Loma Ocean Outfall (PLOO). Oceanographic information presented in the original 1995 301(h) application (presented again herein) remains valid for characterizing Point Loma coastal and offshore receiving waters. It should be noted that updated studies assessing the behavior and tracking of the PLOO plume have been completed, and are presented in Appendix F. Additionally, Appendix H presents information addressing the feasibility of using remote sensing data for tracking the PLOO discharge plume and assessing offshore conditions.

ABSTRACT

The Point Loma Ocean Outfall (PLOO) discharges on the outer edge of the mainland shelf within the Southern California Bight. The bight is an area of complex bathymetry and circulation. The latter is primarily driven by the California Current at the surface, and the California Undercurrent at depth. The water column is density stratified by both temperature and salinity gradients throughout the year over the entrainment region of the water column during the initial dilution process. This density stratification changes over a wide range of time-scales due to internal waves, internal tides, upwelling and downwelling, and interannual variations. In contrast to the situation in the upper 30 meters of the water column, the greatest stratification occurs in the winter.

The wastefield typically forms at an average depth of about 70 meters. The annual net subsurface flow at this depth in the area is upcoast at about 3 centimeters per second (cm/sec). Superimposed on the net flow are variations with time-scales ranging from hours to years. Interannual variability in the currents is comparable to the seasonal changes. The temporal characteristics of the fluctuations are different in the longshore and cross-shore directions. More than half the variance (approximately 45 - 99 cm^2/sec^2) in the longshore direction is associated with changes that occur more slowly than the tidal period; nearly all the variance (21- 81 cm^2/sec^2) in the

cross-shore direction is associated with fluctuations of tidal, or shorter period. Transport over distances in excess of a few km is by the seasonal net flows (1-6 cm/sec) and the slowly varying changes in the currents (root mean square, or rms speeds of 7-10 cm/sec). The dominant direction of flow of these currents is along an axis with an alignment of 177-357 degrees (true) (i.e., essentially along the orientation of the local isobaths).

P.1 REGIONAL SETTING - SOUTHERN CALIFORNIA BIGHT

Bathymetry. The western coast of the United States makes an abrupt change in direction and bends to the east at Point Conception (see Figure P-1 on page P-31). After proceeding east for about 100 km, it turns to the southeast to form the Southern California Bight (SC Bight). The landward boundary of this open embayment extends from Point Conception, California, to the vicinity of Cabo Colnett, Baja California, Mexico (SCCWRP, 1973). It includes the entire coast of southern California. The offshore boundary of the bight is defined by the inner boundary of the California Current.

The bathymetry within this embayment is complex. Landward from the continental slope, it defines a series of coastal basins and troughs, submarine ridges and islands, a nearshore shelf and slope, and submarine canyons (see Figure P-2 on page P-32). Because of this complexity, the region has been labeled a continental borderland (Shepard and Emery, 1941) in order to distinguish it from a normal continental shelf and slope.

The width of the borderland (e.g., from the coast to the 500-meter isobath at the upper edge of the continental slope) reaches a maximum of about 200 km off Newport Beach, California. North of Point Conception and south of the border with Mexico, the width of the continental shelf is about 20 to 35 km. The area of the continental borderland inshore of the Continental slope is about 104,000 km^2 (Emery, 1960; NRC, 1990). Approximately 63 percent of this area is associated with basin and trough slopes; another 17 percent, with the basin and trough floors. Bank tops, islands, and island shelves contribute another 14 percent. The mainland shelf contributes the remaining 6 percent (ca. 6,500 km^2).

This bathymetry plays an important role in the flow of the ocean currents within the bight. Free circulation of ocean currents is limited to the upper 350 meters of the water column. Circulation within areas bounded by depths between 350 meters and about 1,000-1,500 meters is limited to semi-enclosed areas, generally open to the south, and within basins (Jackson, 1986). The San Diego Trough, lying offshore from Point Loma, forms the mouth to one of these embayments. Water depths in excess of 2,000 meters are excluded from the bight, with the exception of Velero, Outer, Animal, and Colnett Basins at the extreme southern end.

The mainland (nearshore) shelf breaks in about 60-110 meters of water. Shelf widths range from less than 2 km (Pt. Dume, Palos Verdes, south of Newport Canyon) to 16-22 km (Ventura, Santa Monica Bay, San Pedro shelf, Santa Monica Bay, Pta. Descanso). The shelf is cut by submarine canyons, with sections disconnected by coastal promontories such as headlands and capes (Hickey, 1993).

Water Properties. The properties of the ocean water in the SC Bight represent a mixture of water of southern (Equatorial) water, Pacific Subartic water, and North Pacific Central water (Hickey, 1993). The Pacific Subartic water, which enters from the north, is characterized by low temperatures and salinity, and high dissolved oxygen and phosphate (Reid et al., 1958). North Pacific central water (entering from the west) is distinguished by warm temperatures, high salinity, and low dissolved oxygen and phosphate (Reid et al., 1958). Southern water, which enters from the south, has relatively high temperatures, salinity, and nutrients, but low dissolved oxygen (Pickard, 1964). North Pacific Central water does not normally directly enter the SC Bight, and the water in the bight can be considered to primarily be a mixture of Subartic and Southern water (Tibby, 1941). At depths of 200-400 meters, the water nearshore is estimated to be a mixture of about 30-40 percent northern water, and 60-70 percent southern water (Sverdrup and Fleming, 1941). A tongue of 80 percent southern water penetrates into the southern end of the SC Bight roughly midway between San Clemente Island and Tanner/Cortez Bank. The fraction of northern water generally increases with decreasing water depth, but salinities associated with a specific water temperature tend to increase with proximity to the coast, suggesting an increasing contribution of southern water (Jackson, 1986).

The California Cooperative Fisheries Investigation (CalCOFI) program has carried out measurements of the properties of the water off California and northern Baja California since 1956. Average values of water quality collected at Station 90.28 (offshore from Los Angeles) provide a summary of water characteristics in the inner portion of the bight. The water column is vertically stratified with regard to temperature, salinity, and density (Jackson, 1986). Salinities are relatively constant and independent of depth in the upper 50-60 meters of the water column (approximately 33.5 to 33.6 parts per thousand).

A strong summer pycnocline/thermocline develops during the summer over the entire SC Bight in response to seasonal warming. This stratification continues through the early fall. Near-surface temperature stratification is generally maintained even during the winter season (Hickey, 1993). Near the coast, minimum surface water temperatures average about 14-15^{o}C, and occur between January and March. Surface water temperatures peak in the late summer (ca. September) at 18-20^{o} C. During most of the year, a thermocline is present over the nearshore shelf at depths ranging from 3 to 25 meters, occasionally reaching to 40 meters. An upward slope in the density and temperature isopleths toward the coast is present in the in all seasons, but strongest (Hickey, 1993). Substantial interannual variations may occur in water temperatures, especially during periods of El Niño.

Average water temperatures at a depth of 100 meters seasonally vary between from a little more than 9°C to a little more than 10°C. In contrast to the surface waters, the lowest temperatures tend to occur during the late spring-early summer (May-July), and the maximum temperatures occur in the winter (January-March). Salinity gradients make an important contribution to density gradients in water with temperatures lower than 11-12°C (approximately 50-60 meter depths), and hence at the entrainment depths for the discharge from the PLOO. Typical salinities vary between about 33.6 and 33.8 parts per thousand, increasing with decreasing water temperature.

California Current. The major surface current in the area is the California Current. The California Current is a broad (approximately ca. 600 km wide), meandering, and diffuse southward flow along the west coast of the United States. It represents a continuation of the North Pacific Subartic Drift and is part of the eastern portion of the North Pacific gyre. It contains low temperature, low salinity water. Typical surface flow speeds are relative low (ca. 10-20 cm/sec), decreasing with depth to about 2 cm/sec at a depth of about 200 meters (Hickey, 1993). The maximum speeds are located about 300 km offshore and occur in the late summer (Hickey, 1993). Fluctuations in the current speed are comparable to the net speed (Jones, 1971). Normal transport rates have been variously estimated between 5.8 x 10^6 m^3/sec (January) to 7.8 x 10^6 m^3/sec (July) (Hickey, 1993), and 10 x 10^6 m^3/sec (Pavlov, 1966). By way of comparison, the effluent discharge rate from the PLOO is approximately 9 m^3/sec, the total mass emissions of treated municipal wastewater into the coastal waters of the SC Bight is on the order of 55 m^3/sec, and the average transport of the Mississippi River is about 1.81 x 10^5 m^3/sec.

The California Current separates from the coast at the break near Point Conception, and continues its southward flow offshore from the Santa Rosa-Cortez ridge and the continental slope. At the southern end of the ridge, it bends to the east, flowing toward the coast in the general region of Cabo Colnett. The inner edge of this current defines the western and southern boundaries of the Southern California Bight.

Southern California Countercurrent. Currents within the Southern California Bight are complex. A seasonal surface counter-clockwise circulating gyre is often present between the coast and the California Current (see Figure P-3 on page P-33). The inner, northward flowing, leg of this gyre is known as the Southern California Countercurrent. The path of this upcoast flow is largely blocked by the east-west trending northern Channel Islands at the northern end of the SC

Bight. These islands (and connecting ridge) deflect the bulk of the water in the Countercurrent to the west, completing the gyre. However, a small part is often deflected to the right, resulting in a narrow (ca. 10-30 km wide), southward (unnamed) surface flow between the Countercurrent and the coast.

The Southern California Countercurrent is strongest in the summer and autumn, and weak (occasionally absent) in the winter and spring (SCCWRP, 1973). During the latter season, there may be a continuous equatorward surface current throughout the SC Bight. Current speeds in the Countercurrent are comparable to the California Current, with estimates ranging from 5-10 cm/sec (Jones, 1971) to 12-18 cm/sec (Sverdrup and Fleming, 1941). The transport is estimated to be only slightly less than the California Current (Jones,1971; Pavlova, 1966; Sverdrup and Fleming, 1941). Typical speeds of the nearshore surface flow are the order of 20 cm/sec, occasionally reaching a knot, or more.

Surface Water Residence Time in the Southern California Bight. Typical travel times between Point Conception and the southern boundary of the gyre for water parcels lying along the inner edge of the California Current (and outer portion of the gyre) have been estimated at about 39 days from heating of the surface water (Sverdrup and Fleming, 1941) and about 25 days from the strength of the currents (Jones, 1971). Rough estimates of the residence time of surface water in the Southern California Bight as a whole have ranged from about one month (heating of the surface waters-Jones, 1971) to two to three months (currents-Jones, 1971; circulation model-SCCWRP, 1973; distribution of *Panulirus* larvae-Hendricks, 1979).

California Undercurrent. The circulation at depths in excess of 100 meters off southern California appears to be less complex than the surface circulations. The most distinctive characteristic is an upcoast subsurface flow (Jones, 1971) on the shoreward side of the California Current (Hickey, 1993). The undercurrent is narrower than the California Current, but appears to be present throughout the bight (Hickey, 1993). Measurements off Santa Monica Bay suggest that the core of the flow is over the mainland slope at a depth of about 100 meters, although other undetected cores may also exist within the bight (Hickey, 1992). The core has been observed over the slope off northern Mexico at a depth of about 150 meters (Wooster and Jones, 1970). Typical speeds are 25 cm/sec, or less (Jones, 1971) although there may be pulses of flow exceeding 50 cm/sec (Hickey, 1993).

The seasonal maximum flow occurs in the late summer and early fall (Hickey, 1993), with a minimum in the spring. A second seasonal maximum in the early winter is present at most locations (Hickey, 1993). Free circulation of this undercurrent within the SC Bight is limited by the bathymetry to depths shallower than about 350 meters (Jackson, 1987). The spatial structure of the Undercurrent, and its relationship to the Southern California Countercurrent is the subject of on-going research (Hickey, 1993). Indirect (geostrophic) estimates of the combined transport of the Undercurrent and the Countercurrent based on hydrographic data collected by the California Cooperative Fisheries Investigation (CalCOFI) yield values of 0.8 x 10^6 m^3/sec in April to 1.8 x 10^6 m^3/sec (Hickey, 1993). These values are only about one-quarter to one-seventh the transport estimated for the SC Countercurrent alone by Pavlov (1966) and Sverdrup and Fleming (1941). Hickey (1993) however, notes that direct measurements indicate a poleward flow that is both stronger (ca. 15-20 cm/sec) and more continuous than indicated by the geostrophic data (ca. 5-10 cm/sec).

Nearshore Currents. The net flow of currents over the nearshore shelf varies above and below the thermocline. Mean transport by the surface currents is typically downcoast during all seasons, although weakest in the fall (e.g., Winant and Bratkovich, 1981). Net annual transport by the subpycnocline (subthermocline) currents is upcoast with speeds on the order of a few cm/sec (Hendricks, 1977, 1980, 1986, , 1990, 1992).

Both the net currents, and fluctuations in the currents, influence the transport of wastewater away from the discharge, and the replenishment of ambient ocean water. The distance that water is transported by variations in the flow depends on the duration of the flow in between reversals (e.g., persistence), as well as the speed of the currents. Variations in the currents of tidal and shorter period (i.e., in the tidal and supertidal frequency bands) in the midwaters of the water column are roughly comparable in the longshore and cross-shore directions, but are often enhanced in the near-bottom flows. Slowly varying fluctuations (subtidal frequency band) make an important contribution to the longshore flows, generally contributing more than one-half the total variance. In contrast, these slow varying changes are usually weak in the cross-shore direction. Transport length-scales associated with the supertidal fluctuations are limited to a few hundred meters, or less. Transport distances associated with the tidal period variations are on the order of a kilometer to a couple of kilometers, or roughly comparable to the length of the PLOO diffuser. Thus, transport of wastewater away from the vicinity of the diffuser is primarily associated with the net flow, and variations in the subtidal frequency band. Since the net flow and the slowly varying fluctuations are primarily associated with the longshore component of the currents, transport away from the outfall is predominantly in the longshore direction.

The correlation or coherence between variations in the currents at spatially separated locations depends on the magnitude of the separation, the frequency band of the fluctuations, the direction of the flow (longshore versus cross-shore component), and the bathymetric complexity of the area. The longest coherence length-scales are associated with the longshore component of fluctuations in the subtidal frequency band along sections of the coast with relatively simple (e.g., straight) bathymetry. Here currents may be coherent over longshore spatial separations on the order of 30 km (Hendricks, 1977; Winant, 1983). In contrast, cross-shore motions in the subtidal frequency band can be essentially uncorrelated over vertical separations of 20 meters, or less, and horizontal separations of less than a couple of kilometers.

Empirical orthogonal eigenfunction (EOF) analysis, which identifies dominant patterns of flow from an array of current measurements, indicates that for areas of simple bathymetry (e.g., off Point Loma), 90 percent or more of the variance associated with variations in the subtidal frequency band can be related to a single flow pattern (Hendricks, unpublished). In areas with an increased level of bathymetric complexity (e.g., within the bight lying downcoast from Point Loma), two flow patterns can be required to account for 80-90 percent of the variance (Hendricks and Christensen, 1987). Areas of even greater bathymetric complexity, such as within Santa Monica Bay, may not be adequately described in terms of a few simple flow patterns.

The properties of the near-bottom currents (e.g., with 5 meters of the bottom) on the mainland shelf can differ from those of the midwater currents due to friction with the bottom. The development of a boundary layer suppresses slowly-varying (subtidal frequency band) fluctuations in the near-bottom currents. On the other hand, fluctuations in the tidal and supertidal frequency bands may be enhanced--particularly in the cross-shore component of the flow. This combination enhances shear between flows at different depths. Monthly average near-bottom current speeds range from about 0.5 to 5 cm/sec (Hendricks, 1993). In contrast to the midwater currents, where the net flow is generally parallel to the local isobaths, the near-bottom net currents generally have an offshore component that is comparable in magnitude, or exceeds, the net longshore component (Hendricks, 1993). This offshore flow can have important consequences for the transport of resuspended sediments.

P.2 POINT LOMA BATHYMETRY

The mainland shelf off Point Loma is about 6.5 km wide. A narrow rocky shelf runs parallel to the coast, extending from the shoreline to water depths of 17 to 20 meters (Moore, 1957). The outer edge of a bed of *Macrocystis* and *Pelaqophycus* kelp marks the offshore edge of this rocky shelf. At its outer edge, the bottom drops sharply by about 3 to 18 meters, terminating in a relatively smooth, gently sloping plain (Moore, 1957). This plain extends seaward to a depth of about 90-95 meters., and with only minor variations in direction and width for at least 15 km to the north and south of the outfall. About 23 km north of the discharge, it is cut by Scripps Canyon. Coronado Canyon and the Coronado Islands are 17 to 24 km to the south.

At the outer edge of the mainland shelf, the bottom slopes sharply downward, descending into the Loma Sea Valley (Moore, 1957). The longshore and cross-shore bathymetry also becomes more complex. The axis of the Loma Sea Valley lies about 15 km offshore, with a depth of about 370 meters. Continuing offshore, the bottom rises sharply to a depth of about 145 meters over the Coronado Escarpment, a narrow (ca. 3 km wide) finger of the mainland shelf extending up from the south. The center of the escarpment lies about 2 km offshore from the axis of Loma Sea Valley. Offshore from the Coronado Escarpment, the bottom plunges to a depth of about 1200 meters in the San Diego Trough (ca. 23-38 km offshore from the coast). The north end of the Coronado Escarpment lies approximately offshore from the PLOO, then slopes downward to the north to intersect the mainland slope in about 800 meters of water about 20 km farther north. At the south end of Point Loma the coast breaks abruptly to the east forming a bight. Immediately to the east of Point Loma, the coast is cut by the entrance to San Diego Bay.

The outer portion of the mainland shelf (e.g., water depths greater than 35-40 meters) is essentially a continuation of the mainland shelf off Point Loma. Bottom slopes are reduced inshore of this isobath, reflecting the increased width (ca. 16 km) of the shelf in the bight. Water depths inshore of an extension of the coastline off Point Loma are shallower than about 33-36 meters. The average depth of the top of the wastefield generated by the Point Loma discharge at the completion of the initial dilution process ranges from about 49 to 63 meters, and the minimum depth to the top during any month ranges from about 32 to 47 meters (Appendix Q, Initial Dilution Simulation Models). Thus wastewater is normally excluded from entering the bight.

P.3 DENSITY STRATIFICATION

Overview. The density structure of the water column plays an important role in the discharge of wastewater. In combination with the ocean currents, the rate of discharge of effluent, and the design of the outfall diffuser it determines the magnitude of the initial dilution and the initial position of the wastefield in the water column. Magnitudes of the density gradients, in combination with current shear in the water column, also determine the rate of vertical mixing. The latter, in turn, affects the properties of the ocean currents as well as the mixing of wastewater and ambient water, or the renewal of dissolved oxygen removed by the decomposition of organic materials in the effluent and natural waters.

The water column above the PLOO diffuser is density stratified by gradients in temperature and salinity. Salinity gradients are small for water temperatures above about 11-12^{o}C, but make an important contribution to the density gradients for lower water temperatures. The strongest density gradients exist during the summer in the upper portion of the water column due to the formation of a seasonal thermocline at depths that range from a few meters to a few tens of meters (typically around 5-20 meters). Surface water temperatures during the summer may reach 18-23^o C. Water temperatures are generally lowest in the late winter, when surface water temperatures can fall to about 12 to 14^{o}C. The seasonal thermocline may disappear, and the density gradients may be minimal.

The situation is reversed in the lower portion of the water column (depths in excess of about 45 meters), where the strongest density gradients occur during the winter. Although the density gradients are weak in comparison with the gradients existing in the upper portion of the water column during the summer, they are sufficient to trap the wastefield at depths of 30 meters, or more, below the surface (see Appendix Q, Initial Dilution Simulation Models).

The density of water is computed from the temperature and salinity of the water. Salinity, in turn, is computed from measurements of the conductivity and temperature of the water. The density structure of the water column in the vicinity of the PLOO has been examined using two sources of data. The first data set consists of hydrocast data collected with a CTD (conductivity-temperature-depth recorder). These measurements provide temperature and conductivity profiles of the water column. They are collected during the monthly hydrocast surveys that are a part of the monitoring program, as well as during special studies. The other source of data is time-series measurements of water temperature from thermistor moorings positioned at various locations (see Figures P-4 and P-5 on pages P-34 and P-35) along two transects off Point Loma, including in the vicinity of the outfall terminus. Simultaneous observations were made at each mooring at 30-minute intervals from March to October, 1990, and again from January to April, 1991. (Appendix N of the City's 1995 301(h) application presents the comprehensive ocean current monitoring data collected during 1991-1995. At Mooring C5, in the vicinity of the present outfall diffuser, measurements were made at 5 meter depth increments between a depth of 44.5 and 93 meters.

The advantage of the CTD measurements is that both water temperature and conductivity are recorded, so that the salinity, and hence the density of the water can be computed directly. The disadvantage is that only one profile is collected per month, per hydrocast station. Since all the stations are typically sampled within 1-3 days of each other, variations in the density structure associated with short-term upwelling and downwelling, internal tides, and internal waves are not measured. Unless a large number of profiles are available, the density profiles determined from the CTD samples may not accurately reflect the receiving water conditions. The time-series measurements of water temperature avoid this potential under-sampling (or aliasing) problem, but introduce another problem - the lack of accompanying data on the distribution of salinity in the water column.

In order to estimate time-series of water column densities from the time-series of water column temperatures, it was necessary to assume that water salinities (and hence densities) are related to water temperature. Water masses are defined by unique temperature-salinity relationships. As noted previously, water at depths of 200-400 meters in the SC Bight can be represented as a mixture of Northern Pacific Subartic water and Equatorial water. Because the length-scales associated with variations in the ratio of this mixture, the time-scales associated with changes in the temperature-salinity relationship at a single location will be long.

Figure P-6 (page P-36) illustrates an example of the change in the density-temperature relationship (via the salinity-temperature relationship). The data was collected with a CTD during hydrocast surveys on calendar days 241 (August 29), 270 (September 27), and 304 (October 31). The data shown was collected at a single station (P5, Figure P-4) in the vicinity of the PLOO diffuser. Changes in the density (sigma-t) vs. temperature relationship are visible, reflecting changes in the mixture of water masses, but the general shape of the relationship is preserved. This may not be as good an assumption in the surface waters, where heating by solar radiation, freshwater runoff, and wave-induced mixing may introduce changes over shorter time-scales. However, since the water at depths of 60-100 meters is relatively insulated from changes in the surface waters by the presence of the thermocline, temporal changes in its salinity-temperature relationship are likely to approach those of deeper water, compared with the time-scales characterizing the surface water. Curves similar to that illustrated in Figure P-6, but using data from stations P1, P2, P4, P5, P7, P8, P9, P10, were used to develop the analytical relationships between the water temperatures and the water density for the hydrocast surveys. An example, for calendar day 241, is illustrated in Figure P-7 (page P-37).

Water Temperatures. Time-series measurements of water temperature were made at an array of moorings in the vicinity of the PLOO from March through September, 1990, and from January to March, 1991 (Figures P-4, P-5). One of the moorings (Mooring C5) was located close to the present location of the outfall diffuser. The time-series measurements of water temperature from this mooring provide the most complete description of water column thermal stratification over time-scales shorter than a year.

The magnitude of the initial dilution achieved by a discharge is inversely related to the strength of the density gradient of ambient water in the entrainment region of the water column. The average depth to the level of minimum dilution within the wastefield was predicted to be on the order of 67 to 70 meters (see Appendix Q, Initial Dilution Simulation Models). The mean depth of the discharge ports is about 93-94 meters. The density difference between ambient water at a depth of about 70 meters and at a depth of 93 meters provides an indication of this stratification. The probability distributions of this density difference are illustrated in Figures P-8 through P-17 for the months of January through March, 1991 and March through October, 1990. Water temperatures have been converted into water densities using temperature-density relationships determined from CTD data collected at monthly intervals during the same measurement period. Average and median values of the difference for each month are summarized in Table P-1 (page P-11) .

Table P-1
Density Difference Between 70 and 93 meter Depths

Month	**Density (Sigma-t Units)**	
	Average	**Median**
January	0.324	0.305
February	0.294	0.280
March	0.192	0.156
April	0.130	0.141
May	0.248	0.242
June	0.143	0.127
July	0.193	0.150
August	0.199	0.194
September	0.131	0.123
October	0.234	0 171

The strongest stratification of the water column, as measured by the average and median differences in sigma-t between the 70 and 93 meter depths occurs in January, 1991. The distribution of density differences is summarized in Table P-2 (below).

Table P-2
Distribution of Density Difference Between 70 and 93-meter Depths
January - Maximum Stratification

Percentile	**Density Difference Delta Sigma-t**
10	0.154
30	0.229
50	0.305
70	0.394
90	0.544
Average	0.324

The water densities at 5 meter increments (i.e., at each thermistor depth) are listed in Table P-3 (page P-12) for each of the density profiles listed in Table P-2. The corresponding density profiles are illustrated in Figure P-18 (page P-43). Density profiles collected with a CTD at a set of stations in the vicinity of the PLOO during a hydrocast survey on January 08, 1991 are illustrated in Figures P-19 through P-21 (pages P-44 through P-46).

The next strongest average density stratification was in February 1991. The weakest average and median stratifications were associated with September 1990. The initial dilutions calculated from this time-series of temperature measurements (see: Appendix Q) had the lowest monthly average value in February and the highest monthly average value in September. A second set of CTD data was available from the monthly monitoring program carried out by the City of San Diego. Water column profiles were obtained during a total of 51 monthly hydrocast surveys carried out between 1991 and 1994. A total of 374 profiles are available from the stations in water depths comparable to the discharge depth during this period. These profiles were also used in the initial dilution calculations (but not illustrated here).

Table P-3
Density Profiles for January 1991

Depth (m)	Percentile[1,2]					
	10	30	50	70	90	Average
44.5	25.010	25.042	25.018	25.100	24.876	24.906
49.5	25.064	25.062	25.023	25.177	24.892	24.925
54.5	25.130	25.086	25.034	25.230	24.920	24.963
59.5	25.184	25.122	25.110	25.273	25.000	25.037
64.5	25.250	25.163	25.096	25.300	25.080	25.054
69.5	25.282	25.219	25.137	25.362	25.106	25.071
74.5	25.282	25.261	25.163	25.479	25.103	25.103
79.5	25.343	25.325	25.250	25.507	25.154	25.154
84.5	25.373	25.381	25.290	25.584	25.238	25.194
89.5	25.381	25.427	25.335	25.658	25.601	25.325
93	25.436	25.448	25.442	25.756	25.651	25.395

1 Derived from time series of temperature, calibrated using CTD data.
2 Based on Sigma-t data for depths of 70-93 meters, as presented in Table P-2 on page P-11.

Temporal Variations in the Density Structure. The temperature variations measured at Mooring C5 (in the vicinity of the outfall diffuser) at the depth of 70 meters in the water column are illustrated in Figure P-22 (page P-47). Variations in the water temperature are evident in the time-series for a wide variety of time-scales. There is an overall increase of slightly more than 1^{o}C in the water temperature at this depth over the seven months of data. This increase may be associated with warming of the surface waters by solar radiation and the downward diffusion of this energy, or with an overall downwelling of the water column.

At the other end of the frequency spectrum, fluctuations of semi-diurnal tidal periodicity (associated with internal tides) are evident throughout the entire period. Although typical temperature changes over a tidal cycle are on the order of a few tenths of a degree, changes in excess of 1^{o}C occasionally occur. In-between these two frequency extremes are fluctuations with periodicities ranging from about one to four weeks, and amplitudes ranging from about 0.25^{o}C to more than 1^{o}C. These changes are probably associated with episodes of up- and downwelling, although they could also result from the advection of water with a different density structure into the area.

These vertical movements of the surfaces of constant water temperature can have important consequences for the initial dilution process. Figure P-23 (page P-47) shows the time-series of the difference between the water temperature at the 70 meters (69.5 meters) and the 93 meter depths. Temperature differences range from less than 0.04^{o}C to more than 1.8^{o}C. A long-term trend over the seven months of data is lacking in the temperature difference time-series, indicating that the trend to increasing temperatures at the 70 meter depth also is present at the 93 meter depth. Fluctuations of tidal and intermediate frequencies are, however, present. These variations indicate that: (1) the vertical spacing between isotherms (contours of constant water temperature) dilate and contract within the water column, as well as moving up and down or, (2) there are significant changes with depth in the temperature gradients in this region of the water column. In either case, the changes in the strength of the temperature gradients in the entrainment region of the water column during the initial dilution process will result in substantial changes in the magnitude of the initial dilution over comparable time-scales.

Vertical Motions. The variations in water temperature shown in Figure P-22 cannot be used to estimate the magnitude of the vertical motions of the isotherms without information on the temperature gradients of the water column. The temperature data from the string of thermistors at the mooring has been used to examine these movements. Figure P-24 (page P-48) shows the magnitude of the vertical excursions of the 12.8^{o}C isotherm for the same time as the temperature data shown in Figure P-22. Tidal fluctuations have been suppressed in this time-series by applying a 24 hour running-average on the original time-series. A downward trend in the depth of this isotherm over the seven months of data is evident, corresponding to the overall increase in water temperature previously illustrated at the 70 meter depth for the same period. The change in isotherm depth over the period is about 30 meters, corresponding to an average vertical speed of the isotherm of about 0.14 m/day.

Internal Tides. Figure P-25 (page P-48) shows the vertical displacements associated with the internal tides. Vertical displacements between the shallowest and deepest isotherm depths during a tidal period are commonly on the order of 5-10 meters, and occasionally reach 20-30 meters.

These internal tide motions can be complex, exhibiting some characteristics of a cross-shelf internal seiche, as illustrated in Figure P-26 (page P-49).

Upwelling and Downwelling. Typical vertical displacements associated with the intermediate time-scales probably associated with up- and downwelling events are on the order of 15 to 30 meters. A short-duration, but large downward displacement of more than 50 meters is evident near calendar day 260 (mid-September), followed by an upward displacement of about 40 meters. These events occur at irregular intervals, and persist for varying lengths of time. There are about 13 occasions of upward displacements exceeding 10 meters over the 216 days of record, yielding an average interval between upwellings of slightly more than two weeks.

Figure P-27 (page P-50) shows the vertical movements of the 12.8^{o}C isotherm from January to April, 1991 after removal of the tidal frequency fluctuations. There has been an overall downwelling of the 12.8^{o}C isotherm from a depth of about 54 meters at the end of the previous record (calendar day 276, 1990) to a depth of about 84 meters at the start of this data period (calendar day 12, 1991). This is followed by an upward movement of the isotherm of about 70 meters over the next 79 days. This corresponds to an average vertical speed of almost 1 m/day, or about almost seven times faster than the average downward speed during the preceding year. There are about eleven instances of upwelling with displacements in excess of 10 meters during the 79 days of data, yielding an average interval between the events of about one week. Vertical motions at the intermediate time-scales during this winter-early spring period are comparable to, or somewhat greater than, the displacements in the spring, summer, and early fall of 1990. Figure P-28 (page P-50) shows the variations for this period associated with the internal tides and internal waves.

P.4 OCEAN CURRENTS

Overview. Ocean currents play an important role in mitigating the effects of the discharge of wastewaters from an ocean outfall. They are characterized by properties that change with time and spatial position. In the immediate vicinity of the outfall (spatial-scales on the order of 1-2 km and time-scales ranging from minutes to hours), the strength and direction of the flow influence the magnitude of the initial dilution, as well as the height-of-rise of the plume, and the spatial dimensions of the wastefield. Over long time-scales (days to weeks) and large spatial-scales (5-50 km), they determine the rate of flushing of wastewater out of the discharge area, and the renewal of effluent-free ambient water.

Although the ocean currents are three-dimensional, the vertical motions are small in comparison with the horizontal motions, and thus difficult to measure directly. For example, vertical displacements of 10 meters over a period of about 6 hours (e.g., semi-diurnal internal tidal oscillation) only correspond to vertical velocities of about 0.05 cm/sec (0.0005 m/sec). Therefore, the current meters used to record the ocean currents essentially only record the horizontal motions. The vertical motions must be inferred from the time-series measurements of water temperatures in the water column.

The two-dimensional measurements of ocean currents can be described either in terms of a speed and a direction of flow, or in terms of the velocity components along two independent spatial axes. Both representations have their merits. For example, the speed-direction representation is most convenient in assessing the short-term response of the initial dilution process to the ocean currents local to the vicinity of the diffuser. Since the temporal characteristics of the currents tend to vary between the longshore and cross-shore components of the flow, the use of velocity components is most convenient for assessing the transport of ocean water (and discharged wastewater) in the larger region around the outfall.

Historical Measurements. The Southern California Coastal Water Research Project (SCCWRP) has carried out measurements of the ocean currents off Point Loma at various times between 1974 and 1985. Virtually all of these measurements were made in water depths ranging between 28 and 60 meters, with the bulk of the measurements made at a depth of 40 meters at a station in 60 meters of water. Although the measurements were made in water depths shallower than the terminus of the present (extended) outfall, they have provided a number of useful insights into some general characteristics of the flows.

The net current , measured at the 40 meter depth in 60 meters of water over a 290 day period from January 11 to December 31, 1976 was upcoast at a speed of 3 cm/sec (Hendricks, 1977). Although the average currents over periods of two weeks varied substantially, there was an indication that the upcoast flow was strongest between summer and early winter, averaging 2 cm/sec during the first half of the record, and 4 cm/sec during the last half.

A current meter mooring was placed off Point Loma about 2 km north of the outfall, and drogues were deployed near the outfall, and also off Mission Beach, during a study in 1975 (Hendricks, 1975). Comparisons were made between the movements of the drogues, and the motions predicted from current meter data. The predicted longshore movements agreed well with the observed longshore movements of the drogues. On the other hand, there was little correlation between the predicted and observed cross-shore motions. In 1976, current meter moorings were placed along the 60 meter isobath off Point Loma (0 km), Mission Beach (6.5km), Pt. La Jolla (17km), Solana Beach (32km), and Encinitas (36.5km). Overall, the variations in the longshore component of the currents measured at Point Loma correlated well with the variations measured off Mission Beach and Point La Jolla--although on a couple of occasions, the peaks were shifted by a few days (Hendricks, 1977). Only major (large-amplitude) fluctuations observed off Encinitas were correlated with the fluctuations observed off Point Loma. No significant correlation was observed between the currents off Point Loma and Oceanside (ca. 50 km upcoast), during another study.

SCCWRP also carried out measurements at several stations along a cross-shore transect off Point Loma during the summer-fall of 1985, and in the winter of 1986-1987. Of particular interest in this data set, is the measurement of near-bottom currents at elevations of 1-2 meters above the bottom. The results are summarized in Table P-4 (page P-17).

A consistent offshore net flow was present during both seasons and at all water depths. There is a suggestion that the strength of this offshore component increases with water depth (correlation coefficient of 0.65 to 0.81), depending on the inclusion/exclusion of the observations at 60 meters).

Engineering-Science Measurements. Engineering-Science, Inc. carried out current measurements at the array of stations (C1-C7), shown in Figures P-4 and P-5, between January and September 1990, and January and April 1991. (Detailed results of this comprehensive monitoring are presented in Appendix N of the City's 1995 301(h) application.) Measurements occurred at intervals of 30 minutes for each mooring along the main transect (Moorings C2 through C5). Measurement depths began at 20 meters and were repeated at 20 meter intervals to the bottom.

At some moorings (e.g., Moorings C2, C4) the proximity of the bottom required that the lowermost current meter on the mooring be less than 20 meter below the meter above it. Although the beginning and ending dates can differ (as well as the servicing dates of the moorings), these current measurements were made simultaneously with the temperature measurements collected by the thermistor strings.

Analysis of the initial dilution simulations (see Appendix Q) indicates that the level of minimum dilution typically falls between 66 and 77 meters. Therefore, the currents measured at the 60 and

80 meter depths at Mooring C5 will best represent the flows affecting the initial dilution and the transport of wastewater. The properties of these currents will be the basis for the subsequent discussion.

The discussion is presented on a seasonal basis. The months of January-March were designated "winter"; April-June as "spring"; July-September as "summer", and October-December as "fall". This particular choice was based on the characteristics of the receiving water environment and the discharge. On occasion, the current meters at the 60 and/or 80 meter depths failed to record an adequate data set for the period. The measurements at Mooring C4, lying inshore of C5, were used for the analysis during these periods. A discussion of the properties of the currents as a group (e.g., inter-meter and inter-mooring correlations, current speeds at the other moorings, etc.) is contained in Hendricks (1990).

Table P-4
Near-Bottom Currents (1-2 MAB)[1]

Water Depth at Mooring (meters)	Beginning Calendar Day & Year	Ending Calendar Day & Year	Cross-Shore (cm/sec) + Onshore	Longshore (cm/sec) +Upcoast
30 N	227-1985	248-1985	-0.5	2.2
30 S	227-1985	248-1985	-0.7	0.8
35	343-1986	373-1986	-2.7	1.6
35	008-1987	026-1987	-3.3	1.6
42	164-1985	199-1985	-2.2	3.9
42	199-1985	227-1985	-2.0	2.8
60[2]	164-1985	199-1985	-0.6[1]	1.0[1]
60[2]	199-1985	227-1985	-0.2[1]	-0.2[1]
65	343-1986	373-1986	-2.5	1.0
77	342-1986	008-1987	-2.6	1.3
77	008-1987	043-1987	-3.0	1.1
100	306-1986	342-1986	-5.2	0.2
100	342-1986	008-1987	-4.7	-2.0

1 Unpublished data from SCCWRP.
2 May be affected by the entrainment flow from the old (mile-long) PLOO outfall.

Current Speeds. The instantaneous (30-minute average) current speeds are important in estimating the actual initial dilutions achieved by the outfall-diffuser system. The distribution of these speeds for the winter of 1990 is illustrated in Figure P-29 (page P-51). The distributions for the winter of 1991, spring of 1990, summer 1990, and fall of 1990 are illustrated in Figures P-30 through P-33, respectively. (Detailed probabilities of current speeds, in 1 cm/sec increments are presented in Appendix N of the City's 1995 301(h) waiver application.)

The median speeds for all the seasons for the meters at Moorings C4 and C5 are summarized in Table P-5. A comparison of the median speeds recorded in 1990 with those recorded in 1991 indicates that interannual variations are comparable with the seasonal changes.

Table P-5
Median Current Speeds

Mooring Depth (meters)	Median Current Speed (meters/second)				
	Winter-90[1]	Winter-91[1]	Spring-90[2]	Summer-90[3]	Fall-90[4]
C5-60	0.094	0.076	0.093	0.078	--
C4-60	0.094	0.084	0.089	0.076	0.081
C5-80	0.125	0.075	0.095	0.085	--
C4-77	0.094	0.100	0.084	0.082	0.076
C5-20	--	--	0.113	0.096	--
C4-20	0.149	--	0.127	0.097	--
C5-40	--	--	0.118	0.085	--
C4-40	0.125	--	0.088	0.077	--

1 Winter includes the months of January-March.
2 Spring includes the months April-June.
3 Summer includes the months July-September.
4 Fall includes the months October-December.

The 10-percentile current speeds are summarized in Table P-6 (page P-19). Typical speeds at the 60 and 80 meter depths are on the order of 2 to 4 cm/sec, averaging 2.9 (±0.6) cm/sec. The 90-percentile current speeds are summarized in Table P-7 (page P-19). At this level, there is less difference between the speeds at the 60 meter depths recorded in 1990 and 1991, but still a substantial interannual change at the 80 meter depth. Typical speeds range from about 16 to 20 cm/sec. The average 90-percentile speed at the 60 and 80 meter depths is 17.2 (±1.9) cm/sec.

The net current speeds for each season at the 60 and 80 meter depths are summarized in Table P-8 (page P-20). The strongest currents were measured during the winter of 1990; the weakest currents, in the summer. However, the currents measured during the winter of 1991 were almost as weak as measured in the summer. Thus interannual variability is comparable with the seasonal variability. The average net velocity over all seasons at the 60 meter depth was 3.4 (±1.1) cm/sec; at the 80 meter depth, 3.1 (±1.9) cm/sec. These speeds are comparable with the net speed of 3 cm/sec reported by Hendricks (1977) for 290 days of measurements in 1976.

Table P-6
10-Percentile Current Speeds

Mooring Depth (meters)	Median Current Speed (meters/second)				
	Winter-90[1]	Winter-91[1]	Spring-90[2]	Summer-90[3]	Fall-90[4]
5-60	0.035	0.028	0.032	0.031	--
4-60	0.039	0.029	0.034	0.027	0.021
5-80	0.040	0.025	0.034	0.018	--
4-77	0.031	0.030	0.024	0.024	0.028
5-20	--	--	0.033	0.033	--
4-20	0.055	--	0.039	0.031	--
5-40	--	--	0.039	0.028	--
4-40	0.041	--	0.024	0.025	--

1 Winter includes the months of January-March.
2 Spring includes the months April-June.
3 Summer includes the months July-September.
4 Fall includes the months October-December.

Table P-7
90-Percentile Current Speeds

Mooring Depth (meters)	Median Current Speed (meters/second)				
	Winter-90[1]	Winter-91[1]	Spring-90[2]	Summer-90[3]	Fall-90[4]
5-60	0.185	0.158	0.192	0.168	--
4-60	0.175	0.158	0.169	0.158	0.152
5-80	0.209	0.157	0.183	0.177	--
4-77	0.214	0.190	0.160	0.159	0.148
5-20	--	--	0.241	0.197	--
4-20	0.284	--	0.265	0.213	--
5-40	--	--	0.219	0.181	--
4-40	0.172	--	0.189	0.171	--

1 Winter includes the months of January-March.
2 Spring includes the months April-June.
3 Summer includes the months July-September.
4 Fall includes the months October-December.

Current Direction. Some caution is in order in interpreting the direction of the net flow. The speed and direction associated with a net flow can be converted into longshore and a cross-shore velocity components. Studies (Hendricks, 1977; Vinant, 1983) show that slowly changing fluctuations in the longshore direction tend to vary as a unit over the water column, and are correlated over longshore separations of 25-35 km. Thus, the longshore component of a net flow measured at the current meter mooring is likely to be representative of the net longshore flow over similar distances.

Table P-8
Net Current Speeds by Season

Season	Net Speed (cm/sec)			
	60-meter Depth[1]		77-meter Depth[1]	
	Speed	Direction	Speed	Direction
Winter[2] - 1990	4.9	020	6.5	005
Winter[2] - 1991	2.1	029	1.3	029
Spring[3]	4.6	018	5.1	008
Summer[4]	2.0	081	0.7	123
Fall[5]	3.3	033	2.6	004

1 Net current speeds at depths of 60 and 77 meters within a water column 81 meters deep. Currents at the 77 meter depth may be affected by proximity to the bottom.
2 Winter includes the months of January-March.
3 Spring includes the months April-June.
4 Summer includes the months July-September.
5 Fall includes the months October-December.

In general, the net flows show an onshore flow combined with a (stronger) upcoast flow. The magnitude of these cross-shore flows should, however, be viewed with some skepticism. Correlations distances for slowly varying cross-shore flows are short, with only small correlations observed over horizontal separations on the order of 1-2 km and over vertical separations of 20 meters (Hendricks, 1990). Variations in the cross-shore component of the currents, such as those in the tidal frequency band, may undergo one or more reversals in direction across the water column.

The current measurements were made at fixed depths in the water column. Density stratification of the water column suppresses transport across isothermal surfaces (surfaces of constant water temperature), so that currents are predominantly parallel to surfaces of constant water temperature. However, the isothermal surfaces at these depths undergo vertical excursions, and the spacings between them expand and contract, with the passage of internal waves and internal tides (see "Temporal Variations in the Density Structures" discussion on page P-12).

These vertical motions can be in the opposite direction between the inner and outer areas of the shelf. Correlations may exist between the vertical displacements of the isotherms, the dilation and contraction of the vertical spacing, and the horizontal movements of the ocean currents. In that case, fictitious slowly-varying, or net, cross-shore flows may be generated in records of the currents recorded at a fixed depth. Clearly, the measured onshore flows cannot persist for long, or over cross-shore distances, in excess of a few kilometers, without encountering the ocean bottom (i.e., the "effective" coastline).

Detailed probability distributions of ocean current speed and directions in the PLOO vicinity are presented in Appendix N of the City's 1995 301(h) application. Transport of wastewater depends on the combination of the speed of the flow, its direction, and the persistence of the flow in a specific direction. The distributions of the direction of flow vary, depending on the time-scales of interest (which, in turn, depend on the transport length-scales of interest). Therefore, the distributions of instantaneous direction (presented in Appendix N of the City's 1995 301(h) application) have little value for the purpose of estimating transport.

As noted earlier, the height of rise to the level of minimum dilution averages about 23-24 meters above the diffuser ports, or a depth of about 70 meters. Therefore, only the measurements at the 80 meter depth will approximate the average direction of flow over the entrainment region of the water column. The directional distributions at this depth are presented in Table P-9 (page P-22) in 30 degree increments.

The distributions tend to be bimodal, with the highest probabilities corresponding to flow approximately up- and down-coast, or roughly paralleling the trend of the two diffuser legs. The most likely period of flow across the diffuser legs is during winter.

Temporal Properties of Currents. The advective transport of ocean water and wastewater by the ocean currents depends on the strength and direction of the flow and on the persistence of the flow in a specific direction. The presence of the coastal boundary inhibits sustained cross-shore flows, while these limitations are not present on flows parallel to the coast. Since the longer a flow continues in a specific direction the greater the transport distance, the coastal boundary tends to inhibit cross-shore flows that have long persistence. Thus it is natural to convert speed-direction measurements into velocity measurements, with the axes for the velocity components aligned approximately longshore and cross-shore. However, the actual alignment of these axes are often correlated with the trend of the isobaths (contours of constant depth) in the area, and may not be aligned with the actual coastline.

Table P-9
Probability Distribution of Current Direction at 80-meter Depth

Sector (Degrees True)	Probability of Current Direction at 80-meter Depth				
	Winter-90[1]	Winter-91[1]	Spring-90[2]	Summer-90[3]	Fall-90[4]
340-010	0.171	0.085	0.255	0.111	0.201
010-040	0.146	0.048	0.115	0.111	0.105
040-070	0.142	0.147	0.113	0.080	0.184
070-100	0.105	0.075	0.072	0.069	0.070
100-130	0.046	0.101	0.055	0.068	0.055
130-160	0.035	0.088	0.064	0.102	0.092
160-190	0.025	0.064	0.052	0.137	0.050
190-220	0.021	0.065	0.028	0.104	0.049
220-250	0.017	0.041	0.021	0.044	0.031
250-280	0.022	0.086	0.029	0.035	0.030
280-310	0.068	0.105	0.047	0.054	0.025
310-340	0.201	0.095	0.150	0.087	0.107

1 Winter includes the months of January-March.
2 Spring includes the months April-June.
3 Summer includes the months July-September.
4 Fall includes the months October-December.

The method for selecting the alignment of the longshore and cross-shore axes will be described later. The temporal properties of the time-series for the two velocity components can be examined by representing the time-series of observations by a series of sine or cosine functions, each with a different frequency (or periodicity) determined by the length of the time-series and the number of observations (Bracewell, 1978; Otnes and Enochson, 1978). The amplitude associated with each periodicity is a measure of strength of the variation at that periodicity. The sum of the squares of all the amplitudes is equal to the variance of the fluctuations about the net current.

An example of this decomposition is illustrated in Figure P-34 (page P-54). It represents the variations in the longshore components of the flows measured at the 60 and 80 meter depths during the winter of 1990. The vertical axis represents the cumulative variance, as the contributions with increasingly long periodicities are added to the sum. Thus the total variance contributed by all the fluctuations present during the 42.7 days of data in the time-series at the 60 meter depth is about 68.5 cm^2/sec^2. The two abrupt increases in the variance at periodicities of about 0.5 and 1 day correspond to variations of tidal periodicity. The oscillations of tidal period, combined with the fluctuations of even shorter periodicity, contribute about 30 cm^2/sec^2 to the variance. The remaining variance, approximately 38-39 cm^2/sec^2, or somewhat more than half the total, is associated with variations in the longshore current that change more slowly than the tidal oscillations. The temporal properties of the variations in the longshore flow at the 80 meter depth are similar to those at the 60 meter depth, but the variations are slightly stronger.

This distribution for the longshore component of the flow can be compared with the variations in the cross-shore component of the flow at the same depths and time period. The temporal dependence of these fluctuations is illustrated in Figure P-35 (page P-54). The total variance at the 60 meter depth is about 22 cm^2/sec^2; the total variance at the 80 meter depth is much larger, at 81 cm^2/sec^2. In contrast to the longshore flow, most of this variance is associated with fluctuations of tidal period, or shorter (ca. 73 percent to 91 percent at the 60 and 80 meter depths, respectively). The variance contributed by fluctuations that vary more slowly than the tidal oscillations is only about 6 to 7 cm^2/sec^2.

The corresponding plots for the spring, summer, and fall of 1990 are illustrated in Figures P-36 through P-41, respectively. Some seasonal differences are apparent by comparing the variance associated with three periodicity bands: (1) shorter than about 1 day, (2) periodicities between about 1 day and 1 week and, (3) periodicities longer than 1 week. The variances in the longshore flows associated with the three bands are summarized by season in Table P-10.

Table P-10
Seasonal Longshore Variances by Periodicity Band

Depth (meters)	Season[1]	Longshore Variance by Periodicity Band ($cm^2/second^2$)		
		< 1.5 days	1.5 days - 1 week	1 - 6 weeks
60	Winter	31	9	27
	Spring	17	5	43
	Summer	25	16	41
	Fall	30	11	> 31
80	Winter	35	14	28
	Spring	19	2	21
	Summer	25	16	42
	Fall	30	9	>11

1 Winter includes the months of January-March. Spring includes the months April-June. Summer includes the months July-September. Fall includes the months October-December.

Fluctuations with periodicities shorter than a week were weakest during the spring. The strongest fluctuations in the tidal (or shorter) frequency band occurred during the winter, with variances about twice those in the spring. Averaged over all four seasons, fluctuations at the 60 and 80 meter depths are of nearly equal strength in both the tidal (and shorter) band and in the intermediate band (1.5 days - 1 week). However, the average variance of the fluctuations associated with periodicities longer than 1 week is about 40 percent greater at the 60 meter depth than at a depth of 80 meters. This difference may be a consequence of friction with the bottom.

Most of the variance in the slowly varying flows is associated with periodicities longer than one week. The average variance of the fluctuations associated with periodicities longer than 1 week is about 40 percent greater at the 60 meter depth than at a depth of 80 meters. This difference may be a consequence of friction with the bottom. The flushing time of parcels of wastewater from an area extending 15 km upcoast and downcoast from the outfall (and 12 km cross-shore) is on the order of 4.5 days. Therefore, most of these very slowly varying components of the longshore flow will appear like net flows, of varying strength, to parcels of wastewater discharged from the outfall. Since the rms (root mean square) speeds associated with these fluctuations are usually greater than the net flow, the predominant direction of transport of wastewater will be along the direction of these oscillations (see "Dominant Direction of Flow" discussion below).

The corresponding breakdown for the cross-shore variances is contained in Table P-11 (page P-25). The cross-shore variations with tidal (and shorter) periodicities are enhanced at the 80 meter depth, relative to 60 meters during all four seasons, but most pronounced during the winter (4.5:1). The enhancement almost disappears in the fall. The variations in the other two bands are weak and nearly comparable at the 60 and 80 meter depths. However, a small reduction is present in the variance at the longest periodicities at the 80 meter depth.

Dominant Direction of Flow. The significance of the difference in temporal properties of the currents between the longshore and cross-shore flows is readily illustrated by the currents measured at the 80 meter depth during the winter of 1990. The total variance in the cross-shore direction (ca. 81 cm^2/sec^2) is slightly greater than the total variance in the longshore direction (ca. 76 cm^2/sec^2). However, nearly all the variance in the cross-shore direction is associated with fluctuations with tidal, or shorter, periodicities, while more than half the variance in the longshore direction is associated with fluctuations occurring more slowly than the tidal oscillations.

Table P-11
Seasonal Cross-Shore Variances by Periodicity Band

Depth (meters)	Season[1]	Cross-Shore Variance by Periodicity Band ($cm^2/second^2$)		
		< 1.5 days	1.5 days - 1 week	1 - 6 weeks
60	Winter	16	3	3
	Spring	27	1	3
	Summer	14	3	5
	Fall	37	3	> 1
80	Winter	73	5	3
	Spring	50	1	2
	Summer	27	3	4
	Fall	40	2	> 0

1 Winter includes the months of January-March. Spring includes the months April-June. Summer includes the months July-September. Fall includes the months October-December.

Two new time-series were constructed from the original time-series. First the net current velocity during the period of observation was removed from the time-series. The resulting time-series was then filtered with a 25-hour running average filter to produce a new time-series containing essentially only the fluctuations that vary more slowly than the tidal oscillations. This "low-pass" time-series was subtracted from the original time-series (but with the net velocity removed) to produce a "high-pass" time-series primarily consisting of fluctuations of tidal, or shorter, periodicities. The net velocity of both the low-pass and high-pass time-series was zero.

Next progressive vector diagrams (PVDs) were constructed from the two time-series. In this process, the velocity at each observation time is represented by an arrow whose length is proportional to the current speed, and the orientation of the arrow along the direction of flow. The arrows are placed end-to-end, with the tail of the new arrow positioned at the head of the previous arrow. If the currents everywhere along the path traveled by the arrows are the same as at the current meter, the PVD represents the movement of a marker initially placed at the origin of the plot.

The motion of the marker due to the currents with fluctuations of tidal and shorter periodicity is illustrated in Figure P-42 (the net current and the slowly varying fluctuations have been removed). The movement of the marker is confined to an area extending about 1.6 km downcoast (to the left) and 2.3 km upcoast (right) from the point of release, and about 1.1 and 3.1 km offshore (up) and onshore (down), respectively. Thus the range of movements of the marker is bounded by a rectangle with dimensions of about 4 km on a side. Most of the time, the marker remains within an area of about 1.1 km (longshore) by 1.8 km (cross-shore).

The motion of the marker due to the currents with fluctuations longer than the tidal period is illustrated in Figure P-43 (the net current and the fluctuations of tidal and shorter periodicity have been removed). Here the longshore motions span a total length of about 75 km; the cross-shore motions, about 26 km. In the longshore direction, this is almost 20 times greater than motion associated with the tidal and shorter periodicities; in the cross-shore direction, it is more than 6 times greater (but, as noted earlier, cross-shore transport over distances in excess of a few km is suspect).

Although the net flows are generally weaker than the rms speeds of the slowly varying fluctuations, they can result in substantial transport. The net longshore component of the current existing during the period illustrated in Figure P-43 (page P-58) was 6.5 cm/sec (the highest measured for any season and depth). This net flow would correspond to upcoast transport of 330 km over this 59 day period (however, any predicted excursions in excess of the correlation length of 25-35 km are likely to be wrong). Thus, the transport over distances in excess of a few kilometers is predominantly associated with the net flow (not included in trajectories shown in Figures P-42 and P-43) and the slowly varying fluctuations.

These slowly varying fluctuations are much more energetic in the longshore direction than they are in the cross-shore direction. Therefore the dominant direction of flow (from the standpoint of the advection of wastewater over distances in excess a few kilometers) will be in the longshore direction. Net currents velocities are often weaker than the variations in the flow and this will be more difficult to measure with precision. This is particularly true for the cross-shore flows. Since vertical mixing is weak, advective transport is primarily along surfaces of constant density (isopycnal surfaces). These surfaces move up and down along with the isotherms, while the current meters remain at fixed elevations of the ocean bottom. This can introduce bias in estimates of the net transport from current measurements if there is shear in the water column, a condition that characterizes the cross-shore component of the currents. Therefore, the alignment of the principal axis for the variations with periodicities longer than the tidal period provides one of the best estimates of the dominant direction of transport. These directions are summarized by season and depth in Table P-12 (page P-27).

The average alignment of the principal axes of variation of fluctuations with periodicities longer than the tidal period at the 60 and 80 meter depths are within 2 degrees of each other, and essentially parallel the alignment of the isobaths in the vicinity of the discharge.

Table P-12
RMS Current Speed and Alignment of Principal Axis of Variation[1]

Season	Current Speed		Principal Axis of Variation	
	RMS[2] Speed (m/sec)		Direction (Degrees, True)	
	60-meter Depth[3]	77-meter Depth[3]	60-meter Depth[3]	77-meter Depth[3]
Winter-1990	0.073	0.065	358	348
Winter-1991	0.064	0.049	346	351
Spring	0.080	0.071	351	348
Summer	0.074	0.075	012	012
Fall[1]	0.058	0.040	001	003
Average	0.070	0.060	358	356

1 Subtidal frequency band.
2 Root mean square current speed
3 As measured at depths of 60 and 77 meters within a water column of 81 meters at Station C4. The currents at the 77 meter depth may be affected by proximity to the bottom.

REFERENCES

Bracewell, R.N., 1978. *The Fourier Transform and its Applications*. New York: McGraw-Hill. 444p.

Emery, K.O., 1960. *The sea off southern California*. New York: John Wiley and Sons, Inc.

Jackson, G., 1986. Physical oceanography of the Southern California Bight. *In* Plankton Dynamics of the Southern California Bight, R. W. Eppley, ed. Lecture Notes on Coastal and Estuarine Studies. No. 15. New York: Springer-Verlag. pp13-52.

Jones, J.H., 1971. General circulation and water characteristics of the Southern California Bight., Southern California Coastal Water Resources Project, Westminster, California. October 1971. p.36.

Hendricks, T.J., 1975. Properties of nearshore currents. In: Coastal Water Resources Project Annual Report • 1975. Southern California Coastal Water Resources Project, Westminster, California. pp.167-172.

Hendricks, T.J., 1977. Coastal currents. In: Coastal Water Resources Project Annual Report • 1977. Southern California Coastal Water Resources Project, Westminster, California. pp 53-62.

Hendricks, T.J., 1979. A study to evaluate the dispersion characteristics of waste discharges into the open coastal waters of California. Institute of Marine Resources Report to California State Water Resources Control Board Scripps Institution of Oceanography, La Jolla, California. May, 1979. 78p.

Hendricks, T.J., 1980. Currents in the Los Angeles area. In: Coastal Water Resources Project Biennial Report 1979-1980. Southern California Coastal Water Resources Project, Westminster, California. pp 243-256.

Hendricks, T.J., 1986. Ocean current and sedimentation studies - Encina Outfall - Carlsbad, California. Report to: Encina Water Pollution Control Project. Southern California Coastal Water Resources Project, Westminster, California. December 2, 1986. 20p + 6 appendix.

Hendricks, T.J., 1990. Analysis of cross-shore transport off Point Loma. Final Report to Engineering-Science. Southern California Coastal Water Resources Project, Westminster, California. December 21, 1990. 59p.

Hendricks, T.J., 1992. Orange County currents: Phase II - SCCWRP measurements. Final Report to County Sanitation District of Orange County, California. Southern California Coastal Water Resources Project, Westminster, California. January 17, 1992. 30p.

Hendricks, T.J., 1993a. Near-bottom currents off Southern California. In: Southern California Coastal Water Resources Project Annual Report 1992-93. Southern California Coastal Water Resources Project, Westminster, California. pp. 65-80.

Hendricks, T.J., 1993b. Temperature variations in the water column off Point Loma. Coastal Water Resources Project Annual Report 1992-93. Southern California Coastal Water Resources Project, Westminster, California. pp. 81-90.

Hendricks, T.J. and N. Christensen, 1987. Current flow patterns in the San Diego Bight. In: Southern California Coastal Water Resources Project Annual Report. Southern California Coastal Water Resources Project, Westminster, California. pp. 27-31.

Hickey, Barbara M., 1992. Circulation over the Santa Monica-San Pedro basin and shelf. *Progress in Oceanography*. 30:37-115.

Hickey, B.M., 1993. Chapter 2 - Physical Oceanography. In: Ecology of the Southern California Bight: A synthesis an interpretation. Ed: M.D. Dailey, D.J. Reisch, and J.W. Anderson. Berkeley, California. University of California Press. pp 19-70.

Moore, D.G., 1957. Acoustic sounding of Quaternary marine sediments off Point Loma, California: U.S. Navy Electronics Laboratory, San Diego, California. Research Report No. 815. 17p.

National Research Council (NRC), 1990. Monitoring Southern California's coastal waters. National Research Council Panel, National Academy Press, Washington, DC. 154p.

Otnes, R.K. and L. Enochson, 1978. *Applied Time-Series Analysis - Volume 1*. New York: John Wiley and Sons. 449p.

Pavlova, Y.V., 1966. Seasonal variations of the California Current. *Oceanology*. 6:806-814. (English translation).

Picard, G.L., 1964. *Descriptive Physical Oceanography*. 214p.

Reid, J.L. Jr., G.I. Roden, and J.B. Wyllie, 1958. Studies of the California Current system. CalCOFI Program Report, 7-1-56, 1-1-58, Marine Residential Committee, California Department Fish and Game, Sacramento, California. pp. 27-56.

Southern California Coastal Water Research Project (SCCWRP), 1973. The ecology of the Southern California Bight: Implications for water quality management. SCCWRP TR104. Southern California Coastal Water Resources Project, Westminster, California. March, 1973. 531p.

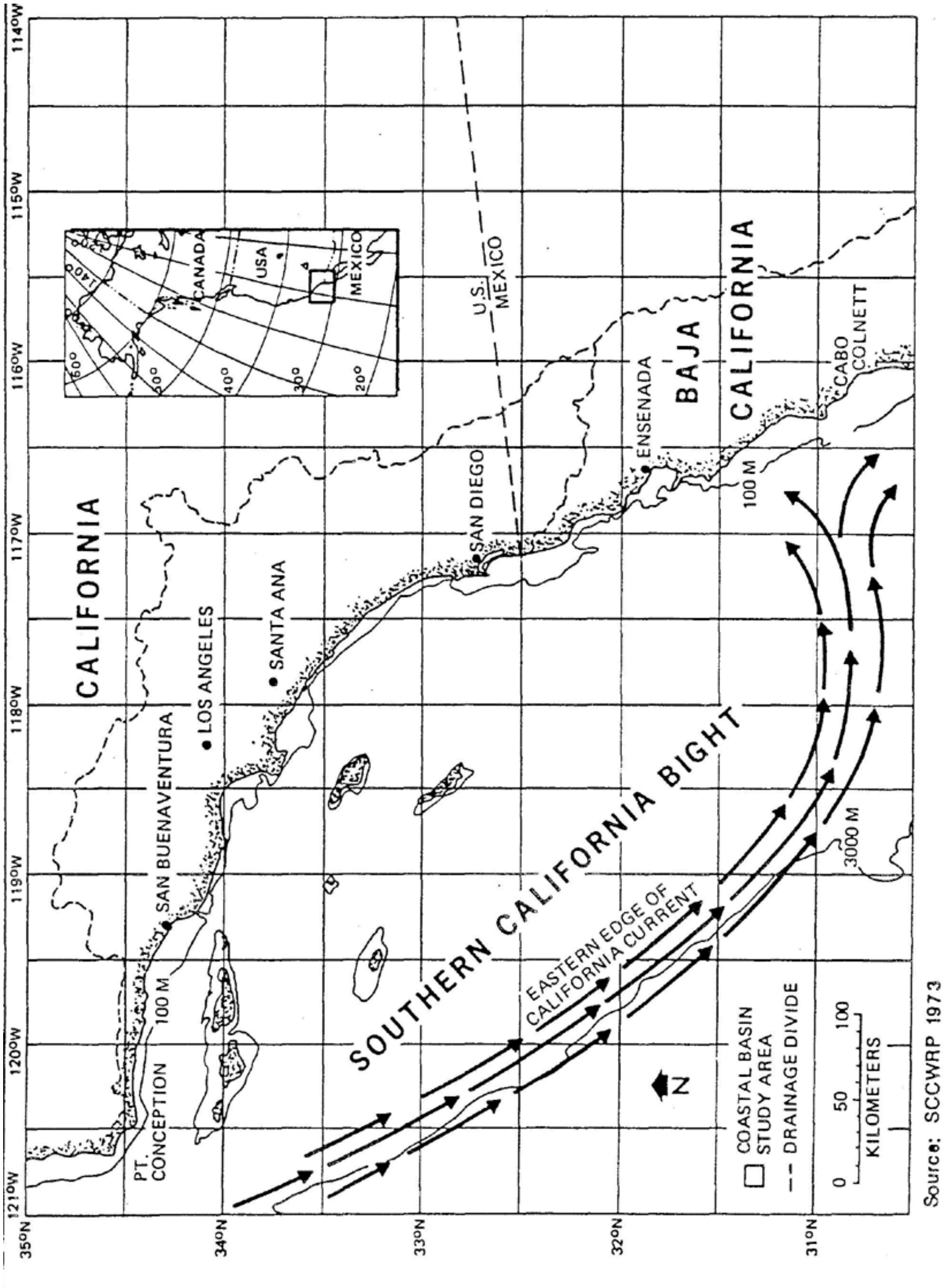
Sverdrup, H.U. and R.H. Fleming, 1941. The waters off the coast of southern California, March to July, 1967. Bulletin of the Scripps Institute of Oceanography. 4(10): 261-387.

Winant, C.D., 1983. Longshore coherence of currents on the Southern California shelf during the summer. Journal Physics Oceanography. 13:54-64.

Winant, C.D. and A.W. Bratkovich, 1981. Temperature and currents on the Southern California shelf: A description of the variability. Journal Physics Oceanography. 11:71-86.

Winant, C.D. and J.R. Olson, 1976. The vertical structure of coastal currents. Deep Sea Resources. 23: 925-936.

Wooster, W.S. and S.H. Jones, 1970. The California Undercurrent off northern Baja California. Journal Marine Resources. 28(2):235-250.



Source: SCCWRP 1973

Figure P-1
Southern California Bight

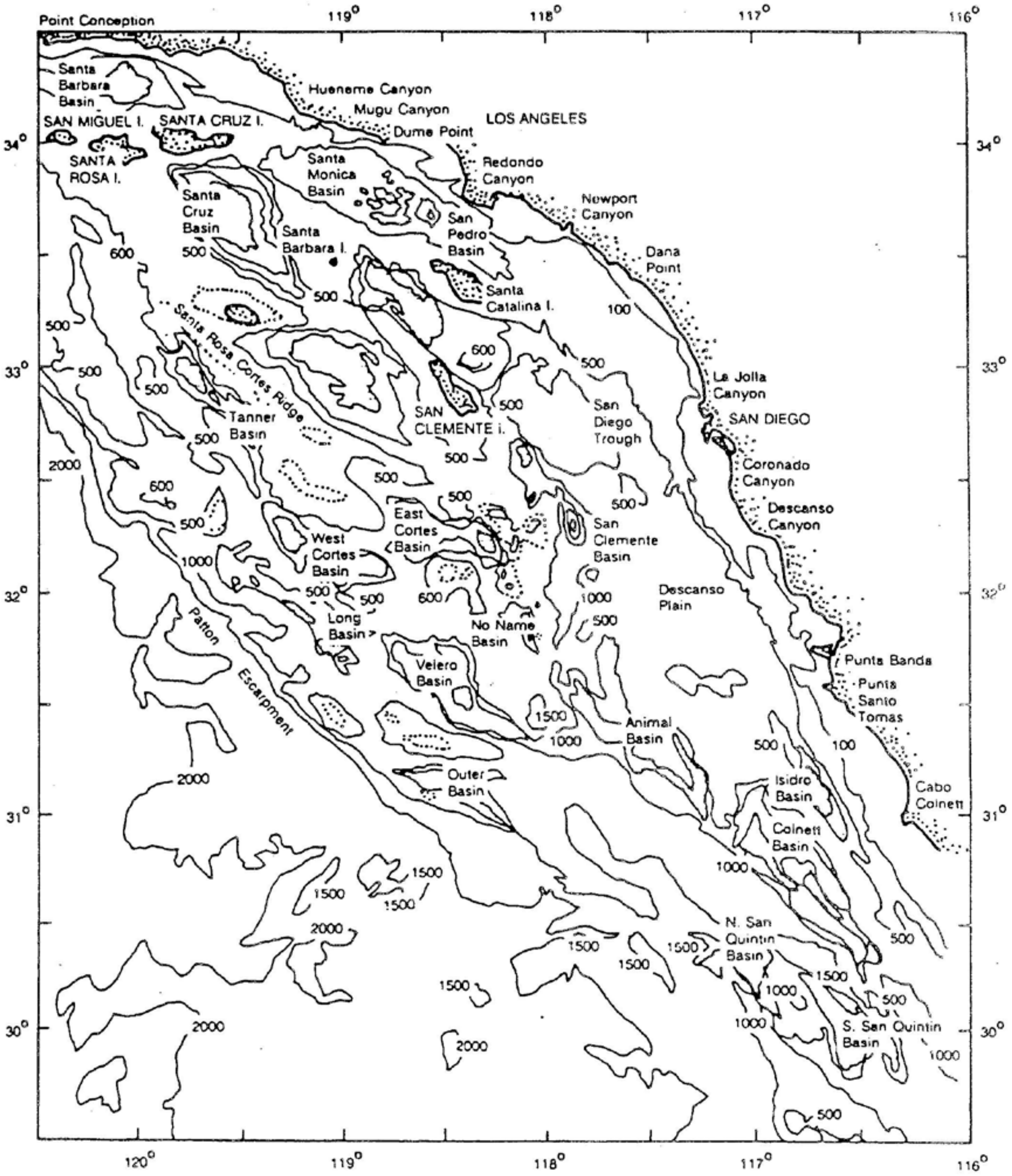


Figure P-2
Bathymetry of the Southern California Bight

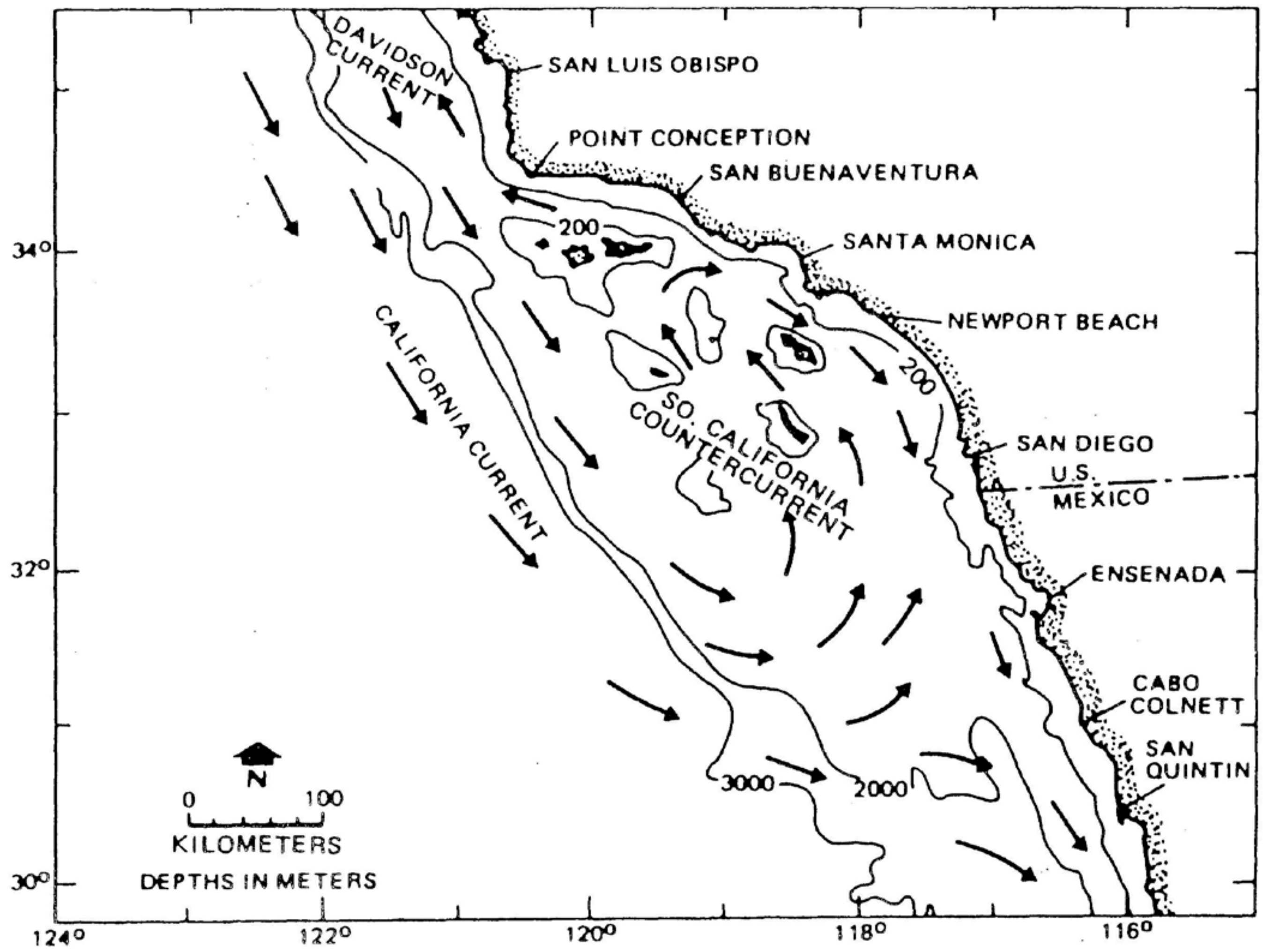


Figure P-3
Currents within the Southern California Bight

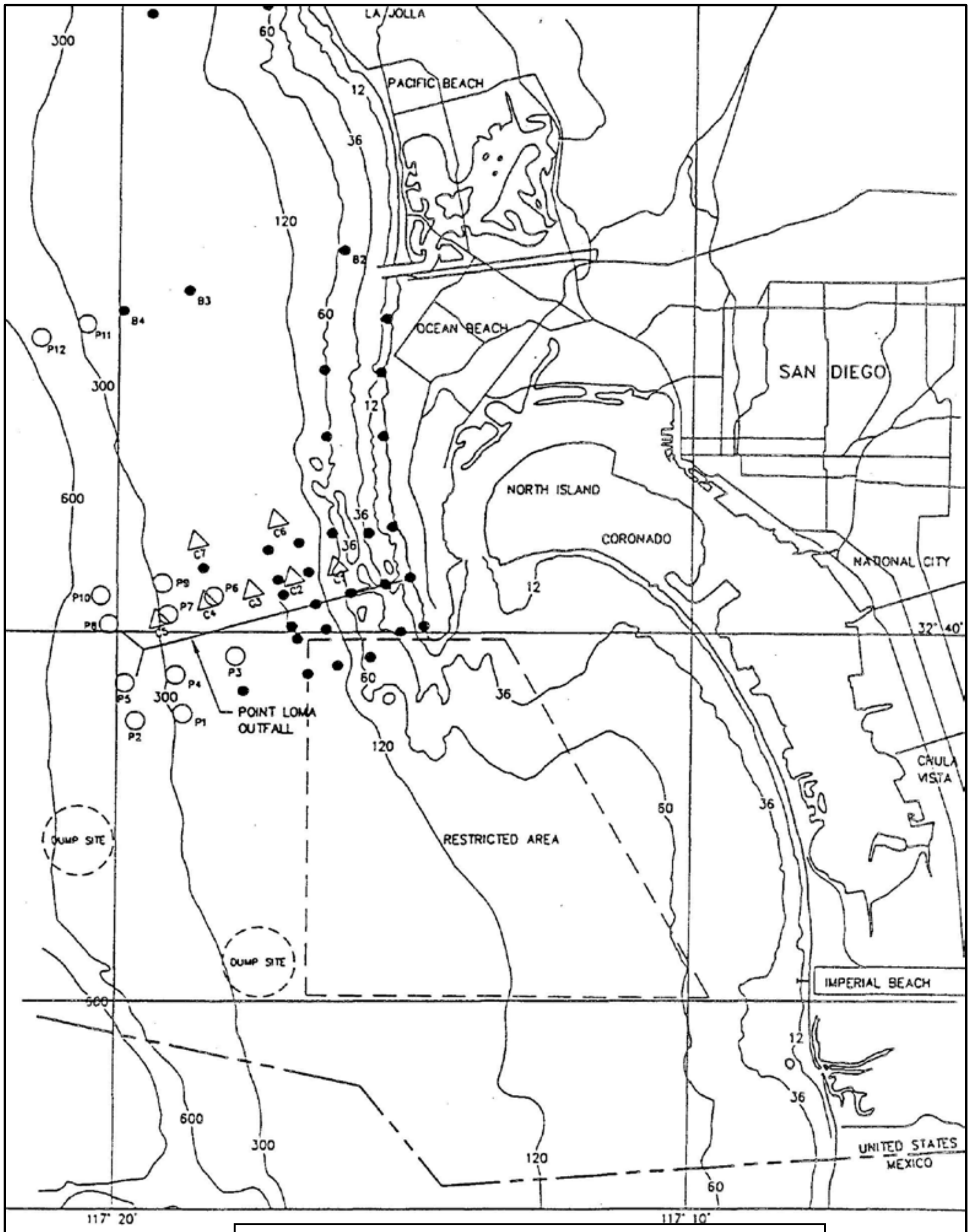


Figure P-4
Study Area Oceanographic Monitoring Stations

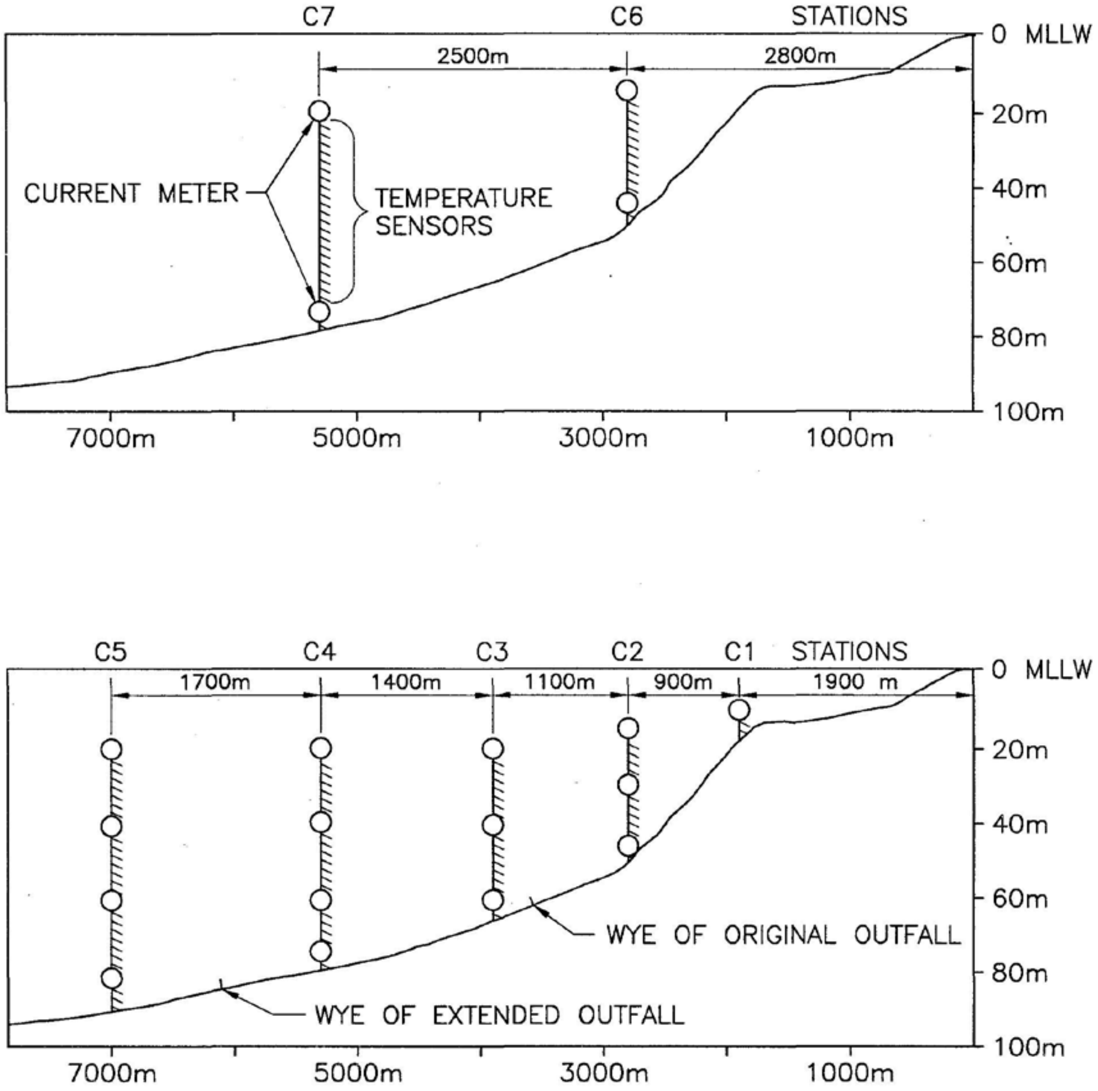


Figure P-5
Current Metering Stations

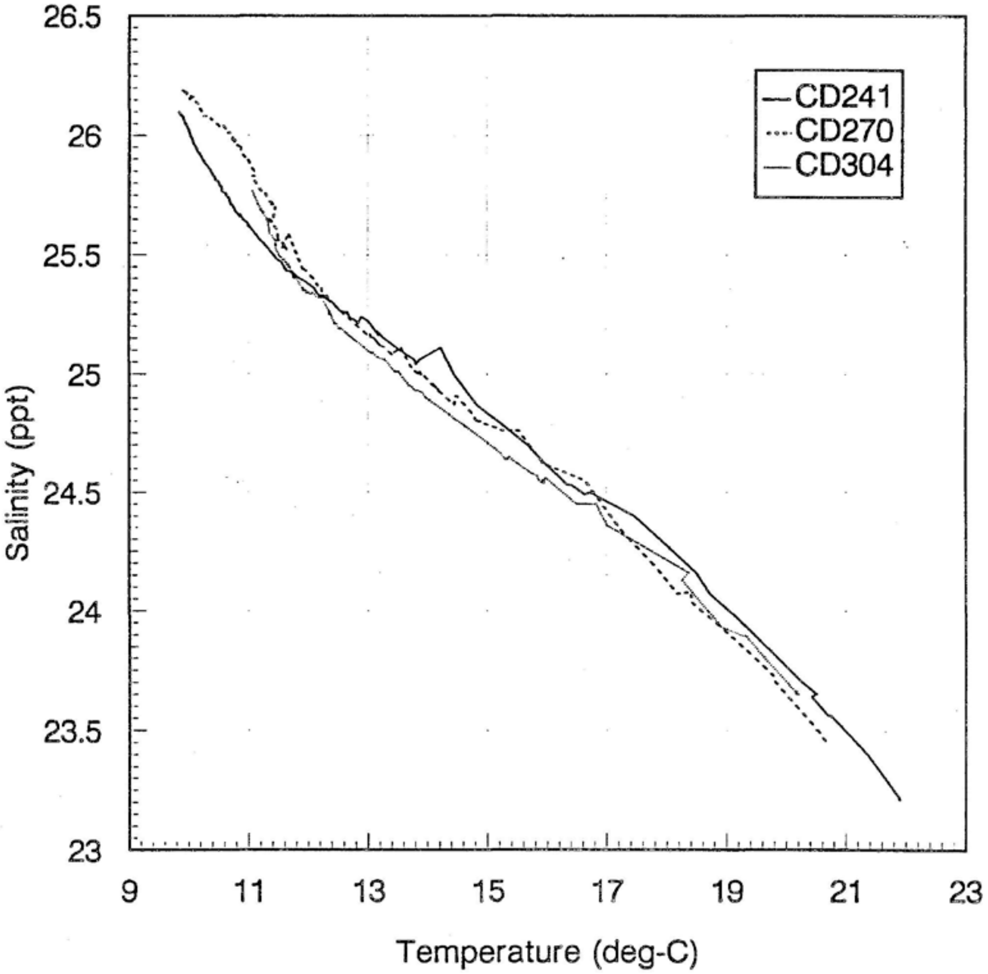
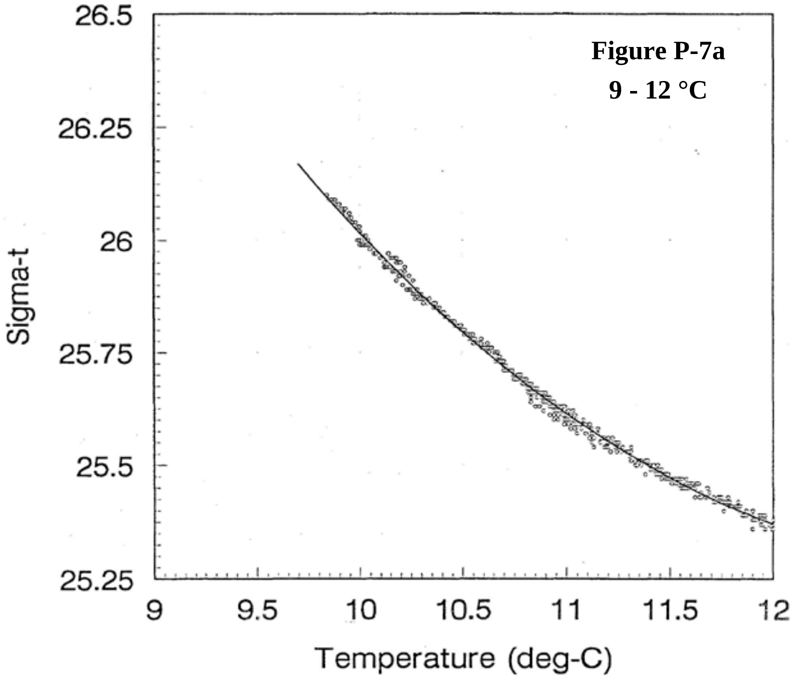


Figure P-6

Temperature/Density Relationship at Station P5 (from CTD Data)



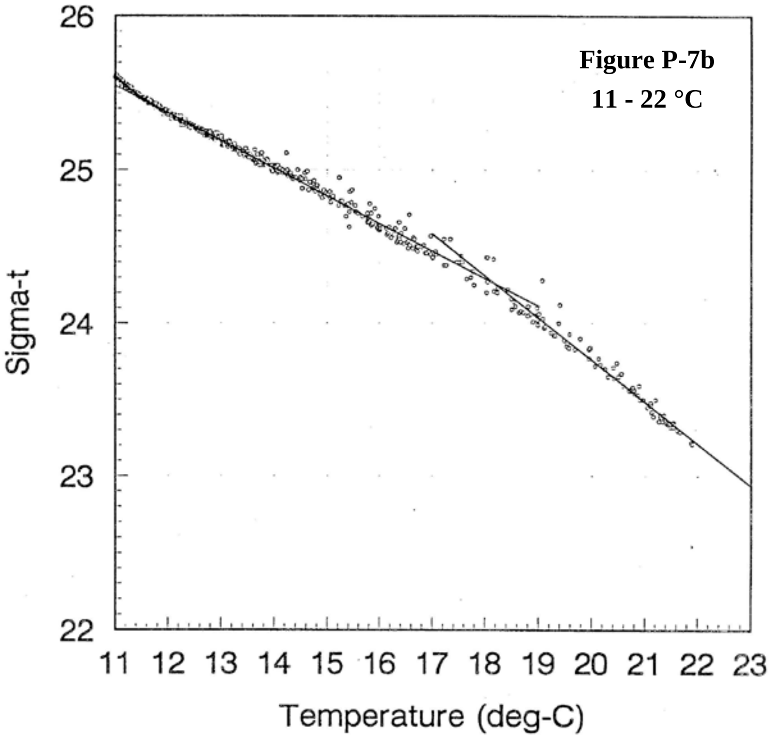


Figure P-7

**Water Temperature vs. Sigma-t
(Calendar Day 241)**

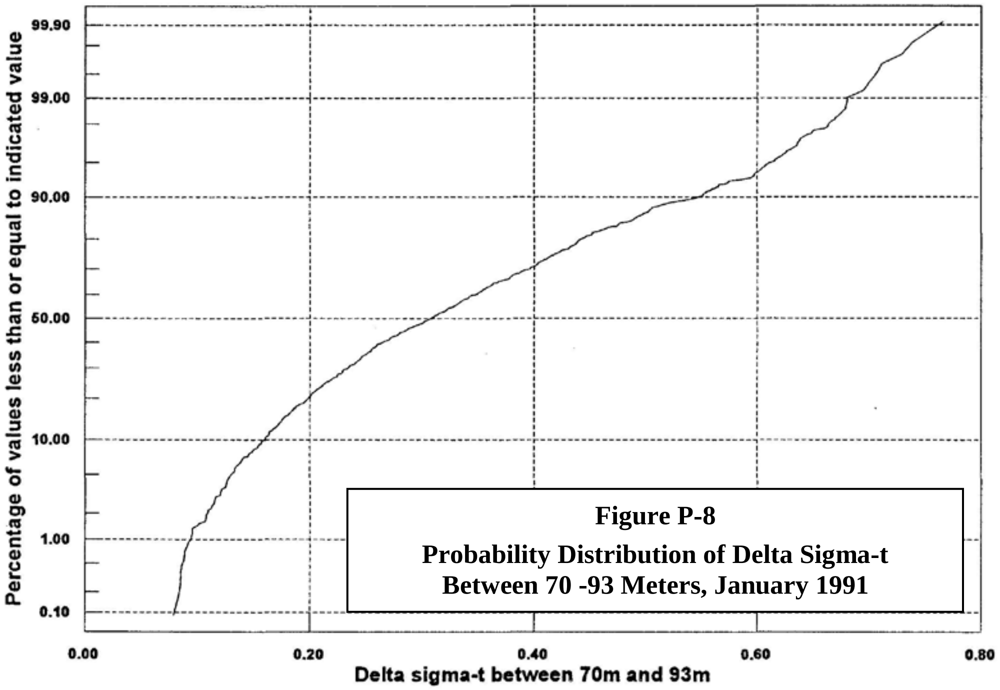


Figure P-8

Probability Distribution of Delta Sigma-t Between 70 -93 Meters, January 1991

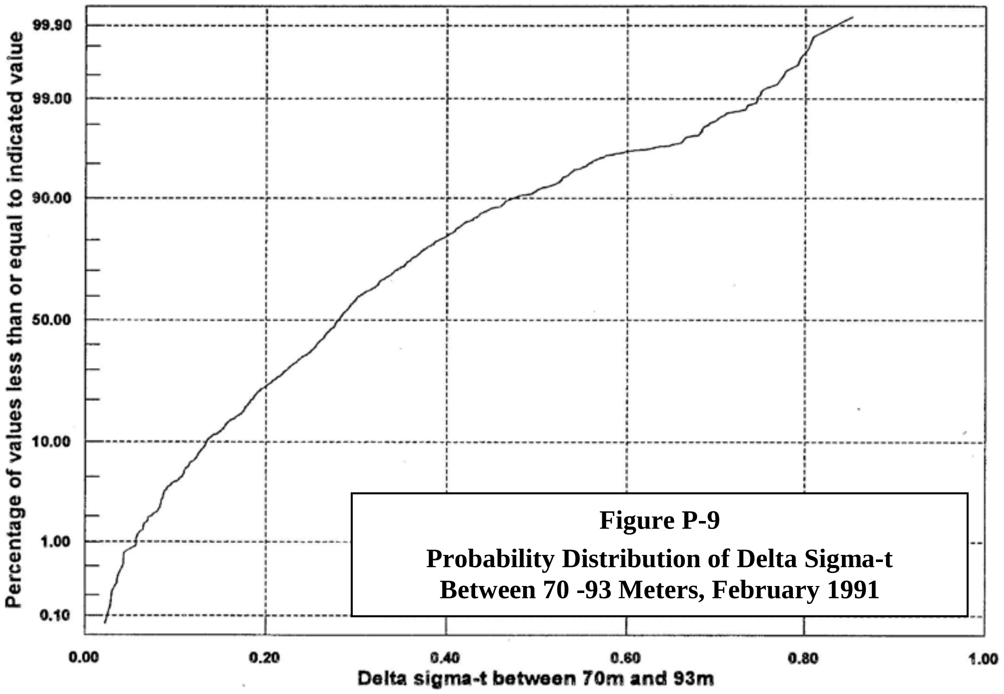


Figure P-9

Probability Distribution of Delta Sigma-t Between 70 -93 Meters, February 1991

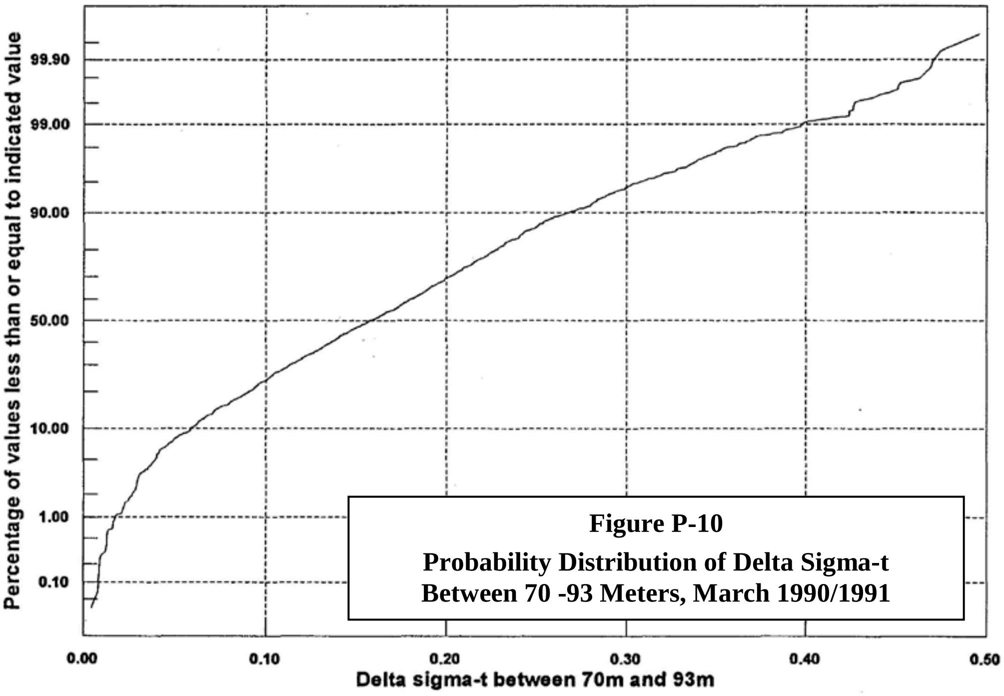


Figure P-10

Probability Distribution of Delta Sigma-t
Between 70 -93 Meters, March 1990/1991

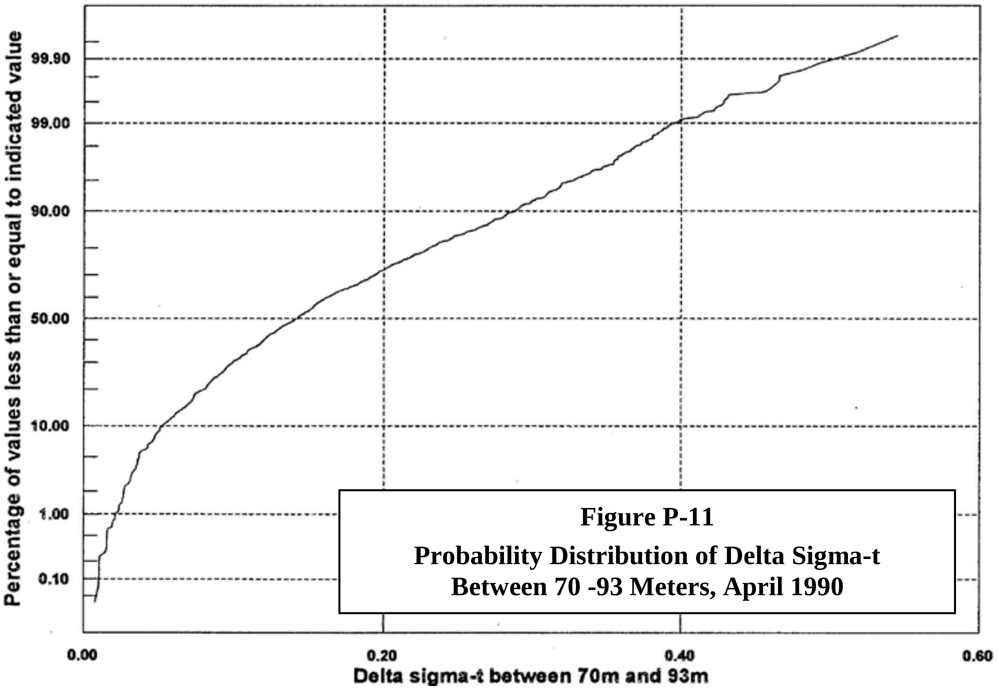


Figure P-11

Probability Distribution of Delta Sigma-t
Between 70 -93 Meters, April 1990

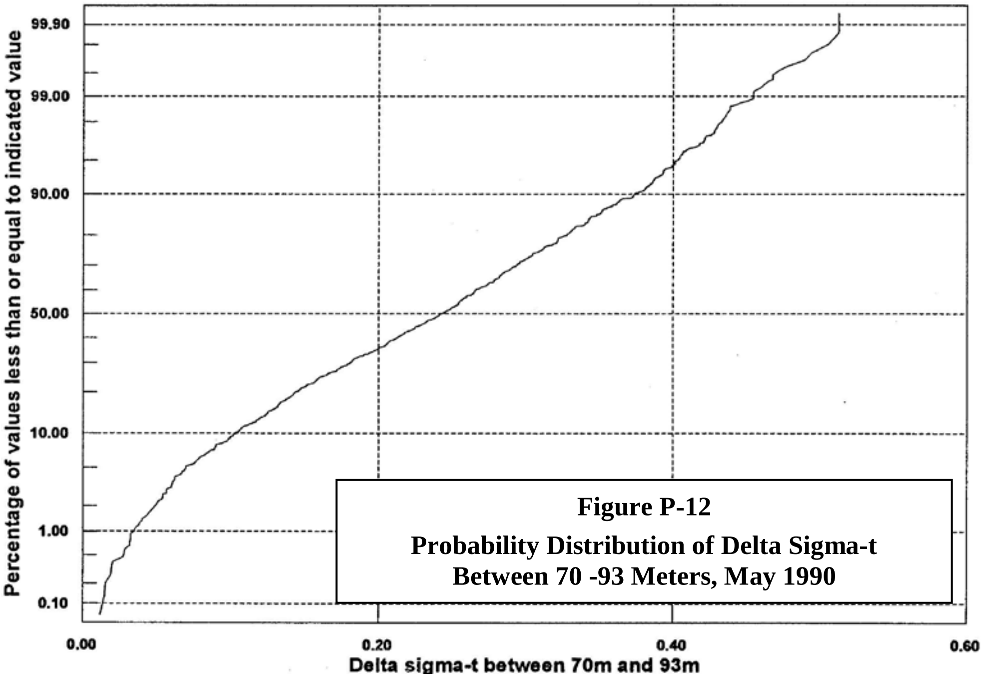


Figure P-12

Probability Distribution of Delta Sigma-t Between 70 -93 Meters, May 1990

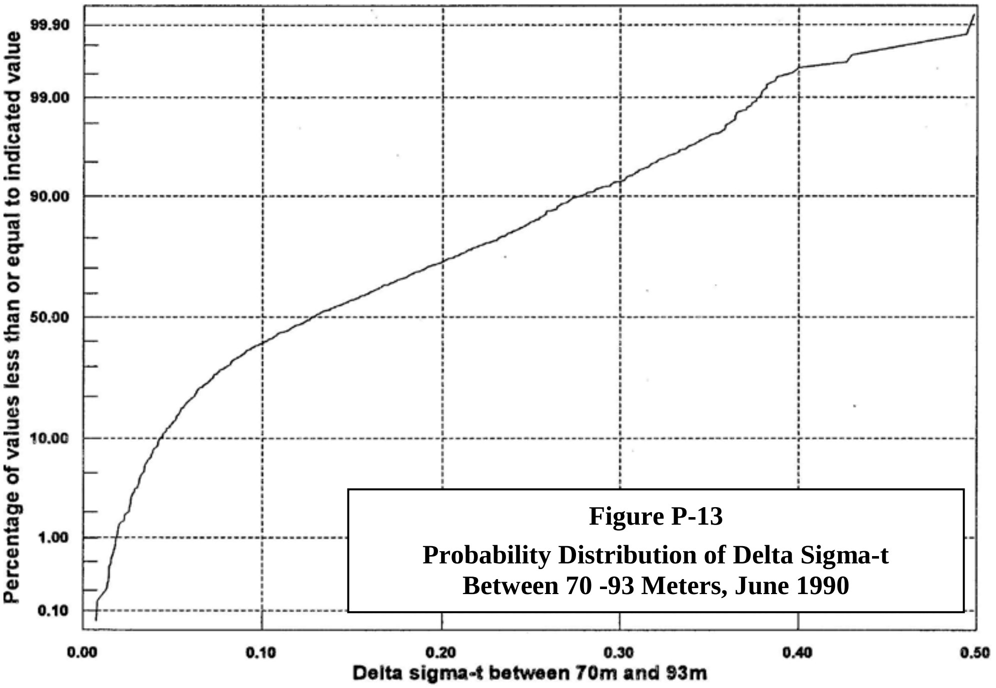


Figure P-13

Probability Distribution of Delta Sigma-t Between 70 -93 Meters, June 1990

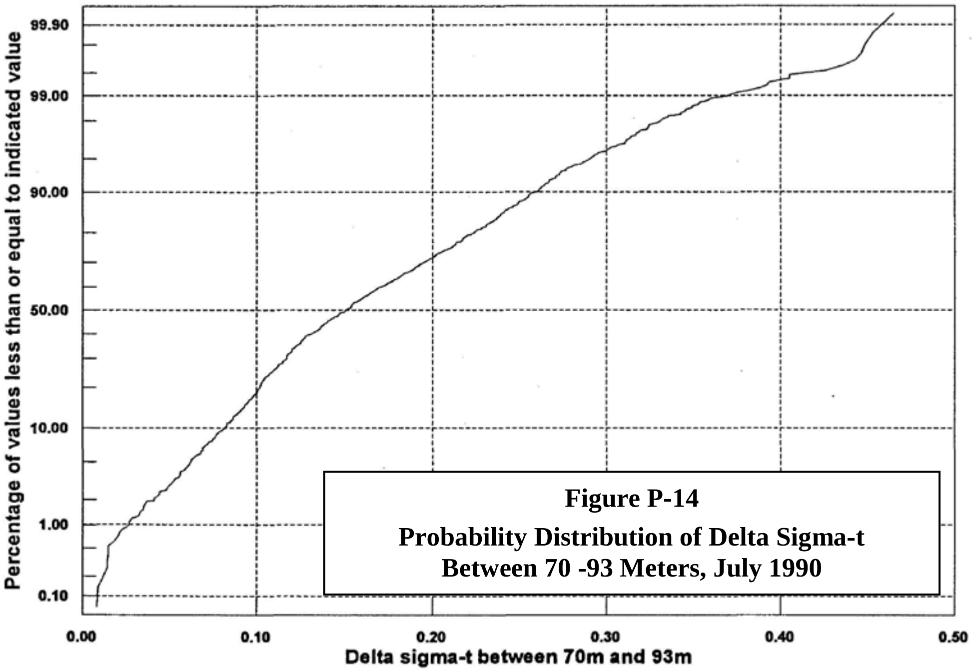


Figure P-14

Probability Distribution of Delta Sigma-t Between 70 -93 Meters, July 1990

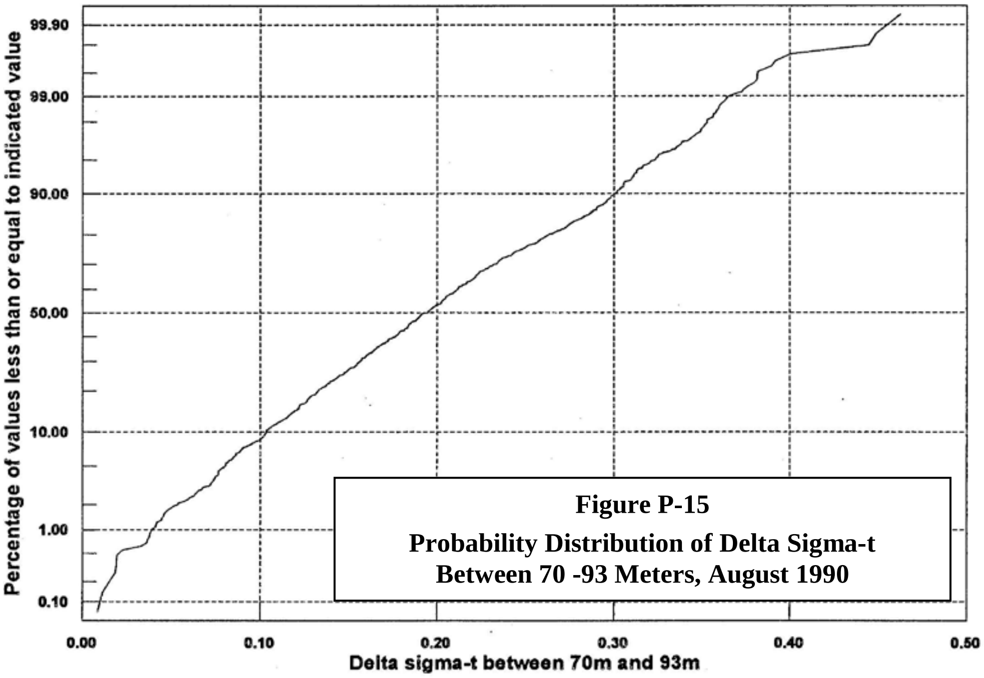


Figure P-15

Probability Distribution of Delta Sigma-t Between 70 -93 Meters, August 1990

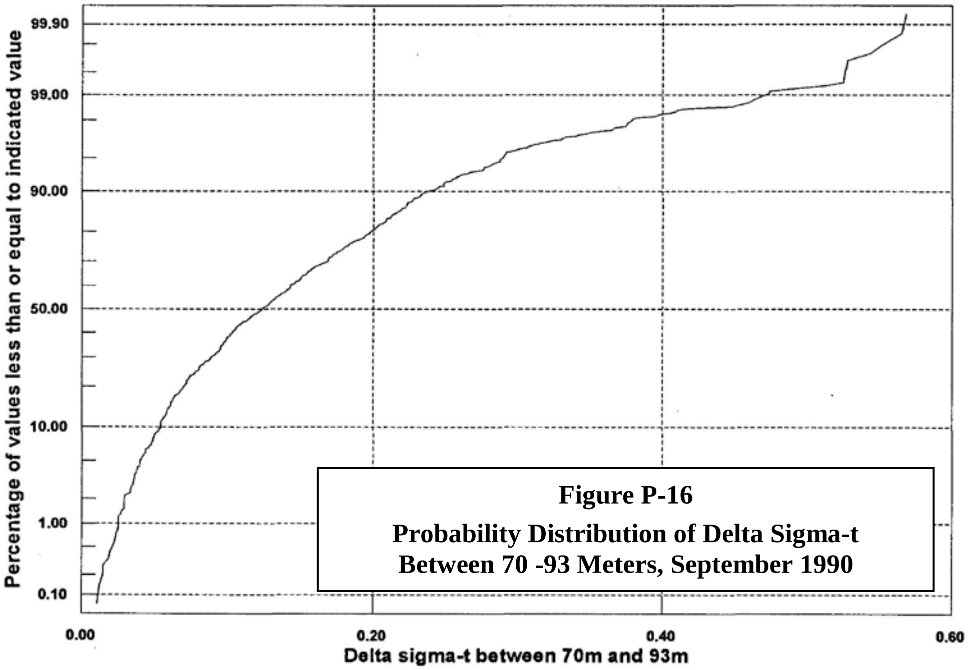


Figure P-16

Probability Distribution of Delta Sigma-t Between 70 -93 Meters, September 1990

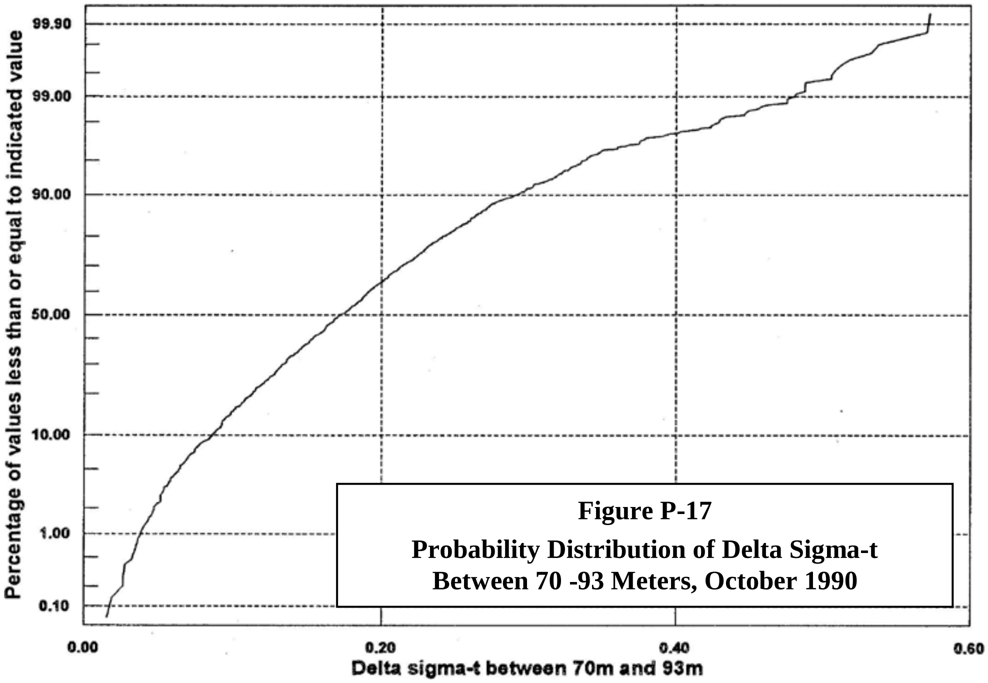
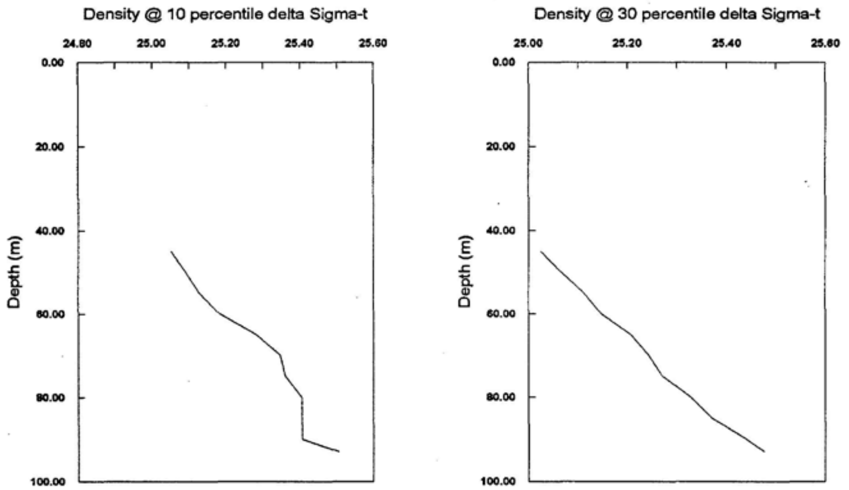
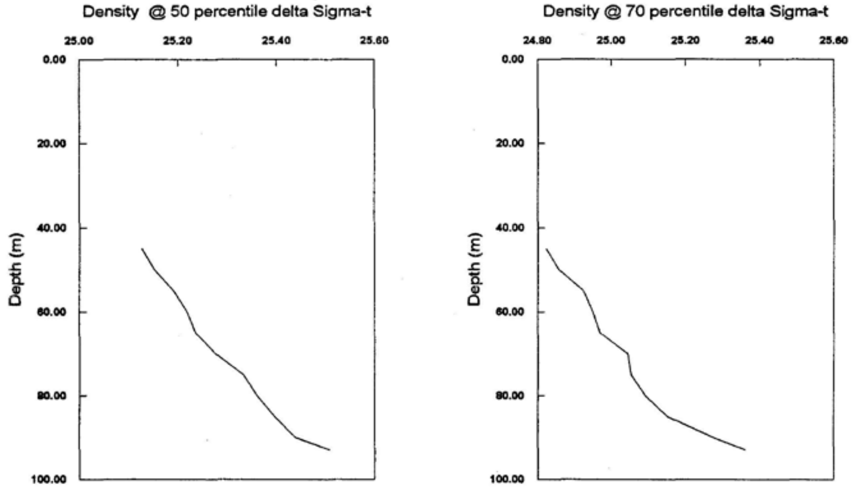


Figure P-17

Probability Distribution of Delta Sigma-t Between 70 -93 Meters, October 1990



Maximum Stratification - January 1990



Maximum Stratification - January 1990

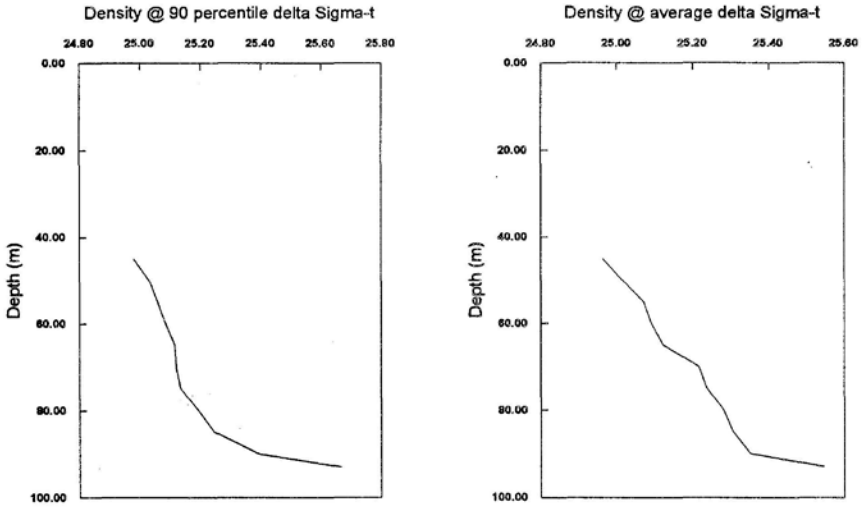
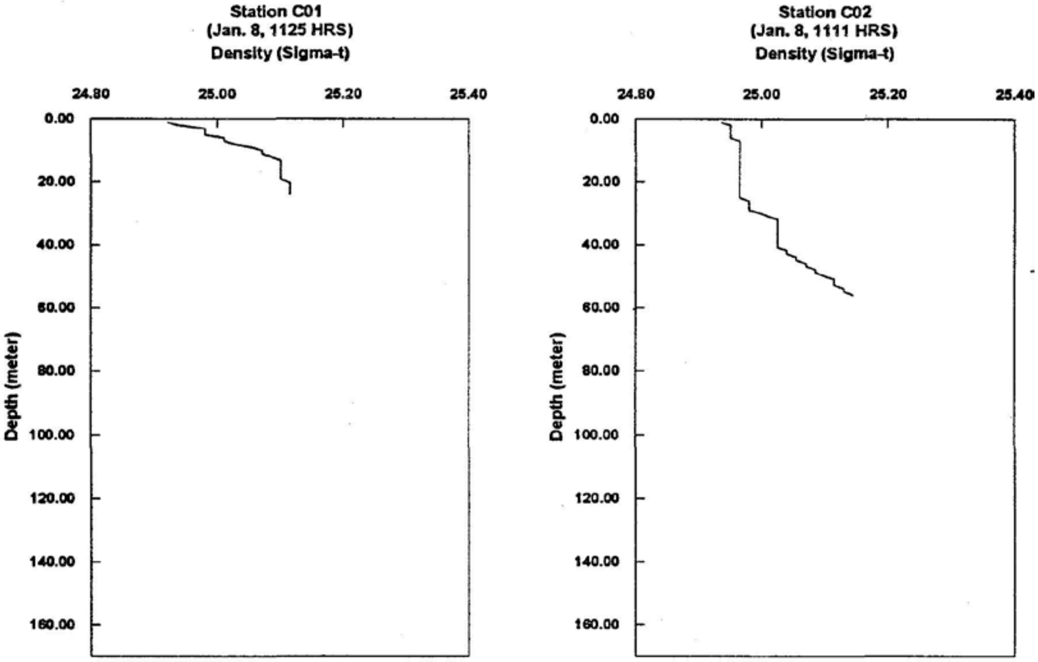


Figure P-18

Density-Depth Profiles for January (Maximum Stratification), Time-Series Data



Maximum Stratification - January 1990

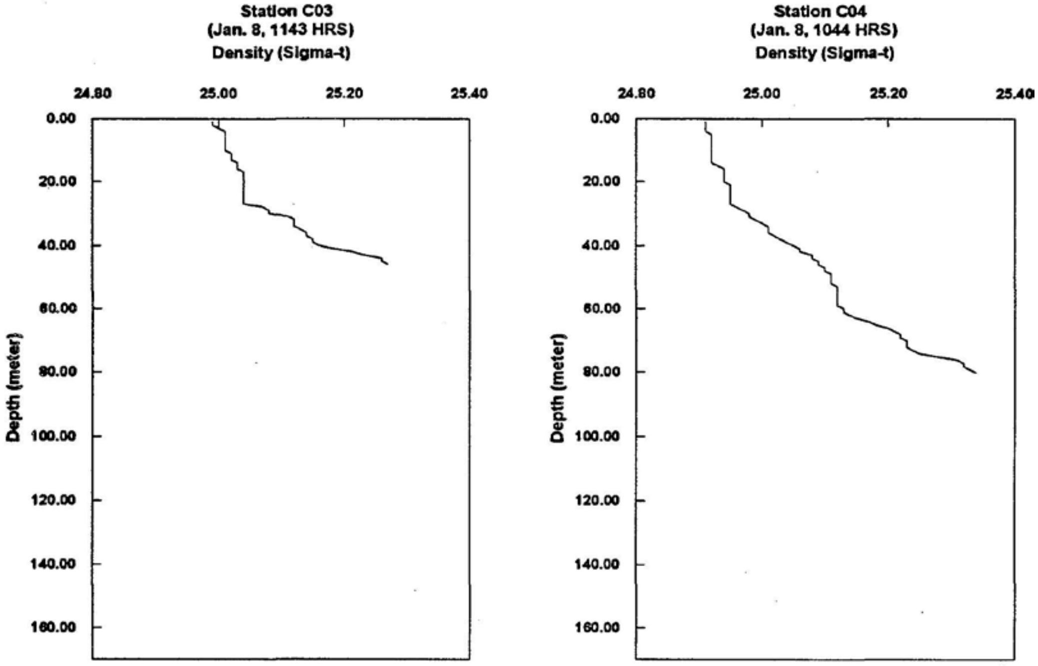
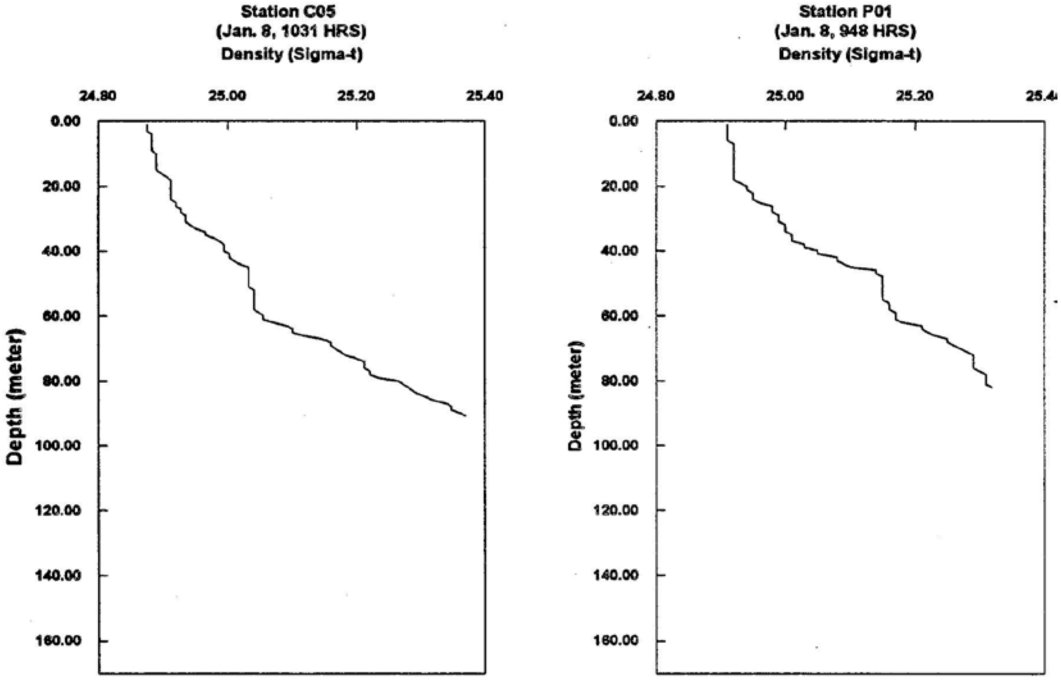


Figure P-19

**Density-Depth Profiles for January (Maximum Stratification)
CTD Data. Stations C1. C2. C3 and C4**



Maximum Stratification - January 1990

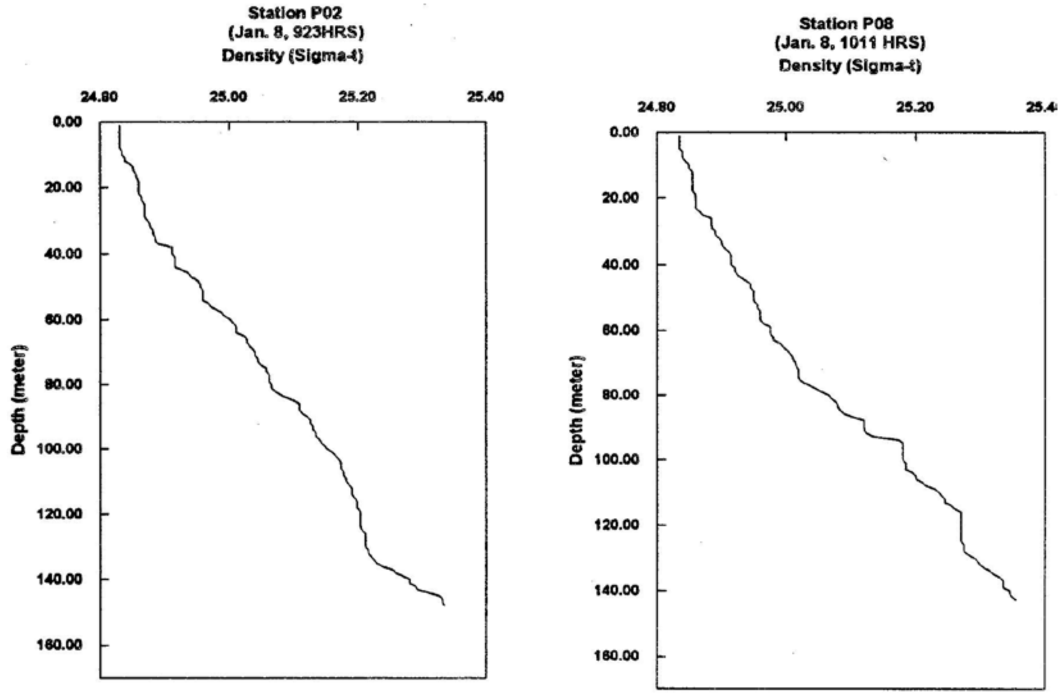
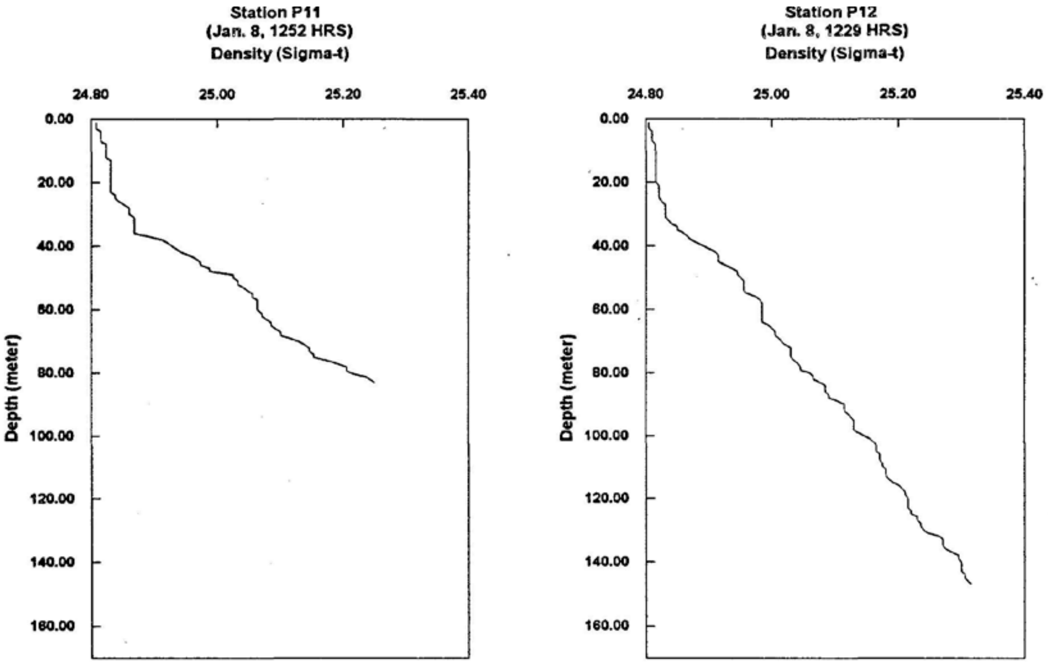


Figure P-20

Density-Depth Profiles for January (Maximum Stratification)
CTD Data. Stations C5. P1. P2 and P8



Maximum Stratification - January 1990

Figure P-21

**Density-Depth Profiles for January (Maximum Stratification)
CTD Data. Stations P11 and P12**

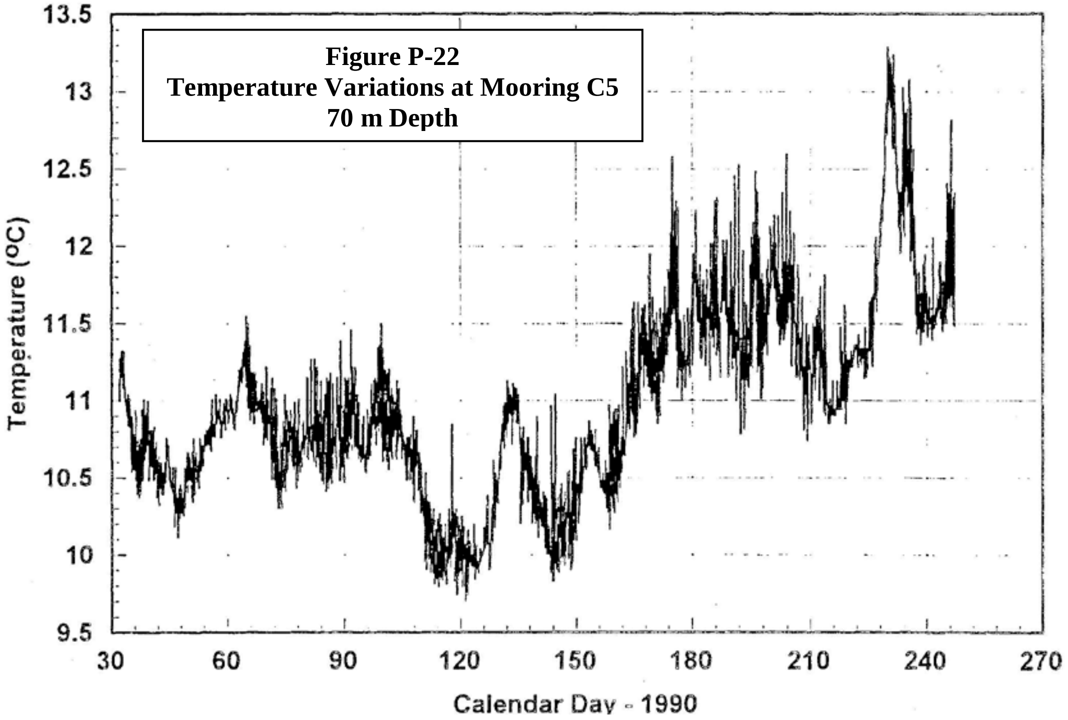


Figure P-22
Temperature Variations at Mooring C5
70 m Depth

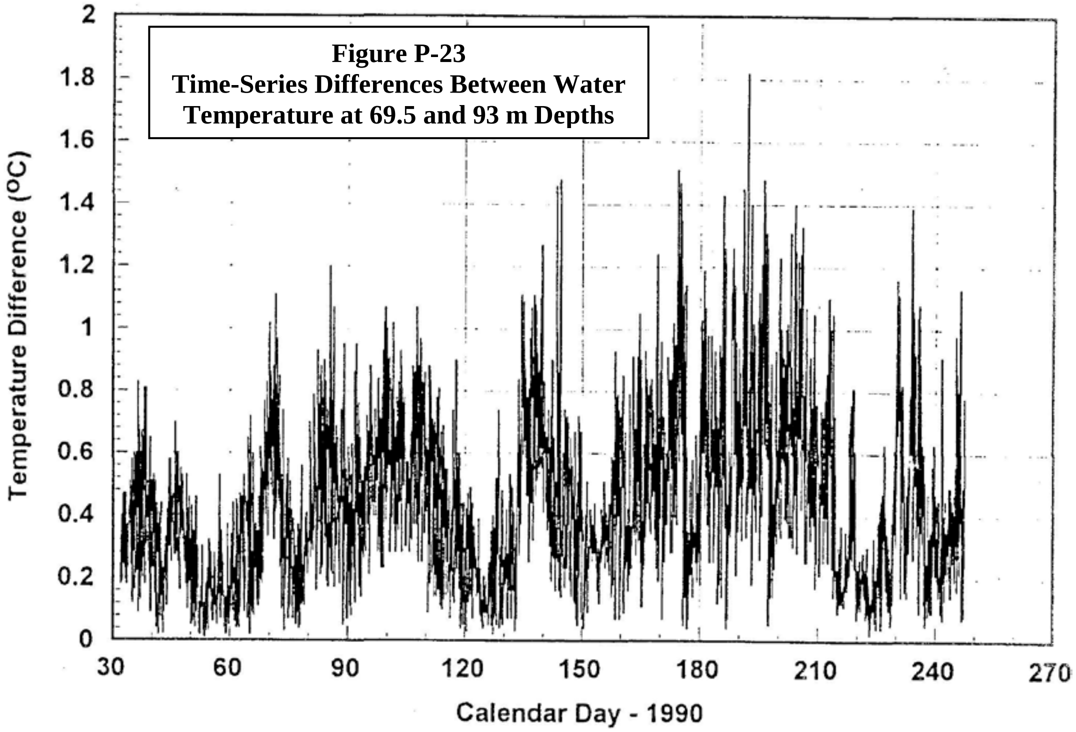


Figure P-23
Time-Series Differences Between Water Temperature at 69.5 and 93 m Depths

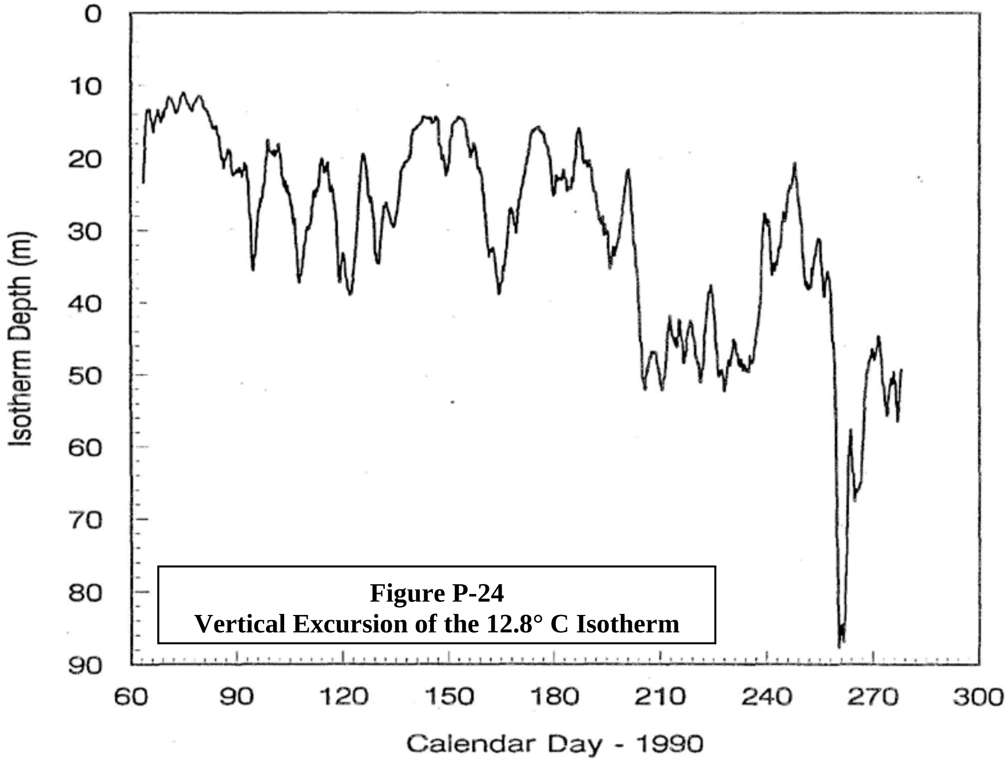


Figure P-24
Vertical Excursion of the 12.8° C Isotherm

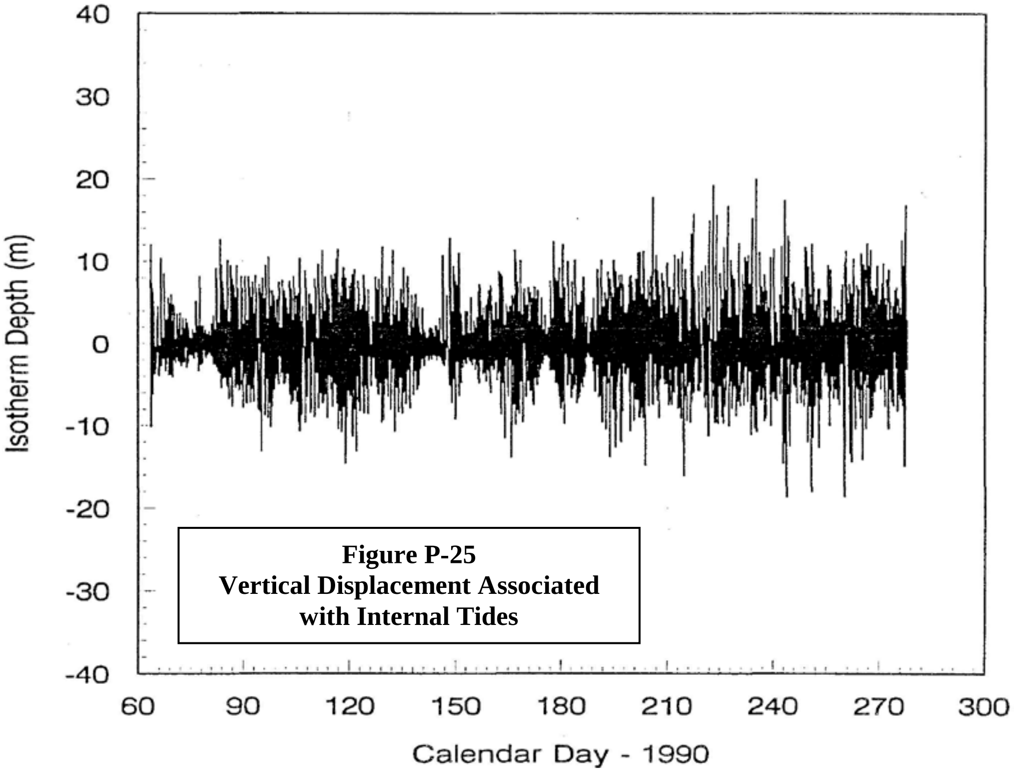
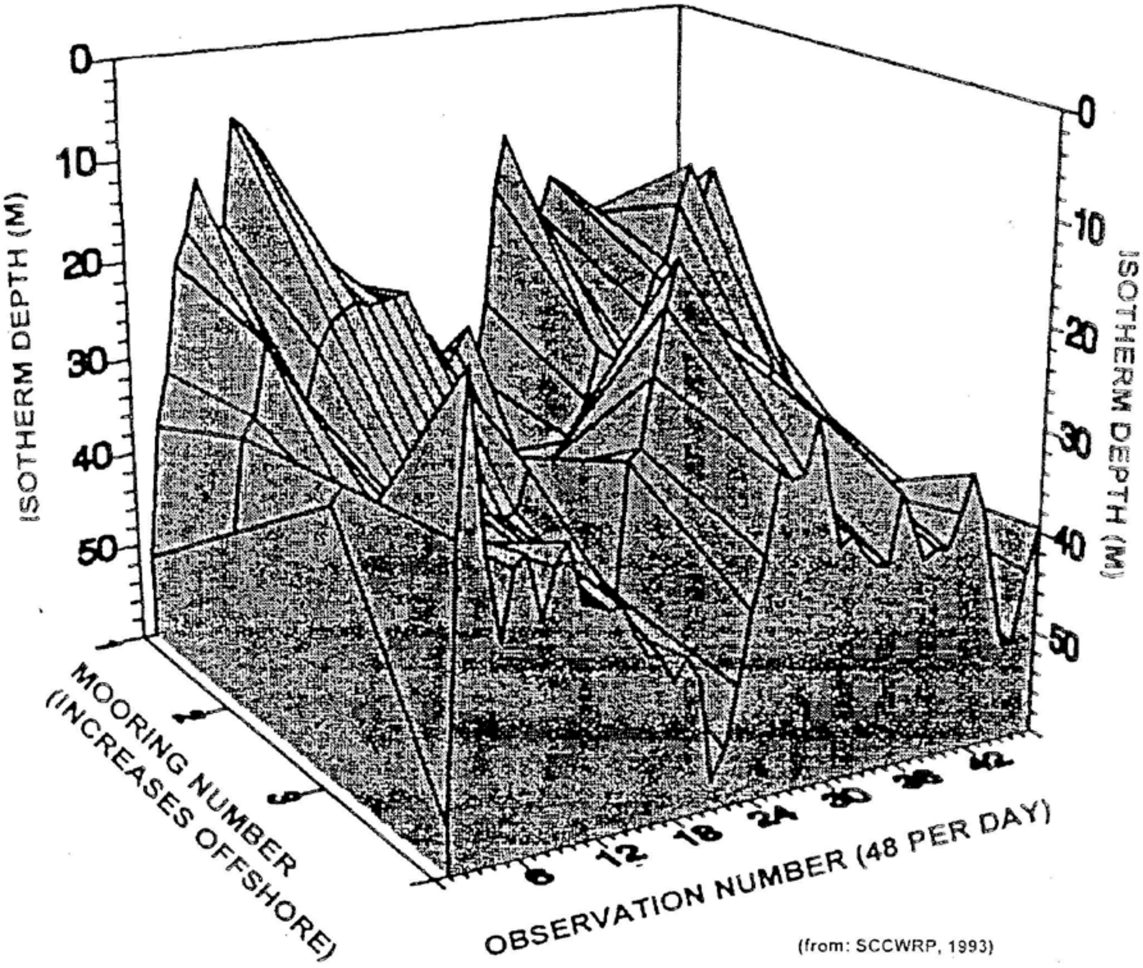


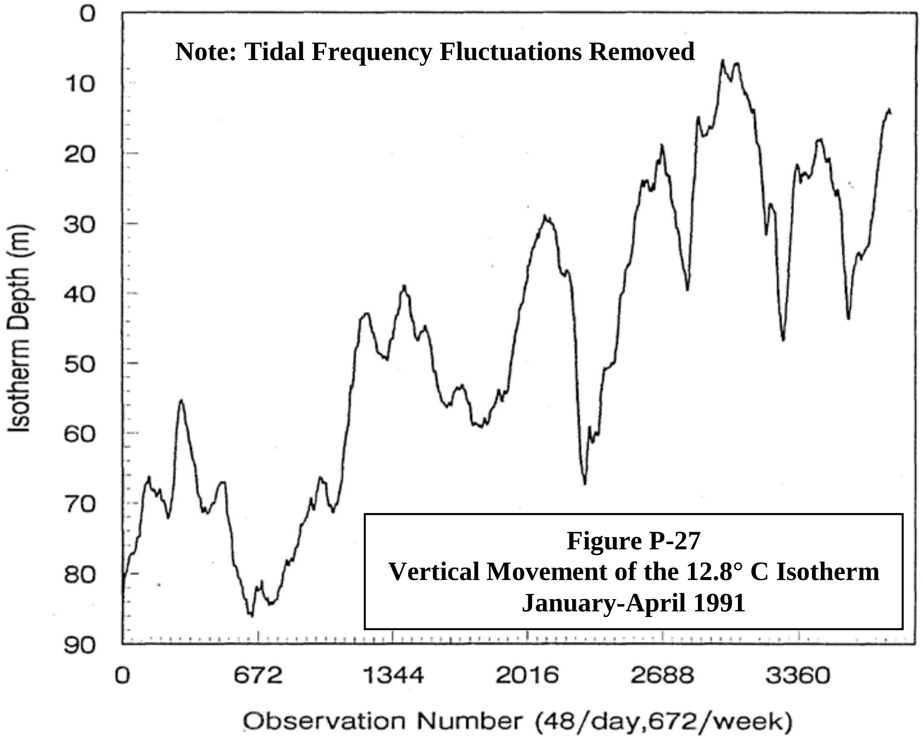
Figure P-25
Vertical Displacement Associated with Internal Tides



(from: SCCWRP, 1993)

Figure P-26

Cross-Shore Depth Variations of the 12.8° C Isotherm Moorings C2, C3, and C4 (June 25-26, 1990)



Note: Tidal Frequency Fluctuations Removed

Figure P-27
Vertical Movement of the 12.8° C Isotherm
January-April 1991

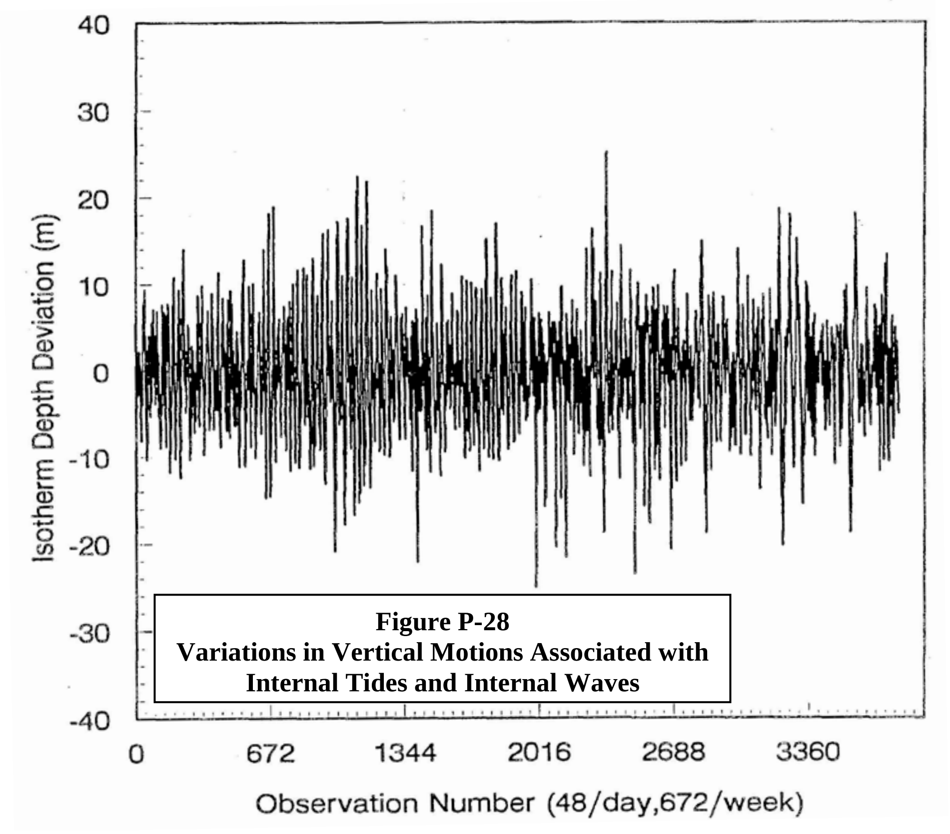


Figure P-28
Variations in Vertical Motions Associated with
Internal Tides and Internal Waves

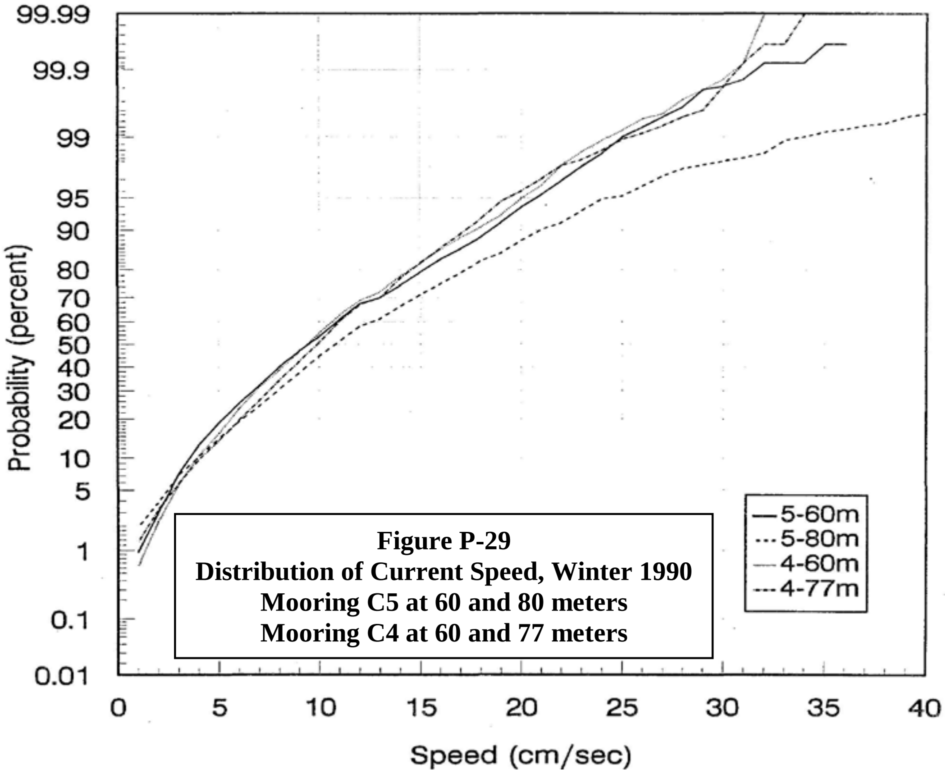


Figure P-29
Distribution of Current Speed, Winter 1990
Mooring C5 at 60 and 80 meters
Mooring C4 at 60 and 77 meters

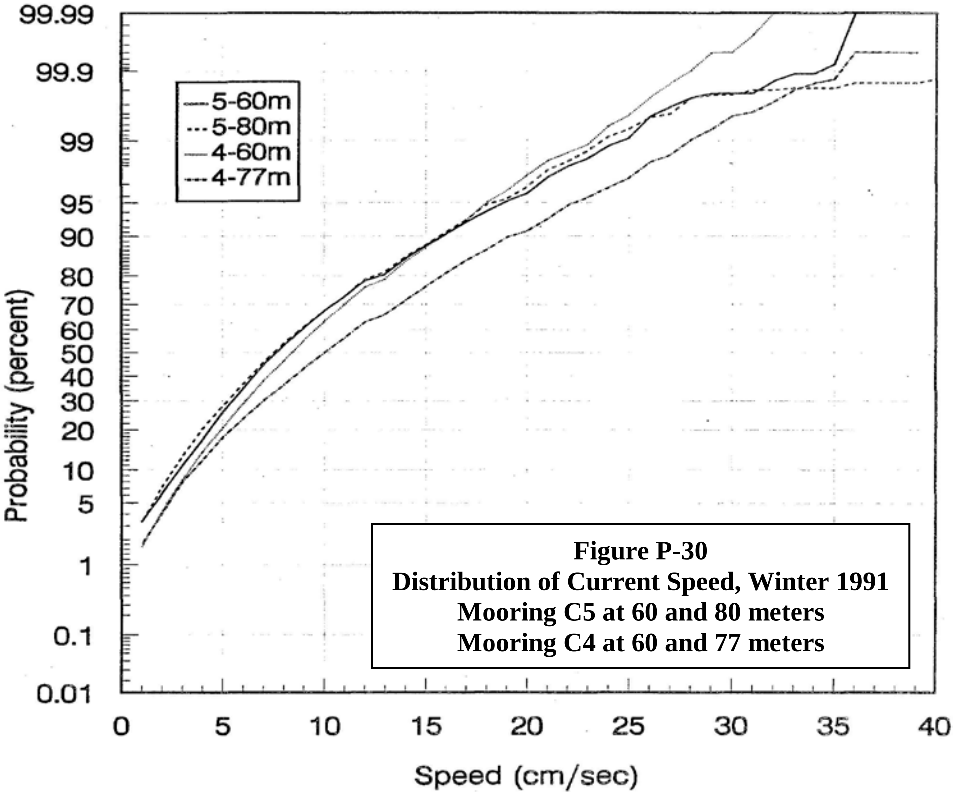


Figure P-30
Distribution of Current Speed, Winter 1991
Mooring C5 at 60 and 80 meters
Mooring C4 at 60 and 77 meters

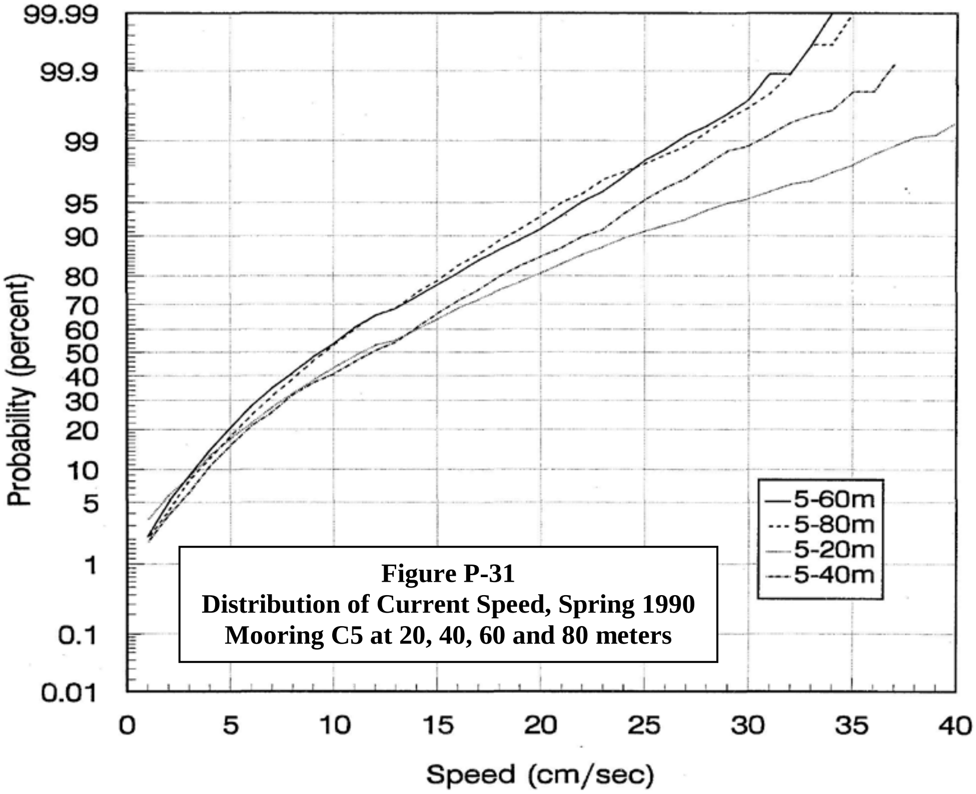


Figure P-31
Distribution of Current Speed, Spring 1990
Mooring C5 at 20, 40, 60 and 80 meters

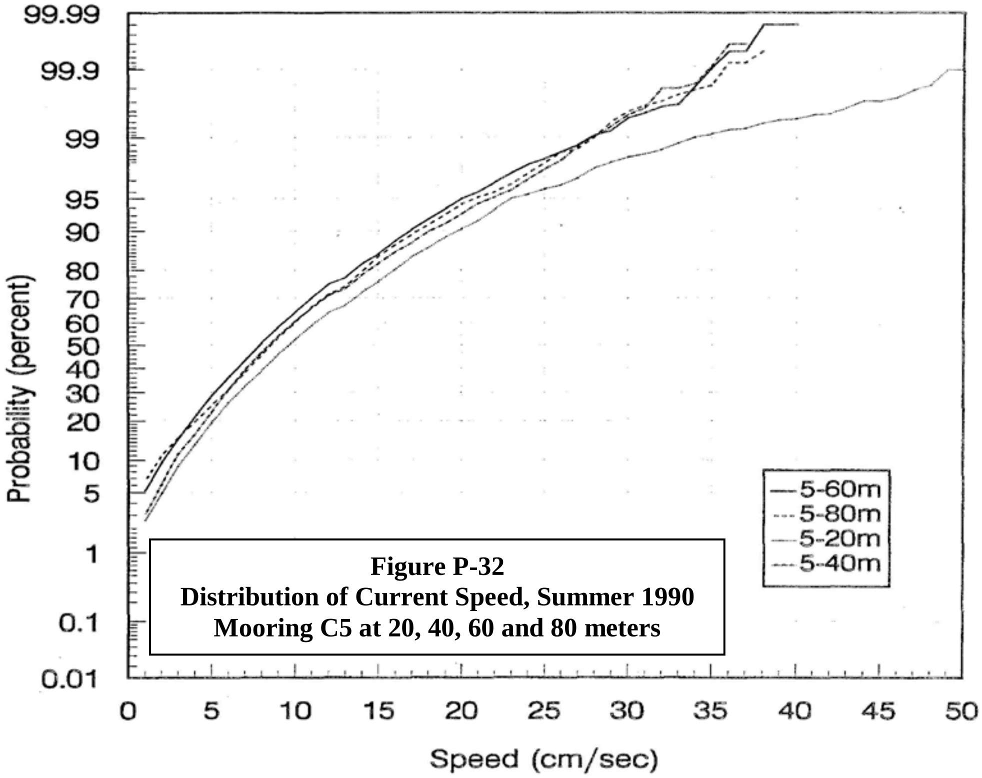


Figure P-32
Distribution of Current Speed, Summer 1990
Mooring C5 at 20, 40, 60 and 80 meters

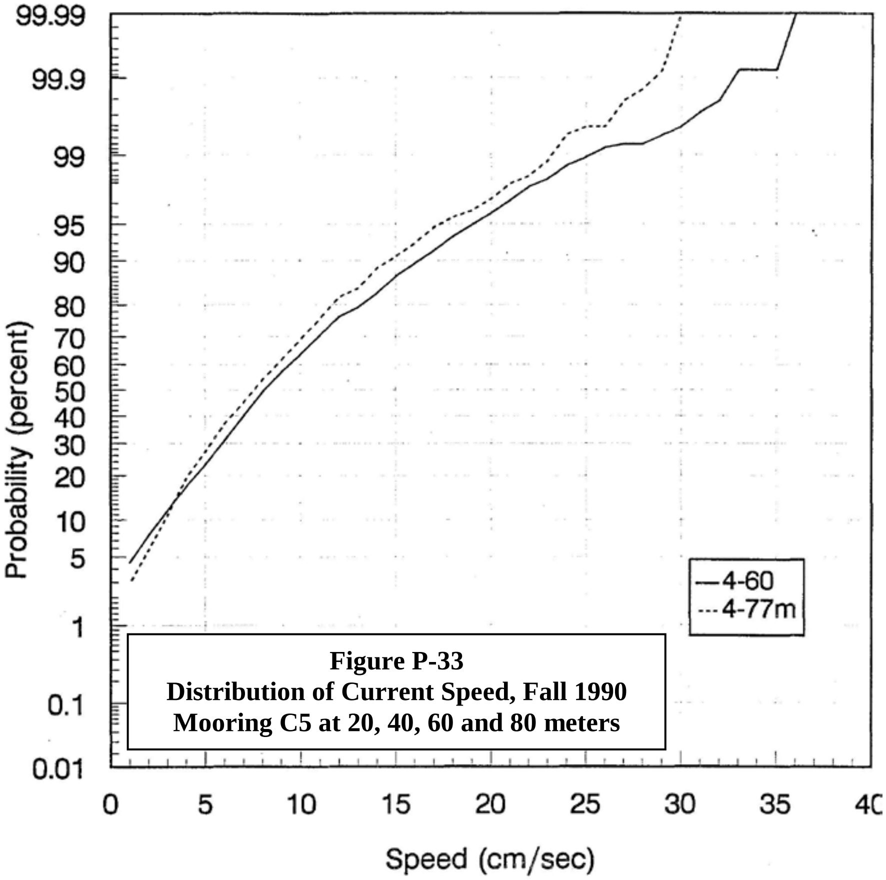


Figure P-33
Distribution of Current Speed, Fall 1990
Mooring C5 at 20, 40, 60 and 80 meters

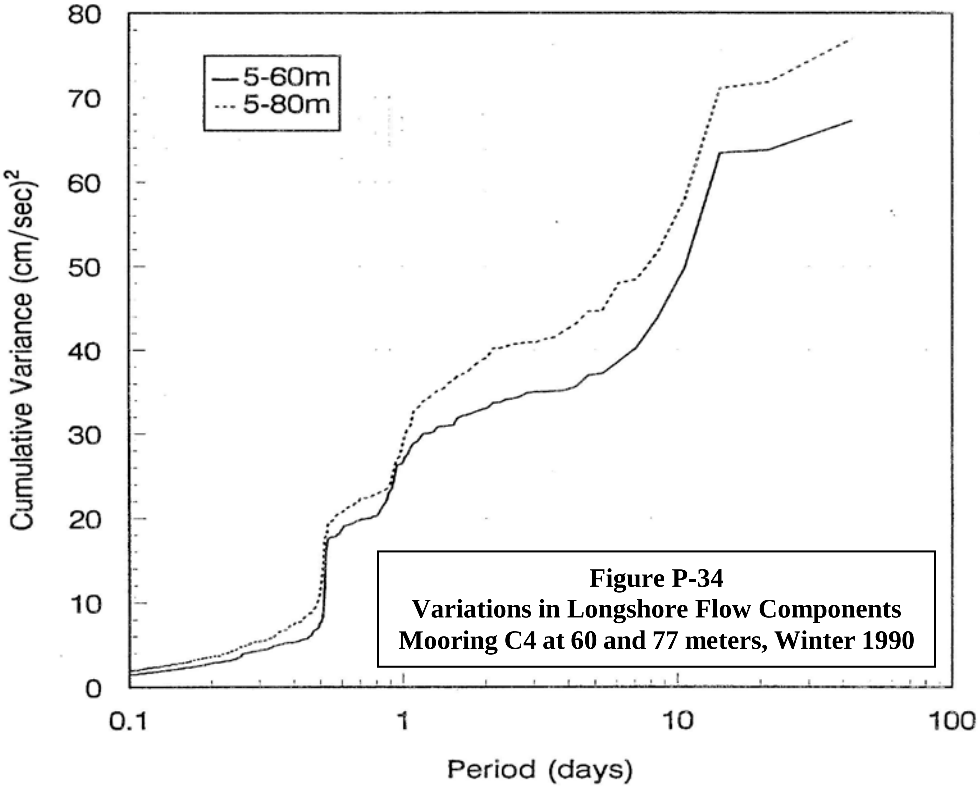


Figure P-34
Variations in Longshore Flow Components Mooring C4 at 60 and 77 meters, Winter 1990

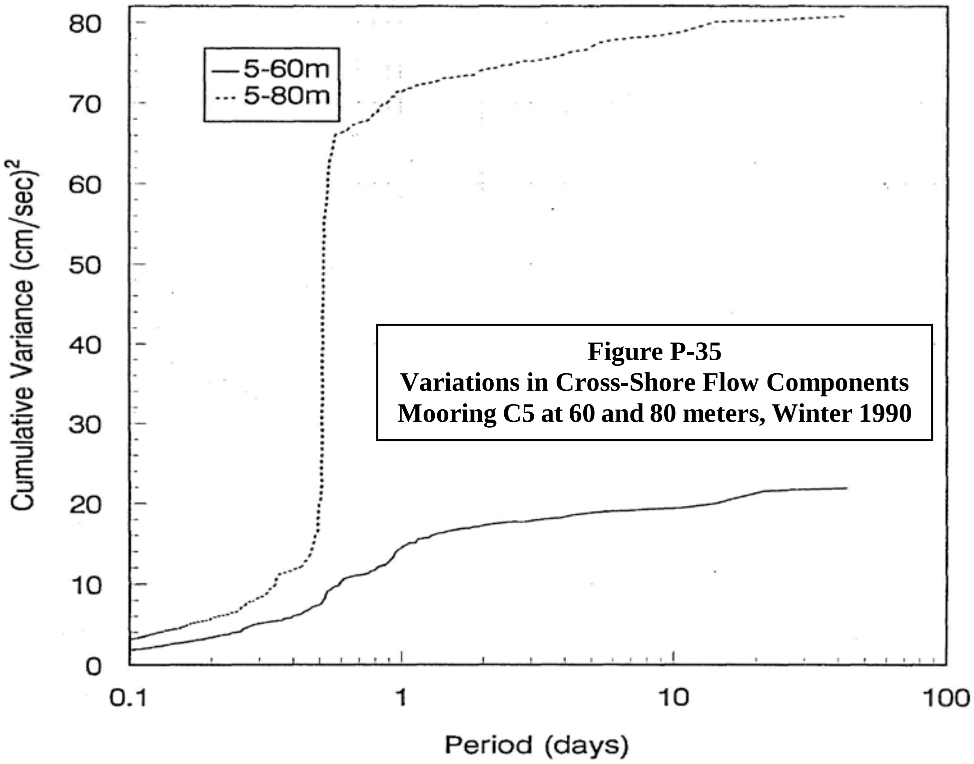


Figure P-35
Variations in Cross-Shore Flow Components Mooring C5 at 60 and 80 meters, Winter 1990

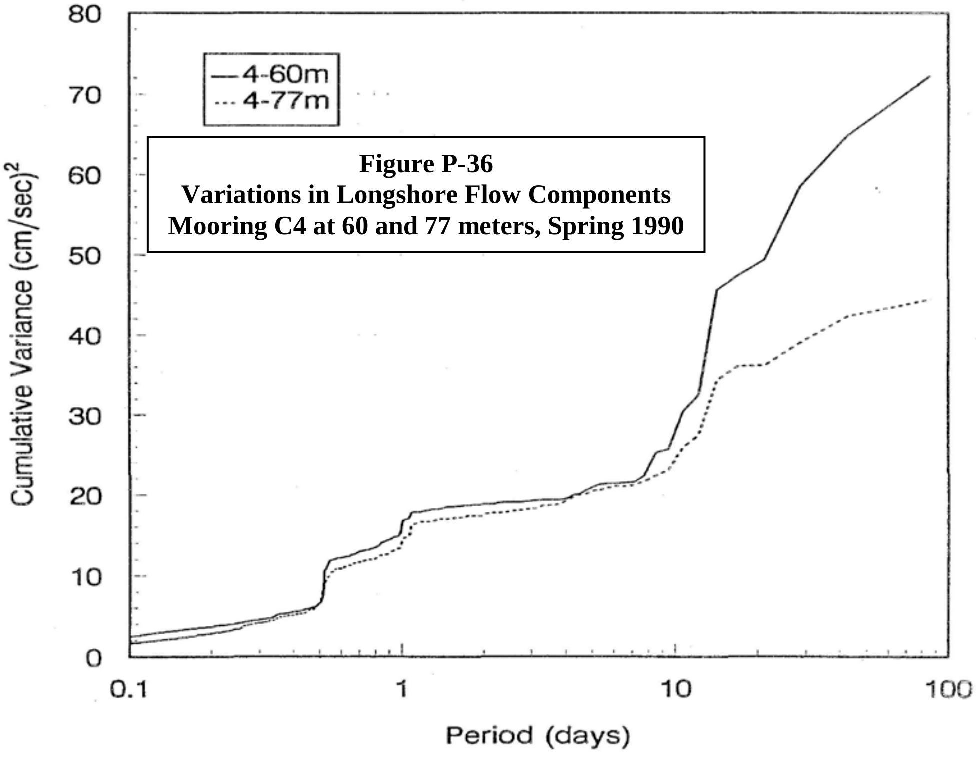


Figure P-36
Variations in Longshore Flow Components
Mooring C4 at 60 and 77 meters, Spring 1990

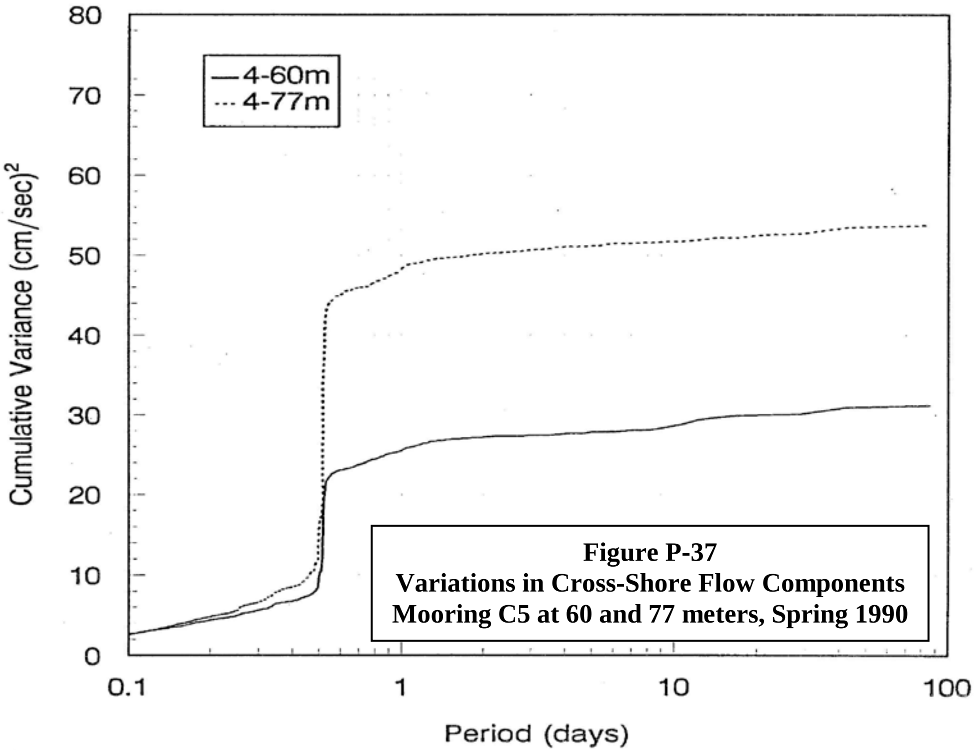


Figure P-37
Variations in Cross-Shore Flow Components
Mooring C5 at 60 and 77 meters, Spring 1990

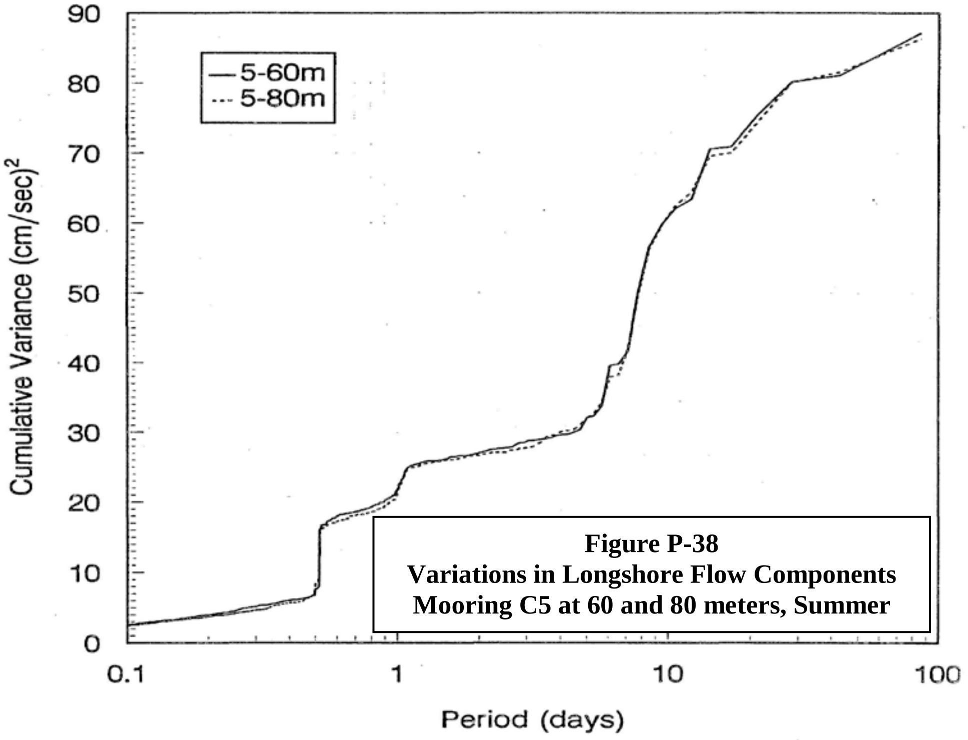


Figure P-38
Variations in Longshore Flow Components
Mooring C5 at 60 and 80 meters, Summer

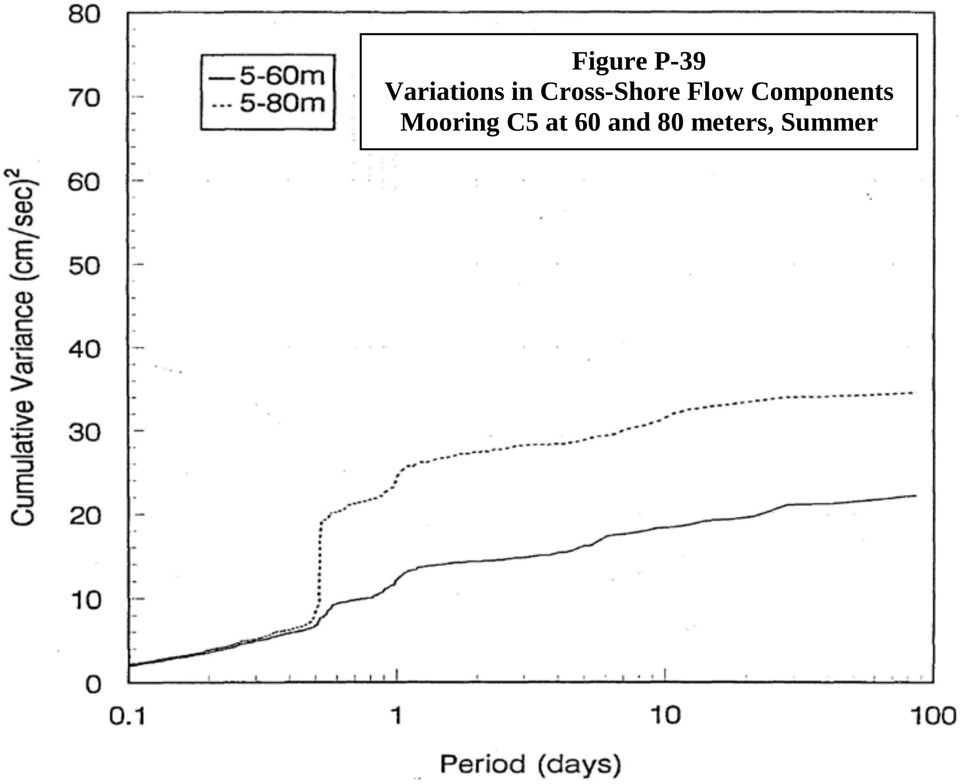


Figure P-39
Variations in Cross-Shore Flow Components
Mooring C5 at 60 and 80 meters, Summer

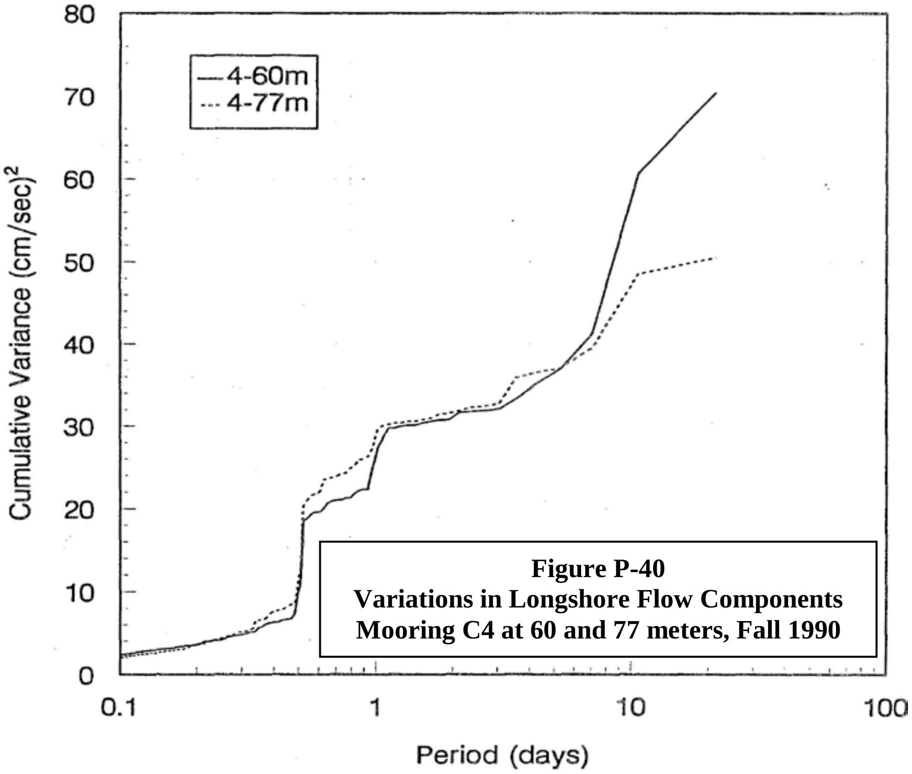


Figure P-40
Variations in Longshore Flow Components Mooring C4 at 60 and 77 meters, Fall 1990

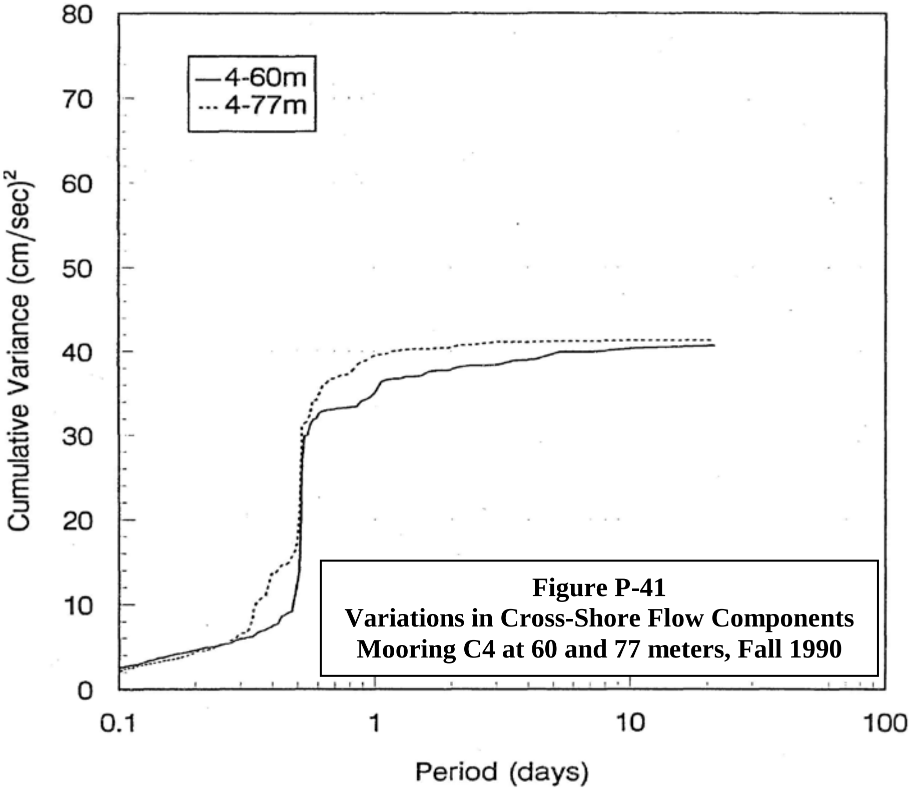


Figure P-41
Variations in Cross-Shore Flow Components Mooring C4 at 60 and 77 meters, Fall 1990

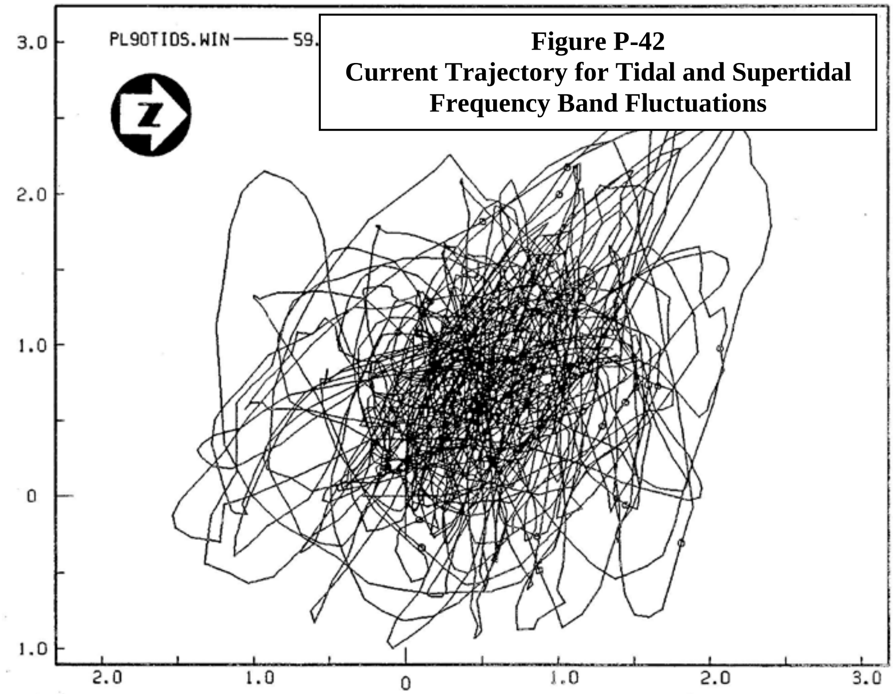


Figure P-42
Current Trajectory for Tidal and Supertidal Frequency Band Fluctuations

Note: Net Current and Subtidal Frequency Fluctuations Removed

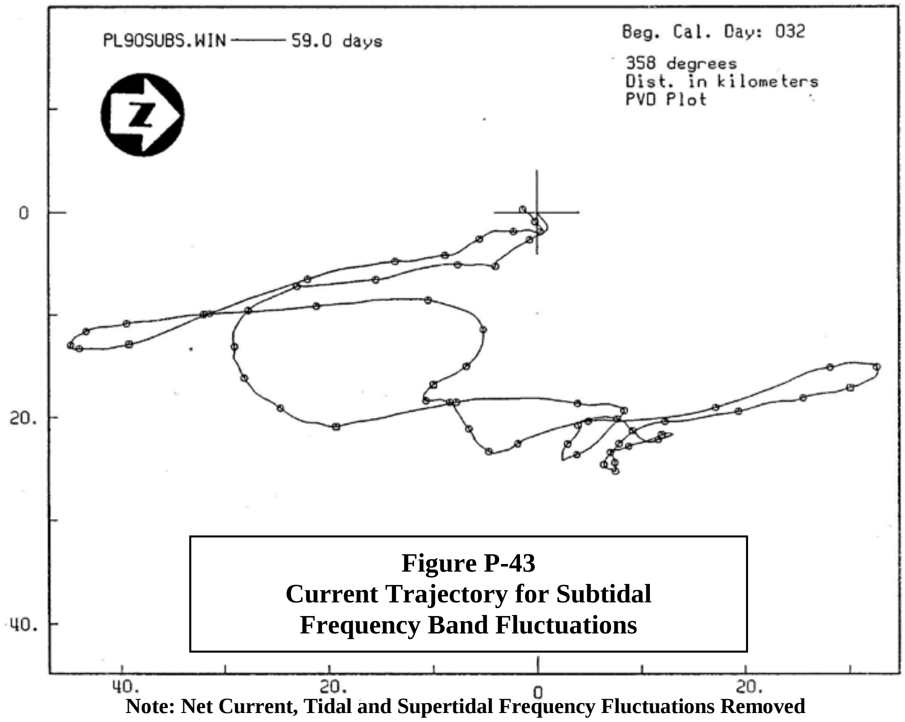


Figure P-43
Current Trajectory for Subtidal Frequency Band Fluctuations

Note: Net Current, Tidal and Supertidal Frequency Fluctuations Removed

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Appendix Q
INITIAL DILUTION SIMULATION MODELS

Renewal of NPDES CA0107409

APPENDIX Q

INITIAL DILUTION SIMULATION MODELS

Evaluation of Initial Dilution for the Point Loma Ocean Outfall Discharge

January 2015

APPENDIX Q

INITIAL DILUITON SIMULATION MODELS

Table of Contents

List of Figures

List of Tables

List of Abbreviations

°C	degrees Centigrade
California Ocean Plan	2012 *Water Quality Control Plan, Ocean Waters of California*
cm	centimeters
CTD	conductivity, temperature, depth recorder
EPA	United States Environmental Protection Agency
m	meters
m^3/sec	cubic meters per second
mgd	million gallons per day
mg/l	milligrams per liter
NPDES	National Pollutant Discharge Elimination System
PLOO	Point Loma Ocean Outfall
S_a	initial dilution
State Board	State Water Resources Control Board

APPENDIX Q
INITIAL DILUTION SIMULATION MODELS

This appendix presents the initial dilution simulation modeling that was presented in the City's original 1995 301(h) application for the Point Loma Ocean Outfall discharge. Initial dilution computations and simulations presented in the City's 301(h) 1995 application (presented again herein) remain valid for characterizing the dilution performance of the PLOO for 205 mgd and 240 mgd discharge flows under a range of seasonal conditions.

ABSTRACT

Point Loma Ocean Outfall (PLOO) initial dilutions presented within this application were computed using the RSB-TSI initial dilution model. This model is based on the physical model and initial dilution studies reported by Roberts et al. (1989a, 1989b, 1989c), and is a derivative of the BASIC RSB simulation model written by Roberts (Baumgartner et al., 1993). Both hydrocast data and time-series measurements of water column density structure and currents have been used to predict the initial dilutions achieved by the PLOO. For an annual average flow rate of 205 million gallons per day (mgd), the median flux-averaged initial dilution achieved by the PLOO is 365:1. If the dilution enhancing effects of currents are disregarded, the median initial dilution is predicted to decline to 300:1.

Using hydrocast data as input, the lowest monthly average initial dilution in the absence of currents (as defined by the *California Ocean Plan*) was 204:1. Using time-series data as input, the lowest monthly average initial dilution was 238:1.

The design maximum annual average flow capacity for the PLOO as currently configured is 240 million gallons per day (mgd). At this flow rate, the median initial dilution is 338:1, or about seven percent less than for the 205 mgd flow rate. Using hydrocast data as input, the lowest

monthly average initial dilution in the absence of currents was predicted to be 202:1. Using time-series data as input, the lowest monthly average initial dilution was 227:1.

R.1 INTRODUCTION

Initial Dilution Process. The PLOO discharges warm, low salinity effluent into southern California coastal ocean waters at a depth of about 93 meters. The discharge is a source of both kinetic energy (associated with the momentum of the jet of water from the diffuser port) and potential energy (due to buoyancy of the effluent in sea water). Shear driven by the energy input results in the entrainment of ambient ocean water into the wastewater plume. For typical municipal wastewater discharges, the bulk of this entrainment is driven by the buoyancy of the effluent, with the initial jet mixing playing a secondary role. The reduction in the concentration of effluent within the plume as the result of this mixing is known as *initial dilution*.

In the absence of ocean currents, the initial jet-induced mixing from a port discharging horizontally is followed by a buoyancy-driven transition to a nearly vertical buoyant rising plume. If the receiving water is not density stratified (or if the stratification is very weak), the plume will rise to the surface and the effluent sea water mixture will spread out to form a horizontal wastefield. In general, any additional mixing subsequent to this transition from a plume to a wastefield is slow compared with the mixing into the rising plume. The initial dilution process is considered to be complete when the buoyant rise of the plume ceases.

If the water column is density stratified, the deep ambient water entrained into the plume will be denser than the ambient water entrained into the plume at shallower depths. For sufficiently strong stratification, enough dense ambient water can be entrained into the plume during its rise so that at some depth the density of the water in the plume becomes equal to the density of the surrounding ambient water. In that case, a submerged horizontal wastefield is formed instead of a surface wastefield.

The magnitude of the initial dilution depends on the design of the outfall and the characteristics of the receiving water environment. Increasing the density difference between the discharged effluent and the receiving water increases the buoyant energy and hence the mixing. Increasing the interface area between the plume and surrounding receiving water (e.g., by increasing the length of the diffuser and the number of ports, and reducing port diameters) promotes entrainment and increases the initial dilution. Conversely, an increase in the discharge rate requires an increased entrainment across the interface to achieve the same dilution, hence the initial dilution may be reduced. Increased density stratification of the water column reduces the height of rise of the plume, reducing the interface area and the initial dilution.

The situation becomes more complicated in the presence of ocean currents. The flow of ambient water past the diffuser changes the current shear and also generates a pressure difference between the upstream and downstream faces of the plumes from the diffuser. This causes the plume to bend over toward in the downstream direction. This has two potentially important consequences: (1) the entrainment length is increased and (2) vertical mixing (across the plume) can become important. Since the density of the rising plume is less than the surrounding water, the upper interface between the plume and the receiving water is gravitationally unstable, and vertical mixing is enhanced (conversely, vertical mixing is suppressed on the lower interface). At low speeds, these current-induced effects are small. However, there is a threshold speed at which they become important, resulting in an increase in initial dilution compared with the dilution of the same discharge in the absence of a current. The magnitude of this threshold speed depends on the design of the diffuser, discharge rate of effluent, effluent-receiving water density difference, the speed of the current, and the current direction relative to the alignment of the diffuser.

It is difficult and expensive to directly measure the magnitude of the initial dilution achieved by an ocean outfall. This is especially true if the discharge rate is large or the wastefield is trapped well below the surface--both characterize the Point Loma discharge. A number of numerical models have been developed to relate the characteristics of the initial dilution process to the diffuser design, discharge rate, effluent density, and the properties of the receiving water environment (e.g., density, density gradient, ocean currents). The numerical models have been developed from a mixture of theoretical principals, heuristic methods, and physical model studies of the initial dilution process. The hydrodynamics of the entrainment process in a density stratified, moving ocean are complex and the characteristics of the receiving water change with time, depth, and position. Thus, a large number of parameters are required to completely describe the initial dilution process. Every simulation model has some limitations in its range of application. Therefore, the model that is most appropriate for the discharge and receiving water conditions existing at the study site should be selected for the simulations.

Initial Dilution Definitions. A number of definitions of dilution and initial dilution are commonly used. For example, the U.S. Environmental Protection Agency (EPA) defines dilution (S) as the reciprocal of the volume concentration (fraction) of effluent (C_e) in the plume ($S = 1/C_e$). Thus, pure effluent has both a concentration and a dilution of unity. In contrast, the *California Ocean Plan* (State Water Resources Control Board, 2012) defines dilution as the volume of diluting ocean water mixed with a unit volume of discharged effluent. In this definition, the concentration of pure effluent is unity; the corresponding dilution is zero; and the concentration of effluent is related to the dilution through the equation:

$$C_e = \frac{1}{1+S} \qquad Equation\ Q-1$$

As will be shown, the initial dilutions resulting from the extended PLOO are in excess of 100:1 at all times. For the PLOO, the two definitions of dilution differ by less than one percent. This difference is less than the typical 10-15 percent uncertainties in the simulation model predictions (Roberts et al., 1989a). Hence, for all practical purposes in the present case, the two definitions can be used interchangeably.

Terms like "initial dilution", "minimum dilution", "minimum initial dilution", "average initial dilution", and "minimum average initial dilution" are frequently used in environmental regulations to describe model predictions and the results of laboratory and field studies. Unfortunately, a specific term may refer to different things in various references. All of the terms usually refer to the dilution after some type of averaging, but the type of averaging is not always clearly expressed. In this application, references to *concentration* mean the concentration of effluent, averaged over a sufficiently long period of time so that fluctuations associated with turbulent mixing are averaged out. Typical averaging times for a sample collected at some point within the plume are on the order of minutes to tens of minutes. *Dilution* means inverse of the concentration and *minimum dilution* means the dilution associated with the highest concentration within the plume/wastefield at the completion of the initial dilution process.

Initial dilution and *average initial dilution* are often used to refer to several different types of averaging schemes. In this appendix, references to *initial dilution* refer to the flux-averaged dilution, S_{fa}. The flux-averaged dilution is related to the flux-averaged concentration across a section of the wastefield. The latter is computed by weighting the concentration of effluent at some location, z, within the wastefield, $C(z)$, by the discharge-induced velocity of flow, $v(z)$ at that elevation:

$$\frac{1}{S_{fa}} = C_{fa} = \frac{\int_{z_1}^{z_2} C(z)v(z)dz}{\int_{z_1}^{z_2} v(z)dz} \qquad Equation\ Q-2$$

The flux-averaged initial dilution is equivalent to the volumetric dilution, (i.e., the total volume of ambient water to the volume of effluent in the wastefield). The volumetric initial dilution is often required to demonstrate regulatory limitations on contaminant concentrations in receiving waters. For example, effluent concentration limitations required to implement *California Ocean Plan* Table 1 receiving water concentrations (to be achieved upon completion of initial dilution) are computed using a volumetric (i.e., flux-averaged) initial dilution.

Minimum initial dilution means the smallest flux-averaged initial dilution value among a set of flux-averaged initial dilution values. This differs from the definition of minimum initial dilution in the *California Ocean Plan*.

Average initial dilution, S_a, is most commonly used to refer to the average of a set of individual initial dilution values. The averaging is usually carried out for some period of time, such as a monthly average initial dilution. Note, however, that both the term "average initial dilution" and the notation, S_a, are used in Roberts et al. (1989a) to denote the spatially-averaged dilution across the plume/wastefield:

$$\frac{1}{S_{sa}} = C_{sa} = \frac{\int_{h_{low}}^{h_{up}} C(z)dz}{\int_{h_{low}}^{h_{up}} dz} \qquad Equation\ Q-3$$

The lower and upper bounds of the wastefield, h_{low} and h_{up}, are not well defined. For practical purposes, they are often selected to correspond to the upper and lower edges of the wastefield, where the effluent concentrations are equal to five percent of the maximum concentration (Roberts et al., 1989a).

In the present application, use of the term *average initial dilution* is limited to the temporal average of a set of initial dilutions. Any references to the spatially-averaged initial dilution are specifically referred to as the spatially-averaged initial dilution, and denoted by S_{sa}.

The term *minimum average initial dilution* is used to mean the smallest value among a set of average initial dilutions. For example, a set of initial dilutions might be computed for a number of cases within each month, producing a set of monthly average initial dilutions. The minimum average initial dilution would be the monthly average initial dilution with the smallest value within this data set.

The most realistic simulation model estimates of the concentrations and dilutions achieved at the end of the initial dilution process are obtained using simultaneous measurements of the density structure of the water column and the ocean currents within the entrainment region of the plume. However, this information is frequently not available, and the data consists of measurements of the density structure and ocean currents taken at different times. In this case, any correlations between the strength and direction of the currents and the density stratification of the water column are not known. Perhaps because of this, the *California Ocean Plan* takes a conservative approach in estimating initial dilutions by requiring that

> "*...Dilution estimates shall be based on observed waste flow characteristics, observed receiving water density structure, and the assumption that no currents of sufficient strength to influence the initial dilution process, flow across the discharge structure*."

The resulting initial dilutions are commonly referred to as "no current" initial dilutions. Initial dilutions meeting this criterion are obtained in the RSB numerical model simulations by setting the ambient current speed to be zero (or sufficiently small so that they lie below the threshold value for enhanced dilution).

In order to distinguish the initial dilution values associated with the artificial requirement of zero currents from the set of initial dilution values associated with the actual currents, initial dilutions obtained by setting the current speed to zero are hereinafter referred to as *regulatory initial dilutions*. Thus, based on the previously presented definitions, initial dilution as defined within the *California Ocean Plan* is referred herein as the *regulatory minimum average initial dilution.*

R.2 RSB INITIAL DILUTION SIMULATION MODELS

Model Overview. The initial dilutions contained in this application were computed using the RSB-TSI initial dilution model. This model is based on the physical model initial dilution studies reported by Roberts et al. (1989a, 1989b, 1989c), and is a derivative of the BASIC RSB simulation model written by Roberts (Baumgartner et al., 1993). Another version of the RSB model (EPA-RSB) is available in the EPA PLUMES initial dilution simulation package (Baumgartner et al., 1993, 1994). The principal changes in the EPA-RSB model from the BASIC RSB model are:

1. A change in the programming language from BASIC to PASCAL.
2. Adaptation of the BASIC RSB computational kernel to the PLUMES package interface and file structure.
3. Termination of the iterative scheme used within the kernel to obtain a solution if the number of iterations exceeds some specified number of iterations.

An initial dilution simulation model, based on the RSB model, was selected for the simulations because:

1. The RSB model (as well as the UM model) is recommended by Baumgartner et al. (1993) for multiport outfalls discharging buoyant sewage wastes into stratified saline waters, who states: "*In general, we believe RSB...is applicable to any case that matches closely the experimental conditions used in its development, which were limited to multiport discharges*." As will be shown later, the range of parameter values in the simulations for the extended PLOO fall within the range of values examined in the development of the model. The principal difference between the model study and the Point Loma conditions is that the density gradient generally varies with depth in the ocean, while a constant density gradient was examined in the laboratory model studies. Roberts allowed for the case of a variable density gradient in the BASIC RSB model, and each of the two derivatives of this model that were used to compute the initial dilutions utilize his

approach. As will be discussed later, the effect of his approximation is to tend to underestimate the initial dilution and the height-of-rise of the plume in the water column

2. Although both the UM and RSB models are appropriate for multiport discharges in the presence of currents, only RSB model (and its derivatives) can provide estimates of the initial dilution and a spatial description of the wastefield when the flow is within forty-five degrees of the alignment of the diffuser. This "along diffuser" flow dominates at the Point Loma discharge, resulting in our selection of the RSB model.

Selection of RSB-TSI Initial Dilution Model. The RSB-TSI simulation model was chosen for the simulations over the BASIC-RSB and EPA-RSB models based on the volume of input data available for the simulations.

Two different sets of Point Loma oceanographic data are available for use in computing initial dilution. The first data set consists of water column density stratification data collected during hydrocast surveys with a CTD (conductivity, temperature, depth recorder). These data are available at roughly monthly intervals from special studies (predesign and pre-discharge) made in the vicinity of the extended PLOO between February 1990 and October 1993 and from monthly monitoring data collected after commencement of the discharge (November 1993) to the present (October 1994). The second set of oceanographic data consists of approximately 287 days (13,760 observations) of simultaneous measurements of water column temperatures and currents at a station close to the terminus of the extended PLOO collected between March 1990 and April 1991. Each of these data sets were collected prior to construction of the PLOO extension, and this are representative of receiving water conditions not affected by or influenced by the PLOO discharge.

The EPA-RSB and the BASIC-RSB initial dilution models were not used for the simulations for a number of reasons:

1. The large number of observations available for the simulations are not efficiently stored in the file structure used in the BASIC RSB model. The file structure used by the EPA-RSB model is in an undocumented binary format. In addition, oceanographic density data was available at nineteen to twenty depths in the water column. This exceeds the storage allotted in the EPA-RSB model.
2. Both the BASIC-RSB and EPA-RSB models use an iterative approach to arrive at a solution to the initial dilution equations. The receiving water density structure existing off Point Loma, however, can result in the BASIC-RSB program failing to converge to a solution. Additionally, the density structure can result in inaccuracies in the simulation output of the EPA-RSB model.

3. Neither the BASIC-RSB nor the EPA-RSB model provides for the automatic processing of an extensive set of simulation cases.
4. The format of the output generated by the RSB-TSI model could be tailored to fit simulation needs for use in subsequent simulations that build on the results of the initial dilution calculations.

The RSB-TSI model is based on the computational kernel in the BASIC-RSB model. Initially, after adapting the input and output file structure to our needs, this kernel, as supplied and without modification, was to be used. This kernel uses an interactive method to obtain a solution to the initial dilution process (for each set of discharge and receiving water condition). The steps in this process are:

1. A trial height-of-rise to the top of the wastefield (above the diffuser port) is chosen. In the BASIC RSB model, this initial trial value is set equal to the depth of the diffuser port below the sea surface.
2. The average density gradient of the receiving waters between the diffuser port and the trial height-of-rise is computed.
3. This "constant" density gradient is combined with the discharge characteristics (e.g., flow rate, effluent density), diffuser characteristics (port diameter, port spacing, number of ports), and ocean current strength and direction of flow (relative to the diffuser) to predict a height-of-rise to the top of the wastefield.
4. The magnitudes of the trial and the predicted heights-of-rise are compared.
5. If the trial and the predicted heights are within one percent of each other, a solution has been obtained and the height-of-rise to the top of the wastefield is known. The rest of the initial dilution characteristics (e.g., magnitude of the minimum initial dilution, wastefield thickness, height-of-rise to level of minimum dilution, and downstream distance to completion of the initial dilution process) are then computed.
6. If the two heights-of-rise are not the same, a solution has not been obtained and a new iteration is executed. A new trial height-of-rise is computed for this iteration and steps 2 through 6 are repeated.

This approach was not practical for the oceanographic conditions found off Point Loma. The computer would fail to converge on a solution while computing the initial dilutions for some of the observations in the data set. Examination of the execution of the program revealed that the program became caught in an infinite loop in which a sequence of trial and predicted heights-of-rise were repeated over and over without any convergence toward a solution. The EPA-RSB model (Baumgartner et al., 1993, 1994) avoids this "lock-up" problem by terminating the iteration process if the solution fails to converge. After exiting the iterative loop, the tentative solution is output with a warning that the results are suspect. Analysis showed that the trial and predicted heights-of-rise generated by the 2nd edition version of the model (Baumgartner et al., 1993) could change radically between sequential iteration steps with corresponding consequences on the initial dilution.

Baumgartner et al. (1994) noted that the iteration technique was changed between the 2nd and 3rd editions to "...converge faster and more regularly." It also issues a warning if convergence is not attained. The modifications are not described, so the effects of the change could not be examined in detail. Various methods of selecting an updated trial solution in the BASIC-RSB iterations were tried (e.g., different weightings, randomizing part of the weightings, "intelligent" weightings depending on a history of previous iteration steps, etc.). All of these modifications changed the details of the iteration process, but none of them guaranteed an acceptable solution for all of our oceanographic data. When the solution failed to converge, averaging the height-of-rise values comprising the repeating sequence was also tried, but the averaging did not provide the best possible estimate. Eventually it was concluded that our desired accuracy and convergence criteria could not be achieved using any of our modifications to the iterative process.

As a result, a different solution method, as well as a different file structure, was used in the RSB-TSI initial dilution simulation program. The principal changes in the RSB-TSI model from the BASIC RSB model are:

1. A change in the programming language from BASIC to FORTRAN.
2. Replacement of the BASIC RSB input data and file structure by a file structure designed to interface with the time-series of oceanographic data (temperature and currents). The output file structure was also adapted to provide output data specific to the application of the modeling results.
3. A change in the method of solution within the computational kernel. The iterative approach used in the BASIC-RSB and EPA-RSB models was replaced by an incremental method.
4. Animation was added to the program output in order to illustrate characteristics of each initial dilution (magnitude, spatial dimensions), the convergence to the height-of-rise solution, the current strength and direction (relative to the diffuser), temperature stratification of the water column, and a set of bar graphs indicating the magnitudes of various parameters that describe the hydrodynamic characteristics of the initial dilution process.

The incremental solution method is analogous to the iterative solution approach, except that:

1. The initial trial value is selected to be a small distance above the diffuser port (3m in the Point Loma simulations).
2. A solution is achieved when the difference between the trial and predicted heights-of-rise is less than some specified distance (10 cm in the Point Loma simulations).
3. If a solution is not achieved, the new trial value is set equal to the previous trial value plus the test distance specified in step 2 (i.e., 10 cm at Point Loma). This is in contrast to the iterative approach, which computes a new trial value from a weighted combination of the previous trial value and the associated predicted value.
4. This process is repeated until a solution is achieved, or until the trial height-of-rise is equal to the depth from the diffuser port to the sea surface. If a solution still has not been obtained in the latter case, the solution height-of-rise is set equal to the average of the trial and predicted values that had the smallest difference. The difference between the trial and predicted heights-of-rise is stored in one of the output files ("detailed" output) for each observation, hence these cases can be removed from the output data, if desired.

In cases where the iterative approach converges to a solution, the predictions from the BASIC-RSB model and the RSB-TSI model are essentially the same. However, small differences can exist in the predicted heights-of-rise since the BASIC-RSB model solution (and, it is assumed, the EPA-RSB model) requires that the trial and predicted values differ by less than 1 percent, while the RSB-TSI model requires that the two values differ by less than a specified distance. This distance was 10 cm for the Point Loma simulations, so the RSB-TSI convergence requirement is more restrictive when the height-of-rise to the top of the wastefield exceeds 10 meters (> 99 percent of the cases). A comparison between the heights-of-rise and initial dilutions predicted by the BASIC-RSB model and the RSB-TSI model for a set of identical input conditions is presented later in this appendix.

Conservative Assumptions. A number of assumptions have been made in the BASIC-RSB and RSB-TSI initial dilution models. Overall, the assumptions should tend to underestimate the initial dilutions actually achieved by the discharge. Three of these assumptions are:

1. On the average, the density gradient in the receiving waters below the seasonal thermocline increases with decreasing depth in the water column. The BASIC-RSB, EPA-RSB, and RSB-TSI models all assume that the density gradient is constant ("linear density profile") over the rise height to the top of the wastefield. Baumgartner et al. (1993) concluded from examining studies reported in Roberts (1993) that: "... *this (linearization) is a conservative*

assumption, as linear stratifications lead to less rapid spreading, thinner wastefield, less subsequent mixing, and, therefore, less dilution than in a wastefield at the same rise height in a non-linear stratification." The ratios of the predicted to the measured minimum initial dilution reported by Roberts (1993) for four discharge scenarios (3 discharge rates, 1 case with and without ambient currents), varied from 0.82 to 0.96 (average: 0.86 ±0.07).

2. The RSB physical model studies examined initial dilution for flow perpendicular, parallel, and at a 45-degree angle to a linear diffuser. The extended PLOO terminates in a diffuser consisting of two legs forming a wide "V" (a "bent" line source). Ocean currents will generally flow across the two legs at different angles. This difference in angles has no effect on the initial dilutions if the Froude number is less than 0.1. At higher Froude numbers, all other conditions being equal, the diffuser leg oriented with the smallest angle to the flow will have the lowest initial dilutions. In the RSB-TSI model, a user selectable option forces the simulation to select the diffuser leg with either the: (1) smallest or, (2) largest angle to the flow (the actual leg will change from case to case as the direction of the flow changes). The initial dilutions in this application were generated for the leg with the smallest angle, thus the predicted initial dilutions will tend to underestimate the dilution for the combination of the two legs.

3. The flux-averaged initial dilution is difficult to measure directly. Based on estimates of entrainment flows measured outside the plume in laboratory studies, Roberts (1989) concluded that the flux-averaged initial dilution is approximately 1.15 times greater than the minimum initial dilution. This factor is incorporated into the RSB models to estimate the flux-averaged initial dilution. For a buoyancy-dominated line discharge, the data reported by Roberts et al. (1989a), and the assumption that the level of minimum dilution (or maximum effluent concentration within the wastefield) corresponds to the level of density equilibrium with the receiving water, our theoretical calculations predict a factor of 1.21. This factor is predicted to decline as the ambient flow increases, but the change cannot be accurately estimated (our equilibrium assumption is expected to break down). Since the *California Ocean Plan* requires that the regulatory minimum initial dilutions be computed assuming no ambient currents, the actual regulatory initial dilutions could be about five percent (1.21/1.15) greater than those predicted.

R.3 SIMULATION DATA

The input data required for the initial dilution simulations consists of three types: (1) data values or parameters that remain constant, (2) values that show more or less regular cycles and, (3) values that are not cyclic, although fluctuations associated with a number of time-scales may be evident.

Type 1 Input Data - Constants. The first type of data includes the characteristics of the diffuser. Examples are: the number of ports, port configuration, port diameter(s), port spacing, port depth(s) below the surface, alignment of the diffuser leg(s), and the annual average discharge rate. The values of these parameters that were used for the initial dilution simulations are summarized in Table Q-1.

Table Q-1
Summary of Type 1 Data - Constants

Parameter	Value
Number of Ports	416
Port Configuration	Paired on opposite side of diffuser
Port spacing	7.33 m
Nominal port diameter	0.108 m
Nominal port depth	93.7 m
Diffuser alignment (deg. true)	190°, 345°
Annual average discharge rate (waiver)	205 mgd (8.98 m^3/sec)
Annual average discharge rate (max. design)	240 mgd (10.51 m^3/sec)

The discharge rate of 240 mgd corresponds to the maximum annual average design flow of the PLOO; the discharge rate of 205 mgd corresponds to the maximum annual average flow anticipated during the upcoming five-year NPDES period.

Type 2 Input Data - Cyclic Variations. Examples of the second type of data include diurnal and seasonal variations in the discharge rate and the effluent density. Annual hydrographs and monthly variations in PLOO effluent density are presented in Table Q-2 (page Q-13). The daily hydrographs used in the simulations are presented in Table Q-3 (page Q-14).

Table Q-2
Annual Hydrograph and Effluent Density

Month	Ratio of Observed Monthly PLOO Flow to Average Annual Flow[1]	Observed Average PLOO Effluent Density[2] (sigma-t)
January	1.139	-1.878
February	1.076	-2.022
March	1.061	-2.313
April	0.976	-2.692
May	0.950	-2.989
June	0.958	-3.279
July	0.966	-3.578
August	0.984	-3.648
September	0.980	-3.097
October	0.990	-2.910
November	0.969	-2.228
December	0.951	-2.767

[1] Based on historic PLOO data which is projected to be characteristic of future flow trends.

[2] Based on historic PLOO temperature and salinity data which are projected to be characteristic of future effluent quality.

Type 3 Input Data - Oceanographic Measurements. Oceanographic data about the density structure of the water column and the ocean currents falls into the third data category. Two types of information on the density stratification of the water column were available for the Point Loma initial dilution simulations: hydrocast data and time-series temperature data..

Hydrocast Data. Hydrocast data were collected at approximately monthly intervals during the predesign and pre-discharge phases of the PLOO construction, and as part of the routine monthly monitoring program following commencement of the PLOO discharge in November 1993.

The advantage of the hydrocast data set is that density profiles are available for every month of the year over a period of four years prior to initiation of the discharge from the extended PLOO. The disadvantage is that the density profiles are subject to aliasing by internal wave and internal tide activity, and by up- and downwelling events. The aliasing effects on the monthly average initial dilutions are reduced if the number of profiles is large. A summary of the number of hydrocast surveys available for each month of the year is presented in Table Q-4 (page Q-15).

Table Q-3
Daily Flow Hydrograph (Relative to Monthly Average)

Time Period	Ratio of Instantaneous Flow to Monthly Average Flow[1]	
	205 mgd	240 mgd
00:00 - 00:30	1.073	0.917
00:30 - 01:00	1.073	0.917
01:00 - 01:30	1.073	0.917
01:30 - 0200	1.073	0.917
02:00 - 02:30	0.756	0.646
02:30 - 03:00	0.756	0.646
03:00 - 03:30	0.756	0.646
03:30 - 04:00	0.756	0.646
04:00 - 04:30	0.756	0.646
04:30 - 05:00	0.463	0.646
05:00 - 05:30	0.463	0.646
05:30 - 06:00	0.463	0.375
06:00 - 06:30	0.463	0.375
06:30 - 07:00	0.463	0.375
07:00 - 07:30	0.463	0.646
07:30 - 08:00	0.463	0.646
08:00 - 08:30	0.756	0.646
08:30 - 09:00	0.756	0.912
09:00 - 09:30	0.915	0.912
09:30 - 10:00	1.073	0.912
10:00 - 10:30	1.073	1.167
10:30 - 11:00	1.390	1.167
11:00 - 11:30	1.390	1.167
11:30 - 12:00	1.390	1.354
12:00 - 12:30	1.390	1.354
12:30 - 13:00	1.390	1.354
13:00 - 13:30	1.390	1.530
13:30 - 14:00	1.390	1.521
14:00 - 14:30	1.390	1.521
14:30 - 15:00	1.390	1.521
15:00 - 15:30	1.073	1.354
15:30 - 16:00	1.073	1.354
16:00 - 16:30	1.073	1.354
16:30 - 17:00	1.073	1.354
17:00 - 17:30	1.073	1.354
17:30 - 18:00	1.073	1.167
18:00 - 18:30	1.073	1.167
18:30 - 19:00	1.073	1.167
19:00 - 19:30	1.073	1.167
19:30 - 20:00	1.073	1.167
20:00 - 20:30	1.073	1.167
20:30 - 21:00	1.073	1.167
21:00 - 21:30	1.073	0.917
21:30 - 22:00	1.073	0.917
22:00 - 22:30	1.073	0.917
22:30 - 23:00	1.073	0.917
23:00 - 23:30	1.073	0.917
23:30 - 00:00	1.073	0.917

[1] Based on historic PLOO data which is projected to be characteristic of future flow trends.

Table Q-4
Available Monthly Hydrocast Data

Month	Number of Hydrocast Profiles					
	1990	1991	1992	1993	1994	Total
January	0	0	9	9	9	27
February	4	2	9	9	9	33
March	4	2	9	9	9	33
April	4	2	9	8	9	32
May	3	0	9	9	9	30
June	4	0	9	7	9	29
July	4	9	9	9	9	40
August	4	9	9	9	9	40
September	4	8	9	9	9	39
October	4	9	9	9	9	40
November	0	9	8	1	0	18
December	0	9	4	0	0	13

1 Number of hydrocast data profiles available for the PLOO diffuser area prior to implementation of the extended PLOO.

Water column profiles of temperature and conductivity were collected with a CTD (conductivity-temperature-depth recorder) during the hydrocast surveys. Salinity profiles were computed from the water conductivity and temperature. The equation of state of sea water was then used with the salinity and temperature profiles to obtain density profiles. For the initial dilution calculations, the density was computed at depth increments of 5 meters between the surface and a depth of 95 meters. The density information obtained from the hydrocast surveys was used in the RSB-TSI initial dilution model to compute monthly average initial dilutions for the (assumed) case of zero current speed. The regulatory minimum average initial dilution required by the *California Ocean Plan* (for calculation of Table 1 receiving water standards to be achieved upon initial dilution) was chosen as the lowest value in this set of regulatory monthly average initial dilutions.

Time-Series Temperature Data. The second type of density stratification information was collected by using strings of thermistors at four moorings positioned along a cross-shore transect off Point Loma between March and September 1990, and between January and April 1991. The data was collected as part of predesign studies for the PLOO extension. The properties of the temperature structure of the water column measured by the thermistor strings is discussed in detail in Appendix P (Oceanography).

The terminus of the PLOO diffuser was constructed close to the location of mooring T5 (Figure Q-1 on page Q-31) in 95 meters of water. Temperature data was collected at half-hour intervals. The string consisted of eleven thermistors, spaced at 5 meter intervals (except for the bottom pair, which had a spacing of 1.5 meters). The uppermost thermistor in the string was at a depth of 44.5 meters; the lowermost thermistor was at 93.0 meters. The advantage of this data set is that the sampling interval was sufficiently short so that the major fluctuations in the temperature structure of the water column are resolved and aliasing effects are minimal. The disadvantage is that data are available for less than ten months of one year.

The initial dilution simulations only require information on the density stratification of the water column between the diffuser port and the top of the wastefield. Prior to carrying out the initial dilution simulations, the distribution of depths to the top of the wastefield could only be estimated from past experience. In order to provide some estimate of the density structure of the water column above the uppermost thermistor, a time-series of water temperatures was synthesized for this portion of the water column using data obtained from the thermistor strings on the moorings in shallower water. Mooring T4 contributed measurements at depths of 30.5, 35.5, and 40.5 meters; mooring T3, depths of 18.3, 23.3, and 28.3 meter; and Mooring T2 at 15.5 meters. Surface water temperatures measured at approximately monthly intervals during the hydrocast surveys, were interpolated to provide a time-series of estimated surface water temperatures.

The depth to an isotherm surface (surface of constant temperature) changes with the passage of internal tides and internal waves over time on the order of tens of minutes to hours. These effects propagate through the study area, thus, there can be shifts in the phase of the oscillations among the thermistor moorings in the cross-shore transect. These phase shifts can introduce some artifacts in the synthesized temperature profile at depths shallower than 44.5 meters (the uppermost thermistor depth at Mooring 5). On occasion, the shifts were sufficient to produce temperature (and hence density) inversions. In order to reduce the effect of these artifacts, a smoothing function was applied to the temperature data in order to remove these inversions. Any artifacts introduced by the synthesized temperatures for the upper portion of the water column are considered minimal. For most of the initial dilution simulations, the top of the wastefield was found to lie at, or below, the uppermost thermistor in the mooring 5 thermistor string.

Maximum heights-of-rise are associated with the maximum average annual discharge rate (240 mgd) and the regulatory condition of no ocean currents. For the simulations associated with these worst-case conditions, the top of the wastefield was predicted to rise above a depth of 44.5 meters less than 12 percent of the time (in only 2 percent of the simulations was the top of the wastefield predicted to rise above a depth of 40.5 meters - the depth of the upper thermistor at Mooring T4, the next closest thermistor mooring). Since RSB-TSI starts the initial dilution calculation near the discharge port, and works its way up the water column, if the predicted height-of-rise is less than 44.5 meters, the actual height of rise is guaranteed to be above that depth--no matter what artifacts or errors are contained in the synthesized temperature profile region of the water column. Large heights-of-rise are often associated with large initial dilutions. Therefore, artifacts in the initial dilution associated with artifacts in the synthesized temperature profiles affect only the largest predicted initial dilutions.

Water temperatures recorded by the thermistors were converted into water densities using CTD data collected monthly at a set of stations in the vicinity of the mooring and the slowly varying temperature-salinity relationship of the local water mass. Water temperature and conductivity is converted into water salinity, and then water density, as described earlier. Then the water density is plotted versus the water temperature. Examples for the months of March and October, 1990 are illustrated on Figures Q-2 and Q-3, respectively (see page Q-32). A set of first and second order polynomials was used to analytically describe the water density as a function of temperature (indicated by the line segments in Figures Q-2 and Q-3). These analytical relationships are used by the RSB-TSI initial dilution model to estimate the density structure of the water column from the thermistor measurements of water temperature.

Time-Series Ocean Current Data. Ocean currents belong to the third type of input data. Currents were measured at five stations along the cross-shore transect containing the thermistor moorings (moorings C1 through C5 on Figure Q-1). The properties of these currents are discussed in Appendix P (Oceanography).

Currents were recorded concurrently with water temperature measurements between March and September 1990, and again between January and April 1991 at mooring C5, located adjacent to the thermistor mooring T5. Currents were measured at depths of 20, 40, 60, and 80 meters at half-hour intervals. Initial dilutions carried out during the predesign phase indicated that a typical height-of-rise to the level of minimum dilution was on the order of 25 meters, corresponding to a wastefield depth of about 68 meters. Thus, the entrainment region of the water column during the initial dilution process is typically between 68 and 93 meters, for an average depth of 80.5 meters. Therefore, the current measurements from a depth of 80 meters were used for the initial dilution simulations.

The mooring C5 meter at the 80 meter depth failed to record data on one occasion, from April 19 to May 21 1990. Current measurements made either at the 60 meter depth at mooring C5, or from mooring C4, lying approximately1.5 km inshore (and adjacent to thermistor mooring T4), were used to provide current data for these periods. Current measurements were made at mooring C4 at depths of 20, 40, 60, and 77 meters. Comparisons were carried out to examine the statistical properties (distribution of speeds, net speed, net direction of flow, etc.) of the currents at each depth at mooring C4, and the 60 and 80 meter depths at mooring C5. The currents at the 60 meter depth at mooring C4 were found to most closely correspond to the currents at the 80 meter depth at mooring C5. Therefore, measurements from this meter were used for the initial dilution calculations when currents were not recorded at the 80 meter depth at mooring C5.

Confirmation of Applicability of the RSB Model. As noted earlier, Baumgartner et al. (1993, 1994) endorse the use of the RSB model provided that the parameters characterizing the discharge to be simulated are within the range of values examined during the Roberts et al. (1989a,b,c) physical model studies. The primary characteristics of the discharge conditions in the physical model studies are summarized by three dimensionless parameters (Roberts, 1989a). These are:

1. Ratio of the port spacing to a characteristic buoyancy length-scale, L_{SB}.
2. Ratio of a characteristic momentum length-scale to the characteristic buoyancy length-scale, L_{MB}.
3. A Froude number ("Roberts Froude number") involving the speed of the ambient currents past the diffuser, F_R.

The ratio of the port spacing to the buoyancy length-scale, L_{SB}, varied from 0.31 to 1.92. Dilution values are independent of this ratio for values less than 0.3 (Roberts et al., 1989a), where the discharge essentially becomes a line source. Figure Q-4 (page Q-33) shows the distribution of L_{SB} values for the simulations for a discharge of 240 mgd and the measured currents (a normal, or Gaussian, distribution of values would lay on a straight line on this probability plot). Only about one percent of the cases simulated have a ratio of less than 0.3 (i.e., the buoyancy length-scale is so large that the discharge acts like a line source). However, all of the cases simulated have ratios less than 1.92--the maximum value in the physical model studies. Thus, use of the RSB model for the Point Loma simulations is appropriate from the standpoint of this parameter.

The ratio of the momentum length-scale to the buoyancy length-scale, L_{MB}, is a measure of the relative importance of the energy associated with the jet momentum to the energy associated with the effluent buoyancy. The range of values examined in the physical model studies was from 0.078 to 0.5. Dilution becomes independent of this ratio for values less than 0.1 (Roberts et al., 1989a). The distribution of L_{MB} values for the Point Loma simulations at a discharge rate of 240 mgd is shown on Figure Q-5 (page Q-33). The ratios for all the cases were less than 0.35 (smaller discharge rates would result in smaller L_{MB} ratios). About one-half the cases had ratios below 0.1; the dilutions for these cases are equivalent to a discharge with negligible jet momentum.

The Roberts Froude number is related to the ratio of the energy associated with the flow past the diffuser and the energy associated with the buoyancy of the discharge. The values examined in the Roberts et al. (1989a,c) studies ranged from 0.0 to 100. There was no significant effect on the currents for Froude numbers less than 0.1, and the effects were minor for flow parallel to the diffuser for Froude numbers less than about 1.0. Froude numbers for the PLOO simulations are summarized on Figure Q-6 (page Q-34). About 30 percent of the values were less than 0.1, hence about one-third of the time there was no significant effect of the currents on the magnitude of the initial dilution. Roughly another one-third of the cases had a Froude number in excess of 1.0. For these cases, the dilution was enhanced by the currents independent of whether the flow was along or perpendicular to the diffuser. The maximum Froude number was 60, which is well within the range of values examined during the physical model studies. These comparisons indicate that the RSB simulation model is appropriate for the discharge and receiving water conditions existing at the PLOO area.

Validation of Model Predictions. Simulations were carried out using both the BASIC RSB and RSB-TSI simulation models for ten randomly selected water column stratifications and current conditions. The purpose of this comparison was to validate the predictions generated by the RSB-TSI model. The observations for the comparisons were selected from the time-series data in the following manner:

1. One observation was randomly selected from each group of 130 observations within the total set of 13,757 observations. This produced a set consisting of 100 observations.
2. Ten observations were randomly selected from this group of 100.

In addition, one simulation was carried out for a case where the solution from the RSB-TSI model had a minimum difference between the trial and predicted height-of-rise of 25 cm (versus the "solution found" criteria of 10 cm). The results of the comparison are summarized in Table Q-5 (page Q-20).

The initial dilutions and heights-of-rise to the top of the wastefield predicted by the RSB-TSI initial dilution model are comparable to those predicted by the BASIC RSB model. Differences in initial dilution values are less than 1 percent in 8 of the 10 cases, and heights-of-rise differ by less than 1 percent in 7 out of the 10 cases. The averages of the initial dilutions predicted by the two RSB models differ by one-tenth of one percent, and the averages of the heights-of-rise are identical. The range of Roberts Froude numbers (F_R) among the 10 cases varied from 0.02 to 15.8 (70 percent are greater than 0.1, consistent with the distribution of Froude numbers among the 13,757 observations). The angle of the flow relative to the diffuser varied from 6^o to 55^o (with $F_R = 0.44$ in the latter case).

Table Q-5
Comparison of RSB-Basic and RSB-TSI Predictions
Average Annual PLOO Discharge of 240 mgd

Date	No. of Observations	Average Annual Initial Dilution			Height of Rise to Top of Waste Field		
		RSB-Basic	RSB-TSI	% Difference	RSB-Basic	RSB-TSI	% Difference
03/06/90	107	388	392	+1.03	35.3	35.9	+1.8
03/28/90	1,165	815	811	-0.49	36.8	36.8	0.0
04/03/90	1,483	362	362	0.00	41.2	41.2	+0.1
04/07/90	1,677	387	386	-0.26	45.6	45.8	+0.5
04/08/90	1,707	275	278	+1.09	48.8	48.8	-0.1
04/14/90	1,987	554	552	-0.36	25.9	25.8	-0.3
09/22/90	9,741	431	431	0.00	39.9	40.0	+0.3
01/19/91	10,299	224	223	-0.45	27.8	27.3	-1.7
02/08/91	11,246	197	196	-0.51	29.2	28.7	-1.7
03/06/91	12,501	483	481	-0.41	39.0	39.1	+0.2
Average		411.6	411.2	-0.10	36.95	36.95	0.0

The least difference between the RSB-TSI trial height-of-rise and the predicted height-of-rise for observation 12,526 (see last row in Table Q-5) was 25 cm, corresponding to a difference of 0.5 percent. The BASIC-RSB model would not provide a solution to this case (the computer would not converge to a solution) - even though the solution criteria in this model only require agreement between the trial and predicted values of 1.0 percent.

Although the test cases in Table Q-5 represent a random selection from among the 13,757 observations in the time-series, they do not include representatives from each of the seasons spanned by the data. Therefore, a second stratified random sampling was carried out. In this sampling, the time-series was partitioned into ten sequential groups, each consisting of 1,375 observations (28.65 days). An observation was then randomly selected from each of the groups. The results are summarized in Table Q-6 (page Q-21).

As might be expected, the results are comparable to the previous comparison. Differences between the predicted flux-averaged dilutions and also the height-of-rise to the top of the wastefield are less than one percent in nine out of the ten cases. The average difference between the two predicted initial dilutions is 0.15 percent; and the average difference between the heights-of-rise is 0.34 percent (in both cases the RSB-TSI predictions are lower).

Table Q-6
Comparison of RSB-Basic and RSB-TSI Predictions
Average Annual PLOO Discharge of 205 mgd

Date	No. of Observations	Average Annual Initial Dilution			Height of Rise to Top of Waste Field		
		RSB-Basic	RSB-TSI	% Difference	RSB-Basic	RSB-TSI	% Difference
03/28/90	1,164	942	944	+0.21	41.4	41.4	-0.0
04/03/90	1,463	412	411	-0.24	40.8	40.8	+0.0
05/10/90	3,221	353	352	-0.28	35.6	35.6	+0.0
06/16/90	5,012	229	229	-0.00	30.0	30.1	+0.4
06/30/90	5,670	362	364	+0.55	36.6	36.6	+0.1
07/25/90	6,903	490	492	+0.41	42.8	42.7	-0.2
09/04/90	8,858	371	364	-1.91	51.1	50.6	-0.9
01/29/91	10,784	337	335	-0.60	32.3	31.7	-1.8
02/09/91	11,311	279	279	-0.00	37.4	37.1	-0.8
03/05/91	12,480	291	290	-0.34	35.9	36.0	+0.2
Average		406.6	406.0	-0.15	38.39	38.26	-0.34

These results demonstrate that the predictions from the RSB-TSI model are comparable to those generated by the BASIC-RSB model, and that the RSB-TSI model is capable of providing adequate predictions for cases where the BASIC-RSB model fails.

R.4 TIME-SERIES INITIAL DILUTIONS

To statistically characterize the range of initial dilutions that are achieved by the PLOO, initial dilutions were computed using time-series of simultaneously measured water column temperatures and ocean currents. Measurements prior to the operation of the extended PLOO were available for the period from March 3 (Calendar Day 63, or CD063) to September 29, 1990 (CD270), and from January 11 (CD011) to April 1, 1991 (CD091). Initial dilutions were calculated at one-half hour intervals for a total of 13,757 individual cases.

240 mgd Maximum Annual Average Design Flow. The time-series of flux-averaged initial dilution values for the measurements in 1990 is illustrated by the bold line on Figure Q-7 (page Q-34), and the time-series for 1991 is illustrated by the light line. Large variations in the magnitude of the initial dilution occur within a tidal cycle. These fluctuations are superimposed on variations occurring over longer time-scales. Initial dilutions between CD063 and CO091 in 1991 tend to be lower than during the same period in 1990.

The probability distribution of initial dilution magnitudes for all the observations (e.g. with currents) is illustrated by the solid line on Figure Q-8 (page Q-35). The dashed line indicates the distribution for the initial dilutions computed with the regulatory requirement of no ambient current. The magnitudes corresponding to selected probability levels are summarized in Table Q-7 (below). As might be expected, the effect of the currents on the initial dilutions is greatest at the highest dilutions (low initial dilutions tend to be associated with weak currents). The minimum simulated flux-averaged initial dilutions with and without currents are nearly equal at 126:1 and 123:1. The presence of currents increases the median (50-percentile) value from 283:1 to 338:1 (an increase of almost 20 percent); the maximum initial dilution is increased by nearly 300 percent.

Table Q-7
Distribution of Flux-Averaged Initial Dilutions
Average Annual PLOO Discharge of 240 mgd

Probability	Computed Flux-Averaged Initial Dilution	
	With Currents	Without Currents
5 Percentile	200	183
10 Percentile	223	202
30 Percentile	284	248
50 Percentile	338	283
70 Percentile	409	319
90 Percentile	544	389
95 Percentile	634	431

1 Probability profile for simulated flux-averaged initial dilution for an annual PLOO discharge flow of 240 mgd. The five percentile value is equaled or exceeded 95 percent of the time.

A running 30-day average of the initial dilutions is shown on Figure Q-9 (page Q-35). The solid line represents the 30-day average initial dilutions calculated with the actual currents; the dashed line, the 30-day average initial dilutions calculated by setting the currents equal to zero. Each 30-day period begins on the calendar day shown at the bottom of the plot. For example, the 30-day average for the month of April begins on CD091. In the absence of currents, the lowest 30-day average (regulatory) initial dilutions occur between January 15-25, with values falling to as low as 221:1. Two secondary minima occur around late April (approximately CD117) and early August (CD217), with values of 246:1 and 293:1, respectively. The maximum 30-day average initial dilution was 360:1 (CD239, August 25).

205 mgd - Maximum Annual Average Flow. The time-series of flux-averaged initial dilution values for the measurements in 1990 is illustrated by the bold line on Figure Q-10 (page Q-36), and the time-series for 1991 by the light line. The probability distribution of initial dilution magnitudes for all the observations (e.g. with currents) is illustrated by the solid line on Figure Q-11 (page Q-36). The dashed line indicates the distribution for the initial dilutions computed with no ambient current. The magnitudes corresponding to selected probability levels are summarized in Table Q-8 (below). The presence of currents increases the median (50-percentile) value from 300:1 to 365:1 (an increase of about 22 percent). The maximum initial dilution is increased by 280 percent.

Table Q-8
Distribution of Flux-Averaged Initial Dilutions
Average Annual PLOO Discharge of 205 mgd

Probability	Computed Flux-Averaged Initial Dilution	
	With Currents	Without Currents
5 Percentile	215	194
10 Percentile	239	214
30 Percentile	306	262
50 Percentile	365	300
70 Percentile	443	340
90 Percentile	592	409
95 Percentile	686	455

1 Probability profile for simulated flux-averaged initial dilution for a PLOO discharge flow of 205 mgd. The five percentile value is equaled or exceeded 95 percent of the time.

A running 30-day average of the initial dilutions is shown in Figure Q-12 (page Q-37). The solid line represents the 30-day average initial dilutions calculated with the actual currents; the dashed line, the 30-day average initial dilutions calculated by setting the currents equal to zero. The lowest 30-day average (regulatory) initial dilutions in the absence of currents occur on about January 15-16 (CD15-16), with a value of 221:1. Similarly, two secondary minima occur around late April (CD114) and early August (CD217), with values of 245:1 and 292:1, respectively. The maximum 30-day average initial dilution was 481:1 (CD239, August 25).

Comparison of Initial Dilutions for 205 mgd and 240 mgd. The probability distribution of initial dilutions for an annual average discharge of 205 mgd is compared with the distribution for a discharge of 240 mgd in Figure Q-13 (page Q-37). Overall, the initial dilutions associated with the 205 mgd discharge (solid line) are about seven percent higher than those associated with a discharge of 240 mgd (dashed line). This is slightly higher than the five percent increase expected for a buoyant plume from a line source in receiving waters with a constant density gradient, but is in agreement with expectations for a buoyancy dominated discharge. Dilutions for some individual observations may, however, be greater for a discharge of 240 mgd than for 205 mgd, depending on the stratification of the water column.

Diurnal Variations in the Initial Dilution. The magnitude of the initial dilution depends on the density stratification of the receiving water, the strength and direction of the ocean currents, and the discharge rate. Surface and internal tides of semidiurnal and diurnal frequency change the density stratification of the water column and the ocean currents over the course of a day. Similarly, the volumetric discharge has a diurnal cycle. The magnitude of the initial dilution will normally be affected by phasing of these fluctuations relative to one another, and may be either enhanced or diminished.

The interplay between the semidiurnal and diurnal tidal period changes in the currents and in the water column stratification, and the diurnal changes in the discharge rate are evident on Figures Q-14 and Q-15 (page Q-38). The figure present the predicted initial dilutions for the period from CD035 to CD040 (February 4 to 9) in 1991 for various discharge and receiving water conditions. Figure Q-14 illustrates the dilutions in the presence of the measured currents and Figure Q-15 without currents. The solid line represents the most realistic estimate, since it includes the variations in the stratification of the water column, currents, and discharge rate. A semidiurnal (two cycles per day) fluctuation is evident in the magnitude of the initial dilution. However, the two peaks within a day are often of different magnitude, corresponding to the diurnal fluctuations in the receiving waters and the discharge rate.

The effect of the varying discharge rate is evident by comparing the initial dilutions predicted for a constant discharge rate (dashed line) with those with the sequence of initial dilutions with the varying discharge rate. At times, the magnitude of the initial dilution may be either enhanced or diminished, depending on the phase of the receiving water and discharge rate fluctuations. In some cases, the difference is as much as 60 to 70 percent during this period.

Figure Q-15 shows the initial dilutions for the same set of conditions, but with the ocean currents set equal to zero. Therefore, the dashed line in Figure Q-15 illustrates the variations in the initial dilution that result solely from changes in the density stratification of the water column. Semidiurnal period density fluctuations are sufficient to change initial dilutions by as much as 80 percent over the course of one-half a period (ca. 6 hours).

Comparison of the initial dilutions for a constant discharge rate (dashed lines - Figures Q-14 and Q-15) illustrates the importance of the tidal period current fluctuations. During this time period, the difference between the highs and the lows is greater in the presence of the currents than in their absence. This suggests that the semidiurnal tidal period variations in the density stratification and in the currents are phased to enhance the variations in the initial dilution.

These variations indicate that care must be exercised in computing regulatory minimum average initial dilutions based on hydrocast data. Since each station is only sampled once during each hydrocast survey, the sample represents only one of the possible stratifications of the water column that may exist over the course of a diurnal tidal cycle. Therefore, the initial dilution predictions may be aliased by the tidal fluctuations unless a sufficient number of density profiles are collected so that the set is representative of the range of stratifications existing during each monthly period. Another factor to consider is that during monitoring surveys, hydrocast data are often collected at the same station at roughly the same time of the day, and at roughly the same time within a month, over the course of a number of years. This has the potential to introduce biases into the initial dilution predictions since there are rough correlations between the timing of the tidal fluctuations between years.

R.5 CALIFORNIA OCEAN PLAN INITIAL DILUTIONS

The *California Ocean Plan* requires that the initial dilutions be determined on the basis of no assumed ocean currents. Because of concerns about the number of independent CTD profiles that were available for the initial dilution calculations, *California Ocean Plan*-based initial dilutions were simulated by assigning a zero ocean current and performing modeling simulations using both the CTD data and the time-series data.

The CTD casts were divided into twelve sets, each corresponding to one month of the year. The years for which CTD data was available is summarized in Table Q-9 (page Q-26). More than one profile is available for each month of each year. However, these data correspond to profiles collected on the same day, or separated by two days, at multiple hydrocast stations near the outfall. For example, the nine profiles available for the month of January in 1992 were all collected on the same day. The purpose of using data from more than one hydrocast station is to average out the effects of the density variations associated with internal waves and tides (the data are collected over a period of several hours).

240 mgd - Maximum Annual Average Design Flow. The regulatory initial dilutions for a discharge of 240 mgd are summarized by month in Table Q-9 (page Q-26). The regulatory average initial dilution is the average of all the values during the month. Values range from lows of 202 to 206:1 in the winter (January, December), to highs of 320 to 324:1 in early summer (June, July). The value of 202:1 corresponds to the regulatory minimum average initial dilution addressed within the *California Ocean Plan*.

Table Q-9
30-Day Average Initial Dilution
Hydrocast Data - No Currents
Average Annual PLOO Discharge of 240 mgd

Month	Average Initial Dilution
January	202
February	224
March	263
April	284
May	295
June	324
July	320
August	294
September	307
October	281
November	249
December	206

1 Monthly average initial dilutions computed using hydrocast data and no currents for a maximum PLOO Discharge flow of 245 mgd.

California Ocean Plan-based monthly average initial dilutions were also estimated using the 30-day running average initial dilutions computed from the time-series measurements for no currents. The monthly average corresponds to the 30-day running average beginning on the calendar day corresponding to the first day of each month (for example, the February monthly average would correspond to calendar day 032). The resulting regulatory monthly average initial dilutions for the time-series from 1990 and 1991 are summarized in Table Q-10 (page Q-27).

Note that calendar days in Table Q-10 that are surrounded by parenthesis () indicate that the listed 30-day average corresponds to the 30-day average beginning on that day, and thus are only approximate estimates of the value for the month (data was not available to compute the 30-day average for the correct beginning day).

The regulatory monthly average initial dilutions predicted from the time-series range from lows of 227:1 in the winter (January, February) to a high of 359:1 in early fall (September). The value of 227:1 corresponds to the regulatory minimum monthly average initial dilution based on the time-series data. This is about twelve percent higher than the regulatory minimum monthly average initial dilution based on the CTD data.

Table Q-10
30-Day Average Initial Dilution
Time-Series Data, No Currents
Average Annual PLOO Discharge of 240 mgd

Month	Beginning Calendar Day of the Month	Computed 30-Day Average Initial Dilution		
		TS 1990[1]	TS 1991[1]	CTD Data 1990-1994[1]
January	1	No Data	227[2]	202
February	32	No Data	227	224
March	60	317[3]	267	263
April	91	285	No Data	284
May	121	260	No Data	295
June	152	304	No Data	324
July	182	341	No Data	320
August	213	294	No Data	294
September	244	359[4]	No Data	307
October	274	No Data	No Data	281
November	305	No Data	No Data	249
December	335	No Data	No Data	206

1 Ocean density data collected prior to operation of the extended PLOO.
2 Value for Calendar day 11.
3 Value for Calendar Day 63.
4 Value for Calendar Day 239.

Overall, the regulatory 30-day average initial dilutions predicted from the time-series are remarkably similar to the values predicted using the CTD data - especially considering the potential effects of internal wave aliasing and interannual variability. For example, the time-series measurements were made in 1990 and early 1991, while the hydrocast data are weighted towards measurements from the years 1992 to 1994. The average of all the regulatory monthly initial dilutions based on the time-series data is 288:1. This is about four percent greater than the regulatory monthly average initial dilution of 276:1 predicted from the CTD data. The variability of the regulatory monthly average initial dilutions within the year is illustrated on Figure Q-16 (page Q-39).

Initial dilutions predicted from the time-series data range from a low of 227 (January-February) to a high of 359 (September), compared with the range of 202-324 predicted from the hydrocast data. The average of all the time-series based initial dilutions is 287:1, or about three percent greater than the average of 279:1 for all the hydrocast-based initial dilutions during the same months.

205 mgd - Maximum Annual Average Flow. Table Q-11 presents minimum monthly initial dilutions computed using the hydrocast CTD data from 1990-1991 (prior to construction of the PLOO extension). As shown below in Table Q-11, the minimum initial dilution for a PLOO discharge of 205 mgd ranges from 204 (February conditions) to 354 (June conditions).

The 30-day average regulatory initial dilutions for the time-series in 1990 and 1991 are summarized in Table Q-12 (page Q-29). The winter lows in the regulatory monthly average initial dilutions predicted from the time-series data range from 238 to 241 (January-February); the early autumn highs reach 384 (September). This compares favorably with the range of 204 to 354 predicted from the hydrocast data. The average of all the time-series based regulatory monthly average initial dilutions is 305:1. This is about four percent greater than the average of 292:1 based on the hydrocast data for the same months. The distribution of regulatory monthly average initial dilutions within the year is illustrated in Figure Q-17 (page Q-39).

Table Q-11
30-Day Average Initial Dilution
Hydrocast Data - No Currents
Average Annual PLOO Discharge of 205 mgd

Month	Average Initial Dilution
January	214
February	204
March	264
April	313
May	315
June	354
July	325
August	325
September	317
October	287
November	264
December	217

1 Monthly average initial dilutions computed using hydrocast data and no currents for a PLOO Discharge flow of 205 mgd.

Table Q-12
30-Day Average Initial Dilution
Time-Series Data, No Currents,
Average Annual PLOO Discharge of 205 mgd

Month	Beginning Calendar Day of the Month	Computed 30-Day Average Initial Dilution		
		TS 1990[1]	TS 1991[1]	CTD Data[1]
January	1	No Data	238[2]	214
February	32	No Data	241	204
March	60	337[3]	287	264
April	91	300	No Data	313
May	121	275	No Data	315
June	152	324	No Data	354
July	182	359	No Data	325
August	213	310	No Data	325
September	244	384[4]	No Data	317
October	274	No Data	No Data	287
November	305	No Data	No Data	264
December	335	No Data	No Data	217

1 Ocean density data collected prior to operation of the extended PLOO.
2 Value for Calendar day 11.
3 Value for Calendar Day 63.
4 Value for Calendar Day 239.

Based on the time-series data, the regulatory minimum monthly average initial dilution required for assessing compliance with *California Ocean Plan* Table 1 receiving water standards is 238:1. The corresponding value for the hydrocast data is 204:1.

Height of Rise. The height-of-rise to the level of minimum dilution, bottom of the wastefield, and top of the wastefield varies over the same time-scales characterizing the variations in the magnitudes of the initial dilutions (e.g., hours to years). The monthly average wastefield depths for an annual average flow of 205 mgd, based on the time-series data from 1990 and 1991, are illustrated in Figures Q-18 (page Q-40). Also shown is the maximum height-of-rise to the top of the wastefield during each month.

For annual average flows of 205 mgd and 240 mgd, the height-of-rise to the level of minimum dilution varies from about 20 to 31 meters, corresponding to depths of 62 to 74 meters below the surface. In general, the months with the highest heights-of-rise also tend to have the highest initial dilutions. The average height-of-rise to the top of the wastefield at the completion of the initial dilution process varies from about 30 to 40 meters, corresponding to depths of about 54 to 64 meters below the surface. The maximum height-of-rise to the top of the wastefield during a month varies from about 50 to 64 meters, corresponding to depths of about 30 to 44 meters. The water depth at the outer edge of the kelp bed lying inshore from the PLOO is about 16 to 17 meters; the water depth at the outer edge of the San Diego bight (i.e., along an extension of the Point Loma coastline) lying downcoast, is about 40-45 meters.

REFERENCES

Baumgartner, D.J., W.E. Frick, and P.J.W. Roberts, 1993. Dilution models for effluent discharges (Second Edition). EPA Report EPA/600/Q-93/139. Newport, Oregon. July, 1993. 181p.

Baumgartner, D.J., W.E. Frick, and P.J.W. Roberts, 1994. Dilution models for effluent discharges (Third Edition). EPA Report EPA/600/Q-94/086. Newport, Oregon. 189p.

Roberts, P.J.W., 1989. Dilution hydraulic model study of the Boston wastewater outfall. Report No. SCEGIT 89-101. Georgia Institute of Technology, Atlanta, Georgia. 57 pages plus appendices

Roberts, P.J.W., 1993. Hydraulic model study for the Boston outfall. I: Riser configuration. *Journal of Hydraulic Engineering*, 119:9, 970-987.

Roberts, P.J.W., W.H. Snyder, and D.J. Baumgartner, 1989a. Ocean outfalls. I: Submerged wastefield formation. *Journal of Hydraulic Engineering*, 115:1,1-25.

Roberts, P.J.W., W.H. Snyder, and D.J. Baumgartner, 1989b. Ocean outfalls. II: Spatial evolution of submerged wastefield. *Journal of Hydraulic Engineering*, 115:9,26-48.

Roberts, P.J.W., W.H. Snyder, and D.J. Baumgartner, 1989c. Ocean outfalls. III: Effects of diffuser design on submerged wastefield. Journal of Hydraulic Engineering, 115:1,49-70.

State Water Resources Control Board (State Board). *Water Quality Control Plan, Ocean Waters of California* (*California Ocean Plan*). 2012.

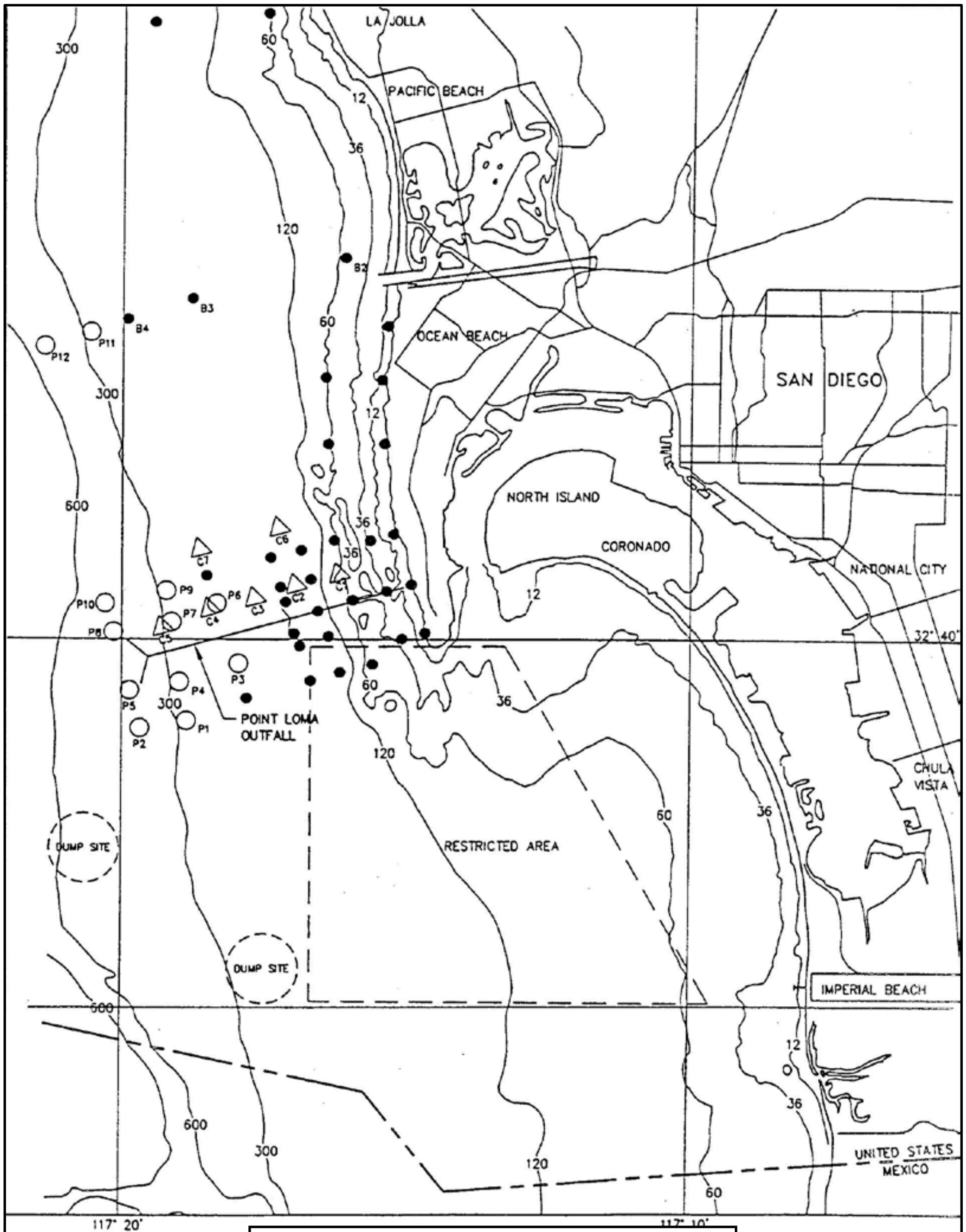


Figure Q-1
Study Area Monitoring Stations

N

0 1 2
GRAPHIC SCALE
NAUTICAL MILES
DEPTH IN FEET

LEGEND:
● – EXISTING CITY OF SAN DIEGO MONITORING STATIONS
○ – POINT LOMA WATER QUALITY, BENTHIC, AND TRAWL STATIONS
△ – POINT LOMA CURRENT METER ARRAYS AND THERMISTOR ARRAYS AT STATIONS C1 THRU C7

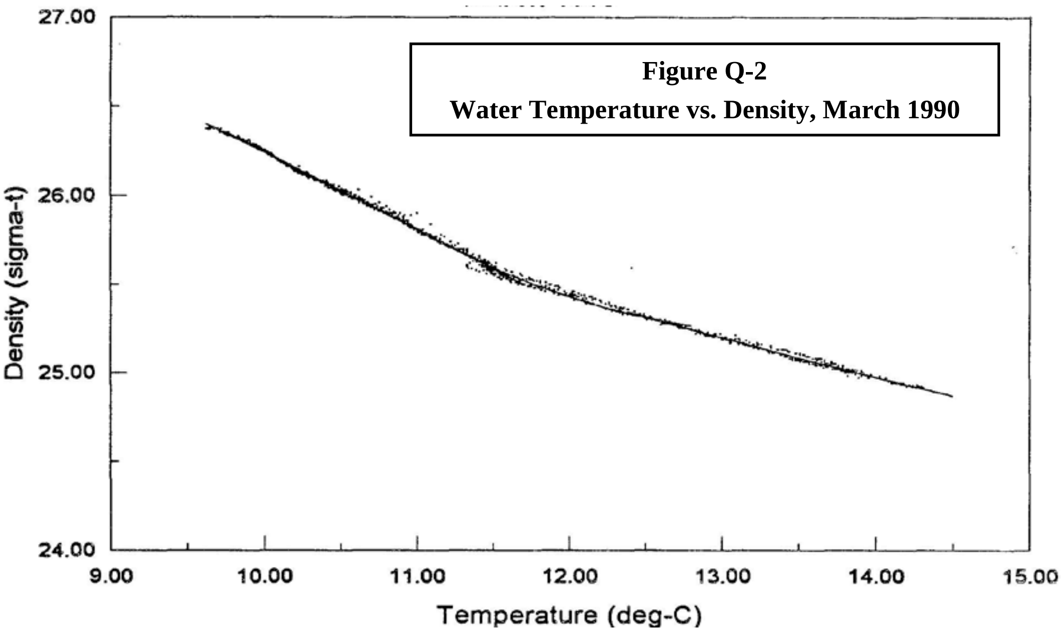


Figure Q-2
Water Temperature vs. Density, March 1990

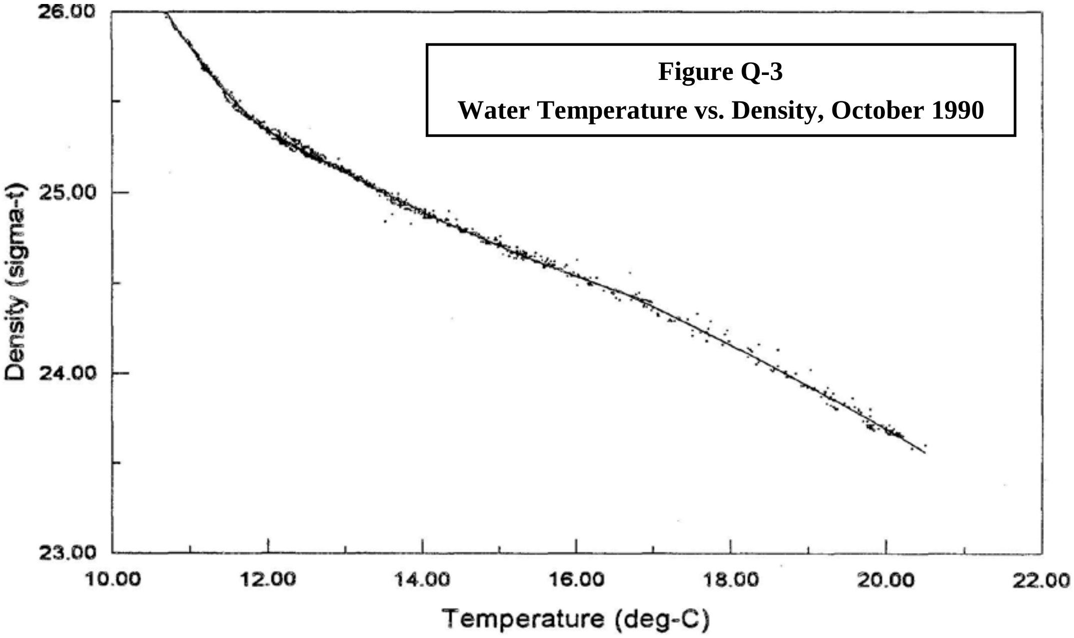


Figure Q-3
Water Temperature vs. Density, October 1990

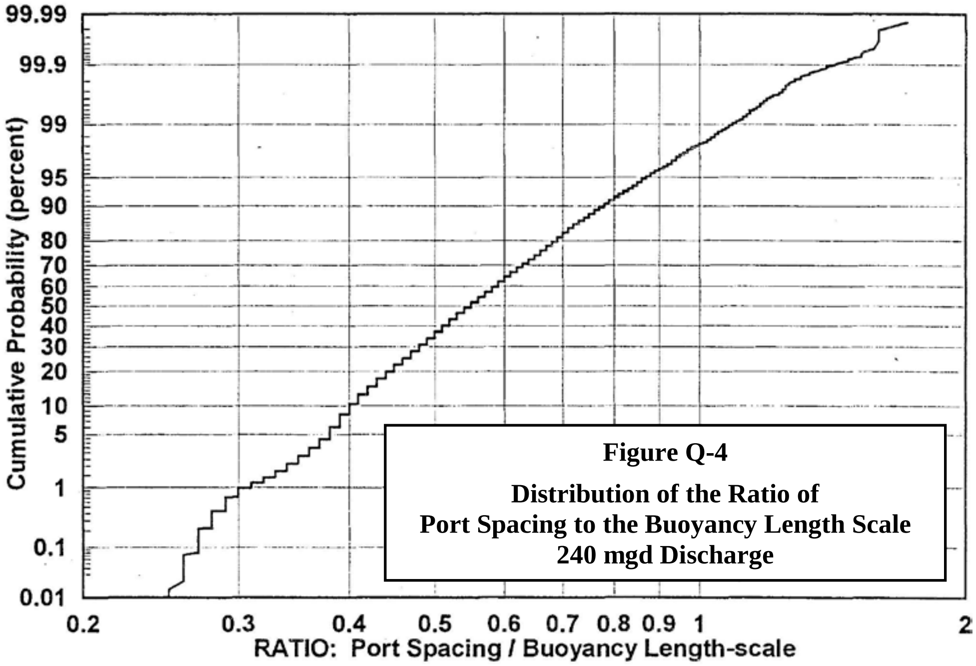


Figure Q-4

**Distribution of the Ratio of
Port Spacing to the Buoyancy Length Scale
240 mgd Discharge**

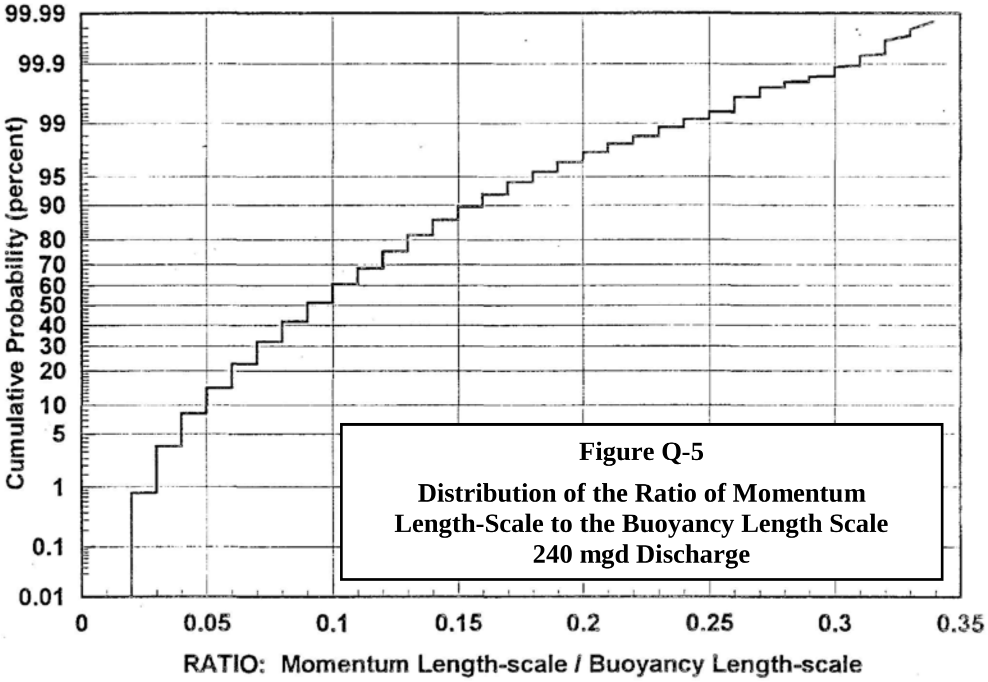


Figure Q-5

**Distribution of the Ratio of Momentum
Length-Scale to the Buoyancy Length Scale
240 mgd Discharge**

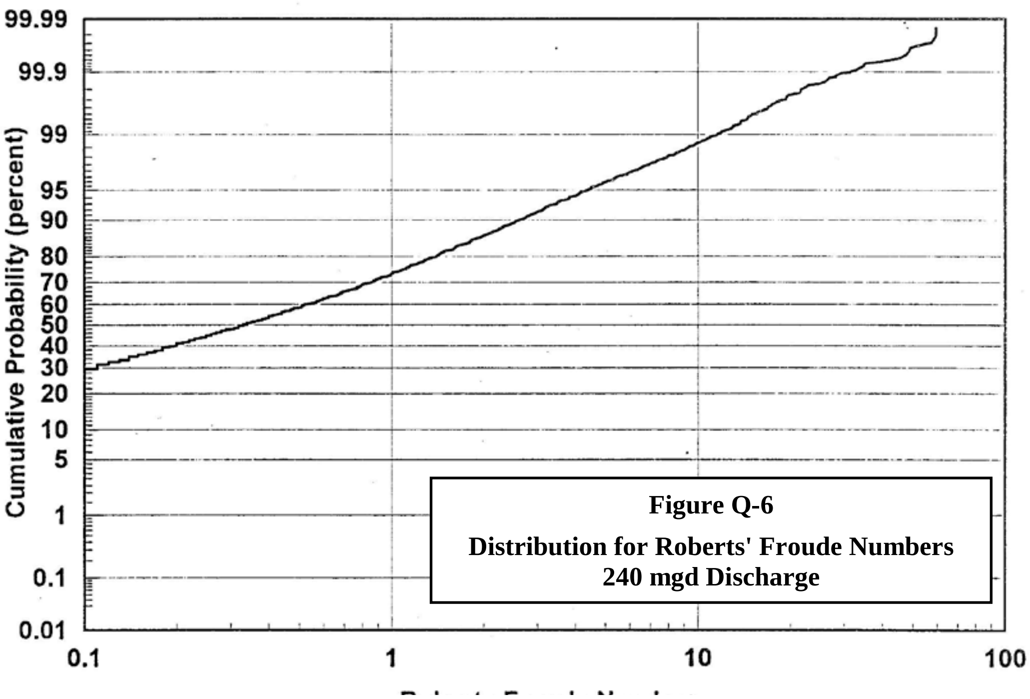


Figure Q-6

Distribution for Roberts' Froude Numbers 240 mgd Discharge

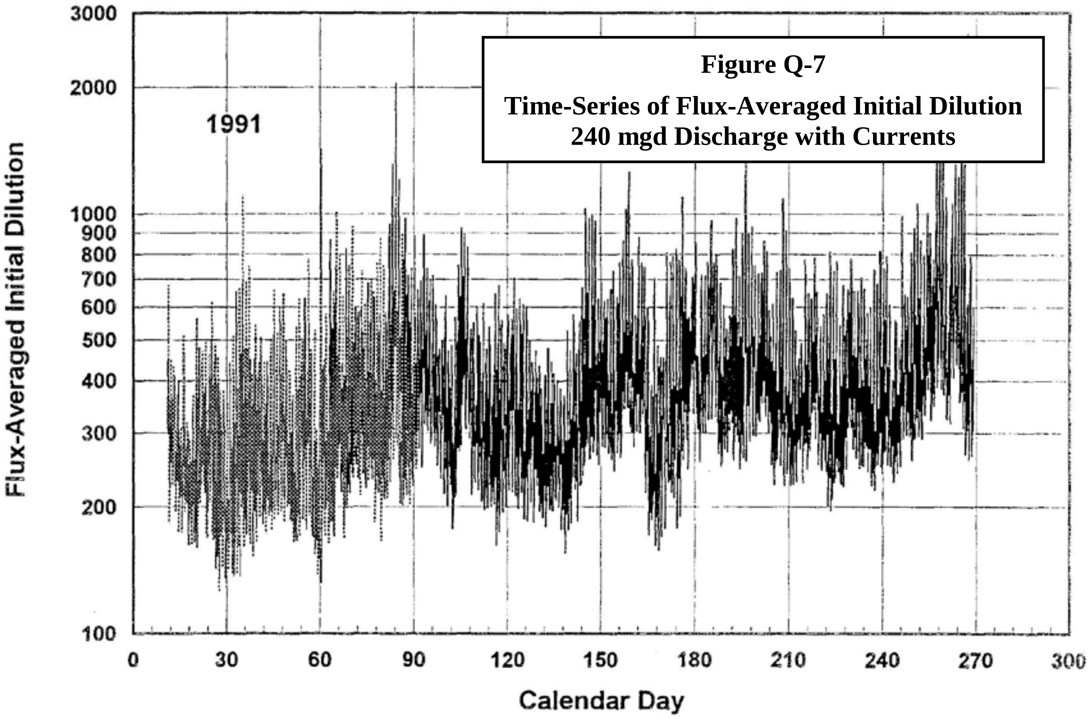


Figure Q-7

Time-Series of Flux-Averaged Initial Dilution 240 mgd Discharge with Currents

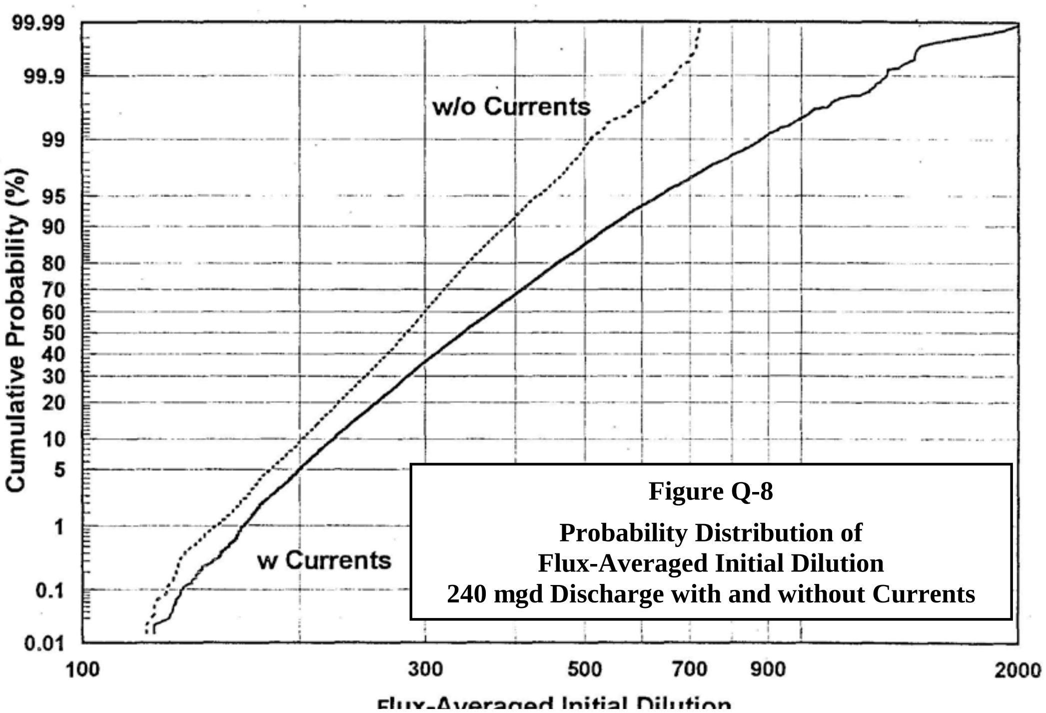


Figure Q-8

**Probability Distribution of
Flux-Averaged Initial Dilution
240 mgd Discharge with and without Currents**

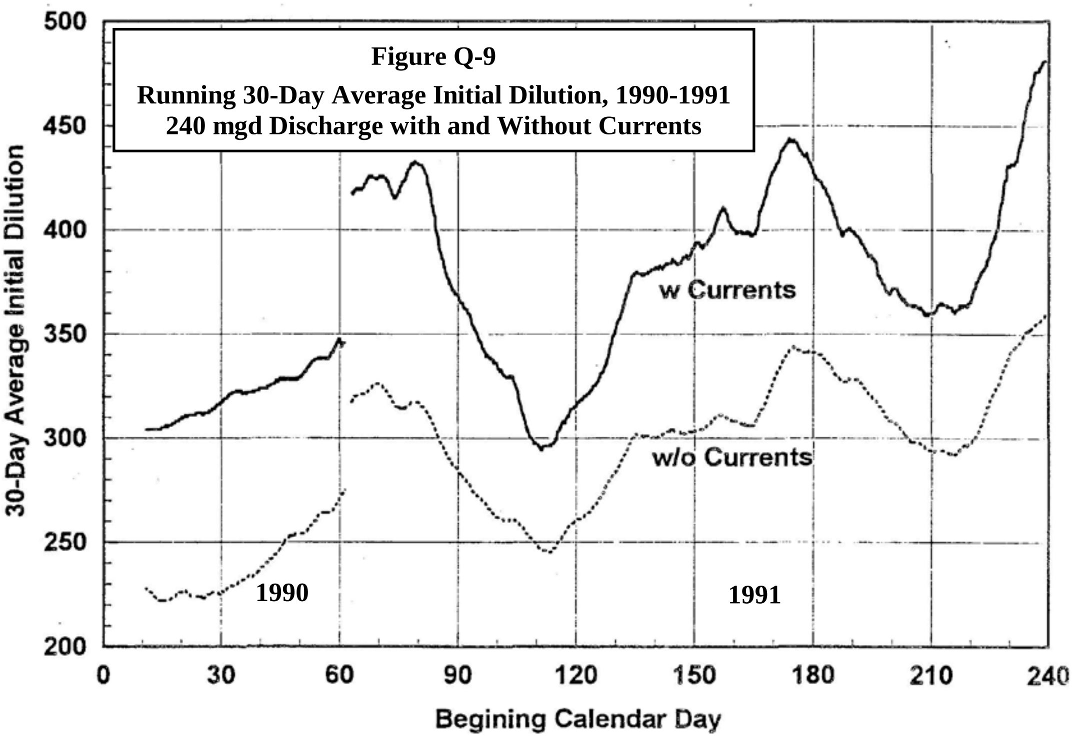


Figure Q-9

**Running 30-Day Average Initial Dilution, 1990-1991
240 mgd Discharge with and Without Currents**

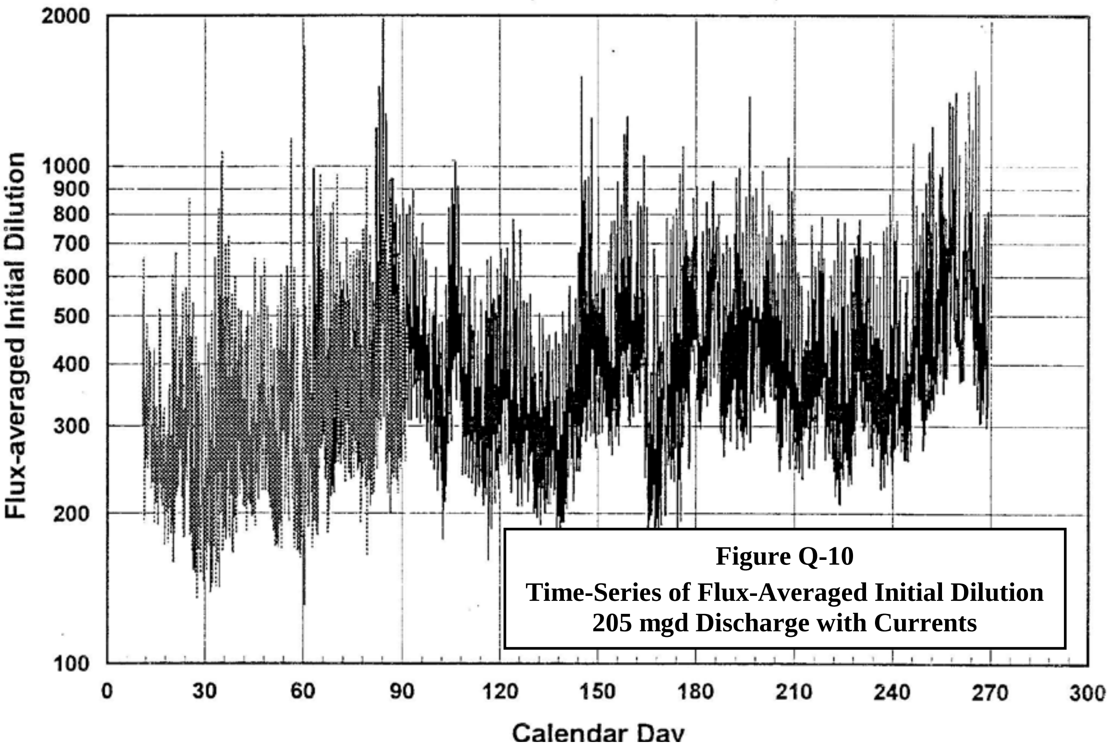


Figure Q-10

Time-Series of Flux-Averaged Initial Dilution
205 mgd Discharge with Currents

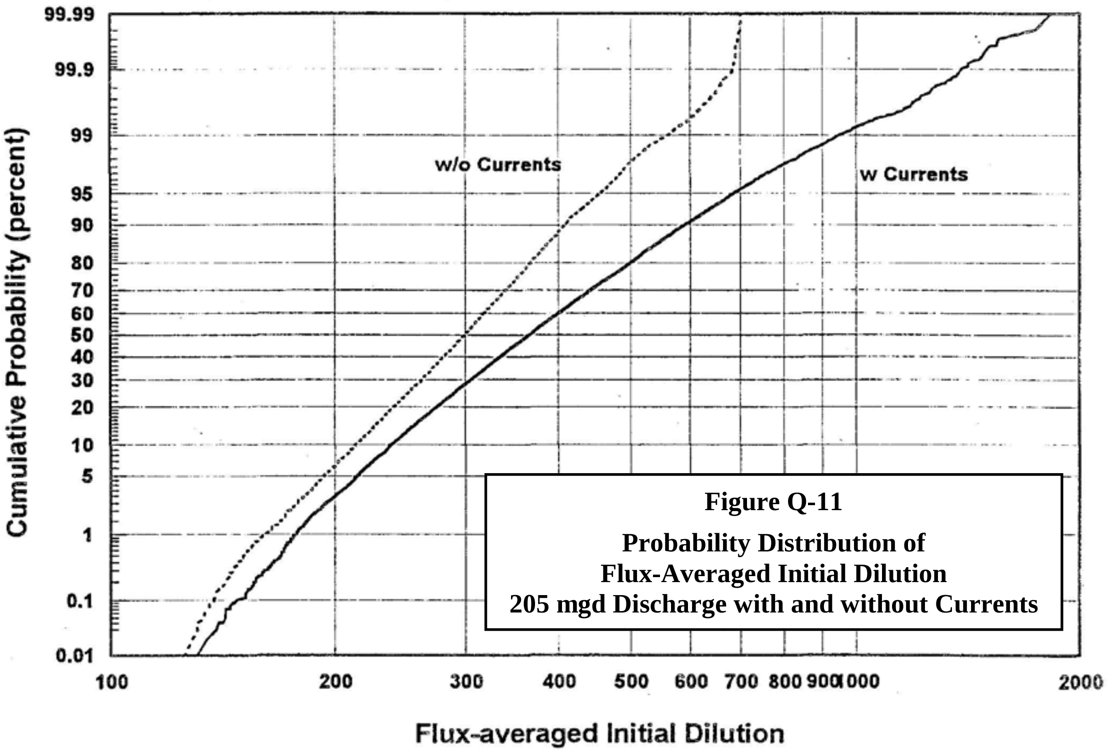


Figure Q-11

Probability Distribution of
Flux-Averaged Initial Dilution
205 mgd Discharge with and without Currents

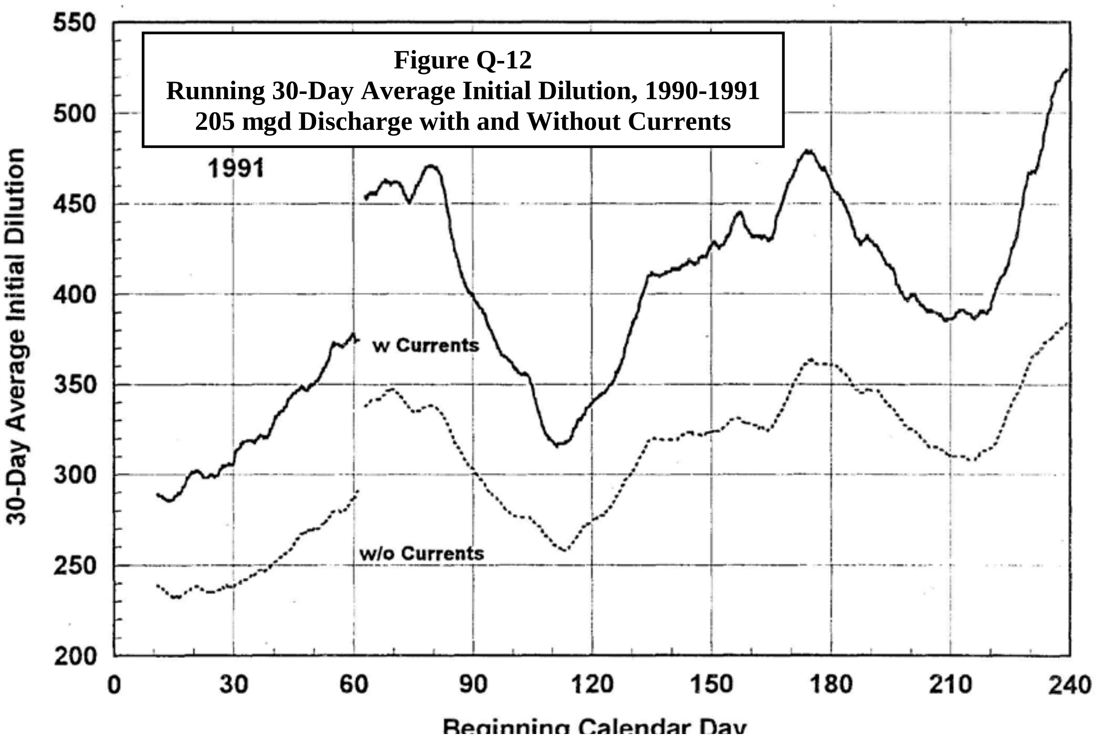


Figure Q-12
Running 30-Day Average Initial Dilution, 1990-1991
205 mgd Discharge with and Without Currents

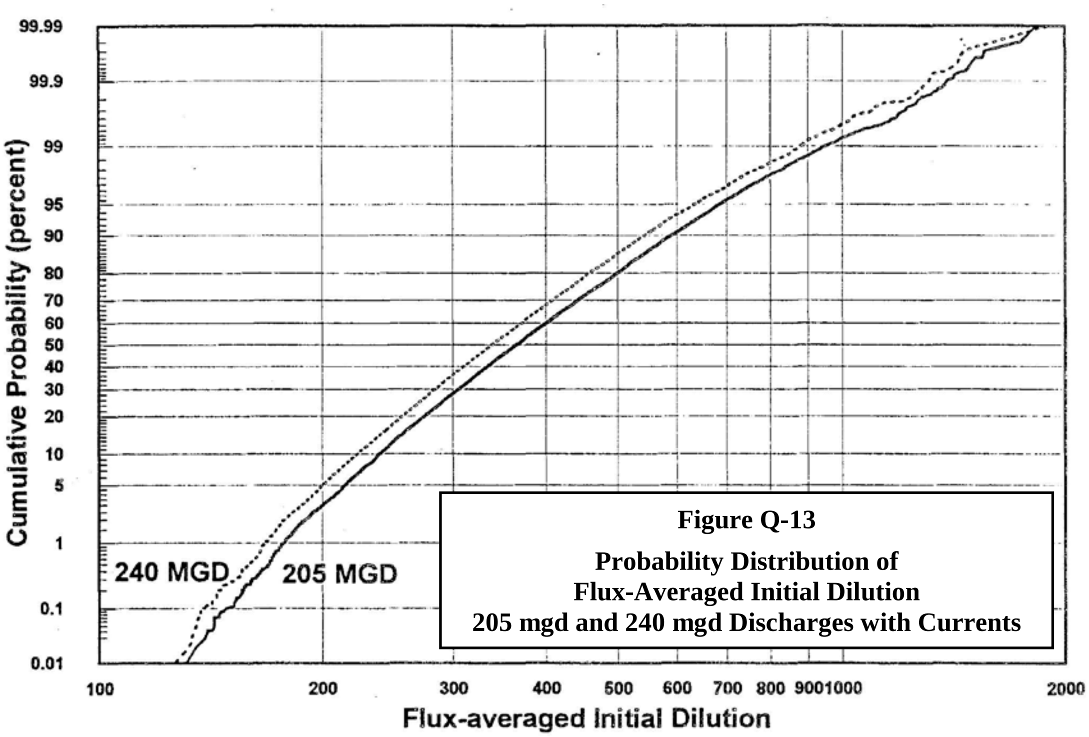


Figure Q-13

Probability Distribution of
Flux-Averaged Initial Dilution
205 mgd and 240 mgd Discharges with Currents

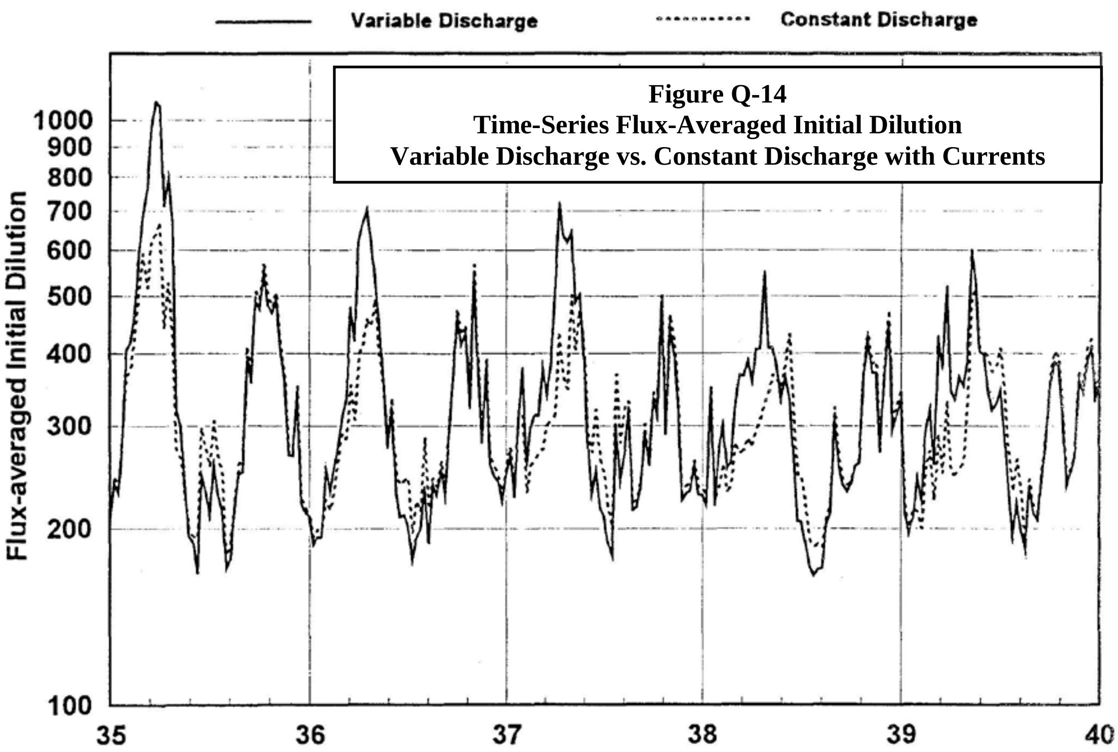


Figure Q-14
Time-Series Flux-Averaged Initial Dilution
Variable Discharge vs. Constant Discharge with Currents

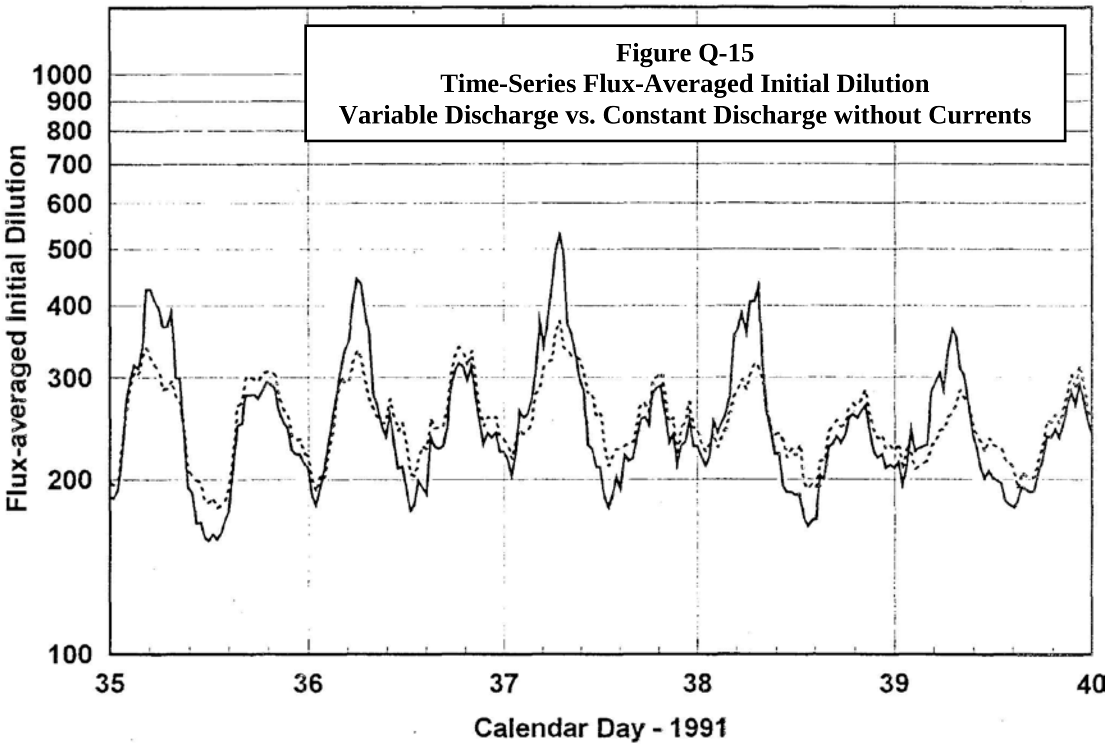


Figure Q-15
Time-Series Flux-Averaged Initial Dilution
Variable Discharge vs. Constant Discharge without Currents

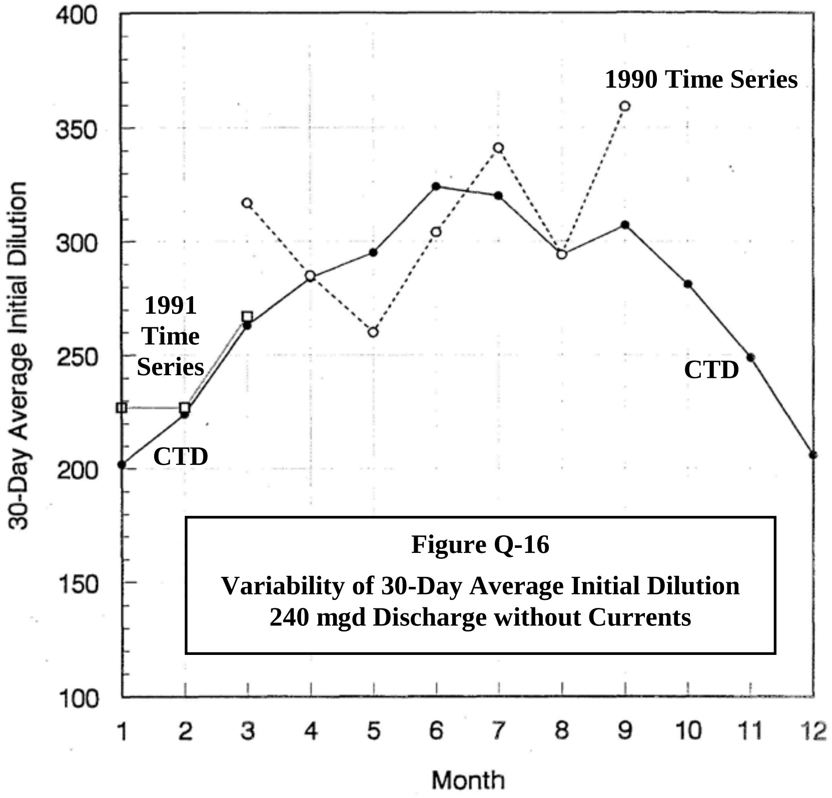


Figure Q-16

Variability of 30-Day Average Initial Dilution
240 mgd Discharge without Currents

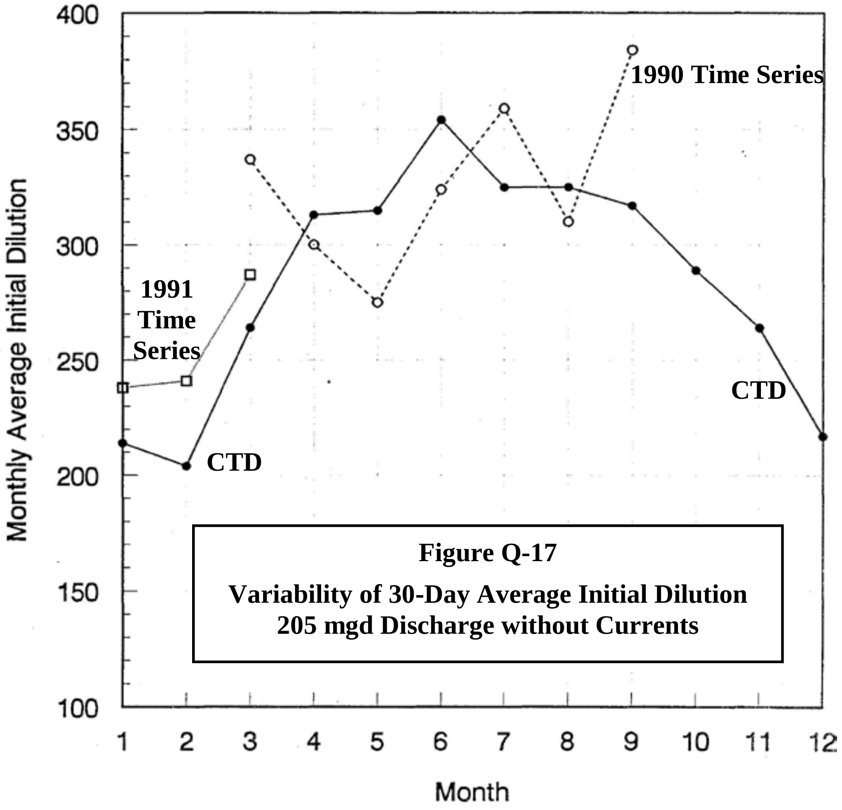
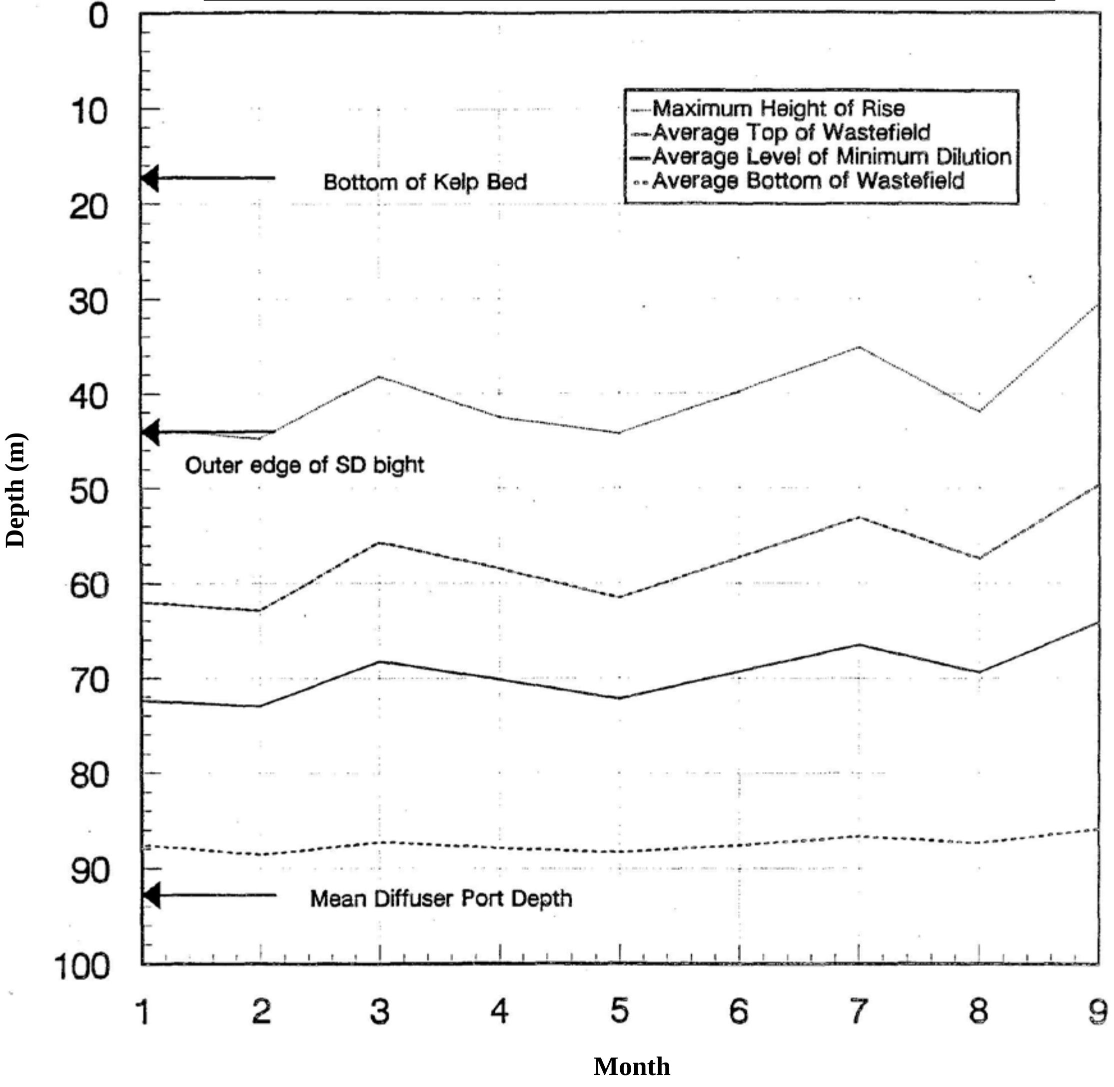


Figure Q-17

Variability of 30-Day Average Initial Dilution
205 mgd Discharge without Currents

Figure Q-18
Monthly Average Wastefield Depth at Completion of Initial Dilution
205 mgd Discharge



Appendix R
RE-ENTRAINMENT

Renewal of NPDES CA0107409

APPENDIX R

RE-ENTRAINMENT

Evaluation of Re-Entrainment of the Discharge Plume of the Point Loma Ocean Outfall

THE CITY OF SAN DIEGO • STATE OF CALIFORNIA •
SEMPER VIGILANS

January 2015

APPENDIX R

RE-ENTRAINMENT

Table of Contents

List of Tables

List of Abbreviations

ATST	EPA Amended 301(h) Technical Support Document
CTD	conductivity, temperature, depth
California Ocean Plan	2012 *Water Quality Control Plan, Ocean Waters of California*
cm/sec	centimeters per second
EPA	United States Environmental Protection Agency
m	meters
m/sec	meters per second
mg/l	milligrams per liter
PLOO	Point Loma Ocean Outfall
rms	root mean square
State Board	State Water Resources Control Board

APPENDIX R

RE-ENTRAINMENT

This appendix evaluates re-entrainment associated with the discharge plume of the Point Loma Ocean Outfall (PLOO). Re-entrainment computations presented in this appendix were originally presented in the City's 1995 301(h) waiver application. Dilution, flow, and receiving water conditions remain the same as those addressed in the original 1995 re-entrainment analyses, so the approach and information presented in the 1995 301(h) application (presented again herein) remain valid and applicable to the current PLOO discharge.

ABSTRACT

Re-entrainment is the mixing of previously discharged effluent or contaminants back into the discharge plume. The effect of re-entrainment is to lessen the effective dilution of discharged wastewater into ambient receiving waters. The Point Loma Ocean Outfall (PLOO) diffuser, discharge depth, and location were designed on the basis of modeling and oceanographic studies to minimize the potential for such re-entrainment.

This appendix evaluates re-entrainment associated with the PLOO discharge. To assess re-entrainment effects, computer simulations of waste field characteristics were performed using conservative assumptions and observed data for ocean currents, ocean density profiles, waste field thickness, and discharge characteristics. The simulations demonstrate that re-entrainment effects associated with the PLOO discharge are minor. Smallest re-entrainment effects on initial dilution (approximately 4 percent) were simulated under February conditions. Largest effects on initial dilution (up to 12.1 percent) occurred during summer conditions. Because initial dilutions tend to be high during such summer conditions, however, re-entrainment does not have a significant effect on overall outfall performance during any simulated conditions.

R.1 INTRODUCTION

Wastewater is carried out of the discharge area, and replaced with new effluent free water, by ocean currents. The spatial dimensions of the wastefield, the strength of the ocean current, and the discharge rate are related to the dilution through the relationship:

$$S_a \cdot Q = H_w \cdot W_w \cdot V_a \qquad Equation\ R-1$$

where: S_a = flux-averaged initial dilution
Q = volumetric discharge rate of effluent (m^3/sec)
H_w = depth of the water column occupied by wastewater (m)
W_w = "effective" width of the wastefield (m)
V_a = speed of the ocean current (m/sec)

At high current speeds, this relationship is satisfied by a decrease in the thickness and width of the wastefield, and by an increase in the initial dilution (e.g., proportional to $V_a^{1/2}$ for flow perpendicular to the diffuser- Roberts et al. 1989).

At lower current speeds, for inviscid (frictionless) flow in density stratified water, the initial dilution becomes independent of current speed and the wastefield width increases (e.g., due to the discharge-induced currents) to maintain the relationship. Over longer time- and length-scales, the effective width of the wastefield, and hence the dilution, can increase due to fluctuations in the component of the ocean flow perpendicular to the dominant direction of flow (e.g., tidal and more slowly varying changes) and by lateral diffusion.

The actual dilution achieved by the outfall, however, may be less than expected if previously discharged wastewater is re-entrained into the plume during the initial dilution process. This re-entrainment may occur under a number of circumstances. Over short time-scales and in the immediate vicinity of the outfall, the effects of viscosity can promote vertical mixing, re-entrainment, and the development of distortions in the local pressure and flow fields that result in "blocking".

Longer periods of very weak currents can result in additional perturbations of the density structure of the ocean due to the entrainment of angular momentum. Even if the currents are relatively strong, re-entrainment may occur if reversals in the flow coincide with downward movements of previously formed segments of the wastefield (e.g., due to downwelling and internal tides).

If all the conditions required for re-entrainment occur, the concentration of effluent in the wastefield will be increased, resulting in a reduction in the "effective" dilution. The magnitude of the effective initial dilution is related to the volumetric flux-averaged initial dilution and the concentration of ambient effluent in the entrained water by the equation:

$$C_w = \frac{(S_a - 1) \cdot C_a + C_e}{S_a} \qquad Equation\ R-2$$

where: C_w = concentration of effluent in the wastefield
C_a = concentration of effluent in the entrained receiving water
C_e = concentration of effluent (set at a value of 1.00, e.g., 100 percent)
S_a = volumetric flux-averaged initial dilution

Under these circumstances, the "effective" initial dilution (i.e., the dilution achieved based on the concentration of effluent in the wastefield at the completion of the initial dilution process) is:

$$C_w = \frac{S_a \cdot C_a + C_3}{S_a + 1} > \frac{S_a \cdot 0 + C_e}{S_a + 1} = \frac{C_e}{S_a + 1} = C_w^o \qquad Equation\ R-3$$

where: C_w = effluent concentration in the wastefield with re-entrainment
C_w^o = effluent concentration in the wastefield without re-entrainment
C_a = effluent concentration in the entrained ambient water
C_e = effluent concentration in the wastewater (established at a value of 1.00, e.g., 100 percent)
S_a = flux-averaged initial dilution

The *California Ocean Plan* (State Board, 2012) establishes receiving water standards to be achieved upon the completion of initial dilution, and requires that minimum month initial dilutions be used for establishing NPDES effluent concentration limits required to implement the receiving water standards. As discussed in Appendix Q (Initial Dilution Simulation Models), initial dilutions over a month (30 day period) may be computed as a flux average, as follows:

$$S_{avg} = \frac{\int_0^{30\ dy} S_a(t')dt'}{30\ days} \qquad Equation\ R-4$$

where: S_{avg} = 30-day average initial dilution
S_a = instantaneous flux-averaged initial-dilution at time, t'

If re-entrainment may occur (e.g., due to current reversals), calculation of the individual effective dilutions making up the monthly-averaged value requires simultaneous information on the volumetric flux-averaged initial dilution and the concentration of previously discharged effluent in the ambient water entrained into the plume. As discussed in Appendix Q, numerous methods have been developed for computing the volumetric flux-average initial dilutions (e.g., Baumgartner et al, 1993). Nonetheless, it is difficult to provide detailed three-dimensional spatial and temporal descriptions of previously discharged wastewater in the receiving water environment that are required to describe the re-entrainment of effluent into the initial dilution plume. This is especially true in density-stratified coastal waters characterized by short coherence length-scales for cross-shore currents and internal wave activity, such as exist in the environment off Point Loma. For example, none of the simulation models suggested in the Amended 301(h) Technical Support Document are appropriate for this environment.

R.2 METHODOLOGY

General Approach. In lieu of such a model, a simplified approach was adopted in order to obtain an estimate of the possible effects of effluent re-entrainment on the discharge from the PLOO. Since the *California Ocean Plan* specifies a minimum month (30-day average) initial dilution for purposes of translating Table 1 receiving water standards (to be achieved upon completion of initial dilution) into effluent concentration standards, an appropriate approach is to calculate the volume of effluent discharged during a 30-day period, and the volume of ocean water containing this effluent. Since 100 percent of the PLOO discharge is wastewater (e.g. the concentration of wastewater in the effluent is 100 percent, or 1.00), the average concentration of effluent in this volume of ocean water is:

$$C_w^{avg} = \frac{V_e^{dschg}}{V_a^{eff}} \qquad Equation\ R-5$$

where: V_a^{eff} = volume of ambient water containing 30-days of discharged effluent

V_e^{dschg} = volume of effluent discharged during the 30-days is given by $V_e^{dschg} = Q \cdot T$

Q = volumetric discharge rate of effluent (m^3/sec)

T = elapsed time (30 days ≈ 2.6×10^6 sec)

C_w^{avg} = average concentration of effluent in the volume V_a^{eff}

Under the conservative assumption that the receiving water in the entrainment region of the water column near the outfall diffuser always contains previously discharged effluent at this concentration, the effective initial dilution associated with the volumetric initial dilution S_e becomes:

$$S_e = \frac{(1 - S_a^*) \cdot S_a^*}{C_w^{avg} \cdot S_a^* + 1} \qquad Equation\ R-6$$

where: S_a^* = the *California Ocean Plan*-defined initial dilution, computed as $S_a^* = S_a - 1$, where S_a is the EPA-defined initial dilution

If the average concentration of effluent in the entrained receiving water, C_w^{avg}, is much less than the initial concentration of effluent in the wastefield in the absence of any re-entrainment, C_w^{o}, then:

$$S_e \cong \left[\left(1 - C_w^{avg}\right) \cdot S_a^*\right] \cdot \left[1 - C_w^{avg} \cdot S_a^*\right] \approx \left(1 - C_w^{avg}\right) \cdot S_a \qquad Equation\ R-7$$

Under these conditions, the 30-day average effective initial dilution is approximately equal to the average of the individual dilutions occurring during the 30-day period, weighted by the factor $(1 - C_w^{avg})$.

Volumetric Estimations. The primary task then is to estimate the volume of ambient water that contains effluent discharged during the previous 30-days. This volume reflects the effects of the ocean currents, oceanic mixing, temporal fluctuations in the depth of isopycnal surfaces in the water column, and variations in the initial position of the wastefield in the water column.

The calculation begins by estimating the longshore extent of this volume (the principal direction of transport). The approach follows the method described in Hendricks, 1992. The first step is to separate the longshore component of the ocean currents into two parts: (1) a net current and (2) fluctuations about the net flow.

$$V_x(t) = V_x^o + V_x^*(t) \qquad \textit{Equation } R-8$$

where:
$V_x(t)$ = longshore component of the ocean current at time, t
V_x^o = longshore component of the net current
$V_x^*(t)$ = longshore component of the current fluctuations about the mean value at the time, t

If there are no fluctuating currents ($V_x^*(t)=0$), then the longshore length of the volume containing the previous 30 days of discharge is simply $L_x = V_x^o \tau$, where $\tau = 30$ days. On the opposite extreme, suppose that the net current is zero, $V_x^o = 0$, but the variable part of the current carries water 50 km upcoast during the 15 days, then reverses and moves 15 km back downcoast. Now the longshore length of the volume containing 30 days of discharge is 50 km. In general, the longshore currents will consist of a net flow plus fluctuations of various time-scales superimposed on the net flow. A statistical approach is used to estimate the longshore transport associated with this mixture of flows.

Suppose first that the currents in the longshore direction have no net flow ($V_x^o = 0$). If the wastefield is represented by a series of contiguous segments, the distribution of the centers-of-mass of these segments will depend on the characteristics of the variations in the longshore currents. These fluctuations can be represented by a series of cosine functions:

$$V_x^*(t) = \sum_{i=1}^{N/2} V_{x_i} \cdot \cos(\omega_i \cdot t + \varphi_i) \qquad \textit{Equation } R-9$$

where:
V_{x_i} = longshore component of the fluctuations in the currents associated with the angular frequency ω_i
ω_i = angular frequency associated with the period, $T_i = 2\pi f_i = 2\pi/T_i$

φ_i = phase associated with the fluctuation at period T_i
N = number of current measurements during the time τ
T_i = $i \cdot \Delta t$, *where* $\Delta t = \tau / N$

Assuming that the measured currents are representative of the currents everywhere within the area of interest (progressive vector hypothesis), the position of a wastefield segment at a time *t* (= *n*·Δ*t*), after it was formed is:

$$x(t) = \int_0^t V_x^*(t')dt' \cong \sum_{i=n}^{N/2} \frac{-vx_i}{\omega_i} \cdot \sin(\omega_i \cdot t \cdot \varphi_i) + \int_0^{n\Delta T} \sum_{i=1}^{n-1} vx_i \cdot \cos(\omega_i \cdot t' \cdot \varphi_i)dt' \qquad Equation\ R-10$$

The first summation term of Equation R-10 represents the movement associated with fluctuations characterized by periodicities equal to or shorter than the elapsed time, *t*. The second summation term of Equation R-10 represents the motions associated with fluctuations with periodicities longer than this time. During the elapsed time, *t*, these motions appear to be associated with fluctuations about the net velocity, but without the cyclical characteristics of the motions associated with the initial summation term of the equation.

Each wastefield segment has a different beginning time associated with it. These differences in starting time can be accommodated by a change in the phase angles, φ_I (this is analogous to constructing an ensemble of motions by randomizing the phase angle - Hendricks, 1978; Koh, 1988). If each component in the cosine series can be considered as independent (Hendricks, 1975), then a measure of the distribution of the positions of the centers-of-mass of the wastefield segments is the variance of this series:

$$VAR_x^* = \sum_{i=n}^{N/2} \left(\frac{vx_i}{\omega_i}\right)^2 + (n \cdot \Delta t)^2 \cdot \sum_{i=i}^{n-1} (vx_i)^2 \qquad Equation\ R-11$$

The variance of a uniform distribution of half-width, W_2, is:

$$VAR = \frac{1}{2}(W_2)^2 \qquad Equation\ R-12$$

where: σ_x = standard deviation
W_2 = $\sqrt{2} \cdot \sigma_x$

The width of this distribution is related to the temporal properties of the currents by the relationship:

$$(W_2)^2 = 2 \cdot \left\{ \sum_{i=n}^{N/2} \left[\frac{vx_i}{\omega_i}\right]^2 + (n \cdot \Delta t)^2 \cdot \sum_{i=1}^{n-1} (vx_i)^2 \right\} \qquad Equation\ R-13$$

In the occurrence of a net flow V_x^{o}, a systematic shift will occur in the center of mass of each wastefield segment by an amount equal to $V_x^{o} \cdot i\ \Delta t$. Thus, the total (statistical) length of the region occupied by effluent discharged during the 30-day period is:

$$L_x \ = \ \sqrt{2} \cdot \sqrt{0.5 \ \cdot (V_x^o \ \cdot \ \tau)^2 + \ VAR_x^*} \qquad Equation\ R-14$$

The same approach can be applied to the cross-shore flows. However, since all the net flow was attributed to the longshore component, the width of the distribution in the cross-shore direction is limited to the standard deviation of the fluctuations in this direction:

$$L_y = 2 \ \cdot \ \sqrt{2 \ \cdot \ VAR_x^*} \qquad Equation\ R-15$$

It is noted, however, that there will be lateral (oceanic) mixing even in the absence of measured fluctuations in the cross-shore component of the currents. The variance associated with this mixing (assuming a diffusion velocity representation) is:

$$VAR_{diff-vel} \ = \ \sigma^2_{diffuser} + \ (v_{diff} \ \cdot t)^2 \qquad Equation\ R-16$$

where: $\sigma_{diffuser}$ = variance associated with the initial width of the wastefield at the conclusion of the initial dilution
v_{diff} = diffusion velocity (cm/sec)
t = elapsed time (seconds)

As documented in Appendix T (Analysis of Ammonia), this representation provides a good description of the subsequent dilution of ammonia in the wastefield generated by PLOO for a diffusion velocity of 1 cm/sec. Similar values have been reported in measurements at a variety of other oceanographic sites (Okubo and Pritchard, 1969; Okubo, 1970).

If the lateral mixing is a process independent of the fluctuating currents in the cross-shore direction, the width of the distribution for the 30-days of discharged effluent would be:

$$L_y = 2 \ \cdot \ \sqrt{2 \ \cdot (VAR_{diff-vel} + \ VAR_y^*} \qquad Equation\ R-17$$

However, the measured fluctuations in the cross-shore component of the ocean currents may be responsible for some of the lateral mixing. Therefore, the (conservative) assumption was adopted so that the lateral (cross-shore) width of the distribution was equal to the larger of the variances associated with lateral diffusion *or* the cross-shore current fluctuations:

$$L_y = 2 \ \cdot \ \sqrt{2 \ \cdot MAX(VAR_{diff-vel}, VAR_y^*)} \qquad Equation\ R-18$$

The area of the ellipse containing the discharged effluent is:

$$AREA = \pi \cdot \left(\frac{L_x}{2}\right)\left(\frac{L_y}{2}\right) \qquad Equation\ R-19$$

Wastefield Thickness. The thickness of the wastefield is estimated in a similar manner. Factors contributing to the effective thickness include:

- the mean thickness of the wastefield,
- variation about the mean thickness,
- variation in the level of minimum dilution in the water column,
- vertical movements of isopycnal surfaces due to internal tides, internal waves, and upwelling and downwelling, and
- vertical mixing.

Thus, the thickness of the uniform concentration layer containing the 30-days of discharged effluent is:

$$H_{eff} = 2\sqrt{2} \cdot \sqrt{(H_w/2)^2 + \sigma_w^2 + \sigma_h^2 + \sigma_I^2 + 2 \cdot \sigma_v^2} \qquad Equation\ R-20$$

where: H_w = mean thickness of the wastefield (m)
σ_w = standard deviation in the thickness of the wastefield (m)
σ_h = standard deviation in the height-of-rise to the level of minimum dilution (m)
σ_I = standard deviation of the vertical motion of the isopycnal surfaces (m)
σ_V = standard deviation of the vertical spreading associated with vertical mixing (m)

The standard deviation associated with vertical mixing is related to the vertical diffusivity by the equation:

$$\sigma_v^2 = 2 \cdot k_z \cdot \tau \qquad Equation\ R-21$$

where: k_z = vertical diffusivity (m^2/sec)

R.3 INPUT DATA

Currents. Current meter data from Mooring C5 during 1990 and 1991 (see Appendix P, Oceanography) are used in this re-entrainment analysis. These measurements were made in the vicinity of the new outfall diffusers, but prior to its construction. The mean height-of-rise to the level of minimum dilution for a discharge of 205 mgd is about 26.6 meters, thus the mean depth to the level of minimum dilution is about 67 meters. Currents were measured at depths of 20, 40, 60, and 80 meters at C5. Therefore, the average effluent concentration was computed in the ambient water using the records collected depths of 60 and 80 meters. A linear interpolation was used to estimate the ambient effluent concentration at a depth of 67 meters.

Each cosine series representing a time-series of current measurements was constructed using a power-of-2 fast Fourier transform. Because of this, none of the periods in the series precisely matched a period of 30 days. Therefore, the variances associated with the fluctuations in the longshore and cross-shore currents were computed for each time-series for durations that were shorter and longer than 30 days. Variances for durations of 30 days or more were estimated by interpolation.

The measurements at the 60 and 80 meter depths were subdivided into seasons since the properties of the currents can change with season as well as depth. The months of January, February, and March were grouped together, since this period was the period of lowest predicted initial dilutions (see Appendix Q, Initial Dilution Simulation Models). The January-March group is labeled as winter, and the months of April, May, and June were designated as spring. Similarly, the months of July, August, and September were designated as summer, and October, November, and December were designated as the fall season. The measurements at the 60 and 80 meter depths at Mooring C5 for the spring and fall periods contained data gaps that were too long to be reliably estimated from the prior and following sections of the time-series. Therefore, the measurements collected at a depth of 60 meters at Mooring C4 (lying inshore in 87 meters of water) were used for these two periods. The measurements at a depth of 77 meters at Mooring C4 were too close to the bottom to be used as a reliable estimator of the currents at typical wastefield depths above the bottom. Thus only the concentration of effluent at a depth of 60 meters could be estimated for these two periods.

Although the net current was not always aligned with the longshore axis, it was assumed that the net flow was in this direction. Since it will be shown that the length of the ellipse (longshore axis) containing the discharged effluent is greater than its width (cross-shore), this assumption has the conservative effect of underestimating the area of the ellipse, and hence overestimating the ambient effluent concentration. The net flows and variances associated with each current meter and season are summarized in Table R-1 (page R-10).

Lateral Diffusion. In Appendix S (Dissolved Oxygen Demand), it was demonstrated that lateral mixing could be described with a diffusion velocity representation using a diffusion velocity of 0.01 m/sec (1 cm/sec). A diffusion velocity of 0.005 m/sec was used for the re-entrainment simulations. The motivation for this reduced velocity was that the inshore spreading of the wastefield resulting from oceanic mixing may be limited by the presence of the coastal boundary.

Effective Wastefield Thickness. The mean height-of-rise of the wastefield was about 26.6 meters for a discharge of 205 mgd (see Appendix Q, Initial Dilution Simulation Models). The *California Ocean Plan* requires that the initial dilutions be calculated without any enhancement from the currents (i.e., by setting the speed of the currents at zero in the simulations). For weak currents, the mean initial thickness of the wastefield is about 10 percent greater than the height-of-rise to minimum dilution (Roberts et al., 1989), or about 29.4 meters.

The height-of-rise of the wastefield to the level of minimum dilution varies roughly uniformly between about 20.2 meter (10-percentile) and 33.4 meter (90-percentile), hence the standard deviation, σ_H, is about 3.3 meters. The corresponding standard deviation for variations in the thickness of the wastefield is 3.7 meters.

Table R-1
Current Velocity Input Data

Mooring	Depth (meters)	Year	Season	Current Speed (cm/second)			Days
				V_{net}	Standard Deviation V_x	Standard Deviation V_y	
5	60	1990	Winter	4.9	28.0	10.7	42.7
5	60	1990	Winter	4.9	17.4	8.2	21.3
5	80	1990	Winter	6.5	32.0	11.0	42.7
5	80	1990	Winter	6.5	17.7	6.3	21.3
5	60	1991	Winter	2.1	34.9	14.4	42.7
5	60	1991	Winter	2.1	27.6	10.6	21.3
5	80	1991	Winter	1.3	31.0	9.1	42.7
5	80	1991	Winter	1.3	18.7	3.1	21.3
4	60	1990	Spring	3.5	42.8	12.6	42.7
4	60	1990	Spring	3.5	20.0	5.2	21.3
5	60	1990	Summer	2.0	29.4	11.4	42.7
5	60	1990	Summer	2.0	20.9	6.3	21.3
5	80	1990	Summer	0.8	31.3	9.6	42.7
5	80	1990	Summer	0.8	20.4	7.1	21.3
4	60	1990	Summer	2.1	25.4	6.6	42.7
4	60	1990	Summer	2.1	17.2	4.5	21.3
4	60	1990	Fall	3.3	23.0	4.22	21.33
4	60	1990	Fall	3.3	5.1	1.99	7.11

A vertical diffusivity of 0.125 x 10^{-4} m^2/sec (0.125 cm^2/sec) was assumed. This is one-eighth the value suggested in Appendix B of the Amended Technical Support Document. The diffusivity was reduced to reflect the presence of the ocean bottom below the wastefield, and increased density stratification above the wastefield. The standard deviation associated with vertical diffusion over a 30-day period, σ_V, is about 11.4 meters.

Isopycnal surfaces (as indicated by isotherms) undergo vertical motions as the result of internal tides and internal waves. These oscillations introduce wastewater into different density layers of the water column at semi-diurnal and diurnal frequencies. The horizontal length-scales corresponding to tidal excursions are on the order of a kilometer, or less. Therefore, the horizontal length-scales characterizing the packets of wastewater within the various density layers are on the order of 0.5 km, or less. Horizontal oceanic mixing rapidly spreads these relatively small-scale packets to fill in the gaps.

The strings of thermistors at Moorings T2 through T5 measured internal tide associated root-mean-square (rms) vertical excursions of isotherms (contours of constant water temperature) of 4.2 meters during 1990, and 6.6 meters during 1991 (see: Appendix P, Oceanography). These magnitudes were used for the standard deviations of the vertical motions of the isopycnal surfaces, σ_I. This is a conservative assumption since it ignores the effects of the vertical motions of comparable, or larger, magnitude that occurred over time-scales of days to weeks (e.g., associated with upwelling and downwelling).

Discharge Flux. A flow of 205 mgd (maximum average flow during the five year waiver period) was used for the calculations. This corresponds to a flow of about 9 m^3/sec, or a volume of 1.3 x 10^8 m^3 over the 30-day period.

R.4 RESULTS

The average ambient water concentrations in the 30-day ellipse are summarized for each season and depth in Table R-2 (page R-12). As noted earlier, current meter data for the spring and fall seasons were only available for measurements made at a depth of 60 meters at Mooring C4.

To compare estimates based on the measurements at the moorings, the ambient background effluent concentrations were computed for the summer season using the data from Moorings C4 and C5. This comparison showed that the ambient background concentration for the summer period, based on the current data recorded at Mooring C4, was comparable with the concentration estimated from data collected at the same depth at Mooring C5.

Table R-2
Ambient Effluent Concentrations

Mooring	Depth	Season	Year	Concentration of Effluent in the Waste Field[1]	
				205 mgd PLOO Discharge	240 mgd PLOO Discharge
5	60	Winter	1990	0.00022	0.00026
5	80	Winter	1990	0.00017	0.00020
5	60	Winter	1991	0.00032	0.00038
5	80	Winter	1991	0.00055	0.00064
4	60	Spring	1990	0.00029	0.00034
5	60	Summer	1990	0.00045	0.00053
5	80	Summer	1990	0.00038	0.00044
4	60	Summer	1990	0.00045	0.00053
4	60	Fall	1990	0.00031	0.00036

1 Ratio of discharged effluent to ambient water in the waste field (e.g. pure wastewater equals a concentration of 1.00).

Table R-3 (page R-13) summaries the effect of re-entrainment on the volumetric initial dilutions. The median dilution values are based on the time-series data. The monthly initial dilutions are the *California Ocean Plan* initial dilutions based on the CTD data. The effects of re-entrainment on the monthly initial dilution values were estimated in the following manner:

1. The average height-of-rise to the level of minimum dilution above the diffuse port was subtracted from a water depth of 96 meters.
2. The background concentration at this depth was estimated by interpolation between the background concentrations at the 60 and 80 meter depths for the appropriate season.
3. The Equation R-6 (page R-4) was used to compute the effective initial dilution for these conditions.

The background concentration for the median initial dilution was estimated in a similar manner using the 50-percentile height-of-rise to the level of minimum dilution, and the average of the seasonal background concentrations. Overall, the effect of re-entrainment was to reduce the volumetric initial dilutions by 8.4 to 8.7 percent. The largest reductions (12.1 percent) occurred for a flow of 25 mgd in the months of July and September. The smallest reduction (4 percent) was for a flow of 205 mgd in February, using the background concentrations based on the currents in 1990.

Table R-3
Effective Initial Dilution after Re-Entrainment

Data Period	Computed Initial Dilution			
	205 mgd PLOO Discharge		240 mgd PLOO Discharge	
	Volumetric Initial Dilution	Effective Initial Dilution	Volumetric Initial Dilution	Effective Initial Dilution
Median[1]	365:1	317:1	338:1	317:1
January[2,3]	214:1	206:1	292:1	195:1
January[2,4]	214:1	195:1	292:1	185:1
February[2,3]	204:1	196:1	224:1	215:1
February[2,4]	204:1	186:1	224:1	203:1
March[2,3]	264:1	251:1	263:1	250:1
March[2,4]	264:1	238:1	263:1	237:1
April[2]	313:1	280:1	284:1	257:1
May[2]	315:1	281:1	295:1	265:1
June[2]	354:1	313:1	324:1	290:1
July[2]	325:1	286:1	320:1	282:1
August[2]	317:1	286:1	294:1	262:1
September[2]	317:1	279:1	307:1	271:1
October[2]	287:1	264:1	281:1	259:1
November[2]	264:1	244:1	249:1	231:1
December[2]	217:1	203:1	206:1	194:1

1 Time-series data (13,757 cases) with observed ocean currents.
2 CTD data with an ocean current velocity set to zero.
3 Current data from 1990.
4 Current data from 1991.

REFERENCES

Hendricks, T.J., 1975. A model of the dispersion of wastewater constituents. In: Coastal Water Resources Project Annual Report-1975. Southern California Coastal Water Resources Project, Westminster, California. p. 173-177.

Hendricks, T.J., 1978. Forecasting changes in sediments near outfalls. In: Coastal Water Resources Project Annual Report-1978. Southern California Coastal Water Resources Project, Westminster, California. p. 127-143.

Hendricks, T.J., 1992. Orange County currents. Final Report to County Sanitation Districts of Orange County, California. From: Southern California Coastal Water Resources Project, Westminster, California. February, 1992. 75 pages plus appendices.

State Water Resources Control Board (State Board). *Water Quality Control Plan, Ocean Waters of California* (*California Ocean Plan*). 2012.

United States Environmental Protection Agency (EPA). *Amended 301(h) Technical Support Document* (ATSD). 1994.

Appendix S
DISSOLVED OXYGEN DEMAND

Renewal of NPDES CA0107409

APPENDIX S

DISSOLVED OXYGEN DEMAND

Evaluation of Dissolved Oxygen Depression and Farfield Dissolved Oxygen Resulting from the Point Loma Ocean Outfall Discharge

THE CITY OF SAN DIEGO • STATE OF CALIFORNIA •
SEMPER VIGILANS

January 2015

APPENDIX S

DISSOLVED OXYGEN DEMAND

Table of Contents

List of Figures

List of Tables

List of Abbreviations

ATSD	EPA Amended 301(h) Technical Support Document
BOD	biochemical oxygen demand
°C	degrees Centigrade
California Ocean Plan	2012 *Water Quality Control Plan, Ocean Waters of California*
CBOD	carbonaceous biochemical oxygen demand
cm	centimeters
CTD	conductivity, temperature, depth
DO	dissolved oxygen
EPA	United States Environmental Protection Agency
IDOD	immediate dissolved oxygen demand
m	meters
mg/l	milligrams per liter
NBOD	nitrogen-related biochemical oxygen demand
NPDES	National Pollutant Discharge Elimination System
PLOO	Point Loma Ocean Outfall
Point Loma WWTP	Point Loma Wastewater Treatment Plant
Regional Board	Regional Water Quality Control Board, San Diego Region
ZID	zone of initial dilution

APPENDIX S
DISSOLVED OXYGEN DEMAND

Dissolved oxygen (DO) computations presented in this appendix were originally presented in the City's 1995 301(h) waiver application. Effluent concentrations of total suspended solids in the Point Loma Wastewater Treatment Plant (Point Loma WWTP) effluent have declined significantly since the original version of this appendix was prepared in 1995. Point Loma WWTP effluent BOD concentrations, however, remain similar to those used in the original 1995 DO deficit computations. Additionally, receiving water conditions addressed in the City's original 1995 301(h) application (including initial dilution, receiving water BOD, and receiving water dissolved oxygen) remain valid. For these reasons, the DO deficit computations presented in the original 1995 301(h) application (presented again herein) remain useful for identifying the maximum potential "upper bound" of DO depression that could occur in the unlikely event that a series of worst case effluent and receiving water conditions simultaneously occur.

ABSTRACT

This appendix presents calculations of the dissolved oxygen (DO) deficit due to Immediate Dissolved Oxygen Demand (IDOD) and the farfield Biological Oxygen Demand (BOD) due to the release of oxygen demanding waste materials from the Point Loma Ocean Outfall (PLOO). Methods for calculating IDOD and BOD are presented, along with corresponding input data.

The section on IDOD uses actual ambient dissolved oxygen and temperature data along with calculated initial dilution and height-of-rise-to-the-trapping-level values to determine the DO depression due to the IDOD. Results of this analysis showed that the IDOD would not depress the ambient receiving water dissolved oxygen more than 0.8 percent.

Effluent BOD can exert oxygen demand through IDOD, carbonaceous BOD, and nitrogenous BOD. Two means were used to assess PLOO outfall effects on receiving water DO. First, procedures established in the EPA Amended 301(h) Technical Support Document (ATSD) were used to calculate DO depression. Using the ATSD procedures, total DO depression caused by IDOD and BOD is conservatively estimated at 2.8 percent. Second, a time-history analysis is used to calculate theoretical initial dilution values required to depress receiving water DO concentrations by 10

percent. For critical PLOO conditions, an initial dilution of approximately 100:1 would be required to cause a 10 percent DO depression at a Point Loma WWTP BOD concentration of 114 mg/l. As documented in Appendix R, minimum month PLOO initial dilutions at a 240 mgd flow greatly exceed this 100:1 value, and typical initial dilutions for the Point Loma outfall are far in excess to the minimum dilutions required to prevent a 10 percent depression of receiving water DO.

S.1 INTRODUCTION

California Ocean Plan. The *California Ocean Plan* (State Board, 2012) requires that: "The dissolved oxygen concentration shall not at any time be depressed more than 10 percent from that which occurs naturally, as the result of the discharge of oxygen demanding waste materials." Mathematically, this is expressed as:

$$\frac{\Delta DO(z_{m)}}{DO_a(z_m)} \leq \; 0.10 \qquad Equation\ S-1$$

where: $\Delta DO(z_m)$ = dissolved oxygen depression due to the oxygen demand of discharged waste at the depth, $z_{m,}$ and

$DO_a(z_m)$ = concentration of dissolved oxygen in the ambient water at the depth z_m.

The oxygen depressions associated with the oxygen demand of the wastewater are proportional to the concentrations of the effluent IDOD, the effluent BOD in the wastefield, and the difference between the DO concentration in the ambient receiving water and in the effluent. The magnitudes of the depressions associated with each of these factors are proportional to their respective concentrations in the plume/wastefield. The latter are inversely proportional to the volumetric initial dilution, S_a:

$$\frac{\Delta DO}{DO_a} \propto \left\{\frac{IDOD, BOD}{DO_a \times S_a}\right\} \qquad Equation\ S-2$$

Dissolved Oxygen - Critical Period. As part of pre-construction studies of ocean conditions for the PLOO outfall extension, time-series of initial dilutions were calculated from corresponding time-series measurements of the ocean currents and the density stratification of the water column (see Appendix Q - Initial Dilution). Minimum DO concentrations monitored over several years were superimposed on computed initial dilutions during critical periods to create a paired DO/stratification data base. Using a conservative approach, the period of most critical DO depression was estimated by assuming that the minimum ambient DO (as measured in a specific month from several years of data collected from hydrographic surveys), may occur simultaneously with the minimum initial dilution for that month. This is a conservative assumption since it is unlikely that both extremes will occur simultaneously. (Available hydrographic data and initial dilution simulations suggest that the two quantities are negatively correlated, i.e., warm water temperatures are associated with low initial dilutions but higher ambient dissolved oxygen concentrations.).

City of San Diego monitoring data collected in the vicinity of the Point Loma outfall between 1991 and 1994 were used to identify the minimum DO concentrations for each month.

DO concentrations at a depth of 82 meters (270 feet) were used since this depth approximately corresponds to the layer of minimum dilution within the wastefield (i.e., the "centerline" of the wastefield for the smallest initial dilutions). Normalized values (based on the minimum value) of the product of the minimum initial dilution and the minimum DO for each month, are shown in Table S-1. As shown in Table S-1, the critical period for DO depression is January through April. (Subsequent DO monitoring by the City continue to show that the January through April months have the lowest DO concentrations at depth. (See Figure II.B-1 in the Large Applicant Questionnaire, Volume II.)

Table S-1
Ranking of Months for Critical DO Period

Month	Relative Value[1]	Rank
January	1.159	4
February	1.000	1
March	1.004	2
April	1.021	3
May	1.214	6
June	1.171	5
July	1.988	8
August	1.223	7
September	2.057	9

[1] $(DO_{min} \text{ x } Sa_{min}) / (DO_{min\text{-}Feb} \text{ x } Sa_{min\text{-}Feb})$

S.2 IMMEDIATE DISSOLVED OXYGEN DEMAND (IDOD)

The dissolved oxygen calculation was carried out using the method described on pages B-14 to B-18 in the ATSD. The dissolved oxygen concentration following initial dilution can be predicted using the following equation (Equation B-6 from the ATSD):

$$\Delta DO\% = DO_a + \frac{DO_e + IDOD + DO_a}{S_a} \qquad Equation\ S - 3$$

where: DO_f = Final dissolved oxygen concentration of receiving water (mg/l) at the plume trapping level,

DO_a = Affected ambient dissolved oxygen concentration (mg/l) immediately up current of the diffuser averaged over the tidal cycle (12.5 hours) and from the diffuser port depth to the trapping level,

DO_e = Effluent dissolved oxygen (mg/l),

$IDOD$ = Immediate dissolved oxygen demand (mg/l),

S_a = Flux averaged initial dilution, and

DO_p = Ambient dissolved oxygen (mg/l) at diffuser port depth (93 meters).

The percent depression of dissolved oxygen due to wastewater is given by Equation B-9 of the ATSD, as follows:

$$\Delta DO\% = 100 \cdot \frac{DO_t - DO_e + IDOD}{DO_t \cdot S_a} \qquad Equation\ S-4$$

where: DO_t = Ambient dissolved oxygen concentration (mg/l) at the trapping level

The IDOD is a difficult value to measure because the chemical test often gives unreliable answers. As a result of this inconsistency, *Standard Methods for the Examination of Water and Wastewater* has eliminated the IDOD test since the 14th edition (1975). Based on PLOO travel times and BOD_5 values, the ATSD (Table B-3) recommends use of IDOD values of 3 to 4 mg/l. Testing performed on the PLOO effluent during 1994 yielded IDOD values ranging from 0.45 to 1.74 mg/l, and no IDOD testing has occurred since that date. (See response to Large Applicant Questionnaire Section II.B.4(b) in Volume II.) To be conservative, the 4 mg/l EPA-recommended value is used in the DO depression calculations in lieu of the lower IDOD values measured in 1994.

Final dissolved oxygen (DO_f) concentrations were calculated using conductivity, temperature, density (CTD) data collected by Engineering-Science during 1990-1991. These data remain valid, and are appropriate for use in assessing DO depression because the data were collected before the extended PLOO was constructed (and thus observed ambient DO concentrations are not influenced by the PLOO discharge).

To ensure that dissolved oxygen values for the lowest initial dilution periods were properly correlated with depth, temperatures recorded at both the port and calculated trapping level were noted. These temperatures were then referenced using the CTD data to get the dissolved oxygen at those depth positions and points in time. Because of internal tides, the DO as measured by the depth can vary rapidly in time, and comparing DO directly to the depth of the trapping level would lead to erroneous results. On the other hand, since temperature and dissolved oxygen do not vary rapidly in time, referencing DO to temperature is preferred.

Table S-2 presents the correlated initial dilution, DO, and temperature data used in the DO depression computation. Using Table S-2, given water temperatures for the port and trapping level on a given calendar day, one can reference these to DO values at the two levels. The ambient dissolved oxygen (DO_a) becomes the DO, "...averaged...from the diffuser port depth to the trapping level", as suggested in the ATSD. The ATSD lists two additional requirements in the definition of DO_a. The first requirement, that the "...dissolved oxygen concentration [be measured] immediately up current of the diffuser..," is met because the CTD data measurements were taken before the outfall was extended. The second, where the DO is "... averaged over the tidal cycle (12.5 hours)...," is met by tagging the DO with temperature, as discussed above, to remove the variability with depth.

Table S-2
Summary of Initial Dilution
240 mgd PLOO Discharge

Date		Initial Dilution S_a	Temperature (°C)		DO (mg/l)	
			At Port	At Trapping Level	At Port	At Trapping Level
1990	Mar. 7	287	10.39	10.85	4.23	5.37
	Apr. 17	253	10.48	10.87	4.30	4.78
	May 23	230	9.72	10.24	3.65	4.47
	Jun. 20	355	9.51	10.03	5.23	5.60
	Jul. 25	238	10.90	12.21	4.35	5.20
	Aug. 29	416	10.67	11.07	5.60	6.08
	Sept. 27	409	11.32	11.55	3.99	4.68
1991	Jan. 26	275	12.20	13.14	6.60	7.15
	Feb. 7	212	10.87	11.49	4.60	5.83
	Mar. 7	260	10.23	10.68	4.15	5.00
	Apr. 7	258	9.97	10.53	3.63	5.18

Using the above data as input, Table S-3 (page S-6) presents computed DO following initial dilution for the 1990-1991 (pre-discharge) database. As shown in Table S-3, the largest DO change occurs under the February 7, 1991 conditions, where DO is reduced from 5.22 mg/l to 5.17 mg/l. The maximum observed percentage DO depression (0.8 percent) occurs for the February 7 and May 23 data points.

S.3 FAR-FIELD DISSOLVED OXYGEN DEMAND

Background. The preceding section discussed the reduction in the concentration of DO in the wastefield due to: (1) the chemical oxidation of reduced compounds in the effluent at the time of discharge and, (2) the difference in DO concentrations in the effluent and the ambient receiving water. These depressions occur during the time the initial dilution process takes place.

Organic materials in the effluent contain carbon and nitrogen that can serve as a source of energy and nutrients for bacteria. Over time, bacteria can convert this material into bacterial cells, consuming additional dissolved oxygen in the process. The amount of oxygen consumed in this process, per unit volume of effluent, is referred to as biological oxygen demand (BOD). The BOD includes both carbon-associated BOD (CBOD) and nitrogen-associated BOD (NBOD). The rates of oxygen consumption differ for CBOD and NBOD demands.

Table S-3
"Worst Case" Dissolved Oxygen Immediately Following Initial Dilution[1]
240 mgd PLOO Discharge

Date		Initial Dilution S_a	Receiving Water Dissolved Oxygen Concentratoin[1] (mg/l)				ΔDO (%)
			DO_p[2]	DO_t[3]	DO_a[4]	DO_f[5]	
1990	Mar. 7	287	4.23	5.37	4.80	4.77	0.6
	Apr. 17	253	4.30	4.78	4.54	4.50	0.7
	May 23	230	3.65	4.47	4.06	4.03	0.8
	Jun. 20	355	5.23	5.60	5.42	5.39	0.5
	Jul. 25	238	4.35	5.20	4.78	4.79	0.7
	Aug. 29	416	5.60	6.08	5.84	5.81	0.4
	Sept. 27	409	3.99	4.68	4.33	4.31	0.5
1991	Jan. 26	275	6.60	7.15	6.88	6.84	0.6
	Feb. 7	212	4.60	5.83	5.22	5.17	0.8
	Mar. 7	260	4.15	5.00	4.58	4.54	0.7
	Apr. 7	258	3.63	5.18	4.41	4.37	0.7

1 Based on simultaneous occurrence of the following worst case conditions: PLOO discharge flow of 240 mgd, Point Loma WWTP effluent IDOD of 4.0 mg/l, Point Loma WWTP effluent dissolved oxygen concentration of zero, and minimum month PLOO initial dilution of 204:1. Actual receiving water DO concentrations would be expected to be greater than the "worst case" scenarios described above.

2 DO_p is the ambient dissolved oxygen at the diffuser port depth (93 meters).

3 DO_t is the ambient dissolved oxygen concentration at the trapping level.

4 DO_a is the affected ambient dissolved oxygen concentration immediately up current of the diffuser averaged over the tidal cycle (12.5 hours) and from the diffuser port depth to the trapping level.

5 DO_f is the final dissolved oxygen concentration of receiving water at the plume trapping level.

The rate of consumption of each type of BOD, and the corresponding rate of demand of dissolved oxygen, can be represented by a first-order rate equation:

$$\frac{d(C_{BOD})}{dt} = -k \cdot C_{BOD} = \frac{d(DO)}{dt} \qquad Equation\ S-5$$

where: C_{BOD} = concentration of either type of BOD (mg/l)
k = first-order decay rate for the corresponding material (e.g., day^{-1})

While the depressions associated with the IDOD and the difference between the DO concentrations in the ambient water and the effluent are established by the time the initial dilution process is finished, the reduction associated with the BOD occurs as the wastefield is carried away by the ocean currents. The magnitude of this reduction depends on the BOD demand of the effluent, the rate at which this demand occurs, and the amount of dissolved oxygen available in the wastefield. The rate of oxygen demand varies with water temperature through the decay rate, k (which increases with increasing temperature), and the concentration of BOD. The latter declines with the passage of time, as the materials associated with the BOD are converted into bacterial cells. Meanwhile, the amount of dissolved oxygen available in the wastefield increases with the passage of time due to mixing of the wastefield with the surrounding ambient water. As a result of these competing processes, the dissolved oxygen reduction reaches a maximum at some time after completion of the initial dilution process.

Approach and Methodology. The time-dependent dissolved oxygen deficiency in the wastefield due to oxygen demanding wastewater materials, ΔDO_w, is:

$$\Delta DO_w = DO_w(t) - DO_t = -\left\{\frac{\Delta O_2^{eff} + \Delta O_2^{IDOD} + \Delta O_2^{BOD}(t)}{D_s(t)}\right\} \qquad Equation\ S-6$$

where: $DO_w(t)$ = dissolved oxygen concentration in the wastefield at the time, *t* (mg/l)
DO_t = dissolved oxygen concentration in the ambient surrounding water at the wastefield depth (mg/l)
ΔO_2^{Eff} = dissolved oxygen reduction due to the difference between the DO concentration in the effluent and the DO concentration in the ambient water [e.g. $(DO_e\text{-}DO_t)/S_a$]
ΔO_2^{IDOD} = dissolved oxygen demand due to effluent IDOD (mg/l)
$\Delta O_2^{BOD}(t)$ = dissolved oxygen demand at time, t, due to the effluent BOD (mg/l)
$D_s(t)$ = subsequent dilution of the wastefield due to oceanic mixing

The above equation does not include the effects of the entrainment of deeper, colder, ambient water, with lower DO values, into the plume. These effects are excluded from the requirements of the *California Ocean Plan*. In keeping with the example in the section on IDOD (equation B-9,

Appendix B, ATSD), the calculations are carried out as though the concentration of ambient DO entrained into the plume during initial dilution is the same as at the trapping level (i.e., $DO_a = DO_t$).

The quantities ΔO_2^{Eff} and ΔO_2^{IDOD} were calculated in the preceding section for an annual average discharge rate of 240 mgd. In combination, they varied from about 0.03 to 0.06 mg/l at the completion of the initial dilution process (for the lowest monthly initial dilution and the lowest monthly ambient dissolved oxygen concentrations).

The oxygen consumption associated with the BOD of the wastewater in the wastefield, $\Delta O_2^{BOD}(t)$ is obtained by integration of the rate equation for oxygen consumption (presented above) for the carbon- and nitrogen-associated BOD:

$$\Delta O_2^{BOD} = \Delta CBOD_L \cdot (1 - e^{-k_C t}) + \Delta NBOD_L \cdot (1 - e^{-k_N t}) \qquad Equation\ S-7$$

where:

$\Delta CBOD_L$ = carbon-associated BOD concentration (above ambient) at completion of the initial dilution (mg/l)

$\Delta NBOD_L$ = nitrogen-associated BOD concentration (above ambient) at completion of the initial dilution (mg/l

k_C = decay rate for carbon-associated BOD (day-1)

k_N = nitrification rate coefficient (day-1)

t = elapsed time since completion of initial dilution (days)

A solution to the equation for ΔDO_w requires information on the parameters, IDOD, $\Delta CBOD_L$, $\Delta NBOD_L$, k_C, k_N, and the time-dependent subsequent dilution, $D_s(t)$. Conservative estimates for each of these parameters are presented below.

Initial Dilution. The concentration of CBOD and NBOD in the wastefield, and the magnitude of the DO reduction associated with the instantaneous oxygen demand (IDOD), are related to the concentration of CBOD, NBOD, and IDOD in the effluent and the flux-averaged initial dilution. The results of simulations of the initial dilution achieved by the PLOO diffuser system are discussed in detail in Appendix Q. The lowest initial dilutions were associated with the period from January through March, and the highest initial dilutions occurred in the late summer to early fall.

A total of 13,757 simultaneous measurements of ocean currents and density structure of the water column (through the water temperatures) were made between January and March, 1991, and March and September, 1990. Although ambient currents were recorded simultaneously with the density structure information, the current speed was set equal to zero in calculating the initial dilutions (as required by the *California Ocean Plan*). The initial dilutions calculated from this data set were used for the IDOD calculations above. The 30-day average monthly initial dilutions for an annual average discharge rate 240 mgd are summarized in Table S-4 (page S-9).

The number of density profiles used in this initial dilution simulation is roughly two orders of magnitude (or more) greater than the number often available for initial dilution calculations. Therefore, the probability of the present data set containing rarely occurring instances of high stratification (resulting in low initial dilutions) is significantly greater. A five percentile initial dilution value of 200:1 (see Table Q-7 in Appendix Q) for the 240 mgd PLOO discharge is close to the 204:1 minimum month regulatory initial dilution assigned in Order No. R9-2009-0001.

Table S-4
Regulatory 30-Day Average Initial Dilutions - Zero Ocean Currents
240 mgd PLOO Discharge

Data Set	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
TS[1] (1990-91)	227	227	267	285	260	304	341	294	359
CTD[2] (1990-1994)	202	224	263	284	295	324	320	294	307

1 Data obtained from time-series measurements.
2 Data obtained from hydrocasts.

Effluent Biological Oxygen Demand (BOD). Point Loma WWTP effluent BOD concentrations during 2013 averaged 115 mg/l. To be conservative, a higher effluent BOD concentration of 121 mg/l (the 70th percentile value for Point Loma WWTP effluent BOD during 2013) was used in the DO depression computations.

Initial Effluent CBOD and NBOD Concentrations in the Wastefield. BOD measurements are normally measured as the oxygen consumed over a period of five days (BOD_5). To estimate CBOD and NBOD, thirteen days of measurements of BOD_5 and $CBOD_5$ (i.e., with nitrification inhibited) were conducted on the Point Loma WWTP effluent between June 1 and July 27, 1992. This data were used to estimate the ratio of nitrogen-associated BOD_5 ($NBOD_5 = BOD_5 - CBOD_5$) to total BOD_5. Observed ratios ranged from 2.2 percent to 27.6 percent (median: 11 percent; average: 12.4 " 8.8 percent).

The decay rate (see discussion on page S-10) for carbon (k_C) exceeds the nitrification rate (k_N). At the same time, the ratio of ultimate CBOD ($CBOD_L$) to $CBOD_5$ is greater than the ratio of ultimate NBOD ($NBOD_L$) to $NBOD_5$. Therefore, the greatest oxygen demand, per unit BOD_5, will occur for the lowest ratio of $NBOD_5$ to BOD_5.

To conservatively estimate the maximum possible oxygen demand, it was assumed that the $CBOD_5$ is 97.8 percent of the total BOD_5 of the effluent, and the $NBOD_5$ is 2.2 percent of the total BOD_5. Thus the maximum $CBOD_5$ is estimated to be 118.3 mg/l (121 x 0.978), and the corresponding $NBOD_5$ is estimated to be 2.7 mg/l.

The next step is to convert the 5-day BOD values into the corresponding ultimate BOD concentrations (i.e., at the completion of the conversion process to bacterial cells). Thomann and Mueller (1987) estimated the ratio of the ultimate carbon-associated BOD ($CBOD_L$) to $CBOD_5$ for primary effluent to be 2.84. This conversion factor was used for the calculations, yielding an ultimate CBOD of 336 mg/l (118.3 x 2.84). Thomas and Mueller also estimated the corresponding ratio for nitrogen-based BOD to be 2.54. Hence, an ultimate NBOD ($NBOD_L$) of 6.8 mg/l (2.7 x 2.54) was used in the calculations.

BOD Decay Rates. The decay rate for CBOD (k_C) can be estimated from the equation (from: Equation B-13, Appendix B, ATSD):

$$k_c = 0.23\ \Theta_c^{(T-20)} \qquad Equation\ S-8$$

where: T = wastefield temperature in degrees Celsius
Θ_c = temperature correction factor

Fair et al. (1968) suggest Θ_C values of 1.15, 1.11, and 1.047 for temperatures of 5, 10, and 20 degrees Celsius, respectively. These three pairs of values were represented by a second-order polynomial to estimate the decay coefficient at intermediate water temperatures. At a water temperature of 12.5°C, the value for Θ_C is estimated to be 1.092. The corresponding value for the decay coefficient, k_C, is then 0.119 day^{-1}, or 0.00495 hr^{-1}.

The corresponding equation for NBOD (from: Equation B-15, Appendix B, ATSD) is:

$$k_n = 0.1\ \Theta_N^{(T-20)} \qquad Equation\ S-9$$

A value of $\Theta_N = 1.08$ is valid for temperatures between 10 and 30 °C (Appendix B, ATSD). At a temperature of 12.5 degrees, the nitrification rate becomes 0.0561/day, or 0.00234/hour.

Water Temperature. As noted earlier, the lowest initial dilutions in the DO/initial dilution database period occurred during January to March, 1991 (3,858 cases). This subset was then sorted by the magnitude of the dilution for the calculation of the decay rates (decay rates are temperature dependent). A second subset was created from this sorted subset, by selecting only the cases with values within 20 percent of the lowest initial dilution.

The average ambient water temperature at the wastefield depth for this set of low initial dilutions was 11.70 °C. The highest temperature was 12.57 °C; the lowest temperature, 10.81 °C. A temperature of 12.5 °C was used to compute the rate constants for the oxygen depressions associated with effluent BOD. This is a conservative assumption, since the water temperature at any depth in the wastefield will be lower than the ambient water temperature at the same depth outside the wastefield.

Ambient BOD. The BOD of the ambient waters is sufficiently low so that the measured values are within the range of error of the measurement. For the purposes of the dissolved oxygen reduction calculations, we assumed it to be zero (this demand is normally satisfied by vertical diffusion of oxygen in the water column). Therefore, the $\Delta CBOD_L$ and $\Delta NBOD_L$ in the preceding equation can be considered to be equal to the effluent $CBOD_L$ and $NBOD_L$ after initial dilution.

Dissolved Oxygen at the Completion of Initial Dilution. The oxygen demand due to the instantaneous dissolved oxygen (IDOD) of the effluent and the entrainment of ambient receiving water during the initial dilution process was discussed in the preceding section of this appendix. These values were used as the dissolved oxygen initial conditions in the calculation of the temporal evolution of dissolved oxygen in the wastefield with the passage of time.

Subsequent Dilution. Horizontal mixing (e.g., along surfaces of constant water density) takes place in the ocean due to turbulent diffusion (from the combination of molecular diffusion and shear in the currents). The process is commonly referred to as dispersion. Current shear is associated with eddies present in the flow field. The most effective mixing of a patch of water with the water surrounding it is associated with the set of eddies with dimensions that range up to the size of the patch. These eddies tend to break down the original patch into ever smaller patches, until the relatively weak process of molecular diffusion becomes effective. On the other hand, eddies with dimensions larger than the patch tend to advect it as a unit rather than producing mixing. The end result is that if turbulent eddies covering a wide range of dimensions are present in the ocean, the eddy diffusivity describing the mixing will increase as the dimension of the dispersed patch grows. Thus the range of eddy dimensions (length-scales) present in the ocean, and the distribution of kinetic energy among eddies of various length-scales, will determine the characteristics of the eddy diffusivity.

The square-root of the spatial variance (i.e., the standard deviation, σ) of a patch along an axis is often used as a measure of its "dimension" along that axis. If all the eddies present in the area of the patch have dimensions that are smaller than the dimension of the patch, the eddy diffusivity will remain constant in magnitude as the patch dimensions increase. For a patch with initial variance $\sigma^2(0)$ the variance of the patch grows linearly with time:

$$\sigma^2(t) = \sigma^2(0) = 2K_H \cdot t \qquad Equation\ S-10$$

where: $\sigma^2(t)$ = variance (e.g., m^2) of the patch at the time t (e.g., sec)
K_H = horizontal eddy diffusivity (e.g., m^2/sec)

Diffusion characterized by a constant diffusivity is often referred to as Fickian diffusion (it is characteristic of molecular diffusion). However, in the ocean the "diffusivity" associated with the current eddies greatly exceeds that associated with molecular diffusion.

If the range of eddy dimensions is always greater than the dimensions of the patch (at any time during the period of interest), and if the energy input supporting the eddies is supplied to the eddies with the largest dimensions, the rate of growth of the patch dimensions will be proportional to the three-halves power of the time (the variance increases as the cube of the time). This leads to an eddy diffusivity that is proportional to the four-thirds power of the dimensions of the patch, giving rise to the so-called "four-thirds" law for eddy diffusion.

Eddies associated with conditions that lie between these two extremes, or different assumptions about the dynamics of the mixing process, can give rise to other patch growth rates. Okubo and Pritchard (1969) and Okubo (1970) note that in coastal waters, the dimensions of a patch are frequently observed to grow linearly with time. Okubo (1970) observed that this apparent growth rate may be associated with the input of energy into eddies at specific length-scales (e.g., corresponding to the dimensions of the tidal ellipse, etc.).

A linear growth rate in the patch dimensions, and a quadratic growth rate in time of its variance, can be quantified dimensionally by the introduction of a diffusion velocity (v_d). For a point patch, the variance grows as:

$$\sigma^2(t) = (v_d \cdot t)^2 \qquad Equation\ S-11$$

Measurements at a wide range of locations indicate diffusion velocities are typically on the order of 1 cm/sec (Okubo and Pritchard, 1969). In general, the patches of interest will not start out at time t=0 as point patches. For example, immediately following the initial dilution process the wastefield will have some width (and corresponding variance $\sigma(0)^2$). Since the initial dilution process is independent of the oceanic mixing process, the initial and subsequent variances are statistically independent. Therefore, for a representation of diffusion velocity, they can be added to get the variance at the beginning of the wastefield (e.g. time t = 0) as follows:

$$\sigma^2(t) = \sigma^2(0) + (v_d \cdot t)^2 \qquad Equation\ S-12$$

A two dimensional patch (e.g., an ellipse) will spread in two dimensions. These are often taken as the "spreading" in the "along-current" and "cross-current" directions, since the apparent eddy diffusivities are frequently different in the two directions. The along-current diffusivity is enhanced by the presence of current shear with water depth and vertical mixing. (Okubo and Pritchard, 1969)

For a continuous discharge, however, it is the cross-current eddy diffusivity that produces most of the reduction in the concentration of wastewater in the wastefield. (This occurs because along-current gradients in wastewater concentrations are small.)

If mixing only occurs along surfaces of constant water density (i.e., vertical mixing is negligible), and if the normalized distribution of some tracer (e.g., wastewater) within a patch remains the same (e.g., a Gaussian distribution). The ratio of the concentrations of the tracer within the patch at two different times is equal to the inverse of the ratio of the dimensions of the patch at these times, as follows:

$$\frac{c(t)}{c(0)} = \frac{1}{Dilution} = \frac{\sigma(0)}{\sigma(t)} \qquad Equation\ S-13$$

where: $c(t)$ = concentration of the tracer at time "t"

Horizontal eddy diffusivity was estimated on the basis of plume tracking studies completed by Hendricks and Harding (1974) using measurements of ammonia. These measurements were made as part of a study of phytoplankton response to wastewater nutrients. At the beginning of the study, a parachute drogue was deployed at the approximate depth of the wastefield immediately downcurrent from the original Point Loma outfall (in 60 meters of water). Two auxiliary drogues were placed 300 meters away from this primary drogue perpendicular to the direction of flow. Measurements of ammonia, nitrite, nitrate, and chlorophyll-" were made at approximately 6-meter intervals between the surface and a depth of 51 meters in the water column. These profiles were measured adjacent to the primary drogue, and each of the secondary drogues, at 5 hour intervals over a period of 40 hours. It was assumed that the effects of vertical mixing were negligible, and the reduction in ammonia concentration was due to horizontal mixing.

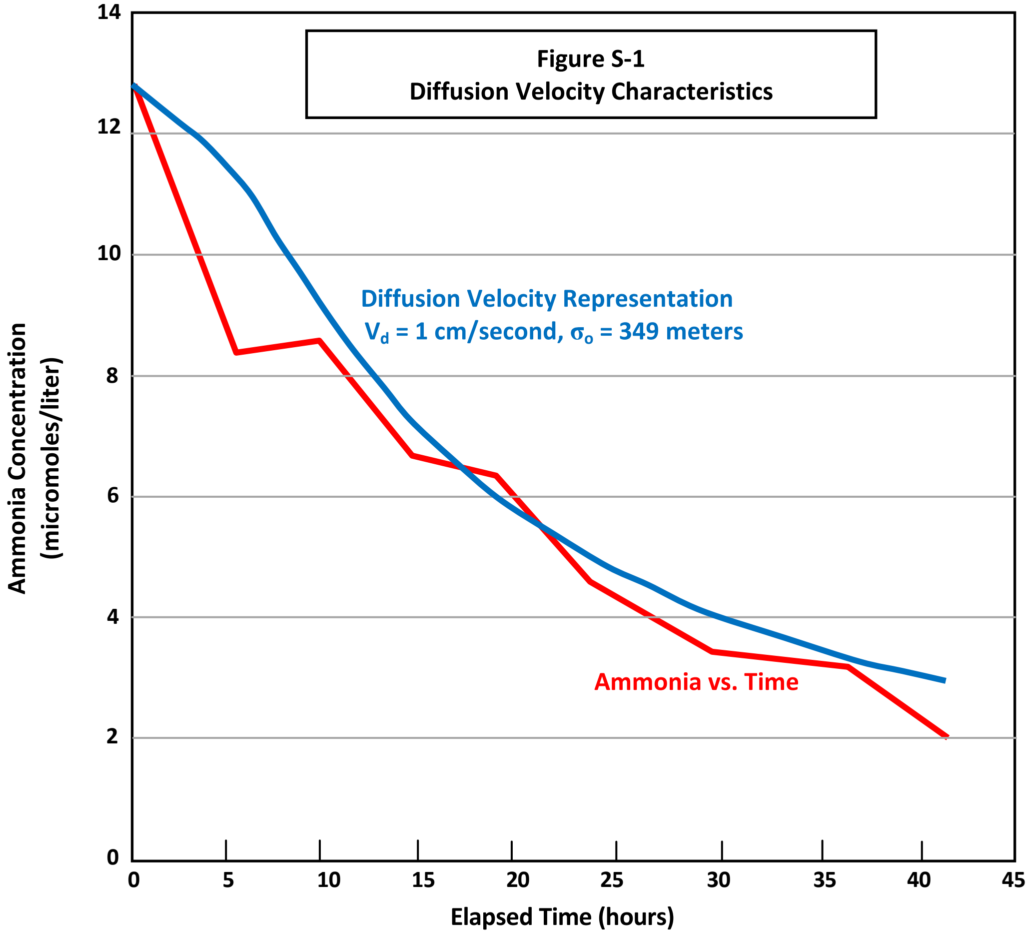
Figure S-1 (page S-14) presents observed reductions in the peak ammonia concentration in the wastefield plume over this period (from Hendricks and Harding, 1974). The wastefield starts out at time t=0 with an initial variance, $\sigma^2(0)$. The variance describing the cross-wastefield distribution of ammonia in the wastefield is:

$$\sigma^2(0) = \int_0^L p(y) \cdot y^2 \ \cdot dy \qquad Equation\ S-14$$

where: y = the cross-wastefield position, relative to its centerline
$p(y)$ = normalized concentration distribution of wastewater within the plume
L = half-width of the plume

The initial standard deviation of the distribution of wastewater across the wastefield (σ_0) depends on the strength and direction of the currents, the discharge rate, diffuser leg lengths, and the downstream distance to the initial profile (t = 0). It was estimated to be 349 meters based on the relative concentrations at the center drogue and side drogues (at *t* = 5 hours), and the decline in the peak concentration between the first two samplings (*t* = 0 and *t* = 5 hours).

The predicted rate of decrease in the peak concentration of ammonia in the wastefield for this initial standard deviation and a diffusion velocity of 1 cm/sec (0.01 m/sec) is shown in Figure S-1 (below). The predicted decrease in peak ammonia concentration is a good approximation to the observed decrease, indicating that a diffusion velocity representation with a diffusion velocity of 1 cm/sec is appropriate for describing the cross-wastefield dispersion in this area.



The 1994 ATSD recommends that: "if the applicant can show that the 4/3 law (or some other relationship) is applicable to the discharge site, then that relationship should be used." A diffusion velocity based representation and diffusion velocity of 1 cm/sec was used to estimate the subsequent dilutions associated with oceanic mixing in the Point Loma area since:

- Coastal dispersion is frequently observed to result in a patch whose variance increases with the square of time (Okubo, 1970).
- Diffusion velocities at a variety of coastal locations have been observed to be on the order of 1 cm/sec (Okubo and Pritchard, 1969).
- The dispersion of ammonia in a subsurface wastefield in the Point Loma area is well represented by a diffusion velocity based representation with a diffusion velocity of 1 cm/sec.

The initial width of the wastefield from the present (extended) outfall will be larger than from the previous outfall, since the length of the diffuser has been increased from about 810 meters to about 1525 meters. The subsequent dilutions used in the farfield DO depression calculations are based on an initial standard deviation of 658 meters (versus the 349 meter standard deviation for the ammonia distribution in the study at the old outfall). This value was selected based on the greatest dimension of the ZID (approximately 1,720 meters) as per the legend for Equation B-17 in Appendix B of the ATSD. To this was added the effects of the spreading as the initial "top-hat" profile is transformed into a normal distribution.

Table S-5 (page S-16) presents subsequent dilutions through 96 hours of elapsed time, based on an initial standard deviation of 658 meters. For comparison, Table S-5 also presents EPA-computed subsequent dilution estimates for 5,000 foot-wide (1,424 meters) wastefield that are based on the following two methods:

- Case 1 - diffusivity (K_H) is a constant, and
- Case 2 - the "4/3's Law" (e.g. diffusivity is a function of distance to the 4/3 power).

Results. Table S-6 (page S-16) presents farfield DO depressions using the data set presented in Table S-3. Within Table S-6, farfield $\Delta DO(\%)$ is computed to include DO depression from the effluent DO, the IDOD, the NBOD, and the CBOD. The calculations are based on the following:

$$\Delta DO(\%) = 100 \cdot \frac{\Delta DO}{DO_f} \qquad \text{Equation } S-15$$

Where: ΔDO = the farfield DO depression

DO_f = the minimum level of DO in the wastefield as the result of the DO and IDOD in the effluent, DO uptake by the BOD exertion, and subsequent oceanic mixing with the surrounding higher DO water

Table S-5
Subsequent Dilution for a Diffusion Velocity of 1 cm/sec

Elapsed Time (hrs)	Subsequent Dilution Ratio[1]		
	Computed Subsequent Dilution (D)	EPA Value for Constant Diffusivity[2] K_H	EPA Value for 4/3's Law[3]
0	1.00 : 1	1.0 : 1	1.0 : 1
4	1.02 : 1	1.1 : 1	1.2 : 1
12	1.20 : 1	1.6 : 1	2.3 : 1
18	1.40 : 1	-	-
24	1.65 : 1	2.1 : 1	4.4 : 1
30	1.92 : 1	-	-
36	2.21 : 1	-	-
42	2.51 : 1	-	-
48	2.81 : 1	2.8 : 1	10.0 : 1
72	4.06 : 1	3.4 : 1	17.0 : 1
96	5.35 : 1	3.9 : 1	24.0 : 1

1 Subsequent dilutions after elapsed time of 96 hours. Based on initial standard deviation of 658 meters, selected on the basis of the greatest dimension of the ZID (approximately 1,720 meters) as per the legend for Equation B-17 in Appendix B of the ATSD.

2 EPA-computed subsequent dilution values for a constant diffusivity, computed per Table B-5 of Appendix B of the ATSD.

3 EPA-computed subsequent dilution values where diffusivity varies to the 4/3's power with distance. Values from Table B-5, Appendix B of the ATSD. (EPA 1994)

Table S-6
Farfield Dissolved Oxygen Depression Due to Discharged Wastewater
240 mgd PLOO Discharge

Date		Initial Dilution (S_a)	DO (mg/l)		Farfield ΔDO (%)	Elapsed Time[1] to ΔDO (hrs)	Subsequent Dilution[1]
			DO_t	ΔDO			
1990	Mar. 7	287	5.37	0.10	1.9	34.5	2.14
	Apr. 17	253	4.78	0.11	2.4	35.5	2.18
	May 23	230	4.47	0.13	2.8	35.5	2.18
	Jun. 20	355	5.60	0.08	1.5	34.5	2.14
	Jul. 25	238	5.20	0.12	2.4	35.0	2.16
	Aug. 29	416	6.08	0.07	1.2	34.0	2.11
	Sept. 27	409	4.68	0.07	1.5	35.5	2.18
1991	Jan. 26	275	7.15	0.11	1.5	32.0	2.02
	Feb. 7	212	5.83	0.14	2.4	34.0	2.11
	Mar. 7	260	5.00	0.11	2.2	35.0	2.16
	Apr. 7	258	5.18	0.11	2.2	35.0	2.16

1 Values at time of maximum DO depression computed using Equation S-15 (page S-15) and input data form Table S-3 (page S-6).

Input values from May 23, 1990 result in the highest farfield DO drawdown (2.8 percent) for a PLOO flow of 240 mgd. Maximum computed DO drawdown during the critical February conditions was 2.4 percent.

Figure S-2 illustrates the predicted depression curve of the dissolved oxygen concentration in the wastefield (with peak DO depression of 2.4 percent) during the critical February conditions. As shown in Figure S-2, the maximum reduction associated with the combination of effluent IDOD and BOD occurs approximately 34 hours after the wastewater release.

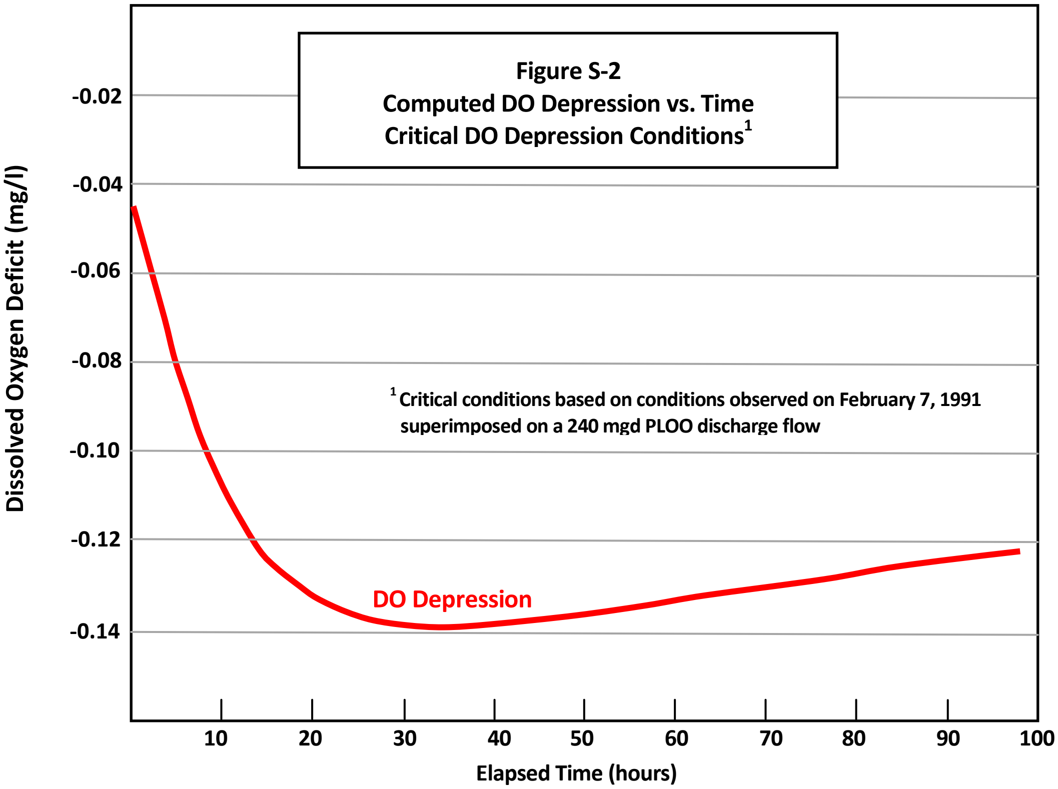


Figure S-2
Computed DO Depression vs. Time
Critical DO Depression Conditions[1]

[1] Critical conditions based on conditions observed on February 7, 1991 superimposed on a 240 mgd PLOO discharge flow

Alternative Approach. In order to demonstrate that there is always enough initial dilution, minimum dilutions required to comply with the *California Ocean Plan* standards for DO are computed. To find the minimum allowable initial dilution for each month, a hypothetical case assuming a peak dissolved oxygen depression of 10 percent was used in conjunction with the historical low reading of DO in the ambient water at the wastefield depth.

Table S-7 (page S-18) summarizes the lowest allowable initial dilutions for each of the input data points (e.g. January, February, etc.) that could cause receiving water DO concentrations to be depressed by 10 percent at a PLOO flow of 240 mgd. Actual minimum PLOO initial dilutions are significantly in excess of these computed "threshold" dilutions required to cause a 10 percent DO reduction.

Table S-7
Initial Dilutions Required to Cause DO Levels to be Depressed by 10 Percent

Parameter	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.
Dissolved Oxygen at Wastefield Depth (DO_t)	3.80	3.60	3.50	2.82	3.25	2.99	3.88	2.66	3.98
Initial Dilution (S_a) Required to Cause 10 Percent Depression of DO	76	80	82	100	88	95	74	106	72

[1] Calculations based on a hypothetical 10 percent depression of $DO_{t,}$ and no any plume calculations.

S.4 CONCLUSIONS

The regulatory initial dilution values attainable by the PLOO discharge are presented in Table S-4. These values are in excess of the minimum dilutions allowable in Table S-6. This demonstrates that the PLOO is well within the *California Ocean Plan* maximum DO depression limit of 10 percent. Moreover, these projected depressions are based on the following compounding conservative assumptions:

- the lowest historical dissolved oxygen concentrations.
- the nitrogen-BOD/total BOD ratio used in the calculation is at the lower limit of its range. (The average and median ratios were substantially larger than used in the simulations: approximately 12 percent versus 2.2 percent.)
- a DO of 0.0 mg/l was assumed for the effluent in lieu of the higher values typical in the PLOO effluent.
- an IDOD value of 4 mg/l was conservatively used based on EPA suggested values, in lieu of actual measured Point Loma WWTP IDOD values which ranged from 0.45 to 1.74 mg/l.
- maximum ambient water temperatures were used in computing decay rates (assuming the higher temperatures increase the decay rate and hence the DO reduction).

It is unlikely that some of these conservative conditions will ever occur, and the probability is infinitesimal that all of the assumed "worst case" conditions would occur at the same time. Because the initial dilution levels achieved by this outfall far exceed the values shown in Table S-6, it is overwhelmingly evident that the farfield DO depression due that could result from the PLOO discharge meets *California Ocean Plan* DO standards at all times with a substantial margin of safety.

REFERENCES

Fair, G.M., J.C. Geyer, and D.A. Okun, 1968. Water and Wastewater Engineering. Vol. 2 - Water Purification and Wastewater Treatment and Disposal. John Wiley & Sons, Publishers, New York, NY.

Hendricks, T.J. and J.M. Harding, 1974. The dispersion and possible biological uptake of ammonia in a wastefield, Point Loma, May 1972. Technical Memorandum TM-210. Southern California Coastal Water Resources Project, Westminster, California. February. 11p.

Okubo, A., 1970. Oceanic Mixing. Technical Report No. 62, Ref. 70-1, Chesapeake Bay Institute, The John Hopkins University.

Okubo, A. and D.W. Pritchard, 1969. Summary of our present knowledge of the physical processes of mixing in the ocean and coastal waters, and a set of practical guidelines for the application of existing diffusion equations in the preparation of nuclear safety evaluations of the use of nuclear power sources in the sea. Report NYO-3109-40, Ref. 69-1, Chesapeake Bay Institute, The John Hopkins University.

State Water Resources Control Board (State Board). *Water Quality Control Plan Ocean Waters of California* (*California Ocean Plan*). 2012

Thomann, R.V. and J.A. Mueller, 1987. Principles of surface water quality modeling and control. Harper and Row, Publishers, New York, NY.

United States Environmental Protection Agency (EPA). *Amended 301(h) Technical Support Document* (ATSD). 1994.

Appendix T
ANALYSIS OF AMMONIA

Renewal of NPDES CA0107409

APPENDIX T

ANALYSIS OF AMMONIA

Evaluation of Compliance with
State of California
Receiving Water Standards for Ammonia

THE CITY OF SAN DIEGO • STATE OF CALIFORNIA

SEMPER VIGILANS

January 2015

APPENDIX T

ANALYSIS OF AMMONIA

Table of Contents

List of Figures

List of Tables

List of Abbreviations

C	Centigrade
California Ocean Plan	2012 *Water Quality Control Plan, Ocean Waters of California*
EPA	United States Environmental Protection Agency
MER	mass emission rate
mg/l	milligrams per liter
N	nitrogen
NH_3	un-ionized ammonia
NH_4^+	ammonium ion
NPDES	National Pollutant Discharge Elimination System
pK_a	acid disassociation constant
PLOO	Point Loma Ocean Outfall
Point Loma WWTP	Point Loma Wastewater Treatment Plant
ppt	parts per thousand
PUD	San Diego Public Utilities Department
Regional Board	Regional Water Quality Control Board, San Diego Region
ZID	zone of initial dilution

APPENDIX T

ANALYSIS OF AMMONIA

This appendix presents an analysis of ammonia discharged from the Point Loma Wastewater Treatment Plant and demonstrates that the Point Loma Ocean Outfall (PLOO) discharge complies with applicable State of California receiving water standards for ammonia. The PLOO discharge also complies with applicable federal water quality criteria for ammonia in marine waters. To assess ammonia compliance under current discharge conditions, this appendix applies current Point Loma WWTP effluent data to the ammonia analysis approach presented in the City's original 1995 301(h) application.

ABSTRACT

This appendix estimates receiving water ammonia-nitrogen concentrations that would result from the discharge of treated wastewater from the Point Loma Wastewater Treatment Plant (Point Loma WWTP) to the ocean via the Point Loma Ocean Outfall (PLOO). Receiving water ammonia concentrations are computed on the basis of Point Loma WWTP effluent ammonia concentrations and initial dilution rates assigned in Regional Board Order No. R9-2009-0001 (NPDES CA0107409).

A maximum day receiving water ammonia concentration of 0.20 mg/l is projected upon completion of initial dilution. A maximum 6-month median receiving water ammonia-nitrogen concentration of 0.11 mg/l is projected. These projected receiving water concentrations are significantly below standards established in the *California Ocean Plan*. The concentrations are also significantly below federal water quality criteria for ammonia-nitrogen in saltwater. Further, the PLOO mass emissions of ammonia-nitrogen are less than mass emission performance goal benchmarks established within Tables 10 and 11 of Order No. R9-2009-0001.

T.1 INTRODUCTION

Ammonia is a common constituent of wastewater formed by the biological degradation of proteins and urea. Ammonia typically occurs at concentrations on the order of 25 to 40 mg/l (as total ammonia-nitrogen, including both NH_4^+-N and NH^3-N) within primary treated effluent and un-nitrified secondary effluent. (Secondary treatment employing a nitrification process can reduce effluent ammonia concentrations from these levels.) Ammonia can also be contributed by industry through the use of ammonia as a means of neutralizing low pH industrial discharges.

Ambient or background levels of ammonia in seawater in Southern California have been shown to range from zero to 0.014 mg/l as ammonium (NH_4^+) (Eppley, et al., 1979). Ammonia is an essential macronutrient, but in higher concentrations, ammonia can be toxic. Ammonia is readily nitrified in oxygenated waters, and is not bioaccumulated, bioconcentrated, or biomagnified.

T.2 AMMONIA SPECIATION

The speciation of total ammonia between its ionized (NH_4^+) and un-ionized (NH_3) forms is a major factor affecting the potential effects of ammonia on the marine environment. The term ionized ammonia is used herein to describe the compound NH_4^+, and the term un-ionized ammonia is used to describe NH_3. Ammonia is considerably more toxic to aquatic organisms in its un-ionized (NH_3) form; since the NH_3 molecule is lipid soluble and uncharged, it rapidly permeates cell membranes, particularly the gills of fish. Equilibrium between the two ammonia species is expressed as:

$$NH_4^+ \ \leftrightarrow \ NH_3 + H^+ \qquad\qquad Equation\ T-1$$

The effects of pH, temperature, and salinity (ionic strength) on this relationship are well studied and documented within standard chemistry and solubility textbooks. At a given ammonia concentration, the un-ionized concentration or percentage that has dissociated will decrease with decreasing pH, decreasing temperature and increasing salinity.

Numerous researchers have addressed ammonia equilibrium and solubility relations in seawater. Research addressing salinity, pH, and temperature effects on ammonia equilibrium in seawater has, in part, included:

1. Whitfield (1974) reported on a precise and detailed evaluation of the effects of pH, temperature, and salinity on the speciation of ammonia.
2. Bower and Bidwell (1978) tabulated the ammonium dissociation constant (pK_a) versus temperature and pH for various salinities on the basis of Whitfield's results.
3. Johannson and Wedborg (1979) assessed the ammonium dissociation constant (pK_a) versus pH for a range of seawater concentrations.
4. Skarheim (1973) tabulated values for the un-ionized fraction of total ammonia under equilibrium conditions corresponding to a range of environmental circumstances.

Clegg and Whitfield (1995) developed a model for determining the ammonia acid dissociation constant (pK^a) in marine waters as a function of temperature and ionic strength. Based on this work, Bell et al. (2007) presented the following simplified formula for estimating the ammonia acid dissociation constant on the basis of receiving water temperature (*t*, measured in °C) and salinity (*S*, measured in parts per thousand):

$$pK_a = 10.0423 - (0.0315536 \cdot t) + (0.003701 \cdot S) \qquad Equation\ T-2$$

City of San Diego receiving water monitoring reports for 2010-2013 document that PLOO receiving water temperatures ranged from approximately 10° C to 22° C and salinity values ranged from 33 to 34 parts per thousand (ppt). (City of San Diego, 2010-2013a) Based on the equation of Bell et al. (2007), the corresponding pK_a value for ammonia is approximately 9.5 at a temperature of 10° C, while the pK_a value would be 9.8 at a 22° C temperature.

Figure T-1 schematically presents the breakdown of speciation between the ammonium ion (NH_4^+) and un-ionized ammonia (NH_3) for a PK_a of 9.5.

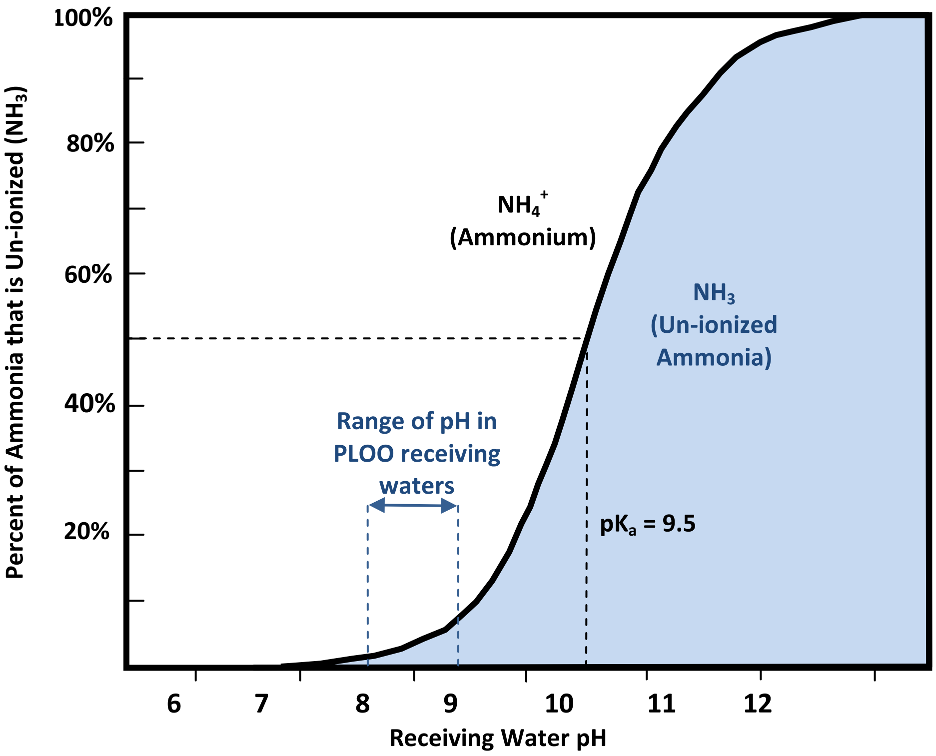


Figure T-1
Ammonium/Ammonia Speciation as a Function of pH

As shown in Figure T-1, over the range of values of pH, temperature, and salinity normally encountered in PLOO receiving waters, the ammonium ion (NH_4^+) is the dominant ammonia species present. Although un-ionized ammonia is favored by high pH, high temperature, and low ionic strength, the dominance of NH_4^+ is a virtual certainty in well buffered, constant salinity system (such as open seawater) in which wastewater constituents are rapidly dispersed. Un-ionized ammonia (see Figure T-1) would typically constitute between 2 and 7 percent of the total ammonia in such a receiving water environment.

T.3 FEDERAL WATER QUALITY CRITERIA

EPA presents federal water quality criteria for the protection of aquatic habitat and human health at http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable. Current EPA salt-water ammonia criteria are set forth in *Ambient Water Quality Criteria for Ammonia (Saltwater)*, (U.S. EPA 440/5-88-004, 1989). Recognizing the pH- and temperature-dependent effects on ammonia speciation, EPA ammonia criteria for saltwater are pH, salinity, and temperature dependent.

Table T-1 summarizes the range of pH and temperature in PLOO receiving waters. As shown in the table, pH values typically range from 7.7 to 8.2 pH units at subsurface depths. Receiving water temperature varies with season, but subsurface waters are almost always within the range of 10 to 15 ºC, with a short-term maximum observed value of 18° C.

Table T-1
Range of Temperature and pH in the PLOO Discharge Zone, 2010-2013[1]

Receiving Water Depth	pH[2] (pH Units)		Temperature[2] (ºC)	
	Low	High	Low	High
Surface Waters[3]	7.8	8.4	10	22
Subsurface[4]	7.7	8.2	9.6	18

1 Data from City of San Diego annual receiving water reports for 2010-2013. (City of San Diego, 2010-2013a)
2 Observed low and high values rounded to two significant figures.
3 Includes data from depths of less than 20 meters.
4 Includes data from depths of more than 20 meters.

Table T-2 (page T-5) presents pH- and temperature-dependent EPA water quality criteria for ammonia in salt water for the range of pH and temperature expected in the PLOO discharge zone. As shown in Table T-2, the most stringent ammonia criteria occur for higher salinities and temperatures.

Based on observed receiving water quality during 2010-2013, the most critical 30-day average receiving water conditions that would be expected at depth near the PLOO zone of initial dilution (ZID) boundary would be pH of 8.2 and a temperature of 15° C. The EPA 30-day average ammonia concentration criterion (see Table T-2) for these conditions is 1.0 mg/l.

Table T-2
EPA Ambient Saltwater Criteria for Ammonia-Nitrogen[1]
(Criteria for Salinity of 30g salt/kg water)

Period	**pH**	**Ammonia Concentration Criteria[1,2] (mg/l NH_3-N)**			
		10° C	**15° C**	**20° C**	**25° C**
Criteria Maximum Concentration[3]	7.6	37	25	21	12
	7.8	23	16	11	7.9
	8.0	15	10	7.3	5.0
	8.2	9.6	6.7	4.6	3.3
	8.4	6.0	4.2	2.9	2.1
Criteria Continuous Concentration[4]	7.6	5.6	3.7	3.1	1.7
	7.8	3.4	2.4	1.7	1.0
	8.0	2.2	1.6	1.1	0.66
	8.2	1.4	1.0	0.69	0.44

1 From U.S. Environmental Protection Agency, *Ambient Water Quality Criteria for Ammonia (Saltwater)*, 1989. Criteria are listed for the range of pH and temperatures common to the Point Loma extended outfall waste field. Ammonia criteria become more relaxed with increasing salinity. The typical ocean salinity near San Diego is approximately 33 to 34 g/kg, so the above values based on a 30 g/kg salinity are conservative.

2 The above water quality criteria are not enforceable standards, but are presented by EPA as guidance to States and Tribes in developing enforceable water quality standards.

3 The criteria maximum concentration is the maximum concentration to which an aquatic community can be briefly exposed without an unacceptable impact.

4 The criteria continuous concentration is the maximum concentration that an aquatic community can be continuously and indefinitely exposed to without an unacceptable impact.

T.4 CALIFORNIA OCEAN PLAN STANDARDS

Ammonia discharges in California are regulated under provisions of the *California Ocean Plan*. The *California Ocean Plan* was most recently updated in 2012. *California Ocean Plan* standards for ammonia are presented in Table T-3.

Table T-3
California Ocean Plan Standards for Ammonia-Nitrogen

Period	**California Ocean Plan Concentration Standard for Total Ammonia Nitrogen Receiving Waters[1]**
6-Month Average	0.6 mg/l
Daily Maximum	2.4 mg/l
Instantaneous Maximum	6.0 mg/l

1 Receiving water standard to be achieved upon completion of initial dilution.

T.5 COMPLIANCE WITH STANDARDS AND CRITERIA

PLOO Effluent Quality. Table T-4 summarizes total ammonia-nitrogen in the Point Loma WWTP effluent during 2010-2013. Point Loma WWTP effluent ammonia-nitrogen during this period averaged 33.8 mg/l, and ranged from a daily maximum value of 40.4 mg/l (June 18, 2013) to a minimum value of 21.7 (January 21, 2010). All Point Loma WWTP effluent ammonia samples during 2010-2013 were more than an order of magnitude less than the 490 mg/l daily maximum performance goal established in Order No. R9-2009-0001. The maximum observed 6-month median ammonia concentration during 2010-2013 was 37 mg/l - a value well within the 120 mg/l 6-month median performance goal established within Order No. R9-2009-0001.

Table T-4
Point Loma WWTP Influent and Effluent
Ammonia-Nitrogen Concentrations, 2010-2013

Period	Point Loma WWTP Effluent Ammonia-Nitrogen Concentration[1] (mg/l as N)			
	2010	2011	2012	2013
January	29.6	29.1	34.6	34.5
February	30.5	31.6	34.2	33.9
March	31.7	30.0	34.9	36.2
April	30.2	32.6	34.3	38.4
May	33.2	33.8	36.1	36.2
June	32.8	35.2	35.6	39.4
July	32.7	34.8	36.3	35.8
August	32.0	34.0	36.0	36.1
September	31.4	32.4	34.8	34.5
October	31.0	33.0	34.8	33.8
November	31.0	33.6	36.7	34.1
December	29.1	33.4	34.1	35.6
Maximum Value[2]	34.7	37.7	39.5	40.4
Minimum Value[3]	21.7	25.5	31.4	30.5
Maximum Month[4]	33.2	35.2	36.7	39.4
Annual Average[5]	31.3	32.8	35.2	35.6
Maximum 6-Month Median Value[6]	32.5	34.1	35.7	37.0

1 Weekly ammonia monitoring data from annual and monthly monitoring reports submitted by the City to the Regional Board during 2010-2013. (City of San Diego, 2020-2013b) Calendar year 2013 is the most recent year for which a complete 12 month data set was available at the time of preparation of this report. Data for calendar year 2014 will be electronically transmitted to regulators under separate cover.
2 Maximum daily value observed during the listed year.
3 Minimum daily value observed during the listed year.
4 Maximum monthly average observed during the listed year.
5 Annual arithmetic average of all samples collected during the listed year.
6 Maximum 6-month median value observed during the listed year.

Projected Receiving Water Quality. The effluent total ammonia-nitrogen concentrations presented in Table T-4 can be combined with projected initial dilutions from the PLOO to estimate receiving water ammonia-nitrogen concentrations at the edge of the ZID upon completion of initial dilution.

As documented in Appendix R, the PLOO is projected to achieve a median initial dilution of 338 to 1 at the ultimate 240 mgd design flow of the Point Loma WWTP. Order No. R9-2009-0001 assigns a minimum month initial dilution of 204 to 1 for purposes of assessing compliance with *California Ocean Plan* receiving standards. Using this median and minimum month initial dilution, Table T-5 presents estimated receiving water ammonia-nitrogen concentrations at the ZID boundary under maximum day and 6-month median conditions. As shown in Table T-5, a maximum day ammonia-nitrogen receiving water concentration of 0.20 mg/l is projected upon completion of initial dilution. A maximum 6-month median ammonia-nitrogen receiving water concentration of 0.11 mg/l is projected upon completion of initial dilution.

Table T-5
Projected Ammonia-Nitrogen Receiving Water Concentrations
Upon Completion of Initial Dilution

Parameter	Units	Maximum Day	Maximum 6-Month Median
Point Loma Effluent Ammonia-Nitrogen Concentration	mg/l (as N)	40.4[1]	37.0[1]
Initial Dilution	--	204:1[2]	338:1[3]
Projected Receiving Water Ammonia-Nitrogen Concentration	mg/l (as N)	0.20[4]	0.11[5]
California Ocean Plan Ammonia-Nitrogen Standard[6]	mg/l (as N)	2.4	0.6

1 Maximum day and maximum 6-month median Point Loma WWTP effluent ammonia concentration values from Table T-4 on page T-6.
2 Minimum month initial dilution assigned in Order No. R9-2009-0001 for purposes of determining compliance with criteria for the protection of aquatic life.
3 Median PLOO initial dilution. See Appendix Q.
4 Computed receiving water concentration at the edge of the zone of initial dilution upon completion of initial dilution at an initial dilution of 204:1 and a maximum day effluent concentration of 40.4 mg/l.
5 Computed receiving water concentration at the edge of the zone of initial dilution upon completion of initial dilution at a median initial dilution of 338:1 and a maximum 6-month median ammonia concentration of 37.0 mg/l.
6 *California Ocean Plan* receiving water standard to be achieved upon completion of initial dilution.

Compliance with California Ocean Plan Ammonia Standards. As shown in Table T-5, the maximum day total ammonia-nitrogen concentration computed at the edge of the Point Loma ZID of 0.20 mg/l is less than the 2.4 mg/l *California Ocean Plan* daily maximum standard by a factor of twelve.

The projected maximum 6-month median ammonia-nitrogen receiving water concentration of 0.11 mg/l is less than one-fifth of the *California Ocean Plan* 6-month median receiving water standard for ammonia-nitrogen. It should be noted that the receiving water concentrations projected in Table T-5 would occur immediately at the edge of the ZID. Receiving water ammonia concentrations beyond the edge of the ZID would be further reduced after initial dilution as a result of:

- dilution and dispersion as the plume is advectively transported by ambient currents,
- oxidation (via nitrification) of ammonia to nitrite and/or nitrate, and
- biological assimilation by marine algae (phytoplankton).

Compliance with Federal Water Quality Criteria. As shown in Table T-2 (page T-5), federal water quality criteria for ammonia-nitrogen are dependent on salinity, pH, and temperature. The maximum day projected PLOO receiving water concentration of 0.20 mg/l is significantly below corresponding federal water quality criteria for all anticipated ranges of PLOO receiving water temperature and salinity.

PLOO receiving water data (see Table T-1 on page T-4) indicate that a receiving water pH of 8.2 and temperature of 15 ºC represent "worst case" sustained conditions for un-ionized ammonia dissociation. Under such sustained pH and temperature conditions, the corresponding criteria continuous concentration limit (e.g. 30-day average criterion) for ammonia-nitrogen criterion is 1.0 mg/l. The projected PLOO maximum 6-month median value of 0.11 mg/l is nearly an order of magnitude less than this criterion.

T.6 AMMONIA MASS EMISSIONS

To implement *California Ocean Plan* receiving water standards, Order No. R9-2009-0001 establishes mass emission performance goals of 210,000 lbs/day (6-month median) and 840,000 lb/day (daily maximum). Table T-6 (page T-9) summarizes PLOO mass emissions during 2010-2013 and compares the mass emissions with the *California Ocean Plan*-based performance goals. As shown in Table T-6, the PLOO maximum day mass emission total for ammonia-nitrogen (57,170 pounds per day) occurred during wet weather conditions on November 16, 2012. Typical PLOO ammonia mass emissions during 2010-2013 ranged from 39,000 to 45,000 pounds per day; the maximum observed 6-month median value during 2010-2013 was 44,700 pounds per day.

The PLOO discharge complied with the *California Ocean Plan*-based daily maximum ammonia mass emission performance goal by more than an order of magnitude. The PLOO discharge during 2010-2013 complied with the *California Ocean Plan*-based 6-month median ammonia mass emission performance goal by approximately a factor of five.

Table T-6
PLOO Ammonia-Nitrogen Mass Emissions
Compliance with California Ocean Plan-Based Mass Emission Performance Goals

Year	PLOO Ammonia Mass Emissions (pounds per day)	
	Maximum Observed Daily Value[1]	Maximum Observed 6-Month Median Value[1]
2010	44,080[2]	41,400
2011	48,010[3]	42,800
2012	57,180[4]	43,660
2013	48,020[5]	44,700
Mass Emission Performance Goal Established in Order No. R9-2009-0001[6] (Based on the *California Ocean Plan*)	840,000	210,000

1 From Point Loma WWTP daily flow and ammonia concentration data submitted by the City to the Regional Board during 2010-2013. Calendar year 2013 is the most recent year for which a complete 12 month data set was available at the time of preparation of this report. Data for calendar year 2014 will be electronically transmitted to regulators under separate cover.

2 Maximum ammonia 2010 daily mass emission occurred on March 3, 2010 at an effluent concentration of 30.5 mg/l and a Point Loma WWTP flow of 173.3 mgd.

3 Maximum ammonia 2011 daily mass emission occurred on February 26, 2011 at an effluent concentration of 26.3 mg/l and a Point Loma WWTP flow of 218.9 mgd.

4 Maximum ammonia 2012 daily mass emission occurred on November 16, 2012 at an effluent concentration of 35.8 mg/l and a Point Loma WWTP flow of 191.5 mgd.

5 Maximum ammonia 2013 daily mass emission occurred on June 23 2013 at an effluent concentration of 40.1 mg/l and a Point Loma WWTP flow of 143.6 mgd.

6 *California Ocean Plan*-based performance goal established in Table 9 of Order No. R9-2009-0001.

Table 10 of Order No. R9-2009-0001 establishes performance goal benchmarks implemented by EPA to establish a framework for evaluating the need for antidegradation analysis. The EPA mass emission benchmarks were determined using the n-day average monthly performance (95th percentile) of the Point Loma WWTP during 1990-1995. Order No. R9-2009-0001 establishes an EPA performance goal benchmark for ammonia of 8,018 metric tons per year. Table T-7 (page T-10) compares annual mass emissions during 2010-2013 with the EPA benchmark. As shown in Table T-7, ammonia mass emissions during 2010-2013 were within the EPA performance goal benchmark that was based on 95th percentile PLOO ammonia mass emissions during 1990-1995.

Table T-7
PLOO Ammonia-Nitrogen Mass Emissions
Compliance with EPA Performance Goal Mass Emission Benchmark

Year	**Annual PLOO Ammonia Mass Emissions[1] (metric tons/year)**	
	Computed Using Average Annual Flow and Annual Average Ammonia oncentration[2]	**Computed as Cumulative Total of Daily Mass Emissions During the Year[3]**
2010	6,760	6,690
2011	7,050	6,990
2012	7,210	7,200
2013	7,070	7,060
EPA Mass Emission Performance Benchmark Established in Table 10 of Order No. R9-2009-0001[4]	8,018	

1 From Point Loma WWTP daily flow and ammonia concentration data submitted by the City to the Regional Board during 2010-2013. Calendar year 2013 is the most recent year for which a complete 12 month data set was available at the time of preparation of this report. Data for calendar year 2014 will be electronically transmitted to regulators under separate cover.

2 Compliance Determination VII.I.2.d of Order No. R9-2009-0001 requires that the mass emission rate (MER) in pounds per day be computed as the product of the Point Loma WWTP flow in mgd (Q) and the ammonia concentration in mg/l (C), as follows:

$$MER\ (lbs/day) = Q \cdot C \cdot 8.34$$

The above values are computed on the basis of the average annual Point Loma WWTP flow multiplied by the average annual Point Loma WWTP ammonia concentration, converted to units of metric tons per year. While this method allows for rapid estimation of annual mass emissions, the method is not entirely accurate, as this method may not be reflective of mass emissions that occur as a result of peak day flows coinciding with peak ammonia concentrations.

3 Computed as the cumulative total of all daily mass emissions during the listed year. On days where ammonia samples were not available, the ammonia concentration from the prior sample was used to compute the ammonia mass emission during that day. This MER computational method is considered more accurate than the method of Footnote 2, as the "average flow multiplied by an average concentration" method of Footnote 2 may not be reflective of peak day mass emissions that occur when high ammonia concentrations occur on days of peak Point Loma WWTP flow.

4 The EPA mass emission benchmarks established in Order No. R9-2009-0001 were established on the basis of the n-day average monthly performance (95th percentile) of the Point Loma WWTP during 1990-1995. The 8,018 metric ton per year ammonia benchmark was implemented to establish a framework for evaluating the need for antidegradation analysis. Under this framework, Point Loma WWTP MER values that exceed the EPA mass emission benchmarks trigger the need for an antidegradation analysis to demonstrate compliance with EPA Tier I (and if applicable Tier II) antidegradation regulations.

T.7 CONCLUSIONS

The discharge of ammonia-nitrogen from the PLOO does not result in toxic concentrations of un-ionized ammonia in the receiving waters. Maximum computed receiving water concentrations of ammonia-nitrogen are projected to be significantly less than *California Ocean Plan* standards and applicable federal water quality criteria. PLOO mass emissions of ammonia-nitrogen remain significantly below the *California Ocean Plan*-based performance goal mass emission levels established in Order No. R9-2009-0001. PLOO mass emissions of ammonia also remain below the antidegradation mass emission benchmarks established by EPA.

REFERENCES

Bell, Thomas G., Martin T. Johnson, Timothy D. Jickells, and Peter S. Liss, Ammonia/ammonium dissociation coefficient in seawater: a significant numerical correction. Environmental Chemistry. Vol. 4, p. 183.

Bower, C.E. and J. P. Bidwell, 1978. Ionization of Ammonia in Seawater: Effects of Temperature, pH, and Salinity. *Journal of the Fisheries Resource Board of Canada.* 35:1012-1016. 1978.

City of San Diego Public Utilities Department, Environmental Monitoring and Technical Services Division. *Annual Receiving Waters Monitoring Report for the Point Loma Ocean Outfall*. 2010 - 2013a.

City of San Diego Public Utilities Department. *Report and Summary, Point Loma Wastewater Treatment Plant & Ocean Outfall, Monitoring and Reporting Program No. R9-2009-0001, NPDES No. CA0107409*. 2010 - 2013b.

Clegg, S.L, and M. Whitfield. A chemical model of seawater including dissolved ammonia and the stoichemetric dissociation constant of ammonia in estuarine and seawater from -2° C to 40° C. *Geochimoca et Cosmochema Acta*, Volume 59, No. 12, pp. 2403-2421. 1995.

Eppley et al. Ammonium Distribution in Southern California Coastal Waters and Its Role in the Growth of Phytoplankton. *Limnology and Oceanography*. Vol. 24, pp. 495-509. 1979.

Johansson, Olof, and Margarita Wedborg. The ammonia-ammonium equilibria in seawater at temperatures between 5 and 25º C. *Journal of Solutions Chemistry.* Vol. 9, pp. 37-44. 1980.

Skarheim, H. P., Tables of the fraction of ammonia in the undissociated form for pH 6-9, temperature 0-30 C, TDS 0-3000 mg/l, and salinity 5-35 g/kg. Sanitary Engineering Research Laboratory, College of Engineering, School of Public Health, University of California, Berkeley. *SERL Report No. 73-5*. 1973.

U.S. Environmental Protection Agency. National Recommended Water Quality Criteria. Located at: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#altable/.

U.S. Environmental Protection Agency, 1989. *Ambient Quality Criteria for Ammonia (Saltwater).* EPA Publication 440/5-88-004.

Whitfield, M., 1974. The hydrolysis of ammonium ions in sea water - a theoretical study. *Journal of the Marine Biological Association of the U.K.* 54:565-580.

Appendix U
CALIFORNIA OCEAN PLAN

Renewal of NPDES CA0107409

WATER QUALITY CONTROL PLAN

OCEAN WATERS OF CALIFORNIA

2012

STATE WATER RESOURCES CONTROL BOARD

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

State of California
Edmund G. Brown Jr. Governor

California Environmental Protection Agency
Matthew Rodriquez, Secretary

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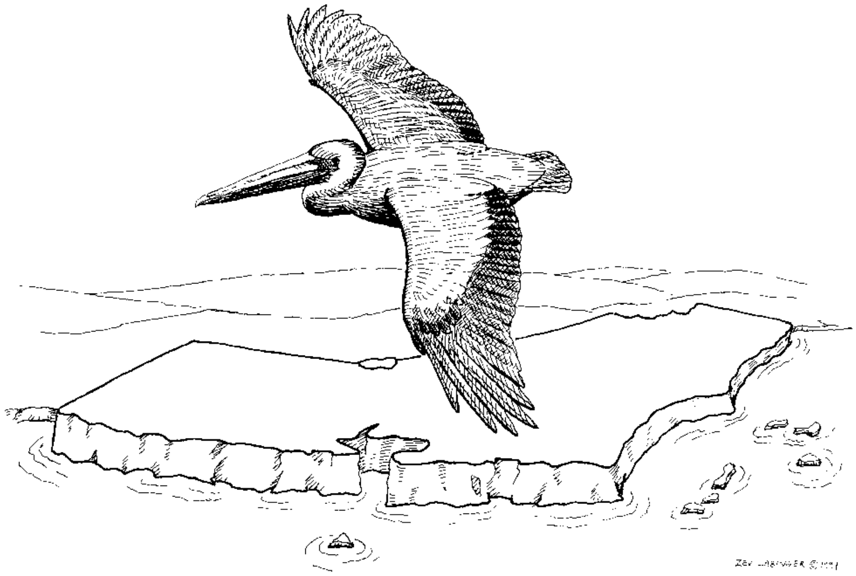
State of California

STATE WATER RESOURCES CONTROL BOARD



2012

CALIFORNIA OCEAN PLAN

WATER QUALITY CONTROL PLAN

OCEAN WATERS OF CALIFORNIA

Effective August 19, 2013

Adopted October 16, 2012

Approved by the Office of Administrative Law on July 03, 2013

STATE WATER RESOURCES CONTROL BOARD
RESOLUTION NO. 2012-0056

ADOPTING THE CALIFORNIA OCEAN PLAN AMENDMENT IMPLEMENTING STATE WATER BOARD RESOLUTIONS 2010-0057 AND 2011-0013 REGARDING STATE WATER QUALITY PROTECTION AREAS AND MARINE PROTECTED AREAS

WHEREAS:

1. The State Water Resources Control Board (State Water Board) adopted the California Ocean Plan (Ocean Plan) in 1972 and revised it in 1978, 1983, 1988, 1990, 1997, 2001, 2005 and 2009.

2. The State Water Board is responsible for reviewing Ocean Plan water quality standards and for modifying and adopting standards in accordance with Section 303 (c)(1) of the federal Clean Water Act and section 13170.2(b) of the California Water Code.

3. On November 16, 2010, the State Water Board adopted Resolution No. 2010–0057, Marine Protected Areas and State Water Quality Protection Areas. The Resolution directed State Water Board staff to propose amendments to the Ocean Plan to address designation of new State Water Quality Protection Areas and to clarify requirements for existing discharges relative to Marine Protected Areas.

4. On March 15, 2011, the State Water Board adopted the Triennial Review Workplan 2011-2013, in Resolution No. 2011-0013, which included under Issue 1 direction to staff to propose an amendment to the Ocean Plan addressing State Water Quality Protection Areas and Marine Protected Areas.

5. On July 8, 2011, the State Water Board held a scoping meeting regarding potential Ocean Plan Amendments to solicit input from public agencies and members of the public on the scope and content of the substitute environmental documentation to be prepared in support of the amendment.

6. On May 1, 2012, the State Water Board conducted a public hearing. Twenty- four written public comments were received and reviewed. Staff considered comments and input from Board Members and the public and drafted revisions to the proposed amendments and draft SED, which were circulated on February 28, 2012.

7. On August 22, 2012, the State Water Board conducted a public workshop to consider changes proposed by staff in response to comments received. A written comment period from July 31, 2012 through August 31, 2012, allowed for submission of comments on the changes from the earlier draft documents.

8. The Ocean Plan is clear that there shall not be degradation of marine communities or other exceedances of water quality objectives due to waste discharges. This is true for all near coastal ocean waters, regardless of whether a Marine Protected Area is present. If sound scientific information becomes available demonstrating that discharges are causing or contributing to the degradation of marine communities, or causing or contributing to the exceedance of narrative or numeric water quality objectives, then new or modified limitations or conditions may be placed in the NPDES permit to provide protections for marine life, both inside and outside of Marine Protected Areas.

9. The State Water Board prepared and circulated a draft Substitute Environmental Document (SED) in accordance with the provisions of the California Environmental Quality Act and title 14, California Code of Regulations section 15251(g) and in compliance with State Water Board regulations governing certified regulatory programs. (See Cal. Code Regs., tit. 23, § 3777) The SED consists of the draft SED dated January 6, 2012, and updated on February 23 and July 25, 2012, and responses to comments on the draft SED and the proposed project. Together, these documents constitute the required environmental documentation under CEQA. (See Cal. Code Regs., tit. 14, §§ 15250, 15252; Cal. Code of Regs., tit. 23, § 3777.)

10. The State Water Board has considered the SED, which analyzes the project, alternatives to the project and reasonably foreseeable methods of compliance with the proposed amendments and concludes that the project will not result in adverse environmental impacts.

11. These amendments to the Ocean Plan do not become effective until approved by the Office of Administrative Law (OAL).

THEREFORE BE IT RESOLVED THAT:

The State Water Board:

1. After considering the entire record, including oral comments at the public hearing, adopts the State Water Quality Protection Areas and Marine Protected Areas amendment to the Ocean Plan.

2. Approves the final SED, which includes the responses to comments, and directs the Executive Director or designee to transmit the Notice of Decision to the Secretary of Resources.

3. Authorizes the Executive Director or designee to submit the amended Ocean Plan to OAL for review and approval.

4. Directs the Executive Director or designee to make minor, non-substantive modifications to the language of the amendment, if OAL determines during its

approval process that such changes are needed, and inform the State Water Board of any such changes.

CERTIFICATION

The undersigned Clerk to the Board does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the State Water Resources Control Board held on October 16, 2012.

AYE: Chairman Charles R. Hoppin
Vice Chair Frances Spivy-Weber
Board Member Tam M. Doduc
Board Member Steven Moore
Board Member Felicia Marcus
NAY: None
ABSENT: None
ABSTAIN: None

Jeanine Townsend

Jeanine Townsend
Clerk to the Board

STATE WATER RESOURCES CONTROL
BOARD RESOLUTION NO. 2012-0057

ADOPTION OF THE CALIFORNIA OCEAN PLAN AMENDMENTS REGARDING MODEL MONITORING, VESSEL DISCHARGES, AND NON-SUBSTANTIVE CHANGES

WHEREAS:

1. The State Water Resources Control Board (State Water Board) adopted the California Ocean Plan (Ocean Plan) in 1972 and revised it in 1978, 1983, 1988, 1990, 1997, 2001, 2005 and 2009.

2. The State Water Board is responsible for reviewing Ocean Plan water quality standards and for modifying and adopting standards in accordance with Section 303 (c)(1) of the federal Clean Water Act and section 13170.2(b) of the California Water Code.

3. On August 1, 8, and 15, of 2006, the State Water Board conducted public scoping meetings in Santa Rosa, Los Angeles, and Monterey respectively to receive public comments for potential revisions to the Ocean Plan.

4. On June 26, 2007, the State Water Board held a public scoping meeting in San Francisco regarding potential Ocean Plan Amendments and solicited public comments on the scope and content of the environmental information that the State Water Board must consider.

5. On March 15, 2011, the State Water Board adopted the Ocean Plan Triennial Review Work Plan for 2011-2013 by Resolution 2011-0013. The work plan identifies issues for which further action is needed, including model monitoring, vessel discharges, and non- substantive changes, which are addressed by the proposed amendments to the Ocean Plan.

6. On November 1, 2011, the State Water Board conducted a public hearing for the proposed amendments to the Ocean Plan. Public comments were received and reviewed, and staff developed edits based on these comments.

7. On August 22, 2012, the State Water Board conducted a public workshop, where the State Water Board solicited comments on staff edits to the proposed amendments to the Ocean Plan related to model monitoring, vessel discharges and non-substantive changes.

8. The State Water Board prepared and circulated a draft Substitute Environmental Document (SED) in accordance with the provisions of the California Environmental Quality Act and title 14, California Code of Regulations section 15251(g) and in compliance with State Water Board regulations governing certified regulatory programs. (See Cal. Code Regs., tit. 23, § 3777) The SED consists of the draft SED

dated January 6, 2012, and updated on February 23 and July 25, 2012, and responses to comments on the draft SED and the proposed project. Together, these documents constitute the required environmental documentation under CEQA. (See Cal. Code Regs., tit. 14, §§ 15250, 15252; Cal. Code of Regs., tit. 23, § 3777.)

9. The State Water Board has considered the SED, which analyzes the project, alternative to the project and reasonably foreseeable methods of compliance with the proposed amendments and concludes that the project will not result in adverse environmental impacts.
10. These amendments to the Ocean Plan do not become affective until approved by the Office of Administrative Law (OAL).

THEREFORE BE IT RESOLVED THAT:

The State Water Board:

1. After considering the entire record, including oral comments at the public hearing, adopts the proposed amendments to the Ocean Plan regarding model monitoring, vessel discharges and non-substantive administrative changes.
2. Approve the final SED, which includes the response to comments and directs the Executive Director or designee to transmit the Notice of Decision to the Secretary of Resources.
3. Authorizes the Executive Director or designee to submit the amended Ocean Plan to OAL for review and approval.
4. Directs the Executive Director or designee to make minor, non-substantive modifications to the language of the Policy, if during the OAL approval process, OAL determines that such changes are needed for clarity or consistency, and inform the State Water Board of any changes.

CERTIFICATION

The undersigned Clerk to the Board does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the State Water Resources Control Board held on October 16, 2012.

AYE: Chairman Charles R. Hoppin
Vice Chair Frances Spivy-Weber
Board Member Tam M. Doduc
Board Member Steven Moore
Board Member Felicia Marcus
NAY: None
ABSENT: None
ABSTAIN: None

Jeanine Townsend

Jeanine Townsend
Clerk to the Board

CALIFORNIA OCEAN PLAN

TABLE OF CONTENTS

CALIFORNIA OCEAN PLAN

WATER QUALITY CONTROL PLAN FOR OCEAN WATERS OF CALIFORNIA

INTRODUCTION

A. Purpose and Authority

1. In furtherance of legislative policy set forth in Section 13000 of Division 7 of the California Water Code (CWC) (Stats. 1969, Chap. 482) pursuant to the authority contained in Section 13170 and 13170.2 (Stats. 1971, Chap. 1288) the State Water Resources Control Board (State Water Board) hereby finds and declares that protection of the quality of the ocean* waters for use and enjoyment by the people of the State requires control of the discharge of waste* to ocean* waters in accordance with the provisions contained herein. The Board finds further that this plan shall be reviewed at least every three years to guarantee that the current standards are adequate and are not allowing degradation* to marine species or posing a threat to public health.

B. Principles

1. Harmony Among Water Quality Control Plans and Policies.

   a. In the adoption and amendment of water quality control plans, it is the intent of this Board that each plan will provide for the attainment and maintenance of the water quality standards of downstream waters.

   b. To the extent there is a conflict between a provision of this plan and a provision of another statewide plan or policy, or a regional water quality control plan (basin plan), the more stringent provision shall apply except where pursuant to Chap. III.J of this Plan, the State Water Board has approved an exception to the Plan requirements.

C. Applicability

1. This plan is applicable, in its entirety, to point source discharges to the ocean*. Nonpoint sources of waste* discharges to the ocean* are subject to Chapter I Beneficial Uses, Chapter II - WATER QUALITY OBJECTIVES (wherein compliance with water quality objectives shall, in all cases, be determined by direct measurements in the receiving waters*) and Chapter III - PROGRAM OF IMPLEMENTATION Parts A.2, D, E, and I.

2. This plan is not applicable to discharges to enclosed* bays and estuaries* or inland waters or the control of dredged* material.

3. Provisions regulating the thermal aspects of waste* discharged to the ocean* are set forth in the Water Quality Control Plan for the Control of Temperature in the Coastal and Interstate Waters and Enclosed* Bays and Estuaries* of California.

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* See Appendix I for definition of terms.

4. Within this Plan, references to the State Board or State Water Board shall mean the State Water Resources Control Board. References to a Regional Board or Regional Water Board shall mean a California Regional Water Quality Control Board. References to the Environmental Protection Agency, USEPA, or EPA shall mean the federal Environmental Protection Agency.

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* See Appendix I for definition of terms.

I. BENEFICIAL USES

A. The beneficial uses of the ocean* waters of the State that shall be protected include industrial water supply; water contact and non-contact recreation, including aesthetic enjoyment; navigation; commercial and sport fishing; mariculture*; preservation and enhancement of designated Areas* of Special Biological Significance (ASBS); rare and endangered species; marine habitat; fish migration; fish spawning and shellfish* harvesting.

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* See Appendix I for definition of terms.

II. WATER QUALITY OBJECTIVES

A. General Provisions

1. This chapter sets forth limits or levels of water quality characteristics for ocean* waters to ensure the reasonable protection of beneficial uses and the prevention of nuisance. The discharge of waste* shall not cause violation of these objectives.

2. The Water Quality Objectives and Effluent Limitations are defined by a statistical distribution when appropriate. This method recognizes the normally occurring variations in treatment efficiency and sampling and analytical techniques and does not condone poor operating practices.

3. Compliance with the water quality objectives of this chapter shall be determined from samples collected at stations representative of the area within the waste field where initial* dilution is completed.

B. Bacterial Characteristics

1. Water-Contact Standards

   Both the State Water Board and the California Department of Public Health (CDPH) have established standards to protect water contact recreation in coastal waters from bacterial contamination. Subsection a of this section contains bacterial objectives adopted by the State Water Board for ocean waters used for water contact recreation. Subsection b describes the bacteriological standards adopted by CDPH for coastal waters adjacent to public beaches and public water contact sports areas in ocean waters.

   a. State Water Board Water-Contact Standards

      (1) 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 from the shoreline, and in areas outside this zone used for water contact sports, as determined by the Regional Board (i.e., waters designated as REC-1), but including all kelp* beds, the following bacterial objectives shall be maintained throughout the water column:

      30-day Geometric Mean – The following standards are based on the geometric mean of the five most recent samples from each site:

      i. Total coliform density shall not exceed 1,000 per 100 mL;
      ii. Fecal coliform density shall not exceed 200 per 100 mL; and
      iii. Enterococcus density shall not exceed 35 per 100 mL.

      Single Sample Maximum:

      i. Total coliform density shall not exceed 10,000 per 100 mL;
      ii. Fecal coliform density shall not exceed 400 per 100 mL;
      iii. Enterococcus density shall not exceed 104 per 100 mL; and

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* See Appendix I for definition of terms.

iv. Total coliform density shall not exceed 1,000 per 100 mL when the fecal coliform/total coliform ratio exceeds 0.1.

(2) 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 Water Board (for consideration under Chapter III. J.). 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.

b. CDPH Standards

CDPH has established minimum protective bacteriological standards for coastal waters adjacent to public beaches and for public water-contact sports areas in ocean waters. These standards are found in the California Code of Regulations, title 17, section 7958, and they are identical to the objectives contained in subsection a. above. When a public beach or public water-contact sports area fails to meet these standards, CDPH or the local public health officer may post with warning signs or otherwise restrict use of the public beach or public water-contact sports area until the standards are met. The CDPH regulations impose more frequent monitoring and more stringent posting and closure requirements on certain high-use public beaches that are located adjacent to a storm drain that flows in the summer.

For beaches not covered under AB 411 regulations, CDPH imposes the same standards as contained in Title 17 and requires weekly sampling but allows the county health officer more discretion in making posting and closure decisions.

2. Shellfish* Harvesting Standards

a. At all areas where shellfish* may be harvested for human consumption, as determined by the Regional Board, the following bacterial objectives shall be maintained throughout the water column:

(1) 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 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 the 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*.

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* See Appendix I for definition of terms.

D. Chemical Characteristics

1. The dissolved oxygen concentration shall not at any time be depressed more than 10 percent from that which occurs naturally, as the 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 1, 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 that would degrade* marine life.
6. Nutrient materials shall not cause objectionable aquatic growths or degrade* indigenous biota.
7. Numerical Water Quality Objectives
    a. Table 1 water quality objectives apply to all discharges within the jurisdiction of this Plan. Unless otherwise specified, all metal concentrations are expressed as total recoverable concentrations.
    b. Table 1 Water Quality Objectives

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* See Appendix I for definition of terms.

TABLE 1 (formerly TABLE B)
WATER QUALITY OBJECTIVES

		Limiting Concentrations		
	Units of Measurement	6-Month Median	Daily Maximum	Instantaneous Maximum
OBJECTIVES FOR PROTECTION OF MARINE AQUATIC LIFE				
Arsenic	µg/L	8.	32.	80.
Cadmium	µg/L	1.	4.	10.
Chromium (Hexavalent) (see below, a)	µg/L	2.	8.	20.
Copper	µg/L	3.	12.	30.
Lead	µg/L	2.	8.	20.
Mercury	µg/L	0.04	0.16	0.4
Nickel	µg/L	5.	20.	50.
Selenium	µg/L	15.	60.	150.
Silver	µg/L	0.7	2.8	7.
Zinc	µg/L	20.	80.	200.
Cyanide (see below, b)	µg/L	1.	4.	10.
Total Chlorine Residual (For intermittent chlorine sources see below, c)	µg/L	2.	8.	60.
Ammonia (expressed as nitrogen)	µg/L	600.	2400.	6000.
Acute* Toxicity	TUa	N/A	0.3	N/A
Chronic* Toxicity	TUc	N/A	1.	N/A
Phenolic Compounds (non-chlorinated)	µg/L	30.	120.	300.
Chlorinated Phenolics	µg/L	1.	4.	10.
Endosulfan	µg/L	0.009	0.018	0.027
Endrin	µg/L	0.002	0.004	0.006
HCH*	µg/L	0.004	0.008	0.012
Radioactivity	Not to exceed limits specified in Title 17, Division 1, Chapter 5, Subchapter 4, Group 3, Article 3, Section 30253 of the California Code of Regulations. Reference to Section 30253 is prospective, including future changes to any incorporated provisions of federal law, as the changes take effect.			

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* See Appendix I for definition of terms.

TABLE 1 (formerly TABLE B) Continued

	30-day Average (µg/L)	
Chemical	Decimal Notation	Scientific Notation
OBJECTIVES FOR PROTECTION OF HUMAN HEALTH – NONCARCINOGENS		
acrolein	220.	2.2×10^{2}
antimony	1,200.	1.2×10^{3}
bis(2-chloroethoxy) methane	4.4	4.4×10^{0}
bis(2-chloroisopropyl) ether	1,200.	1.2×10^{3}
chlorobenzene	570.	5.7×10^{2}
chromium (III)	190,000.	1.9×10^{5}
di-n-butyl phthalate	3,500.	3.5×10^{3}
dichlorobenzenes*	5,100.	5.1×10^{3}
diethyl phthalate	33,000.	3.3×10^{4}
dimethyl phthalate	820,000.	8.2×10^{5}
4,6-dinitro-2-methylphenol	220.	2.2×10^{2}
2,4-dinitrophenol	4.0	4.0×10^{0}
ethylbenzene	4,100.	4.1×10^{3}
fluoranthene	15.	1.5×10^{1}
hexachlorocyclopentadiene	58.	5.8×10^{1}
nitrobenzene	4.9	4.9×10^{0}
thallium	2.	$2. \times 10^{0}$
toluene	85,000.	8.5×10^{4}
tributyltin	0.0014	1.4×10^{-3}
1,1,1-trichloroethane	540,000.	5.4×10^{5}
OBJECTIVES FOR PROTECTION OF HUMAN HEALTH – CARCINOGENS		
acrylonitrile	0.10	1.0×10^{-1}
aldrin	0.000022	2.2×10^{-5}
benzene	5.9	5.9×10^{0}
benzidine	0.000069	6.9×10^{-5}
beryllium	0.033	3.3×10^{-2}
bis(2-chloroethyl) ether	0.045	4.5×10^{-2}
bis(2-ethylhexyl) phthalate	3.5	3.5×10^{0}
carbon tetrachloride	0.90	9.0×10^{-1}
chlordane*	0.000023	2.3×10^{-5}
chlorodibromomethane	8.6	8.6×10^{0}

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* See Appendix I for definition of terms.

TABLE 1 (formerly TABLE B) Continued

Chemical	30-day Average (µg/L) Decimal Notation	Scientific Notation
OBJECTIVES FOR PROTECTION OF HUMAN HEALTH – CARCINOGENS		
chloroform	130.	1.3×10^{2}
DDT*	0.00017	1.7×10^{-4}
1,4-dichlorobenzene	18.	1.8×10^{1}
3,3'-dichlorobenzidine	0.0081	8.1×10^{-3}
1,2-dichloroethane	28.	2.8×10^{1}
1,1-dichloroethylene	0.9	9×10^{-1}
dichlorobromomethane	6.2	6.2×10^{0}
dichloromethane	450.	4.5×10^{2}
1,3-dichloropropene	8.9	8.9×10^{0}
dieldrin	0.00004	4.0×10^{-5}
2,4-dinitrotoluene	2.6	2.6×10^{0}
1,2-diphenylhydrazine	0.16	1.6×10^{-1}
halomethanes*	130.	1.3×10^{2}
heptachlor	0.00005	5×10^{-5}
heptachlor epoxide	0.00002	2×10^{-5}
hexachlorobenzene	0.00021	2.1×10^{-4}
hexachlorobutadiene	14.	1.4×10^{1}
hexachloroethane	2.5	2.5×10^{0}
isophorone	730.	7.3×10^{2}
N-nitrosodimethylamine	7.3	7.3×10^{0}
N-nitrosodi-N-propylamine	0.38	3.8×10^{-1}
N-nitrosodiphenylamine	2.5	2.5×10^{0}
PAHs*	0.0088	8.8×10^{-3}
PCBs*	0.000019	1.9×10^{-5}
TCDD equivalents*	0.0000000039	3.9×10^{-9}
1,1,2,2-tetrachloroethane	2.3	2.3×10^{0}
tetrachloroethylene	2.0	2.0×10^{0}
toxaphene	0.00021	2.1×10^{-4}
trichloroethylene	27.	2.7×10^{1}
1,1,2-trichloroethane	9.4	9.4×10^{0}
2,4,6-trichlorophenol	0.29	2.9×10^{-1}
vinyl chloride	36.	3.6×10^{1}

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* See Appendix I for definition of terms.

Table 1 Notes:

a) Dischargers may at their option meet this objective as a total chromium objective.

b) If a discharger can demonstrate to the satisfaction of the Regional Water Board (subject to EPA approval) that an analytical method is available to reliably distinguish between strongly and weakly complexed cyanide, effluent limitations for cyanide may be met by the combined measurement of free cyanide, simple alkali metal cyanides, and weakly complexed organometallic cyanide complexes. In order for the analytical method to be acceptable, the recovery of free cyanide from metal complexes must be comparable to that achieved by the approved method in 40 CFR PART 136, as revised May 14, 1999.

c) Water quality objectives for total chlorine residual applying to intermittent discharges not exceeding two hours, shall be determined through the use of the following equation:

$$\log y = -0.43 (\log x) + 1.8$$

where: y = the water quality objective (in µg/L) to apply when chlorine is being discharged;
x = the duration of uninterrupted chlorine discharge in minutes.

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 bioaccumulate to levels that are harmful to human health.

F. Radioactivity

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

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* See Appendix I for definition of terms.

III. PROGRAM OF IMPLEMENTATION

A. General Provisions

1. Effective Date

a. The *Water Quality Control Plan, Ocean Waters of California, California Ocean Plan* was adopted and has been effective since 1972. There have been multiple amendments of the Ocean Plan since its adoption.

2. General Requirements For Management Of Waste Discharge To The Ocean*

a. Waste* management systems that discharge to the ocean* must be designed and operated in a manner that will maintain the indigenous marine life and a healthy and diverse marine community.

b. Waste discharged* to the ocean* must be essentially free of:

(1) Material that is floatable or will become floatable upon discharge.

(2) Settleable material or substances that may form sediments which will degrade* benthic communities or other aquatic life.

(3) Substances which will accumulate to toxic levels in marine waters, sediments or biota.

(4) Substances that significantly* decrease the natural* light to benthic communities and other marine life.

(5) Materials that result in aesthetically undesirable discoloration of the ocean* surface.

c. Waste* effluents shall be discharged in a manner which provides sufficient initial* dilution to minimize the concentrations of substances not removed in the treatment.

d. Location of waste* discharges must be determined after a detailed assessment of the oceanographic characteristics and current patterns to assure that:

(1) Pathogenic organisms and viruses are not present in areas where shellfish* are harvested for human consumption or in areas used for swimming or other body-contact sports.

(2) Natural water quality conditions are not altered in areas designated as being of special biological significance or areas that existing marine laboratories use as a source of seawater.

(3) Maximum protection is provided to the marine environment.

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* See Appendix I for definition of terms.

e. Waste* that contains pathogenic organisms or viruses should be discharged a sufficient distance from shellfishing* and water-contact sports areas to maintain applicable bacterial standards without disinfection. Where conditions are such that an adequate distance cannot be attained, reliable disinfection in conjunction with a reasonable separation of the discharge point from the area of use must be provided. Disinfection procedures that do not increase effluent toxicity and that constitute the least environmental and human hazard should be used.

3. Areas of Special Biological Significance

a. ASBS* shall be designated by the State Water Board following the procedures provided in Appendix IV. A list of ASBS* is available in Appendix V.

4. Combined Sewer Overflow: Not withstanding any other provisions in this plan, discharges from the City of San Francisco's combined sewer system are subject to the US EPA's Combined Sewer Overflow Policy.

B. Table 2 Effluent Limitations

TABLE 2 (formerly TABLE A)
EFFLUENT LIMITATIONS

		Limiting Concentrations		
	Unit of Measurement	Monthly (30-day Average)	Weekly (7-day Average)	Maximum at any time
Grease and Oil	mg/L	25.	40.	75.
Suspended Solids			See below +	
Settleable Solids	mL/L	1.0	1.5	3.0
Turbidity	NTU	75.	100.	225.
pH	Units		Within limit of 6.0 to 9.0 at all times	

Table 2 Notes:

\+ Suspended Solids: Dischargers shall, as a 30-day average, remove 75% of suspended solids from the influent stream before discharging wastewaters to the ocean*, except that the effluent limitation to be met shall not be lower than 60 mg/l. Regional Boards may recommend that the State Water Board (Chapter III.J), with the concurrence of the Environmental Protection Agency, adjust the lower effluent concentration limit (the 60 mg/l above) to suit the environmental and effluent characteristics of the discharge. As a further consideration in making such recommendation for adjustment, Regional Water Boards should evaluate effects on existing and potential water* reclamation projects.

If the lower effluent concentration limit is adjusted, the discharger shall remove 75% of suspended solids from the influent stream at any time the influent concentration exceeds four times such adjusted effluent limit.

1. Table 2 effluent limitations apply only to publicly owned treatment works and industrial discharges for which Effluent Limitations Guidelines have not been established pursuant to Sections 301, 302, 304, or 306 of the Federal Clean Water Act.

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* See Appendix I for definition of terms.

2. Table 2 effluent limitations shall apply to a discharger's total effluent, of whatever origin (i.e., gross, not net, discharge), except where otherwise specified in this Plan.
3. The State Water Board is authorized to administer and enforce effluent limitations established pursuant to the Federal Clean Water Act. Effluent limitations established under Sections 301, 302, 306, 307, 316, 403, and 405 of the aforementioned Federal Act and administrative procedures pertaining thereto are included in this plan by reference. Compliance with Table 2 effluent limitations, or Environmental Protection Agency Effluent Limitations Guidelines for industrial discharges, based on Best Practicable Control Technology, shall be the minimum level of treatment acceptable under this plan, and shall define reasonable treatment and waste control technology.

C. Implementation Provisions for Table 1

1. Effluent concentrations calculated from Table 1 water quality objectives shall apply to a discharger's total effluent, of whatever origin (i.e., gross, not net, discharge), except where otherwise specified in this Plan.
2. If the Regional Water Board determines, using the procedures in Appendix VI, that a pollutant is discharged into ocean* waters at levels which will cause, have the reasonable potential to cause, or contribute to an excursion above a Table 1 water quality objective, the Regional Water Board shall incorporate a water quality-based effluent limitation in the Waste Discharge Requirement for the discharge of that pollutant.
3. Effluent limitations shall be imposed in a manner prescribed by the State Water Board such that the concentrations set forth below as water quality objectives shall not be exceeded in the receiving water* upon completion of initial* dilution, except that objectives indicated for radioactivity shall apply directly to the undiluted waste* effluent.
4. Calculation of Effluent Limitations
    a. Effluent limitations for water quality objectives listed in Table 1, with the exception of acute* toxicity and radioactivity, shall be determined through the use of the following equation:

Equation 1: $Ce = Co + Dm (Co - Cs)$

where:

Ce = the effluent concentration limit, µg/L

Co = the concentration (water quality objective) to be met at the completion of initial* dilution, µg/L

Cs = background seawater concentration (see Table 3 below, with all metals expressed as total recoverable concentrations), µg/L

Dm = minimum probable initial* dilution expressed as parts seawater per part wastewater.

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* See Appendix I for definition of terms.

TABLE 3 (formerly TABLE C)
BACKGROUND SEAWATER CONCENTRATIONS (Cs)

Waste Constituent	Cs (µg/L)
Arsenic	3.
Copper	2.
Mercury	0.0005
Silver	0.16
Zinc	8.

For all other Table 1 parameters, Cs = 0.

b. Determining a Mixing Zone for the Acute* Toxicity Objective

The mixing zone for the acute* toxicity objective shall be ten percent (10%) of the distance from the edge of the outfall structure to the edge of the chronic mixing zone (zone of initial dilution). There is no vertical limitation on this zone. The effluent limitation for the acute* toxicity objective listed in Table 1 shall be determined through the use of the following equation:

Equation 2: $Ce = Ca + (0.1)\, Dm\, (Ca)$

where:

Ca = the concentration (water quality objective) to be met at the edge of the acute mixing zone.

Dm = minimum probable initial* dilution expressed as parts seawater per part wastewater (This equation applies only when $Dm > 24$).

c. Toxicity Testing Requirements based on the Minimum Initial* Dilution Factor for Ocean Waste Discharges

(1) Dischargers shall conduct acute* toxicity testing if the minimum initial* dilution of the effluent is greater than 1,000:1 at the edge of the mixing zone.

(2) Dischargers shall conduct either acute* or chronic* toxicity testing if the minimum initial* dilution ranges from 350:1 to 1,000:1 depending on the specific discharge conditions. The Regional Water Board shall make this determination.

(3) Dischargers shall conduct chronic* toxicity testing for ocean waste discharges with minimum initial* dilution factors ranging from 100:1 to 350:1. The Regional Water Board may require that acute toxicity testing be conducted in addition to chronic as necessary for the protection of beneficial uses of ocean waters.

(4) Dischargers shall conduct chronic toxicity testing if the minimum initial* dilution of the effluent falls below 100:1 at the edge of the mixing zone.

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* See Appendix I for definition of terms.

d. For the purpose of this Plan, minimum initial* dilution is the lowest average initial* dilution within any single month of the year. Dilution estimates shall be based on observed waste flow characteristics, observed receiving water* density structure, and the assumption that no currents, of sufficient strength to influence the initial* dilution process, flow across the discharge structure.

e. The Executive Director of the State Water Board shall identify standard dilution models for use in determining Dm, and shall assist the Regional Board in evaluating Dm for specific waste discharges. Dischargers may propose alternative methods of calculating Dm, and the Regional Board may accept such methods upon verification of its accuracy and applicability.

f. The six-month median shall apply as a moving median of daily values for any 180-day period in which daily values represent flow weighted average concentrations within a 24-hour period. For intermittent discharges, the daily value shall be considered to equal zero for days on which no discharge occurred.

g. The daily maximum shall apply to flow weighted 24 hour composite samples.

h. The instantaneous maximum shall apply to grab sample determinations.

i. If only one sample is collected during the time period associated with the water quality objective (e.g., 30-day average or 6-month median), the single measurement shall be used to determine compliance with the effluent limitation for the entire time period.

j. Discharge requirements shall also specify effluent limitations in terms of mass emission rate limits utilizing the general formula:

Equation 3: $\text{lbs/day} = 0.00834 \times Ce \times Q$

where:

Ce = the effluent concentration limit, µg/L

Q = flow rate, million gallons per day (MGD)

k. The six-month median limit on daily mass emissions shall be determined using the six-month median effluent concentration as Ce and the observed flow rate Q in millions of gallons per day. The daily maximum mass emission shall be determined using the daily maximum effluent concentration limit as Ce and the observed flow rate Q in millions of gallons per day.

l. Any significant change in waste* flow shall be cause for reevaluating effluent limitations.

5. Minimum* Levels

For each numeric effluent limitation, the Regional Board must select one or more Minimum* Levels (and their associated analytical methods) for inclusion in the permit.

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* See Appendix I for definition of terms.

The "reported" Minimum* Level is the Minimum* Level (and its associated analytical method) chosen by the discharger for reporting and compliance determination from the Minimum* Levels included in their permit.

a. Selection of Minimum* Levels from Appendix II

The Regional Water Board must select all Minimum* Levels from Appendix II that are below the effluent limitation. If the effluent limitation is lower than all the Minimum* Levels in Appendix II, the Regional Board must select the lowest Minimum* Level from Appendix II.

b. Deviations from Minimum* Levels in Appendix II

The Regional Board, in consultation with the State Water Board's Quality Assurance Program, must establish a Minimum* Level to be included in the permit in any of the following situations:

1. A pollutant is not listed in Appendix II.
2. The discharger agrees to use a test method that is more sensitive than those described in 40 CFR 136 (revised May 14, 1999).
3. The discharger agrees to use a Minimum* Level lower than those listed in Appendix II.
4. The discharger demonstrates that their calibration standard matrix is sufficiently different from that used to establish the Minimum* Level in Appendix II and proposes an appropriate Minimum* Level for their matrix.
5. A discharger uses an analytical method having a quantification practice that is not consistent with the definition of Minimum* Level (e.g., US EPA methods 1613, 1624, 1625).

6. Use of Minimum* Levels

a. Minimum* Levels in Appendix II represent the lowest quantifiable concentration in a sample based on the proper application of method-specific analytical procedures and the absence of matrix interferences. Minimum* Levels also represent the lowest standard concentration in the calibration curve for a specific analytical technique after the application of appropriate method-specific factors.

Common analytical practices may require different treatment of the sample relative to the calibration standard. Some examples are given below:

Substance or Grouping	Method-Specific Treatment	Most Common Factor
Volatile Organics	No differential treatment	1
Semi-Volatile Organics	Samples concentrated by extraction	1000
Metals	Samples diluted or concentrated	½ , 2 , and 4
Pesticides	Samples concentrated by extraction	100

b. Other factors may be applied to the Minimum* Level depending on the specific sample preparation steps employed. For example, the treatment typically applied when there are matrix effects is to dilute the sample or sample aliquot by a factor of ten. In such cases, this additional factor must be applied during the

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* See Appendix I for definition of terms.

computation of the reporting limit. Application of such factors will alter the reported Minimum* Level.

c. Dischargers are to instruct their laboratories to establish calibration standards so that the Minimum* Level (or its equivalent if there is differential treatment of samples relative to calibration standards) is the lowest calibration standard. At no time is the discharger to use analytical data derived from *extrapolation* beyond the lowest point of the calibration curve. In accordance with Section 4b, above, the discharger's laboratory may employ a calibration standard lower than the Minimum* Level in Appendix II.

7. Sample Reporting Protocols

a. Dischargers must report with each sample result the reported Minimum* Level (selected in accordance with Section 4, above) and the laboratory's current MDL*.

b. Dischargers must also report the results of analytical determinations for the presence of chemical constituents in a sample using the following reporting protocols:

(1) Sample results greater than or equal to the reported Minimum* Level must be reported "as measured" by the laboratory (i.e., the measured chemical concentration in the sample).

(2) Sample results less than the reported Minimum* Level, but greater than or equal to the laboratory's MDL*, must be reported as "Detected, but Not Quantified", or DNQ. The laboratory must write the estimated chemical concentration of the sample next to DNQ as well as the words "Estimated Concentration" (may be shortened to "Est. Conc.").

(3) Sample results less than the laboratory's MDL* must be reported as "Not Detected", or ND.

8. Compliance Determination

Sufficient sampling and analysis shall be required to determine compliance with the effluent limitation.

a. Compliance with Single-Constituent Effluent Limitations

Dischargers are out of compliance with the effluent limitation if the concentration of the pollutant (see Section 7c, below) in the monitoring sample is greater than the effluent limitation and greater than or equal to the reported Minimum* Level.

b. Compliance with Effluent Limitations expressed as a Sum of Several Constituents

Dischargers are out of compliance with an effluent limitation which applies to the sum of a group of chemicals (e.g., PCB's) if the sum of the individual pollutant concentrations is greater than the effluent limitation. Individual pollutants of the group will be considered to have a concentration of zero if the constituent is reported as ND or DNQ.

c. Multiple Sample Data Reduction

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* See Appendix I for definition of terms.

The concentration of the pollutant in the effluent may be estimated from the result of a single sample analysis or by a measure of central tendency (arithmetic mean, geometric mean, median, etc.) of multiple sample analyses when all sample results are quantifiable (i.e., greater than or equal to the reported Minimum* Level). When one or more sample results are reported as ND or DNQ, the central tendency concentration of the pollutant shall be the median (middle) value of the multiple samples. If, in an even number of samples, one or both of the middle values is ND or DNQ, the median will be the lower of the two middle values.

d. Powerplants and Heat Exchange Dischargers

Due to the large total volume of powerplant and other heat exchange discharges, special procedures must be applied for determining compliance with Table 1 objectives on a routine basis. Effluent concentration values (Ce) shall be determined through the use of equation 1 considering the minimal probable initial* dilution of the combined effluent (in-plant waste streams plus cooling water flow). These concentration values shall then be converted to mass emission limitations as indicated in equation 3. The mass emission limits will then serve as requirements applied to all inplant waste* streams taken together which discharge into the cooling water flow, except that limits for total chlorine residual, acute* (if applicable per Section (3)(c)) and chronic* toxicity and instantaneous maximum concentrations in Table 1 shall apply to, and be measured in, the combined final effluent, as adjusted for dilution with ocean water. The Table 1 objective for radioactivity shall apply to the undiluted combined final effluent.

9. Pollutant Minimization Program

a. Pollutant Minimization Program Goal

The goal of the Pollutant Minimization Program is to reduce all potential sources of a pollutant through pollutant minimization (control) strategies, including pollution prevention measures, in order to maintain the effluent concentration at or below the effluent limitation.

Pollution prevention measures may be particularly appropriate for persistent bioaccumulative priority pollutants where there is evidence that beneficial uses are being impacted. The completion and implementation of a Pollution Prevention Plan, required in accordance with CA Water Code Section 13263.3 (d) will fulfill the Pollution Minimization Program requirements in this section.

b. Determining the need for a Pollutant Minimization Program

1. The discharger must develop and conduct a Pollutant Minimization Program if all of the following conditions are true:
    - (a) The calculated effluent limitation is less than the reported Minimum* Level
    - (b) The concentration of the pollutant is reported as DNQ
    - (c) There is evidence showing that the pollutant is present in the effluent above the calculated effluent limitation.

2. Alternatively, the discharger must develop and conduct a Pollutant Minimization Program if all of the following conditions are true:

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* See Appendix I for definition of terms.

(a) The calculated effluent limitation is less than the Method Detection Limit*.

(b) The concentration of the pollutant is reported as ND.

(c) There is evidence showing that the pollutant is present in the effluent above the calculated effluent limitation.

c. Regional Water Boards may include special provisions in the discharge requirements to require the gathering of evidence to determine whether the pollutant is present in the effluent at levels above the calculated effluent limitation. Examples of evidence may include:

1. health advisories for fish consumption,
2. presence of whole effluent toxicity,
3. results of benthic or aquatic organism tissue sampling,
4. sample results from analytical methods more sensitive than methods included in the permit (in accordance with Section 4b, above).
5. the concentration of the pollutant is reported as DNQ and the effluent limitation is less than the MDL

d. Elements of a Pollutant Minimization Program

The Regional Board may consider cost-effectiveness when establishing the requirements of a Pollutant Minimization Program. The program shall include actions and submittals acceptable to the Regional Board including, but not limited to, the following:

1. An annual review and semi-annual monitoring of potential sources of the reportable pollutant, which may include fish tissue monitoring and other bio-uptake sampling;
2. Quarterly monitoring for the reportable pollutant in the influent to the wastewater treatment system;
3. Submittal of a control strategy designed to proceed toward the goal of maintaining concentrations of the reportable pollutant in the effluent at or below the calculated effluent limitation;
4. Implementation of appropriate cost-effective control measures for the pollutant, consistent with the control strategy; and,
5. An annual status report that shall be sent to the Regional Board including:
    (a) All Pollutant Minimization Program monitoring results for the previous year;
    (b) A list of potential sources of the reportable pollutant;
    (c) A summary of all action taken in accordance with the control strategy; and,
    (d) A description of actions to be taken in the following year.

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* See Appendix I for definition of terms.

10. Toxicity Reduction Requirements

    a. If a discharge consistently exceeds an effluent limitation based on a toxicity objective in Table 1, a toxicity reduction evaluation (TRE) is required. The TRE shall include all reasonable steps to identify the source of toxicity. Once the source(s) of toxicity is identified, the discharger shall take all reasonable steps necessary to reduce toxicity to the required level.

    b. The following shall be incorporated into waste discharge requirements: (1) a requirement to conduct a TRE if the discharge consistently exceeds its toxicity effluent limitation, and (2) a provision requiring a discharger to take all reasonable steps to reduce toxicity once the source of toxicity is identified.

D. Implementation Provisions for Bacterial Characteristics

1. Water-Contact Monitoring

    a. Weekly samples shall be collected from each site. The geometric mean shall be calculated using the five most recent sample results.

    b. If a single sample exceeds any of the single sample maximum (*SSM*) standards, repeat sampling at that location shall be conducted to determine the extent and persistence of the exceedance. Repeat sampling shall be conducted within 24 hours of receiving analytical results and continued until the sample result is less than the SSM standard or until a sanitary survey is conducted to determine the source of the high bacterial densities.

       i) Total coliform density will not exceed 10,000 per 100 mL; or
       ii) Fecal coliform density will not exceed 400 per 100 mL; or
       iii) Total coliform density will not exceed 1,000 per 100 mL when the ratio of fecal/total coliform exceeds 0.1;
       iv) enterococcus density will not exceed 104 per 100 mL.

       When repeat sampling is required because of an exceedance of any one single sample density, values from all samples collected during that 30-day period will be used to calculate the geometric mean.

    c. It is state policy that the geometric mean bacterial objectives are strongly preferred for use in water body assessment decisions, for example, in developing the Clean Water Act section 303(d) list of impaired waters, because the geometric mean objectives are a more reliable measure of long-term water body conditions. In making assessment decisions on bacterial quality, single sample maximum data must be considered together with any available geometric mean data. The use of only single sample maximum bacterial data is generally inappropriate unless there is a limited data set, the water is subject to short-term spikes in bacterial concentrations, or other circumstances justify the use of only single sample maximum data.

    d. For monitoring stations outside of the defined water-contact recreation zone (REC-1), samples will be analyzed for total coliform only.

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* See Appendix I for definition of terms.

E. Implementation Provisions for Marine Managed Areas*

1. Section E addresses the following Marine Managed Areas*:

   (a) State Water Quality Protection Areas (SWQPAs)* consisting of:

      (1) SWQPA – Areas of Special Biological Significance (ASBS) designated by the State Water Board that require special protections as defined under section 4 below.

      (2) SWQPA – General Protection (GP) designated by the State Water Board to protect water quality within Marine Protected Areas (MPAs) that require protection under the provisions described under section 5 below.

   (b) Marine Protected Areas as defined in the California Public Resources Code as State Marine Reserves, State Marine Parks and State Marine Conservation Areas, established by the Fish and Game Commission, or the Parks and Recreation Commission.

2. The designation of State Marine Parks and State Marine Conservation Areas may not serve as the sole basis for new or modified limitations, substantive conditions, or prohibitions upon existing municipal point source wastewater discharge outfalls. This provision does not apply to State Marine Reserves.

3. The State Water Board may designate SWQPAs* to prevent the undesirable alteration of natural water quality within MPAs. These designations may include either SWQPA-ASBS or SWQPA-GP or in combination. In considering the designation of SWQPAs over MPAs, the State Water Board will consult with the affected Regional Water Quality Control Board, the Department of Fish and Game and the Department of Parks and Recreation, in accordance with the requirements of Appendix IV.

4. Implementation Provisions for SWQPA-ASBS*

   (a) Waste* shall not be discharged to areas designated as being of special biological significance. Discharges shall be located a sufficient distance from such designated areas to assure maintenance of natural water quality conditions in these areas.

   (b) Regional Water Boards may approve waste discharge requirements or recommend certification for limited-term (i.e. weeks or months) activities in ASBS*. Limited-term activities include, but are not limited to, activities such as maintenance/repair of existing boat facilities, restoration of sea walls, repair of existing storm water pipes, and replacement/repair of existing bridges. Limited-term activities may result in temporary and short-term changes in existing water quality. Water quality degradation shall be limited to the shortest possible time. The activities must not permanently degrade water quality or result in water quality lower than that necessary to protect existing uses, and all practical means of minimizing such degradation shall be implemented.

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* See Appendix I for definition of terms.

5. Implementation Provisions for SWQPAs-GP*

(a) Implementation provisions for existing point source wastewater discharges (NPDES)

(1) An SWQPA-GP shall not be designated over existing permitted point source wastewater outfalls or encroach upon the zone of initial dilution associated with an existing discharge. This requirement does not apply to discharges less than one million gallons per day.

(2) Designation of an SWQPA-GP shall not include conditions to move existing point source wastewater outfalls.

(3) Where a new SWQPA-GP is established in the vicinity of existing municipal wastewater outfalls, there shall be no new or modified limiting condition or prohibitions for the SWQPA-GP relative to those wastewater outfalls.

(4) Regulatory requirements for discharges from existing treated municipal wastewater outfalls shall be derived from the Chapter II – Water Quality Objectives and Chapter III – Program of Implementation.

(b) Implementation provisions for existing seawater intakes

(1) Existing permitted seawater intakes must be controlled to minimize entrainment and impingement by using best technology available. Existing permitted seawater intakes with a capacity less than one million gallons per day are excluded from this requirement.

(c) Implementation provisions for permitted separate storm sewer system (MS4) discharges and nonpoint source discharges.

(1) Existing waste discharges are allowed, but shall not cause an undesirable alteration in natural water quality. For purposes of SWQPA-GP, an undesirable alteration in natural water quality means that for intermittent (e.g. wet weather) discharges, Table 1 instantaneous maximum concentrations for chemical constituents, and daily maximum concentrations for chronic toxicity, must not be exceeded in the receiving water.

(2) An NPDES permitting authority may authorize NPDES-permitted non-storm water discharges to an MS4 with a direct discharge to an SWQPA-GP only to the extent the NPDES permitting authority finds that the discharge does not cause an undesirable alteration in natural water quality in an SWQPA-GP.

(3) Non-storm water (dry weather) flows are effectively prohibited as required by the applicable permit. Where capacity and infrastructure exists, all dry weather flows shall be diverted to municipal sanitary sewer systems. The permitting authority may allow discharges essential for emergency response purposes, structural stability, and slope stability, which may include but are not limited to the following:

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* See Appendix I for definition of terms.

a. Discharges associated with emergency fire fighting operations.
b. Foundation and footing drains.
c. Water from crawl space or basement pumps.
d. Hillside dewatering.

(4) The following naturally occurring discharges are allowed:

a. Naturally occurring groundwater seepage via a storm drain
b. Non-anthropogenic flows from a naturally occurring stream via a culvert or storm drain, as long as there are no contributions of anthropogenic runoff.

(5) Existing storm water discharges into an SWQPA-GP shall be characterized and assessed to determine what effect if any these inputs are having on natural water quality in the SWQPA-GP. Such assessments shall include an evaluation of cumulative impacts as well as impacts stemming from individual discharges. Information to be considered shall include:

a. Water quality;
b. Flow;
c. Watershed pollutant sources; and
d. Intertidal and/ or subtidal biological surveys.

Within each SWQPA-GP the assessment shall be used to rank these existing discharges into low, medium and high threat impact categories. Cumulative impacts will be ranked similarly as well.

(6) An initial analysis shall be performed for pre- and post-storm receiving water quality of Table 1 constituents and chronic toxicity. If post-storm receiving water quality has larger concentrations of constituents relative to pre-storm, and Table 1 instantaneous maximum concentrations for chemical constituents, and daily maximum concentrations for chronic toxicity, are exceeded, then receiving water shall be re-analyzed along with storm runoff (end of pipe) for the constituents that are exceeded.

(7) If undesirable alterations of natural water quality and/or biological communities are identified, control strategies/measures shall be implemented for those discharges characterized as a high threat or those contributing to higher threat cumulative impacts first.

(8) If those strategies fail, additional control strategies/measures will be implemented for discharges characterized as medium impact discharges. If these strategies do not result in improvement of water quality, those discharges classified as low threat shall also implement control strategies/measures.

(d) Implementation Provisions for New Discharges

(1) Point Source Wastewater Outfalls
No new point source wastewater outfalls shall be established within an SWQPA-GP.

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* See Appendix I for definition of terms.

(2) Seawater intakes
No new surface water seawater intakes shall be established within an SWQPA-GP. This does not apply to sub-seafloor intakes where studies are prepared showing there is no predictable entrainment or impingement of marine life.

(3) All Other New Discharges
There shall be no increase in nonpoint sources or permitted storm drains directly into an SWQPA-GP.

6. Impaired Tributaries to MPAs, SWQPA-ASBS and SWQPA-GP

All water bodies draining to, or that are designated as, MPAs and SWQPAs that appear on the State's CWA Section 303(d) list shall be given a high priority to have a TMDL developed and implemented.

F. Revision of Waste* Discharge Requirements

1. The Regional Water Boards may establish more restrictive water quality objectives and effluent limitations than those set forth in this Plan as necessary for the protection of beneficial uses of ocean* waters.

2. Regional Water Boards may impose alternative less restrictive provisions than those contained within Table 1 of the Plan, provided an applicant can demonstrate that:

    a. Reasonable control technologies (including source control, material substitution, treatment and dispersion) will not provide for complete compliance; or

    b. Any less stringent provisions would encourage water* reclamation;

3. Provided further that:

    a. Any alternative water quality objectives shall be below the conservative estimate of chronic* toxicity, as given in Table 4 (with all metal concentrations expressed as total recoverable concentrations), and such alternative will provide for adequate protection of the marine environment;

    b. A receiving water* quality toxicity objective of 1 TUc is not exceeded; and

    c. The State Water Board grants an exception (Chapter III.J.) to the Table 1 limits as established in the Regional Board findings and alternative limits.

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* See Appendix I for definition of terms.

G. Compliance Schedules in National Pollutant Discharge Elimination System (NPDES) Permits

1. Compliance schedules in NPDES permits are authorized in accordance with the provisions of the State Water Board's Policy for Compliance Schedules in [NPDES] Permits (2008).

TABLE 4 (formerly TABLE D)
CONSERVATIVE ESTIMATES OF CHRONIC TOXICITY

Constituent	**Estimate of Chronic Toxicity (µg/L)**
Arsenic	19.
Cadmium	8.
Hexavalent Chromium	18.
Copper	5.
Lead	22.
Mercury	0.4
Nickel	48.
Silver	3.
Zinc	51.
Cyanide	10.
Total Chlorine Residual	10.0
Ammonia	4000.0
Phenolic Compounds (non-chlorinated)	a) (see below)
Chlorinated Phenolics	a)
Chlorinated Pesticides and PCB's	b)

Table 4 Notes:

a) There are insufficient data for phenolics to estimate chronic toxicity levels. Requests for modification of water quality objectives for these waste* constituents must be supported by chronic toxicity data for representative sensitive species. In such cases, applicants seeking modification of water quality objectives should consult the Regional Water Quality Control Board to determine the species and test conditions necessary to evaluate chronic effects.

b) Limitations on chlorinated pesticides and PCB's shall not be modified so that the total of these compounds is increased above the objectives in Table 1.

H. Monitoring Program

1. The Regional Water Boards shall require dischargers to conduct self-monitoring programs and submit reports necessary to determine compliance with the waste* discharge requirements, and may require dischargers to contract with agencies or persons acceptable to the Regional Water Board to provide monitoring reports.

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* See Appendix I for definition of terms.

Monitoring provisions contained in waste discharge requirements shall be in accordance with the Monitoring Procedures provided in Appendices III and VI.

2. The Regional Water Board may require monitoring of bioaccumulation of toxicants in the discharge zone. Organisms and techniques for such monitoring shall be chosen by the Regional Water Board on the basis of demonstrated value in waste* discharge monitoring.

I. Discharge Prohibitions

1. <u>Hazardous Substances</u>

    a. The discharge of any radiological, chemical, or biological warfare agent or high-level radioactive waste* into the ocean* is prohibited.

2. <u>Areas Designated for Special Water Quality Protection</u>

    a. Waste* shall not be discharged to designated Areas* of Special Biological Significance except as provided in Chapter III. E. Implementation Provisions for Marine Managed Areas*.

3. <u>Sludge</u>

    a. Pipeline discharge of sludge to the ocean* is prohibited by federal law; the discharge of municipal and industrial waste* sludge directly to the ocean*, or into a waste* stream that discharges to the ocean*, is prohibited by this Plan. The discharge of sludge digester supernatant directly to the ocean*, or to a waste* stream that discharges to the ocean* without further treatment, is prohibited.

    b. It is the policy of the State Water Board that the treatment, use and disposal of sewage sludge shall be carried out in the manner found to have the least adverse impact on the total natural and human environment. Therefore, if federal law is amended to permit such discharge, which could affect California waters, the State Water Board may consider requests for exceptions to this section under Chapter III. J of this Plan, provided further that an Environmental Impact Report on the proposed project shows clearly that any available alternative disposal method will have a greater adverse environmental impact than the proposed project.

4. <u>By-Passing</u>

    a. The by-passing of untreated wastes* containing concentrations of pollutants in excess of those of Table 2 or Table 1 to the ocean* is prohibited.

5. <u>Vessels</u>

    a. Discharges of hazardous waste (as defined in California Health and Safety Code section 25117 et seq. [but not including sewage]), oily bilgewater, medical waste (as defined in section 117600 et seq. of the California Health and Safety Code) dry-cleaning waste, and film-processing waste from large passenger vessels and oceangoing vessels are prohibited.

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* See Appendix I for definition of terms.

b. Discharges of graywater* and sewage* from large passenger vessels are prohibited.

c. Discharges of sewage and sewage sludge from vessels are prohibited in No Discharge Zones promulgated by U.S. EPA.

J. State Board Exceptions to Plan Requirements

1. The State Water Board may, in compliance with the California Environmental Quality Act, subsequent to a public hearing, and with the concurrence of the Environmental Protection Agency, grant exceptions where the Board determines:

   a. The exception will not compromise protection of ocean* waters for beneficial uses, and,

   b. The public interest will be served.

2. All exceptions issued by the State Water Board and in effect at the time of the Triennial Review will be reviewed at that time. If there is sufficient cause to re-open or revoke any exception, the State Water Board may direct staff to prepare a report and to schedule a public hearing. If after the public hearing the State Water Board decides to re-open, revoke, or re-issue a particular exception, it may do so at that time.

K. Implementation Provisions for Vessel Discharges

1. Vessel discharges must comply with State Lands Commission (SLC) requirements for ballast water discharges and hull fouling to control and prevent the introduction of non-indigenous species, found in the Public Resources Code sections 71200 et seq. and title 2, California Code of Regulations, section 22700 et. seq.

2. Discharges incidental to the normal operation large passenger vessels and ocean-going vessels must be covered and comply with an individual or general NPDES permit.

3. Vessel discharges must not result in violations of water quality objectives in this plan.

4. Vessels subject to the federal NPDES Vessel General Permit (VGP) which are not large passenger vessels must follow the best management practices for graywater* as required in the VGP, including the use of only those cleaning agents (e.g., soaps and detergents) that are phosphate-free, non-toxic, and non-bioaccumulative.

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* See Appendix I for definition of terms.

APPENDIX I
DEFINITION OF TERMS

ACUTE TOXICITY

a. Acute Toxicity (TUa)

Expressed in Toxic Units Acute (TUa)

$$\text{TUa} = \frac{100}{\text{96-hr LC } 50\%}$$

b. Lethal Concentration 50% (LC 50)

LC 50 (percent waste giving 50% survival of test organisms) shall be determined by static or continuous flow bioassay techniques using standard marine test species as specified in Appendix III. If specific identifiable substances in wastewater can be demonstrated by the discharger as being rapidly rendered harmless upon discharge to the marine environment, but not as a result of dilution, the LC 50 may be determined after the test samples are adjusted to remove the influence of those substances.

When it is not possible to measure the 96-hour LC 50 due to greater than 50 percent survival of the test species in 100 percent waste, the toxicity concentration shall be calculated by the expression:

$$\text{TUa} = \frac{\log(100 - S)}{1.7}$$

where:

S = percentage survival in 100% waste. If $S > 99$, TUa shall be reported as zero.

AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE (ASBS) are those areas designated by the State Water Board as ocean areas requiring protection of species or biological communities to the extent that maintenance of natural water quality is assured. All Areas of Special Biological Significance are also classified as a subset of STATE WATER QUALITY PROTECTION AREAS. ASBS are also referred to as State Water Quality Protection Areas – Areas of Special Biological Significance (SWQPA-ASBS).

CHLORDANE shall mean the sum of chlordane-alpha, chlordane-gamma, chlordene-alpha, chlordene-gamma, nonachlor-alpha, nonachlor-gamma, and oxychlordane.

CHRONIC TOXICITY: This parameter shall be used to measure the acceptability of waters for supporting a healthy marine biota until improved methods are developed to evaluate biological response.

a. Chronic Toxicity (TUc)

Expressed as Toxic Units Chronic (TUc)

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* See Appendix I for definition of terms.

$$\text{TUc} = \frac{100}{\text{NOEL}}$$

b. No Observed Effect Level (NOEL)

The NOEL is expressed as the maximum percent effluent or receiving water* that causes no observable effect on a test organism, as determined by the result of a critical life stage toxicity test listed in Appendix III, Table III-1.

DDT shall mean the sum of 4,4’DDT, 2,4’DDT, 4,4’DDE, 2,4’DDE, 4,4’DDD, and 2,4’DDD.

DEGRADE: Degradation shall be determined by comparison of the waste field and reference site(s) for characteristic species diversity, population density, contamination, growth anomalies, debility, or supplanting of normal species by undesirable plant and animal species. Degradation occurs if there are significant differences in any of three major biotic groups, namely, demersal fish, benthic invertebrates, or attached algae. Other groups may be evaluated where benthic species are not affected, or are not the only ones affected.

DICHLOROBENZENES shall mean the sum of 1,2- and 1,3-dichlorobenzene.

DOWNSTREAM OCEAN WATERS shall mean waters downstream with respect to ocean currents.

DREDGED MATERIAL: Any material excavated or dredged from the navigable waters of the United States, including material otherwise referred to as “spoil”.

ENCLOSED BAYS are indentations along the coast which enclose an area of oceanic water within distinct headlands or harbor works. Enclosed bays include all bays where the narrowest distance between headlands or outermost harbor works is less than 75 percent of the greatest dimension of the enclosed portion of the bay. This definition includes but is not limited to: Humboldt Bay, Bodega Harbor, Tomales Bay, Drakes Estero, San Francisco Bay, Morro Bay, Los Angeles Harbor, Upper and Lower Newport Bay, Mission Bay, and San Diego Bay.

ENDOSULFAN shall mean the sum of endosulfan-alpha and -beta and endosulfan sulfate.

ESTUARIES AND COASTAL LAGOONS are waters at the mouths of streams that serve as mixing zones for fresh and ocean waters during a major portion of the year. Mouths of streams that are temporarily separated from the ocean by sandbars shall be considered as estuaries. Estuarine waters will generally be considered to extend from a bay or the open ocean to the upstream limit of tidal action but may be considered to extend seaward if significant mixing of fresh and salt water occurs in the open coastal waters. The waters described by this definition include but are not limited to the Sacramento-San Joaquin Delta as defined by Section 12220 of the California Water Code, Suisun Bay, Carquinez Strait downstream to Carquinez Bridge, and appropriate areas of the Smith, Klamath, Mad, Eel, Noyo, and Russian Rivers.

GRAYWATER is drainage from galley, dishwasher, shower, laundry, bath, and lavatory wash basin sinks, and water fountains, but does not include drainage from toilets, urinals, hospitals, or cargo spaces.

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* See Appendix I for definition of terms.

HALOMETHANES shall mean the sum of bromoform, bromomethane (methyl bromide) and chloromethane (methyl chloride).

HCH shall mean the sum of the alpha, beta, gamma (lindane) and delta isomers of hexachlorocyclohexane.

INDICATOR BACTERIA includes total coliform bacteria, fecal coliform bacteria (or *E. coli*), and/or Enterococcus bacteria.

INITIAL DILUTION is the process which results in the rapid and irreversible turbulent mixing of wastewater with ocean water around the point of discharge.

For a submerged buoyant discharge, characteristic of most municipal and industrial wastes that are released from the submarine outfalls, the momentum of the discharge and its initial buoyancy act together to produce turbulent mixing. Initial dilution in this case is completed when the diluting wastewater ceases to rise in the water column and first begins to spread horizontally.

For shallow water submerged discharges, surface discharges, and nonbuoyant discharges, characteristic of cooling water wastes and some individual discharges, turbulent mixing results primarily from the momentum of discharge. Initial dilution, in these cases, is considered to be completed when the momentum induced velocity of the discharge ceases to produce significant mixing of the waste, or the diluting plume reaches a fixed distance from the discharge to be specified by the Regional Board, whichever results in the lower estimate for initial dilution.

KELP BEDS, for purposes of the bacteriological standards of this plan, are significant aggregations of marine algae of the genera Macrocystis and Nereocystis. Kelp beds include the total foliage canopy of Macrocystis and Nereocystis plants throughout the water column.

LARGE PASSENGER VESSELS are vessels of 300 gross registered tons or greater engaged in carrying passengers for hire. The following vessels are not large passenger vessels:

(1) Vessels without berths or overnight accommodations for passengers;
(2) Noncommercial vessels, warships, vessels operated by nonprofit entities as determined by the Internal Revenue Service, and vessels operated by the state, the United States, or a foreign government;
(3) Oceangoing vessels, as defined below (e.g. those used to transport cargo).

MARICULTURE is the culture of plants and animals in marine waters independent of any pollution source.

MARINE MANAGED AREAS are named, discrete geographic marine or estuarine areas along the California coast designated by law or administrative action, and intended to protect, conserve, or otherwise manage a variety of resources and their uses. According to the California Public Resources Code (sections 36600 et. seq.) there are six classifications of marine managed areas, including State Marine Reserves, State Marine Parks and State Marine Conservation Areas, State Marine Cultural Preservation Areas, State Marine Recreational Management Areas, and State Water Quality Protection Areas.

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* See Appendix I for definition of terms.

MATERIAL: (a) In common usage: (1) the substance or substances of which a thing is made or composed (2) substantial; (b) For purposes of this Ocean Plan relating to waste disposal, dredging and the disposal of dredged material and fill, MATERIAL means matter of any kind or description which is subject to regulation as waste, or any material dredged from the navigable waters of the United States. See also, DREDGED MATERIAL.

MDL (Method Detection Limit) is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero, as defined in 40 CFR PART 136 Appendix B.

MINIMUM LEVEL (ML) is the concentrations at which the entire analytical system must give a recognizable signal and acceptable calibration point. The ML is the concentration in a sample that is equivalent to the concentration of the lowest calibration standard analyzed by a specific analytical procedure, assuming that all the method-specified sample weights, volumes and processing steps have been followed.

NATURAL LIGHT: Reduction of natural light may be determined by the Regional Board by measurement of light transmissivity or total irradiance, or both, according to the monitoring needs of the Regional Board.

NO DISCHARGE ZONE (NDZ) is an area in which both treated and untreated sewage discharges from vessels are prohibited. Within NDZ boundaries, vessel operators are required to retain their sewage discharges onboard for disposal at sea (beyond three miles from shore) or onshore at a pump-out facility.

NON-STORM WATER DISCHARGE is any runoff that is not the result of a precipitation event. This is often referred to as “dry weather flow.”

OCEAN WATERS are the territorial marine waters of the State as defined by California law to the extent these waters are outside of enclosed bays, estuaries, and coastal lagoons. If a discharge outside the territorial waters of the State could affect the quality of the waters of the State, the discharge may be regulated to assure no violation of the Ocean Plan will occur in ocean waters.

OCEANGOING VESSELS (i.e., oceangoing ships) means commercial vessels of 300 gross registered tons or more calling on California ports or places, excluding active military vessels.

OILY BILGE WATER includes bilge water that contains used lubrication oils, oil sludge and slops, fuel and oil sludge, used oil, used fuel and fuel filters, and oily waste.

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.

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.

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* See Appendix I for definition of terms.

PERMITTING AUTHORITY means the State Water Board or Regional Water Board, whichever issues the permit.

RECEIVING WATER, for permitted storm water discharges and nonpoint sources, should be measured at the point of discharge(s), in the surf zone immediately where runoff from an outfall meets the ocean water (a.k.a., at point zero).

SHELLFISH are organisms identified by the California Department of Public Health as shellfish for public health purposes (i.e., mussels, clams and oysters).

SIGNIFICANT difference is defined as a statistically significant difference in the means of two distributions of sampling results at the 95 percent confidence level.

STATE WATER QUALITY PROTECTION AREAS (SWQPAs) are nonterrestrial marine or estuarine areas designated to protect marine species or biological communities from an undesirable alteration in natural water quality. All Areas of Special Biological Significance (ASBS) that were previously designated by the State Water Board in Resolutions 74-28, 74-32, and 75-61 are now also classified as a subset of State Water Quality Protection Areas and require special protections afforded by this Plan.

STATE WATER QUALITY PROTECTION AREAS – GENERAL PROTECTION (SWQPA-GP) designated by the State Water Board to protect marine species and biological communities from an undesirable alteration in natural water quality within State Marine Parks and State Marine Conservation Areas.

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 in the table below.

Isomer Group	Toxicity Equivalence 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
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

WASTE: As used in this Plan, waste includes a discharger's total discharge, of whatever origin, i.e., gross, not net, discharge.

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* See Appendix I for definition of terms.

WATER RECLAMATION: The treatment of wastewater to render it suitable for reuse, the transportation of treated wastewater to the place of use, and the actual use of treated wastewater for a direct beneficial use or controlled use that would not otherwise occur.

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* See Appendix I for definition of terms.

APPENDIX II
MINIMUM* LEVELS

The Minimum* Levels identified in this appendix represent the lowest concentration of a pollutant that can be quantitatively measured in a sample given the current state of performance in analytical chemistry methods in California. These Minimum* Levels were derived from data provided by state-certified analytical laboratories in 1997 and 1998 for pollutants regulated by the California Ocean Plan and shall be used until new values are adopted by the State Water Board. There are four major chemical groupings: volatile chemicals, semi-volatile chemicals, inorganics, pesticides & PCB's. "No Data" is indicated by "--".

TABLE II-1
MINIMUM* LEVELS – VOLATILE CHEMICALS

		Minimum* Level (µg/L)	
Volatile Chemicals	**CAS Number**	**GC Method [a]**	**GCMS Method [b]**
Acrolein	107028	2.	5
Acrylonitrile	107131	2.	2
Benzene	71432	0.5	2
Bromoform	75252	0.5	2
Carbon Tetrachloride	56235	0.5	2
Chlorobenzene	108907	0.5	2
Chlorodibromomethane	124481	0.5	2
Chloroform	67663	0.5	2
1,2-Dichlorobenzene (volatile)	95501	0.5	2
1,3-Dichlorobenzene (volatile)	541731	0.5	2
1,4-Dichlorobenzene (volatile)	106467	0.5	2
Dichlorobromomethane	75274	0.5	2
1,1-Dichloroethane	75343	0.5	1
1,2-Dichloroethane	107062	0.5	2
1,1-Dichloroethylene	75354	0.5	2
Dichloromethane	75092	0.5	2
1,3-Dichloropropene (volatile)	542756	0.5	2
Ethyl benzene	100414	0.5	2
Methyl Bromide	74839	1.	2
Methyl Chloride	74873	0.5	2
1,1,2,2-Tetrachloroethane	79345	0.5	2
Tetrachloroethylene	127184	0.5	2
Toluene	108883	0.5	2
1,1,1-Trichloroethane	71556	0.5	2
1,1,2-Trichloroethane	79005	0.5	2
Trichloroethylene	79016	0.5	2
Vinyl Chloride	75014	0.5	2

Table II-1 Notes

a) GC Method = Gas Chromatography
b) GCMS Method = Gas Chromatography / Mass Spectrometry
* To determine the lowest standard concentration in an instrument calibration curve for these techniques, use the given ML (see Chapter III, "Use of Minimum* Levels").

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* See Appendix I for definition of terms.

TABLE II-2
MINIMUM* LEVELS – SEMI VOLATILE CHEMICALS

		Minimum* Level (µg/L)			
Semi-Volatile Chemicals	**CAS Number**	**GC Method** [a, *]	**GCMS Method** [b, *]	**HPLC Method** [c,*]	**COLOR Method** [d]
Acenapthylene	208968	--	10	0.2	--
Anthracene	120127	--	10	2	--
Benzidine	92875	--	5	--	--
Benzo(a)anthracene	56553	--	10	2	--
Benzo(a)pyrene	50328	--	10	2	--
Benzo(b)fluoranthene	205992	--	10	10	--
Benzo(g,h,i)perylene	191242	--	5	0.1	--
Benzo(k)floranthene	207089	--	10	2	--
Bis 2-(1-Chloroethoxy) methane	111911	--	5	--	--
Bis(2-Chloroethyl)ether	111444	10	1	--	--
Bis(2-Chloroisopropyl)ether	39638329	10	2	--	--
Bis(2-Ethylhexyl) phthalate	117817	10	5	--	--
2-Chlorophenol	95578	2	5	--	--
Chrysene	218019	--	10	5	--
Di-n-butyl phthalate	84742	--	10	--	--
Dibenzo(a,h)anthracene	53703	--	10	0.1	--
1,2-Dichlorobenzene (semivolatile)	95504	2	2	--	--
1,3-Dichlorobenzene (semivolatile)	541731	2	1	--	--
1,4-Dichlorobenzene (semivolatile)	106467	2	1	--	--
3,3-Dichlorobenzidine	91941	--	5	--	--
2,4-Dichlorophenol	120832	1	5	--	--
1,3-Dichloropropene	542756	--	5	--	
Diethyl phthalate	84662	10	2	--	--
Dimethyl phthalate	131113	10	2	--	--
2,4-Dimethylphenol	105679	1	2	--	--
2,4-Dinitrophenol	51285	5	5	--	--
2,4-Dinitrotoluene	121142	10	5	--	--
1,2-Diphenylhydrazine	122667	--	1	--	--
Fluoranthene	206440	10	1	0.05	--
Fluorene	86737	--	10	0.1	--
Hexachlorobenzene	118741	5	1	--	--
Hexachlorobutadiene	87683	5	1	--	--
Hexachlorocyclopentadiene	77474	5	5	--	--

Table II-2 continued on next page…

* See Appendix I for definition of terms.

Table II-2 (Continued)
Minimum* Levels – Semi Volatile Chemicals

		Minimum* Level (µg/L)			
Semi-Volatile Chemicals	**CAS Number**	**GC Method** [a, *]	**GCMS Method** [b, *]	**HPLC Method** [c,*]	**COLOR Method** [d]
Hexachloroethane	67721	5	1	--	--
Indeno(1,2,3-cd)pyrene	193395	--	10	0.05	--
Isophorone	78591	10	1	--	--
2-methyl-4,6-dinitrophenol	534521	10	5	--	--
3-methyl-4-chlorophenol	59507	5	1	--	--
N-nitrosodi-n-propylamine	621647	10	5	--	--
N-nitrosodimethylamine	62759	10	5	--	--
N-nitrosodiphenylamine	86306	10	1	--	--
Nitrobenzene	98953	10	1	--	--
2-Nitrophenol	88755	--	10	--	--
4-Nitrophenol	100027	5	10	--	--
Pentachlorophenol	87865	1	5	--	--
Phenanthrene	85018	--	5	0.05	--
Phenol	108952	1	1	--	50
Pyrene	129000	--	10	0.05	--
2,4,6-Trichlorophenol	88062	10	10	--	--

Table II-2 Notes:

a) GC Method = Gas Chromatography
b) GCMS Method = Gas Chromatography / Mass Spectrometry
c) HPLC Method = High Pressure Liquid Chromatography
d) COLOR Method= Colorimetric

* To determine the lowest standard concentration in an instrument calibration curve for this technique, multiply the given ML by 1000 (see Chapter III, "Use of Minimum* Levels").

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* See Appendix I for definition of terms.

TABLE II-3
MINIMUM* LEVELS - INORGANICS

		Minimum* Level (µg/L)								
Inorganic Substances	**CAS Number**	**COLOR Method[a]**	**DCP Method[b]**	**FAA Method[c]**	**GFAA Method[d]**	**HYDRIDE Method[e]**	**ICP Method[f]**	**ICPMS Method[g]**	**SPGFAA Method[h]**	**CVAA Method[i]**
Antimony	7440360	--	1000.	10.	5.	0.5	50.	0.5	5.	--
Arsenic	7440382	20.	1000.	--	2.	1.	10.	2.	2.	--
Beryllium	7440417	--	1000.	20.	0.5	--	2.	0.5	1.	--
Cadmium	7440439	--	1000.	10.	0.5	--	10.	0.2	0.5	--
Chromium (total)	--	--	1000.	50.	2.	--	10.	0.5	1.	--
Chromium (VI)	18540299	10.	--	5.	--	--	--	--	--	--
Copper	7440508	--	1000.	20.	5.	--	10.	0.5	2.	--
Cyanide	57125	5.	--	--	--	--	--	--	--	--
Lead	7439921	--	10000.	20.	5.	--	5.	0.5	2.	--
Mercury	7439976	--	--	--	--	--	--	0.5	--	0.2
Nickel	7440020	--	1000.	50.	5.	--	20.	1.	5.	--
Selenium	7782492	--	1000.	--	5.	1.	10.	2.	5.	--
Silver	7440224	--	1000.	10.	1.	--	10.	0.2	2.	--
Thallium	7440280	--	1000.	10.	2.	--	10.	1.	5.	--
Zinc	7440666	--	1000.	20.	--	--	20.	1.	10.	--

Table II-3 Notes

a) COLOR Method = Colorimetric
b) DCP Method = Direct Current Plasma
c) FAA Method = Flame Atomic Absorption
d) GFAA Method = Graphite Furnace Atomic Absorption
e) HYDRIDE Method = Gaseous Hydride Atomic Absorption
f) ICP Method = Inductively Coupled Plasma
g) ICPMS Method = Inductively Coupled Plasma / Mass Spectrometry
h) SPGFAA Method = Stabilized Platform Graphite Furnace Atomic Absorption (i.e., US EPA 200.9)
i) CVAA Method = Cold Vapor Atomic Absorption

* To determine the lowest standard concentration in an instrument calibration curve for these techniques, use the given ML (see Chapter III, “Use of Minimum* Levels”).

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* See Appendix I for definition of terms.

TABLE II-4
MINIMUM* LEVELS – PESTICIDES AND PCBs*

Pesticides – PCB's	CAS Number	Minimum* Level (µg/L) GC Method[a],*
Aldrin	309002	0.005
Chlordane	57749	0.1
4,4'-DDD	72548	0.05
4,4'-DDE	72559	0.05
4,4'-DDT	50293	0.01
Dieldrin	60571	0.01
a-Endosulfan	959988	0.02
b-Endosulfan	33213659	0.01
Endosulfan Sulfate	1031078	0.05
Endrin	72208	0.01
Heptachlor	76448	0.01
Heptachlor Epoxide	1024573	0.01
a-Hexachlorocyclohexane	319846	0.01
b-Hexachlorocyclohexane	319857	0.005
d-Hexachlorocyclohexane	319868	0.005
g-Hexachlorocyclohexane (Lindane)	58899	0.02
PCB 1016	--	0.5
PCB 1221	--	0.5
PCB 1232	--	0.5
PCB 1242	--	0.5
PCB 1248	--	0.5
PCB 1254	--	0.5
PCB 1260	--	0.5
Toxaphene	8001352	0.5

Table II-4 Notes

a) GC Method = Gas Chromatography

* To determine the lowest standard concentration in an instrument calibration curve for this technique, multiply the given ML by 100 (see Chapter III, “Use of Minimum* Levels”).

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* See Appendix I for definition of terms.

APPENDIX III
STANDARD MONITORING PROCEDURES

1. INTRODUCTION

The purpose of this appendix is to provide guidance to the Regional Water Boards on implementing the Ocean Plan and to ensure the reporting of useful information. Monitoring should be question driven rather than just gathering data and should be focused on assuring compliance with narrative and numeric water quality standards, the status and attainment of beneficial uses, and identifying sources of pollution.

It is not feasible to prescribe requirements in the Ocean Plan that encompass all circumstances and conditions that could be encountered by all dischargers, nor is it desirable to limit the flexibility of the Regional Water Boards in the monitoring of ocean waters. This appendix should therefore be considered the basic framework for the design of an ocean discharger monitoring program. The Regional Water Boards are responsible for issuing monitoring and reporting programs (MRPs) that will implement this monitoring guidance. Regional Water Boards can deviate from the procedures required in the appendix only with the approval of the State Water Resources Control Board.

This monitoring guidance utilizes a model monitoring framework. The model monitoring framework has three components that comprise a range of spatial and temporal scales: (1) core monitoring, (2) regional monitoring, and (3) special studies.

1) Core monitoring consists of the basic site-specific monitoring necessary to measure compliance with individual effluent limits and/or impacts to receiving water* quality. Core monitoring is typically conducted in the immediate vicinity of the discharge by examining local scale spatial effects.

2) Regional monitoring provides information necessary to make assessments over large areas and serves to evaluate cumulative effects of all anthropogenic inputs. Regional monitoring data also assists in the interpretation of core monitoring studies. It is recommended that the Regional Water Boards require participation by the discharger in an approved regional monitoring program, if available, for the receiving water*. In the event that a regional monitoring effort takes place during a permit cycle in which the MRP does not specifically address regional monitoring, a Regional Water Board may allow relief from aspects of core monitoring components in order to encourage participation.

3) Special studies are directed monitoring efforts designed in response to specific management or research questions identified through either core or regional monitoring programs. Often they are used to help understand core or regional monitoring results, where a specific environmental process is not well understood, or to address unique issues of local importance. Regional Water Boards may require special studies as appropriate. Special studies are not addressed further in this guidance because they are beyond its scope.

The Ocean Plan does not address all site-specific monitoring issues and allows the Regional Water Boards to select alternative protocols with the approval of the State Water Board. If no direction is given in this appendix for a specific provision of the Ocean Plan, it is within the

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* See Appendix I for definition of terms.

discretion of the Regional Water Boards to establish the monitoring requirements for that provision.

2. QUALITY ASSURANCE

All receiving and ambient water monitoring conducted in compliance with MRPs must be comparable with the Quality Assurance requirements of the Surface Water Ambient Monitoring Program (SWAMP).

SWAMP comparable means all sample collection and analyses shall meet or exceed the measurement quality objectives (MQOs) – including all sample types, frequencies, control limits and holding time requirements – as specified in the SWAMP Quality Assurance Project Plan (QAPrP)

The SWAMP QAPrP is located at:
http://www.waterboards.ca.gov/water_issues/programs/swamp/tools.shtml#qa.

For those measurements that do not have SWAMP MQOs available, then MQOs shall be at the discretion of the Regional Water Board. Refer to the USEPA guidance document (EPA QA/G-4) for selecting data quality objectives, located at http://www.epa.gov/quality/qs-docs/g4-final.pdf.

Water Quality data must be reported according to the California Environmental Data Exchange Network (CEDEN) “Data Template” format for all constituents that are monitored in receiving and ambient water. CEDEN Data Template are available at: http://ceden.org.

3. TYPE OF WASTE DISCHARGE SOURCES

Discharges to ocean waters are highly diverse and variable, exhibiting a wide range of constituents, effluent quality and quantity, location and frequency of discharge. Different types of discharges will require different approaches. This Appendix provides specific direction for three broad types of discharges: (1) Point Sources, (2) Storm Water Point Sources and (3) Non-point Sources.

3.1. Point Sources

Industrial, municipal, marine laboratory and other traditional point sources of pollution that discharge wastewater directly to surface waters and are required to obtain NPDES permits.

3.2. Storm Water Point Sources

Storm Water Point Sources, hereafter referred to as Storm Water Sources, are those NPDES permitted discharges regulated by Construction or Industrial Storm Water General Permits or municipal separate storm sewer system (MS4s) Permits. MS4 Permits are further divided into Phase I and II Permits. A Phase I MS4 Permit is issued by a Regional Water Board for medium (serving between 100,000 and 250,000 people) and large (serving 250,000 or more people) municipalities. A Phase II MS4 General Permit is issued by the State Water Resources Control Board for the discharge of storm water for smaller municipalities, and includes nontraditional Small MS4s, which are governmental facilities such as military bases, public campuses, prison and hospital complexes.

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* See Appendix I for definition of terms.

3.3. Non-point Sources

A Non-point Point Source is any source of pollutants that is not a Point Source described in Section 3.1 or a Storm Water Point Source as described in Section 3.2. Land use categories contributing to non-point sources include but are not limited to:

a. Agriculture
b. Grazing
c. Forestry/timber harvest
d. Urban not covered under an NPDES permit
e. Marinas and mooring fields
f. Golf Courses not covered under an NPDES Permit

Only agricultural and golf course related non-point source discharge monitoring is addressed in this Appendix, but Regional Water Boards may issue MRPs for other non-point sources at their discretion. Agriculture includes irrigated lands. Irrigated lands are where water is applied for the purpose of producing crops, including, but not limited to, row and field crop, orchards, vineyard, rice production, nurseries, irrigated pastures, and managed wetlands.

4. INDICATOR BACTERIA*

4.1. Point Sources

Primary questions to be addressed:

1. Does the effluent comply with the water quality standards in the receiving water*?
2. Does the sewage effluent reach water contact zones or commercial shellfish beds?

To answer these questions, core monitoring shall be conducted in receiving water* on the shoreline for the indicator bacteria* at a minimum weekly for any point sources discharging treated sewage effluent:

a. within one nautical mile of shore, or
b. within one nautical mile of a commercial shellfish bed, or
c. if the discharge is in excess of 10 million gallons per day (MGD).

Alternatively, these requirements may be met through participation in a regional monitoring program to assess the status of marine contact recreation water quality. If the permittee participates in a regional monitoring program, in conjunction with local health organization(s), core monitoring may be suspended for that period at the discretion of the Regional Water Board. Regional monitoring should be used to answer the above questions, and may be used to answer additional questions. These additional questions may include, but are not limited to, questions regarding the extent and magnitude of current or potential receiving water* indicator bacteria* problems, or the sources of indicator bacteria.

4.2. Storm Water

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* See Appendix I for definition of terms.

Primary questions to be addressed:

1. Does the receiving water* comply with water quality standards?
2. Is the condition of the receiving water* protective of contact recreation and shellfish harvesting beneficial uses?
3. Are the indicator bacteria levels in receiving water* getting better or worse?
4. What is the relative contribution of indicator bacteria to the receiving water* from storm water runoff?

To answer these questions, core monitoring for indicator bacteria* shall be required periodically for storm water discharges representative of the area of concern. At a minimum, for municipal storm water discharges, all receiving water* at outfalls greater than 36 inches in diameter or width must be monitored (ankle depth, point zero) at the following frequencies:

a. During wet weather with a minimum of three storms per year, and
b. When non-storm water discharges* occur (flowing during dry weather), and if located at an AB 411 beach, at least weekly. (An AB 411 Beach is defined as a beach visited by more than 50,000 people annually and located on an area adjacent to a storm drain that flows in the summer. (Health & Saf. Code § 115880.)).

Regional Water Boards may waive monitoring once structural best management practices have been installed, evaluated and determined to have successfully controlled indicator bacteria.

Alternatively, these requirements may be met through participation in a regional monitoring program to assess the status of marine contact recreation water quality. If the permittee participates in a regional monitoring program, in conjunction with local health organization(s), core monitoring may be suspended for that period at the discretion of the Regional Water Board. Regional monitoring should be used to answer the above questions, and may be used to answer additional questions. These additional questions may include, but are not limited to, questions regarding the extent and magnitude of current or potential receiving water* indicator bacteria problems, or the sources of indicator bacteria*.

4.3. Non-point Sources

Primary questions to be addressed:

1. Does the receiving water* comply with water quality standards?
2. Do agricultural and golf course non-point source discharges reach water contact or shellfish harvesting zones?
3. Are the indicator bacteria levels in receiving water* getting better or worse?
4. What is the relative contribution of indicator bacteria* to the receiving water* from agricultural and golf course non-point sources?

To answer these questions, core monitoring of representative agricultural irrigation tail water and storm water runoff, at a minimum, will be conducted in receiving water* (ankle depth, point zero) for indicator bacteria:

a. During wet weather, at a minimum of two storm events per year, and
b. When non-storm water discharges* occur (flowing during dry weather), and if located at an AB 411 beach or within one nautical mile of shellfish bed, at least weekly.

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* See Appendix I for definition of terms.

Alternatively, these requirements may be met through participation in a regional monitoring program to assess the status of marine contact recreation water quality. If the discharger participates in a regional monitoring program, in conjunction with local health organization(s), core monitoring may be suspended for that period at the discretion of the Regional Water Board. Regional monitoring should be used to answer the above questions, and may be used to answer additional questions. These additional questions may include, but are not limited to, questions regarding the extent and magnitude of current or potential receiving water* indicator bacteria problems, or the sources of indicator bacteria*.

5. CHEMICAL CONSTITUENTS

5.1. Point Sources

Primary questions addressed:

1. Does the effluent meet permit effluent limits thereby ensuring that water quality standards are achieved in the receiving water*?
2. What is the mass of the constituents that are discharged annually?
3. Is the effluent concentration or mass changing over time?

Consistent with Appendix VI, the core monitoring for the substances in Table 1 and Table 2 shall be required periodically. For discharges less than 10 MGD, the monitoring frequency shall be at least one complete scan of the Table 1 substances annually. Discharges greater than 10 MGD shall be required to monitor at least semiannually.

5.2. Storm Water

Primary questions addressed:

1. Does the receiving water* meet the water quality standards?
2. Are the conditions in receiving water* getting better or worse?
3. What is the relative runoff contribution to pollution in the receiving water*?

For Phase I and Phase II MS4 dischargers, core receiving water* monitoring will be required at a minimum for 10 percent of all outfalls greater than 36 inches in diameter or width once per year. If a discharger has less than five outfalls exceeding 36 inches in diameter or width, they shall conduct monitoring at a minimum of only once per outfall during a five year period. Monitoring shall be for total suspended solids, oil & grease, total organic carbon, pH, temperature, biochemical oxygen demand, turbidity, Table 1 metals, PAHs*, and pesticides determined by the Regional Water Boards. Regional Water Boards may waive monitoring once structural best management practices have been installed, evaluated and determined to have successfully controlled pollutants.

For industrial storm water discharges, runoff monitoring must be conducted at all outfalls at least two storm events per year. In addition, at least one representative receiving water* sample must be collected per industrial storm water permittee during two storm events per year. Monitoring shall be conducted for total suspended solids, oil & grease, total organic carbon, pH, temperature, biochemical oxygen demand, turbidity, and Table 1 metals and PAHs*.

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* See Appendix I for definition of terms.

The requirements for individual core monitoring for Table 1 metals, PAHs* and pesticides may be waived at the discretion of the Regional Water Board, if the permittee participates in a regional program for monitoring runoff and/or receiving water* to answer the above questions as well as additional questions. Additional questions may include, but are not limited to, questions regarding the extent and magnitude of current or potential receiving water* problems from storm water runoff, or sources of any runoff pollutants.

5.3. Non-point Sources

The primary questions are:

1. Does the agricultural or golf course runoff meet water quality standards in the receiving water*?
2. Are nutrients present that would contribute to objectionable aquatic algal blooms or degrade indigenous biota?
3. Are the conditions in receiving water* getting better or worse?
4. What is the relative agricultural runoff or golf course contribution to pollution in the receiving water*?

To answer these questions, a statistically representative sample (determined by the Regional Water Board) of receiving water at the sites of agricultural irrigation tail water and storm water runoff, and golf course runoff in each watershed will be monitored for Ocean Plan Table 1 metals, ammonia as N, nitrate as N, phosphate as P, and pesticides determined by the Regional Board:

a. During wet weather, at a minimum of two storm events per year, and
b. During dry weather, when flowing, at a frequency determined by the Regional Boards.

This requirement may be satisfied by core monitoring individually, or through participation in a regional program for monitoring runoff and receiving water* at the discretion of the Regional Water Board to answer the above questions as well as additional questions. Additional questions may include, but are not limited to, questions regarding the sources of agricultural pollutants.

<u>6. SEDIMENT MONITORING</u>

All Sources:
1. Is the dissolved sulfide concentration of waters in sediments significantly increased above that present under natural conditions?
2. Is the concentration of substances set forth in Table 1, for protection of marine aquatic life, in marine sediments at levels which would degrade the benthic community?
3. Is the concentration of organic pollutants in marine sediments at levels that would degrade the benthic community?

6.1. Point Sources

For discharges greater than 10 MGD, acid volatile sulfides, OP Pesticides, Table 1 metals, ammonia N, PAHs*, and chlorinated hydrocarbons will be measured in sediments annually in a core monitoring program approved by the Regional Water Board. Sediment sample locations will be determined by the Regional Water Board. If sufficient data exists from previous water

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* See Appendix I for definition of terms.

column monitoring for these parameters, the Regional Water Board at its discretion may reduce the frequency of monitoring, or may allow this requirement to be satisfied through participation in a regional monitoring program.

6.2. Storm Water

For Phase I MS4 permittees, discharges greater than 72 inches in diameter or width discharging to low energy coastal environments with the likelihood of sediment deposition, acid volatile sulfides, OP Pesticides, Ocean Plan Table 1 metals, ammonia N, PAHs*, and chlorinated hydrocarbons will be measured in sediments once per permit cycle.

Regional Water Boards may waive monitoring once structural best management practices have been installed, evaluated and determined to have successfully controlled pollutants.

This requirement may be satisfied by core monitoring individually or through participation in a regional monitoring program at the discretion of the Regional Water Board. Sediment sample locations will be determined by the Regional Water Board.

7. AQUATIC LIFE TOXICITY

Toxicity tests are another method used to assess risk to aquatic life. These tests assess the overall toxicity of the effluent, including the toxicity of unmeasured constituents and/or synergistic effects of multiple constituents.

7.1. Point Sources

1. Does the effluent meet permit effluent limits for toxicity thereby ensuring that water quality standards are achieved in the receiving water*?
2. If not:
   a. Are unmeasured pollutants causing risk to aquatic life?
   b. Are pollutants in combinations causing risk to aquatic life?

Core monitoring for Table 1 effluent toxicity shall be required periodically. For discharges less than 0.1 MGD the monitoring frequency for acute and/or chronic toxicity shall be twice per permit cycle. For discharges between 0.1 and 10 MGD, the monitoring frequency for acute and/or chronic toxicity of the effluent should be at least annually. For discharges greater than 10 MGD, the monitoring frequency for acute and/or chronic toxicity of the effluent should be at least semiannually.

For discharges greater than 10 MGD in a low energy coastal environment with the likelihood of sediment deposition, Core monitoring for acute sediment toxicity is required and will utilize alternative amphipod species (*Eohaustorius estuarius, Leptocheirus plumulosus, Rhepoxynius abronius*).

If an exceedance is detected, six additional toxicity tests are required within a 12-week period. If an additional exceedance is detected within the 12-week period, a toxicity reduction evaluation (TRE) is required, consistent with Section III.C.10. which requires a TRE if a discharge consistently exceeds an effluent limitation based on a toxicity objective in Table 1.

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* See Appendix I for definition of terms.

7.2. Storm Water

1. Does the runoff meet objectives for toxicity in the receiving water*?
2. Are the conditions in receiving water* getting better or worse with regard to toxicity
3. What is the relative runoff contribution to the receiving water* toxicity?
4. What are the causes of the toxicity and the sources of the constituents responsible?

For Phase I MS4, Phase II MS4, and industrial storm water discharges, core toxicity monitoring will be required at a minimum for 10 percent of all outfalls greater than 36 inches in diameter or width at a minimum of once per year. Receiving water* monitoring shall be for Table 1 critical life stage chronic toxicity for a minimum of one invertebrate species.

For storm water discharges greater than 72 inches in diameter or width in a low energy coastal environment with the likelihood of sediment deposition, core sediment monitoring for acute sediment toxicity is required and will utilize alternative amphipod species (*Eohaustorius estuarius, Leptocheirus plumulosus, Rhepoxynius abronius*).

Regional Water Boards may waive monitoring once structural best management practices have been installed, evaluated and determined to have successfully controlled toxicity.

If an exceedence is detected, an additional toxicity test is required during the subsequent storm event. If an additional exceedance is detected at that time, a TRE is required, consistent with Section III.C.10. which requires a TRE if a discharge consistently exceeds an effluent limitation based on a toxicity objective in Table 1. A sufficient volume must be collected to conduct a TIE, if necessary, as a part of a TRE.

The requirement for core toxicity monitoring may be waived at the discretion of the Regional Water Board, if the permittee participates in a regional monitoring program to answer the above questions, as well as any other additional questions that may be developed by the regional monitoring program.

7.3. Non-point Sources

1. Does the agricultural and golf course runoff meet water quality standards for toxicity in the receiving water*?
2. Are the conditions in receiving water* getting better or worse with regard to toxicity?
3. What is the relative agricultural and golf course runoff contribution to receiving water* toxicity?
4. What are the causes of the toxicity, and the sources of the constituents responsible?

To answer these questions, a statistically representative sample (determined by the Regional Water Board) of receiving water* at the sites of agricultural irrigation tail water and storm water runoff, and golf course runoff, in each watershed will be monitored:

   a. During wet weather, at a minimum of two storm events per year, and
   b. During dry weather, when flowing, at a frequency determined by the Regional Boards.

Core receiving water* monitoring shall include Table 1 critical life stage chronic toxicity for a minimum of one invertebrate species.

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* See Appendix I for definition of terms.

For runoff in a low energy coastal environment with the likelihood of sediment deposition, core sediment monitoring shall include acute sediment toxicity utilizing alternative amphipod species (*Eohaustorius estuarius, Leptocheirus plumulosus, Rhepoxynius abronius*) at a minimum once per year.

If an exceedence is detected, an additional toxicity test is required during the subsequent storm event. If an additional exceedance is detected, a TRE is required, consistent with Section III.C.10. which requires a TRE if a discharge consistently exceeds an effluent limitation based on a toxicity objective in Table 1. A sufficient volume must be collected to conduct a TIE, if necessary, as a part of a TRE.

The requirement for core monitoring may be waived at the discretion of the Regional Water Board, if the permittee participates in a regional monitoring program to answer the above questions, as well as any other additional questions that may be developed by the regional monitoring program.

8. BENTHIC COMMUNITY HEALTH

8.1. Point Sources

1. Are benthic communities degraded as a result of the discharge?

To answer this question, benthic community monitoring shall be conducted

  a. for all discharges greater than 10 MGD, or
  b. those discharges greater than 0.1 MGD and one nautical mile or less from shore, or
  c. discharges greater than 0.1 MGD and one nautical mile or less from a State Water Quality Protection Area or a State Marine Reserve.

The minimum frequency shall be once per permit cycle, except for discharges greater than 100 MGD the minimum frequency shall be at least twice per permit cycle.

This requirement may be satisfied by core monitoring individually or through participation in a regional monitoring program at the discretion of the Regional Board.

9. BIOACCUMULATION

9.1. Point Sources

1. Does the concentration of pollutants in fish, shellfish*, or other marine resources used for human consumption bioaccumulate to levels that are harmful to human health?
2. Does the concentration of pollutants in marine life bioaccumulate to levels that degrade marine communities?

To answer these questions, bioaccumulation monitoring shall be conducted, at a minimum, once per permit cycle for:

  a. discharges greater than 10 MGD, or
  b. those discharges greater than 0.1 MGD and one nautical mile or less from shore, or
  c. discharges greater than 0.1 MGD and one nautical mile or less from a State Water Quality Protection Area or a State Marine Reserve, Park or Conservation Area.

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* See Appendix I for definition of terms.

Constituents to be monitored must include pesticides (at the discretion of the Regional Board), Table 1 metals, and PAHs*. Bioaccumulation may be monitored by a mussel watch program or a fish tissue program. Resident mussels are preferred over transplanted mussels. Sand crabs and/or fish may be added or substituted for mussels at the discretion of the Regional Water Board.

This requirement may be satisfied individually as core monitoring or through participation in a regional monitoring program at the discretion of the Regional Water Board.

9.2. Storm Water

1. Does the concentration of pollutants in fish, shellfish*, or other marine resources used for human consumption bioaccumulate to levels that are harmful to human health?
2. Does the concentration of pollutants in marine life bioaccumulate to levels that degrade marine communities?

For Phase I MS4 dischargers, bioaccumulation monitoring shall be conducted, at a minimum, once per permit cycle. Constituents to be monitored must include OP Pesticides, Ocean Plan Table 1 metals, Table 1 PAHs*, Table 1 chlorinated hydrocarbons, and pyrethroids. Bioaccumulation may be monitored by a mussel watch program or a fish tissue program. Sand crabs, fish, and/or Solid Phase Microextraction may be added or substituted for mussels at the discretion of the Regional Water Board.

This requirement may be satisfied individually as core monitoring or through participation in a regional monitoring program at the discretion of the Regional Water Board.

10. RECEIVING WATER* CHARACTERISTICS

All Sources:

1. Is natural light significantly reduced at any point outside the zone of initial dilution as the result of the discharge of waste?
2. Does the discharge of waste cause a discoloration of the ocean surface?
3. Does the discharge of oxygen demanding waste cause the dissolved oxygen concentration to be depressed at any time more than 10 percent from that which occurs naturally, as the result of the discharge of oxygen demanding* waste materials?
4. Does the discharge of waste cause the pH to change at any time more than 0.2 units from that which occurs naturally?
5. Does the discharge of waste cause the salinity to become elevated in the receiving water*?
6. Do nutrients cause objectionable aquatic growth or degrade indigenous biota?

10.1. Point Sources

For discharges greater than 10 MGD, turbidity (alternatively light transmissivity or surface water transparency), color [Chlorophyll-A and/or color dissolved organic matter (CDOM)], dissolved oxygen and pH shall be measured in the receiving water* seasonally, at a minimum, in a core monitoring program approved by the Regional Water Board. If sufficient data exists from previous water column monitoring for these parameters, the Regional Water Board, at its

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* See Appendix I for definition of terms.

discretion, may reduce the frequency of water column monitoring, or may allow this requirement to be satisfied through participation in a regional monitoring program. Use of regional ocean observing programs, such as the Southern California Coastal Ocean Observing System (SCCOOS) and the Central and Northern California Ocean Observing System (CeNCCOOS) is encouraged.

Salinity must also be monitored by all point sources discharging desalination brine as part of their core monitoring program.

10.2. Storm Water

At a minimum, at 10 percent of Phase I MS4 discharges greater than 36 inches in diameter or width, receiving water* turbidity, color, dissolved oxygen, pH, nitrate, phosphate, and ammonia shall be measured annually in a core monitoring program approved by the Regional Water Board.

Regional Water Boards may waive monitoring once structural best management practices have been installed, evaluated and determined to have successfully controlled pollutants. The Regional Water Board, at its discretion, may also allow this requirement to be satisfied through participation in a regional monitoring program.

10.3. Non-point Sources

Representative agricultural and golf course discharges shall be measured, at a minimum twice annually (during the storm season and irrigation season) for receiving water* turbidity, color, dissolved oxygen, pH, nitrate, phosphate, ammonia in a core monitoring program approved by the Regional Water Board. The Regional Water Board, at its discretion, may allow this requirement to be satisfied through participation in a regional monitoring program.

11. ANALYTICAL REQUIREMENTS

Procedures, calibration techniques, and instrument/reagent specifications shall conform to the requirements of 40 CFR PART 136. Compliance monitoring shall be determined using an U.S. EPA approved protocol as provided in 40 CFR PART 136. All methods shall be specified in the monitoring requirement section of waste discharge requirements.

Where methods are not available in 40 CFR PART 136, the Regional Water Boards shall specify suitable analytical test methods in waste discharge requirements. Acceptance of data should be predicated on demonstrated laboratory performance.

Laboratories analyzing monitoring data shall be certified by the California Department of Public Health, in accordance with the provisions of Water Code section 13176, and must include quality assurance quality control data with their reports.

Sample dilutions for total and fecal coliform bacterial analyses shall range from 2 to 16,000. Sample dilutions for enterococcus bacterial analyses shall range from 1 to 10,000 per 100 mL. Each test method number or name (e.g., EPA 600/4-85/076, Test Methods for *Escherichia coli* and *Enterococci* in Water by Membrane Filter Procedure) used for each analysis shall be specified and reported with the results.

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* See Appendix I for definition of terms.

Test methods used for coliforms (total and fecal) shall be those presented in Table 1A of 40 CFR PART 136, unless alternate test methods have been approved in advance by U.S. EPA pursuant to 40 CFR PART 136.

Test methods used for enterococcus shall be those presented in U.S. EPA publication EPA 600/4-85/076, Test Methods for *Escherichia coli* and *Enterococci* in Water by Membrane Filter Procedure or any improved test method determined by the Regional Board to be appropriate. The Regional Water Board may allow analysis for *Escherichia coli* (*E. coli)* by approved test methods to be substituted for fecal coliforms if sufficient information exists to support comparability with approved test methods and substitute the existing test methods.

The State or Regional Water Board may, subject to U.S. EPA approval, specify test methods which are more sensitive than those specified in 40 CFR PART 136. Because storm water and non-point sources are not assigned a dilution factor, sufficient sampling and analysis shall be required to determine compliance with Table 1 Water Quality Objectives. Total chlorine residual is likely to be a test method detection limit effluent limitation in many cases. The limit of detection of total chlorine residual in standard test methods is less than or equal to 20 µg/L.

Toxicity monitoring requirements in permits prepared by the Regional Water Boards shall use marine test species instead of freshwater species when measuring compliance. The Regional Water Board shall require the use of critical life stage toxicity tests specified in this Appendix to measure TUc. For Point Sources, a minimum of three test species with approved test protocols shall be used to measure compliance with the toxicity objective. If possible, the test species shall include a fish, an invertebrate, and an aquatic plant. After a screening period, monitoring can be reduced to the most sensitive species.

Dilution and control water should be obtained from an unaffected area of the receiving waters*. The sensitivity of the test organisms to a reference toxicant shall be determined concurrently with each bioassay test and reported with the test results.

Use of critical life stage bioassay testing shall be included in waste discharge requirements as a monitoring requirement for all Point Source discharges greater than 100 MGD

Procedures and test methods used to determine compliance with benthic monitoring should use the following federal guidelines when applicable: Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters (1990) -- EPA/600/4-90/030 (PB91-171363). This manual describes guidelines and standardized procedures for the use of macroinvertebrates in evaluating the biological integrity of surface waters.

Procedures used to determine compliance with bioaccumulation monitoring should use the U.S. EPA. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories (November 2000, EPA 823-B-00-007), NOAA Technical Memorandum NOS ORCA 130, Sampling and Analytical Methods of the National Status and Trends Program Mussel Watch Project (1998 update), and/or State Mussel Watch Program, 1987-1993 Data Report, State Water Resources Control Board 94-1WQ.

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* See Appendix I for definition of terms.

TABLE III-1
APPROVED TESTS – CHRONIC TOXICITY (TUc)

Species	Effect	Tier	Reference
giant kelp, *Macrocystis pyrifera*	percent germination; germ tube length	1	1,3
red abalone, *Haliotis rufescens*	Abnormal shell development	1	1,3
oyster, *Crassostrea gigas*; mussels, *Mytilus spp.*	Abnormal shell development; percent survival	1	1,3
urchin, *Strongylocentrotus purpuratus*; sand dollar, *Dendraster excentricus*	Percent normal development	1	1,3
urchin, *Strongylocentrotus purpuratus*; sand dollar, *Dendraster excentricus*	Percent fertilization	1	1,3
shrimp, *Holmesimysis costata*	Percent survival; growth	1	1,3
shrimp, *Mysidopsis bahia*	Percent survival; growth; fecundity	2	2,4
topsmelt, *Atherinops affinis*	Larval growth rate; percent survival	1	1,3
Silversides, *Menidia beryllina*	Larval growth rate; percent survival	2	2,4

Table III-1 Notes

The first tier test methods are the preferred toxicity tests for compliance monitoring. A Regional Water Board can approve the use of a second tier test method for waste discharges if first tier organisms are not available.

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* See Appendix I for definition of terms.

Protocol References

1. Chapman, G.A., D.L. Denton, and J.M. Lazorchak. 1995. Short-term methods for estimating the chronic toxicity of effluents and receiving waters to west coast marine and estuarine organisms. U.S. EPA Report No. EPA/600/R-95/136.

2. Klemm, D.J., G.E. Morrison, T.J. Norberg-King, W.J. Peltier, and M.A. Heber. 1994. Short-term methods for estimating the chronic toxicity of effluents and receiving water to marine and estuarine organisms. U.S. EPA Report No. EPA-600-4-91-003.

3. SWRCB 1996. Procedures Manual for Conducting Toxicity Tests Developed by the Marine Bioassay Project. 96-1WQ.

4. Weber, C.I., W.B. Horning, I.I., D.J. Klemm, T.W. Nieheisel, P.A. Lewis, E.L. Robinson, J. Menkedick and F. Kessler (eds). 1988. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms. EPA/600/4-87/028. National Information Service, Springfield, VA.

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* See Appendix I for definition of terms.

APPENDIX IV
PROCEDURES FOR THE NOMINATION AND DESIGNATION OF STATE WATER QUALITY PROTECTION AREAS*.

1. Any person may nominate areas of ocean waters for designation as SWQPA-ASBS or SWQPA-GP by the State Water Board. Nominations shall be made to the appropriate Regional Water Board and shall include:

   (a) Information such as maps, reports, data, statements, and photographs to show that:

      (1) Candidate areas are located in ocean waters as defined in the “Ocean Plan”.

      (2) Candidate areas are intrinsically valuable or have recognized value to man for scientific study, commercial use, recreational use, or esthetic reasons.

      (3) Candidate areas need protection beyond that offered by waste discharge restrictions or other administrative and statutory mechanisms.

   (b) Data and information to indicate whether the proposed designation may have a significant effect on the environment.

      (1) If the data or information indicate that the proposed designation will have a significant effect on the environment, the nominee must submit sufficient information and data to identify feasible changes in the designation that will mitigate or avoid the significant environmental effects.

2. The State Water Board or a Regional Water Board may also nominate areas for designation as SWQPA-ASBS or SWQPA-GP on their own motion.

3. A Regional Water Board may decide to (a) consider individual SWQPA-ASBS or SWQPA-GP nominations upon receipt, (b) consider several nominations in a consolidated proceeding, or (c) consider nominations in the triennial review of its water quality control plan (basin plan). A nomination that meets the requirements of 1. above may be considered at any time but not later than the next scheduled triennial review of the appropriate basin plan or Ocean Plan.

4. After determining that a nomination meets the requirements of paragraph 1. above, the Executive Officer of the affected Regional Water Board shall prepare a Draft Nomination Report containing the following:

   (a) The area or areas nominated for designation as SWQPA-ASBS or SWQPA-GP.

   (b) A description of each area including a map delineating the boundaries of each proposed area.

   (c) A recommendation for action on the nomination(s) and the rationale for the recommendation. If the Draft Nomination Report recommends approval of the proposed designation, the Draft Nomination Report shall comply with the CEQA documentation requirements for a water quality control plan amendment in Section 3777, Title 23, California Code of Regulations.

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* See Appendix I for definition of terms.

5. The Executive Officer shall, at a minimum, seek informal comment on the Draft Nomination Report from the State Water Board, Department of Fish and Game, other interested state and federal agencies, conservation groups, affected waste dischargers, and other interested parties. Upon incorporation of responses from the consulted agencies, the Draft Nomination Report shall become the Final Nomination Report.

6. (a) If the Final Nomination Report recommends approval of the proposed designation, the Executive Officer shall ensure that processing of the nomination complies with the CEQA consultation requirements in Section 3778, Title 23, California Code of Regulations and proceed to step 7 below.

   (b) If the Final Nomination Report recommends against approval of the proposed designation, the Executive Officer shall notify interested parties of the decision. No further action need be taken. The nominating party may seek reconsideration of the decision by the Regional Water Board itself.

7. The Regional Water Board shall conduct a public hearing to receive testimony on the proposed designation. Notice of the hearing shall be published three times in a newspaper of general circulation in the vicinity of the proposed area or areas and shall be distributed to all known interested parties 45 days in advance of the hearing. The notice shall describe the location, boundaries, and extent of the area or areas under consideration, as well as proposed restrictions on waste discharges within the area.

8. The Regional Water Board shall respond to comments as required in Section 3779, Title 23, California Code of Regulations, and 40 C.F.R. Part 25 (July 1, 1999).

9. The Regional Water Board shall consider the nomination after completing the required public review processes required by CEQA.

   (a) If the Regional Water Board supports the recommendation for designation, the board shall forward to the State Water Board its recommendation for approving designation of the proposed area or areas and the supporting rationale. The Regional Water Board submittal shall include a copy of the staff report, hearing transcript, comments, and responses to comments.

   (b) If the Regional Water Board does not support the recommendation for designation, the Executive Officer shall notify interested parties of the decision, and no further action need be taken.

10. After considering the Regional Water Board recommendation and hearing record, the State Water Board may approve or deny the recommendation, refer the matter to the Regional Water Board for appropriate action, or conduct further hearing itself. If the State Water Board acts to approve a recommended designation, the State Water Board shall amend Appendix V, Table V-1, of this Plan. The amendment will go into effect after approval by the Office of Administrative Law and US EPA. In addition, after the effective date of a designation, the affected Regional Water Board shall revise its water quality control plan in the next triennial review to include the designation.

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* See Appendix I for definition of terms.

12. The State Water Board Executive Director shall advise other agencies to whom the list of designated areas is to be provided that the basis for an SWQPA-ASBS or SWQPA-GP designation is limited to protection of marine life from waste discharges.

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* See Appendix I for definition of terms.

APPENDIX V
STATE WATER QUALITY PROTECTION AREAS
AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE

TABLE V-1
STATE WATER QUALITY PROTECTION AREAS
AREAS OF SPECIAL BIOLOGICAL SIGNIFICANCE
(DESIGNATED OR APPROVED BY THE STATE WATER RESOURCES CONTROL BOARD)

No.	ASBS Name	Date Designated	State Water Board Resolution No.	Region No.
1.	Jughandle Cove	March 21, 1974,	74-28	1
2.	Del Mar Landing	March 21, 1974,	74-28	1
3.	Gerstle Cove	March 21, 1974,	74-28	1
4.	Bodega	March 21, 1974,	74-28	1
5.	Saunders Reef	March 21, 1974,	74-28	1
6.	Trinidad Head	March 21, 1974,	74-28	1
7.	King Range	March 21, 1974,	74-28	1
8.	Redwoods National Park	March 21, 1974,	74-28	1
9.	James V. Fitzgerald	March 21, 1974,	74-28	2
10.	Farallon Islands	March 21, 1974,	74-28	2
11.	Duxbury Reef	March 21, 1974,	74-28	2
12.	Point Reyes Headlands	March 21, 1974,	74-28	2
13.	Double Point	March 21, 1974,	74-28	2
14.	Bird Rock	March 21, 1974,	74-28	2
15.	Año Nuevo	March 21, 1974,	74-28	3
16.	Point Lobos	March 21, 1974,	74-28	3
17.	San Miguel, Santa Rosa, and Santa Cruz Islands	March 21, 1974,	74-28	3
18.	Julia Pfeiffer Burns	March 21, 1974,	74-28	3
19.	Pacific Grove	March 21, 1974,	74-28	3
20.	Salmon Creek Coast	March 21, 1974,	74-28	3
21.	San Nicolas Island and Begg Rock	March 21, 1974,	74-28	4
22.	Santa Barbara and Anacapa Islands	March 21, 1974,	74-28	4
23.	San Clemente Island	March 21, 1974,	74-28	4

Table V-1 Continued on next page…

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* See Appendix I for definition of terms.

Table V-1 (Continued)

Areas of Special Biological Significance
(Designated or Approved by the State Water Resources Control Board)

No.	ASBS Name	Date Designated	State Water Board Resolution No.	Region No.
24.	Laguna Point to Latigo Point	March 21, 1974,	74-28	4
25.	Northwest Santa Catalina Island	March 21, 1974,	74-28	4
26.	Western Santa Catalina Island	March 21, 1974,	74-28	4
27.	Farnsworth Bank	March 21, 1974,	74-28	4
28.	Southeast Santa Catalina	March 21, 1974,	74-28	4
29.	La Jolla	March 21, 1974,	74-28	9
30.	Heisler Park	March 21, 1974,	74-28	9
31.	San Diego-Scripps	March 21, 1974,	74-28	9
32.	Robert E. Badham	April 18, 1974	74-32	8
33.	Irvine Coast	April 18, 1974	74-32	8,9
34.	Carmel Bay	June 19, 1975	75-61	3

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* See Appendix I for definition of terms.

APPENDIX VI

REASONABLE POTENTIAL ANALYSIS PROCEDURE FOR DETERMINING WHICH TABLE 1 OBJECTIVES REQUIRE EFFLUENT LIMITATIONS

In determining the need for an effluent limitation, the Regional Water Board shall use all representative information to characterize the pollutant discharge using a scientifically defensible statistical method that accounts for the averaging period of the water quality objective, accounts for and captures the long-term variability of the pollutant in the effluent, accounts for limitations associated with sparse data sets, accounts for uncertainty associated with censored data sets, and (unless otherwise demonstrated) assumes a lognormal distribution of the facility-specific effluent data.

The purpose of the following procedure (see also Figure VI-1) is to provide direction to the Regional Water Boards for determining if a pollutant discharge causes, has the reasonable potential to cause, or contributes to an excursion above Table 1 water quality objectives in accordance with 40 CFR 122.44 (d)(1)(iii). The Regional Water Board may use an alternative approach for assessing reasonable potential such as an appropriate stochastic dilution model that incorporates both ambient and effluent variability. The permit fact sheet or statement of basis will document the justification or basis for the conclusions of the reasonable potential assessment. This appendix does not apply to permits or any portion of a permit where the discharge is regulated through best management practices (BMP) unless such discharge is also subject to numeric effluent limitations.

Step 1: Identify C_o, the applicable water quality objective from Table 1 for the pollutant.

Step 2: Does information about the receiving water* body or the discharge support a reasonable potential assessment (RPA) without characterizing facility-specific effluent monitoring data? If yes, go to *Step 13* to conduct an RPA based on best professional judgment (BPJ). Otherwise, proceed to *Step 3*.

Step 3: Is facility-specific effluent monitoring data available? If yes, proceed to *Step 4.* Otherwise, go to *Step 13.*

Step 4: Adjust all effluent monitoring data C_e, including censored (ND or DNQ) values to the concentration X expected after complete mixing. For Table 1 pollutants use $X = (C_e + D_m C_s) / (D_m + 1)$; for acute toxicity use $X = C_e / (0.1 D_m + 1)$; where D_m is the minimum probable initial dilution expressed as parts seawater per part wastewater and C_s is the background seawater concentration from Table ~~C~~3. For ND values, C_e is replaced with "<MDL;" for DNQ values C_e is replaced with "<ML." Go to *Step 5*.

Step 5: Count the total number of samples n, the number of censored (ND or DNQ) values, c and the number of detected values, d, *such that* $n = c + d$.

Is any *detected* pollutant concentration after complete mixing greater than C_o? If yes, the discharge causes an excursion of C_o; go to *Endpoint 1*. Otherwise, proceed to *Step 6*.

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* See Appendix I for definition of terms.

Step 6: Does the effluent monitoring data contain three or more detected observations ($d \geq 3$)? If yes, proceed to *Step 7* to conduct a parametric RPA. Otherwise, go to *Step11* to conduct a nonparametric RPA.

Step 7: Conduct a parametric RPA. Assume data are lognormally distributed, unless otherwise demonstrated. Does the data consist entirely of detected values ($c/n = 0$)? If yes,

- calculate summary statistics M_L and S_L, the mean and standard deviation of the natural logarithm transformed effluent data expected after complete mixing, ln(X),
- go to *Step 9*.

Otherwise, proceed to *Step 8*.

Step 8: Is the data censored by 80% or less ($c/n \leq 0.8$)? If yes,

- calculate summary statistics M_L and S_L using the censored data analysis method of Helsel and Cohn (1988),
- go to *Step 9*.

Otherwise, go to Step 11.

Step 9: Calculate the UCB i.e., the one-sided, upper 95 percent confidence bound for the 95th percentile of the effluent distribution after complete mixing. For lognormal distributions, use $UCBL_{(.95,.95)} = \exp(M_L + S_L\, g'_{(.95,.95,n)})$, where g' is a normal tolerance factor obtained from the table below (Table VI-1). Proceed to *Step 10*.

Step 10: Is the UCB greater than C_o? If yes, the discharge has a reasonable potential to cause an excursion of C_o; go to *Endpoint 1*. Otherwise, the discharge has no reasonable potential to cause an excursion of C_o; go to *Endpoint 2*.

Step 11: Conduct a non-parametric RPA. Compare each data value X to C_o. Reduce the sample size n by 1 for each tie (i.e., inconclusive censored value result) present. An adjusted ND value having C_o < MDL is a tie. An adjusted DNQ value having C_o < ML is also a tie.

Step 12: Is the adjusted $n > 15$? If yes, the discharge has no reasonable potential to cause an excursion of C_o; go to *Endpoint 2*. Otherwise, go to *Endpoint 3*.

Step 13: Conduct an RPA based on BPJ. Review all available information to determine if a water quality-based effluent limitation is required, notwithstanding the above analysis in *Steps 1* through *12*, to protect beneficial uses. Information that may be used includes: the facility type, the discharge type, solids loading analysis, lack of dilution, history of compliance problems, potential toxic impact of discharge, fish tissue residue data, water quality and beneficial uses of the receiving water*, CWA 303(d) listing for the pollutant, the presence of endangered or threatened species or critical habitat, and other information.

Is data or other information unavailable or insufficient to determine if a water quality-based effluent limitation is required? If yes, go to *Endpoint 3.* Otherwise, go to either *Endpoint 1* or *Endpoint 2* based on BPJ.

Endpoint 1: An effluent limitation must be developed for the pollutant. Effluent monitoring for the pollutant, consistent with the monitoring frequency in Appendix III, is required.

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* See Appendix I for definition of terms.

<u>Endpoint 2</u>: An effluent limitation is not required for the pollutant. Appendix III effluent monitoring is not required for the pollutant; the Regional Board, however, may require occasional monitoring for the pollutant or for whole effluent toxicity as appropriate.

<u>Endpoint 3</u>: The RPA is inconclusive. Monitoring for the pollutant or whole effluent toxicity testing, consistent with the monitoring frequency in Appendix III, is required. An existing effluent limitation for the pollutant shall remain in the permit, otherwise the permit shall include a reopener clause to allow for subsequent modification of the permit to include an effluent limitation if the monitoring establishes that the discharge causes, has the reasonable potential to cause, or contributes to an excursion above a Table 1 water quality objective.

Appendix VI References:

Helsel D. R. and T. A. Cohn. 1988. Estimation of descriptive statistics for multiply censored water quality data. Water Resources Research, Vol 24(12):1977-2004.

Hahn J. H. and W. Q. Meeker. 1991. Statistical Intervals, A guide for practitioners. J. Wiley & Sons, NY.

TABLE VI-1: Tolerance factors $g'_{(.95,.95,n)}$ for calculating normal distribution one-sided upper 95 percent tolerance bounds for the 95th percentile (Hahn & Meeker 1991)

n	$g'_{(.95,.95,n)}$	***n***	$g'_{(.95,.95,n)}$
2	26.260	21	2.371
3	7.656	22	2.349
4	5.144	23	2.328
5	4.203	24	2.309
6	3.708	25	2.292
7	3.399	26	2.275
8	3.187	27	2.260
9	3.031	28	2.246
10	2.911	29	2.232
11	2.815	30	2.220
12	2.736	35	2.167
13	2.671	40	2.125
14	2.614	50	2.065
15	2.566	60	2.022
16	2.524	120	1.899
17	2.486	240	1.819
18	2.453	480	1.766
19	2.423	∞	1.645
20	2.396		

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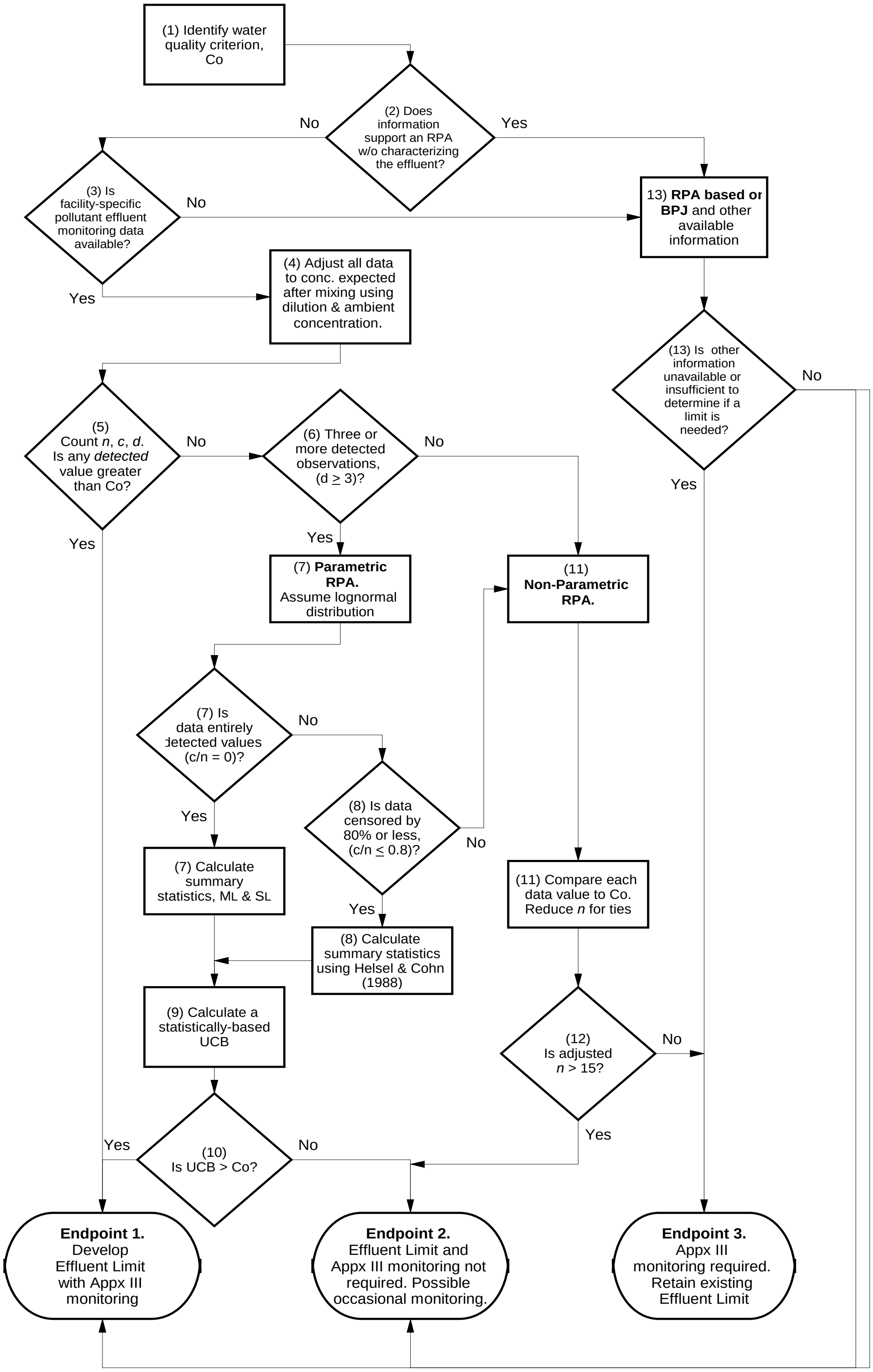
* See Appendix I for definition of terms.

Figure VI-1. Reasonable potential analysis flow chart



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* See Appendix I for definition of terms.

APPENDIX VII

EXCEPTIONS TO THE CALIFORNIA OCEAN PLAN

TABLE VII-1
EXCEPTIONS TO THE OCEAN PLAN

(GRANTED BY THE STATE WATER RESOURCES CONTROL BOARD)

Year	Resolution	Applicable Provision	Discharger
1977	77-11	Discharge Prohibition, ASBS #23	US Navy San Clemente Island
1979	79-16	Discharge Prohibition for wet weather discharges from combined storm and wastewater collection system.	The City and County of San Francisco
1983	83-78	Discharge Prohibition, ASBS #7	Humboldt County Resort Improvement District No.1
1984	84-78	Discharge Prohibition, ASBS #34	Carmel Sanitary District
1988	88-80	Total Chlorine Residual Limitation	Haynes Power Plant Harbor Power Plant Scattergood Power Plant Alamitos Power Plant El Segundo Power Plant Long Beach Power Plant Mandalay Power Plant Ormond Beach Power Plant Redondo Power Plant
1990	90-105	Discharge Prohibition, ASBS #21	US Navy San Nicolas Island
2004	2004-0052	Discharge Prohibition, ASBS #31	UC Scripps Institution of Oceanography
2006	2006-0013	Discharge Prohibition, ASBS #25	USC Wrigley Marine Science Center
2007	2007-0058	Discharge Prohibition, ASBS #4	UC Davis Bodega Marine Laboratory
2011	2011-0049	Discharge Prohibition, ASBS #6	HSU Telonicher Marine lab
2011	2011-0050	Discharge Prohibition, ASBS #19	Monterey Bay Aquarium
2011	2011-0051	Discharge Prohibition, ASBS #19	Stanford Hopkins Marine Station
2012	2012-0012, as amended on June 19	ASBS Discharge Prohibition, General Exception for Storm Water and Nonpoint Sources	27 applicants for the General Exception

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* See Appendix I for definition of terms.

	2012; in 2012-0031		

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* See Appendix I for definition of terms.

APPENDIX VIII
MAPS OF THE OCEAN, COAST, AND ISLANDS

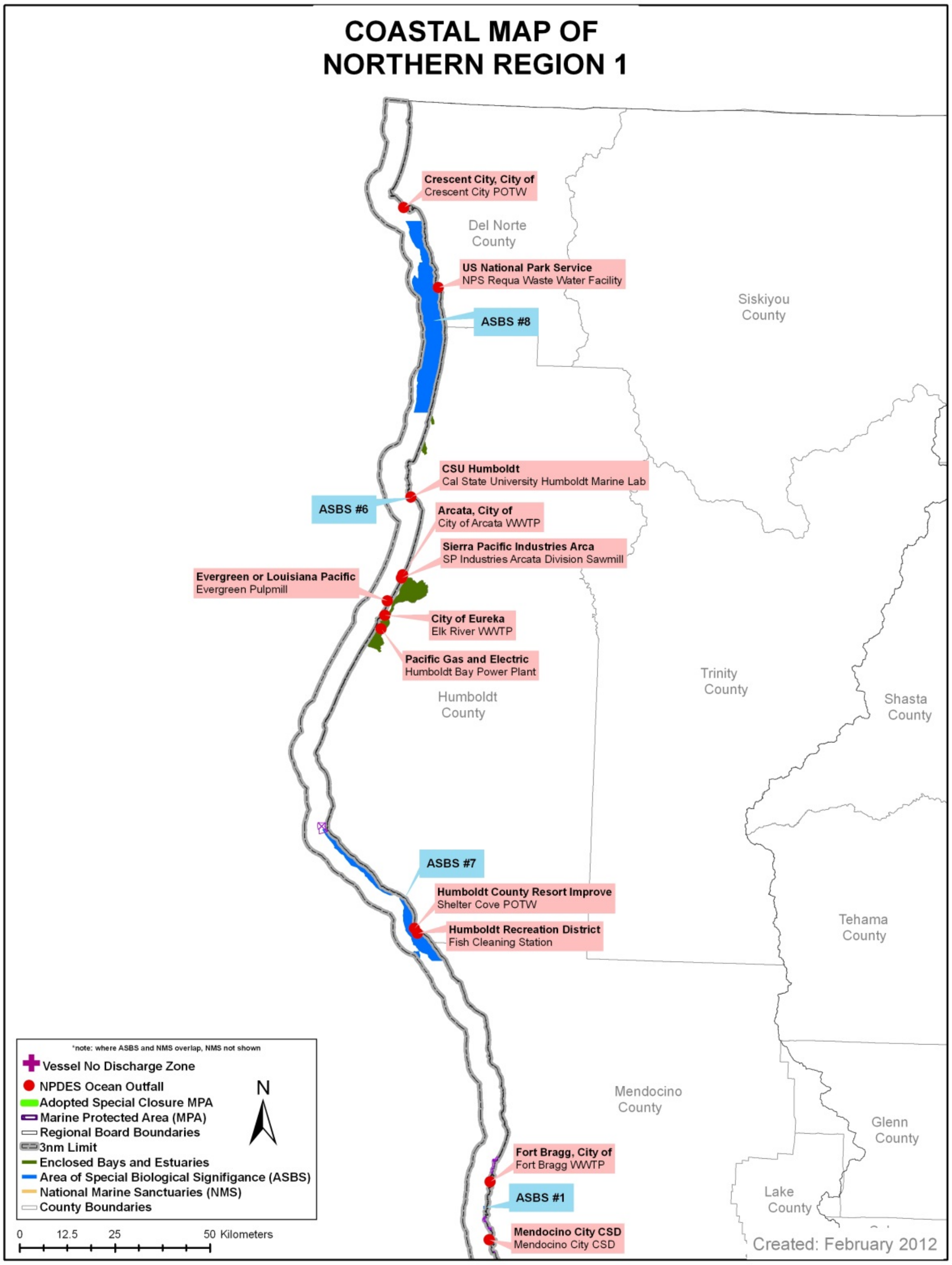

Figure VIII-1. ASBS Boundaries, MPA Boundaries, Wastewater Outfall Points, Marine Sanctuary Boundaries, and Enclosed Bays in northern Region 1.

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* See Appendix I for definition of terms.

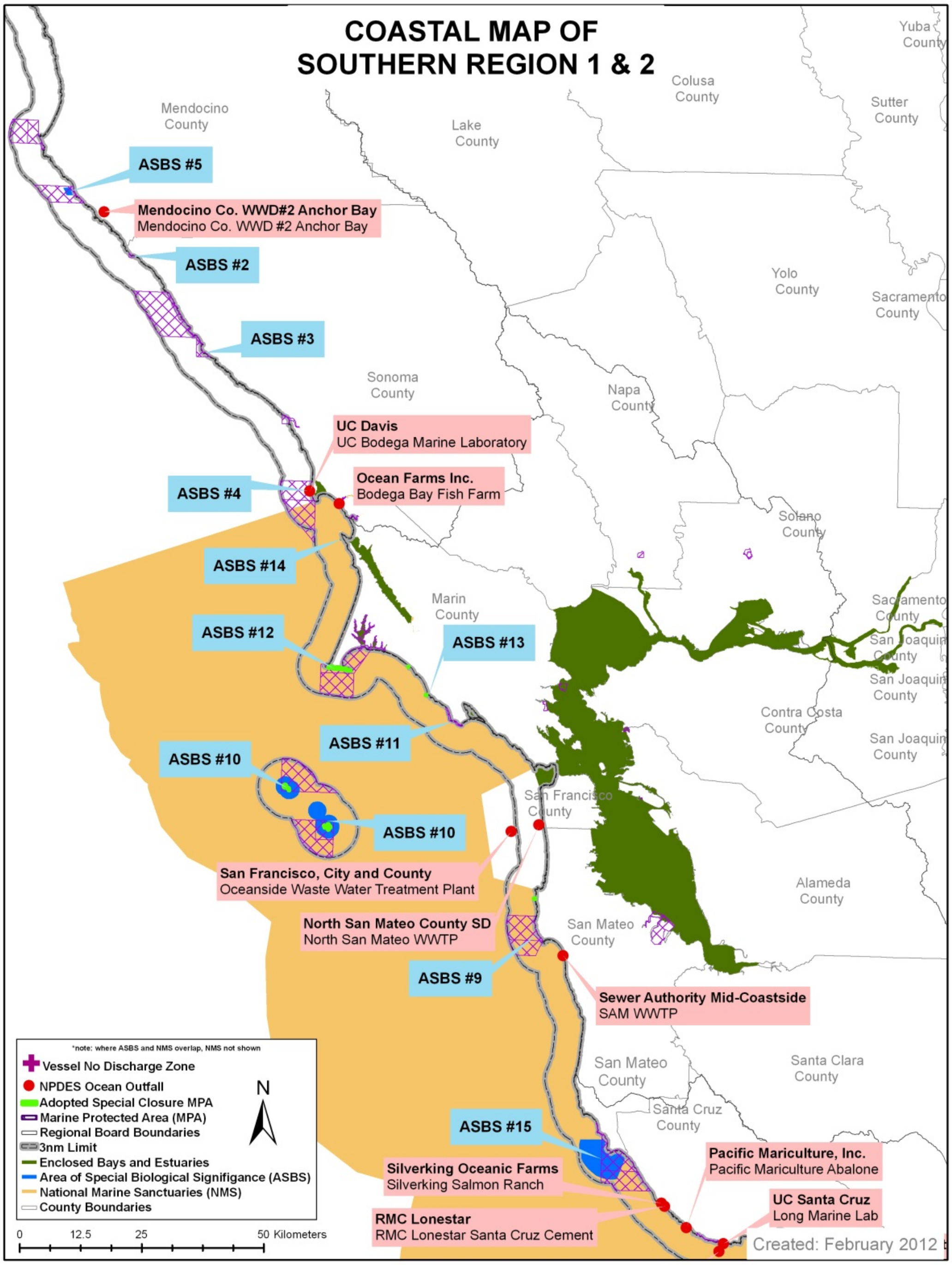

Figure VIII-2. ASBS Boundaries, MPA Boundaries, Wastewater Outfall Points, Marine Sanctuary Boundaries, and Enclosed Bays in southern Region 1 and Region 2.

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* See Appendix I for definition of terms.

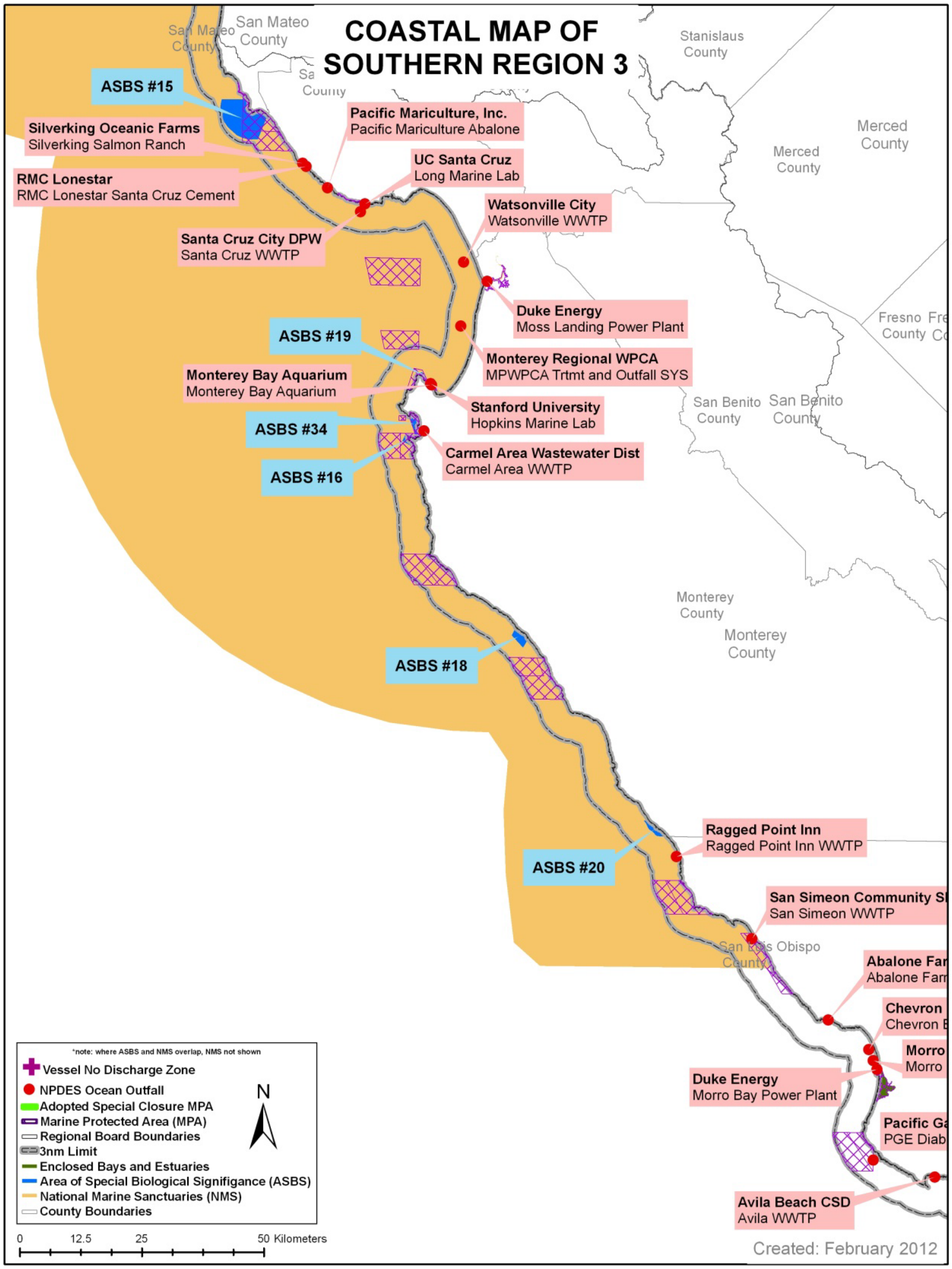

Figure VIII-3. ASBS Boundaries, MPA Boundaries, Wastewater Outfall Points, Marine Sanctuary Boundaries, and Enclosed Bays in northern Region 3.

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* See Appendix I for definition of terms.

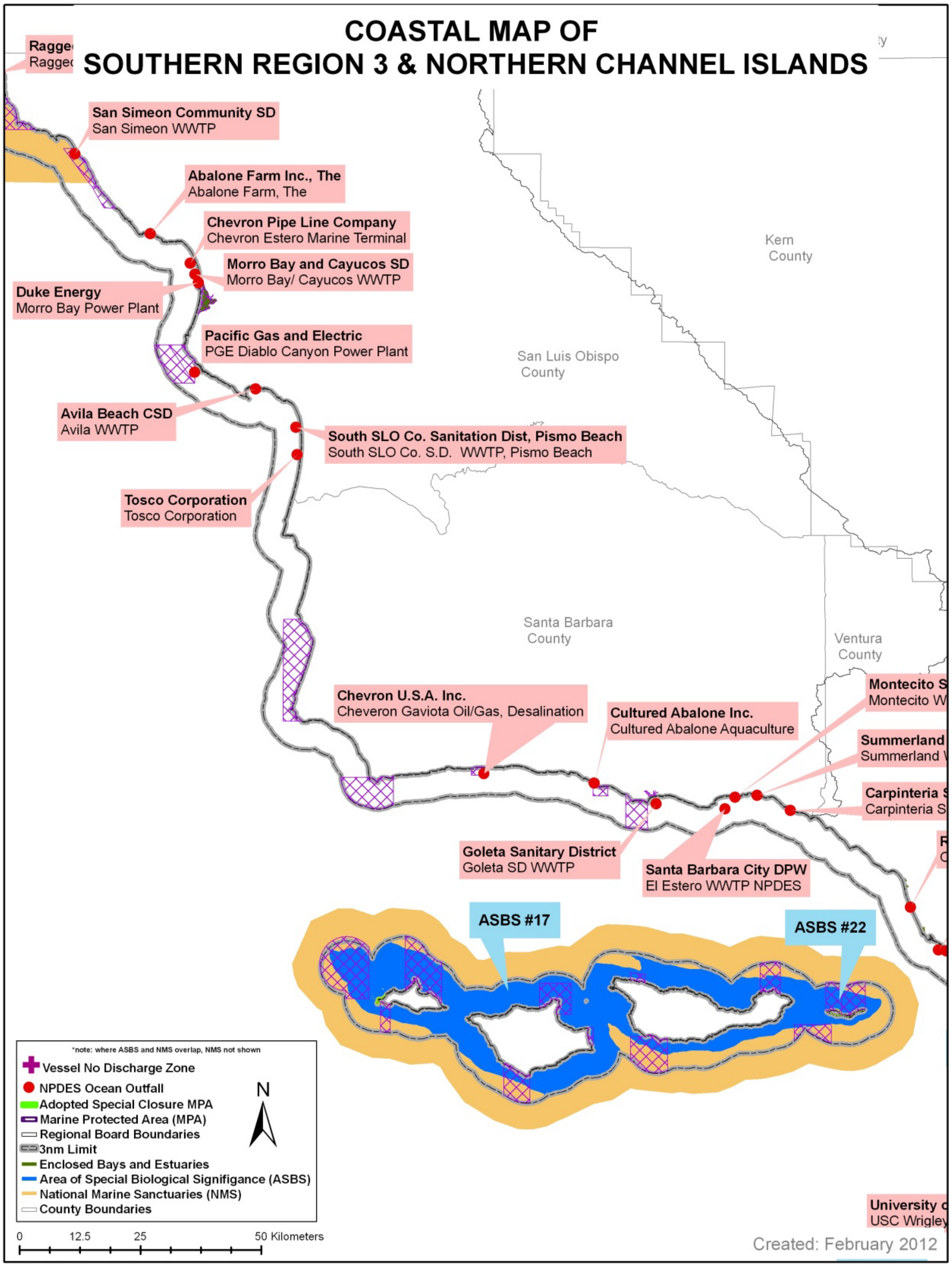

Figure VIII-4. ASBS Boundaries, MPA Boundaries, Wastewater Outfall Points, Marine Sanctuary Boundaries, and Enclosed Bays in southern Region 3 and northern Channel Islands.

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* See Appendix I for definition of terms.

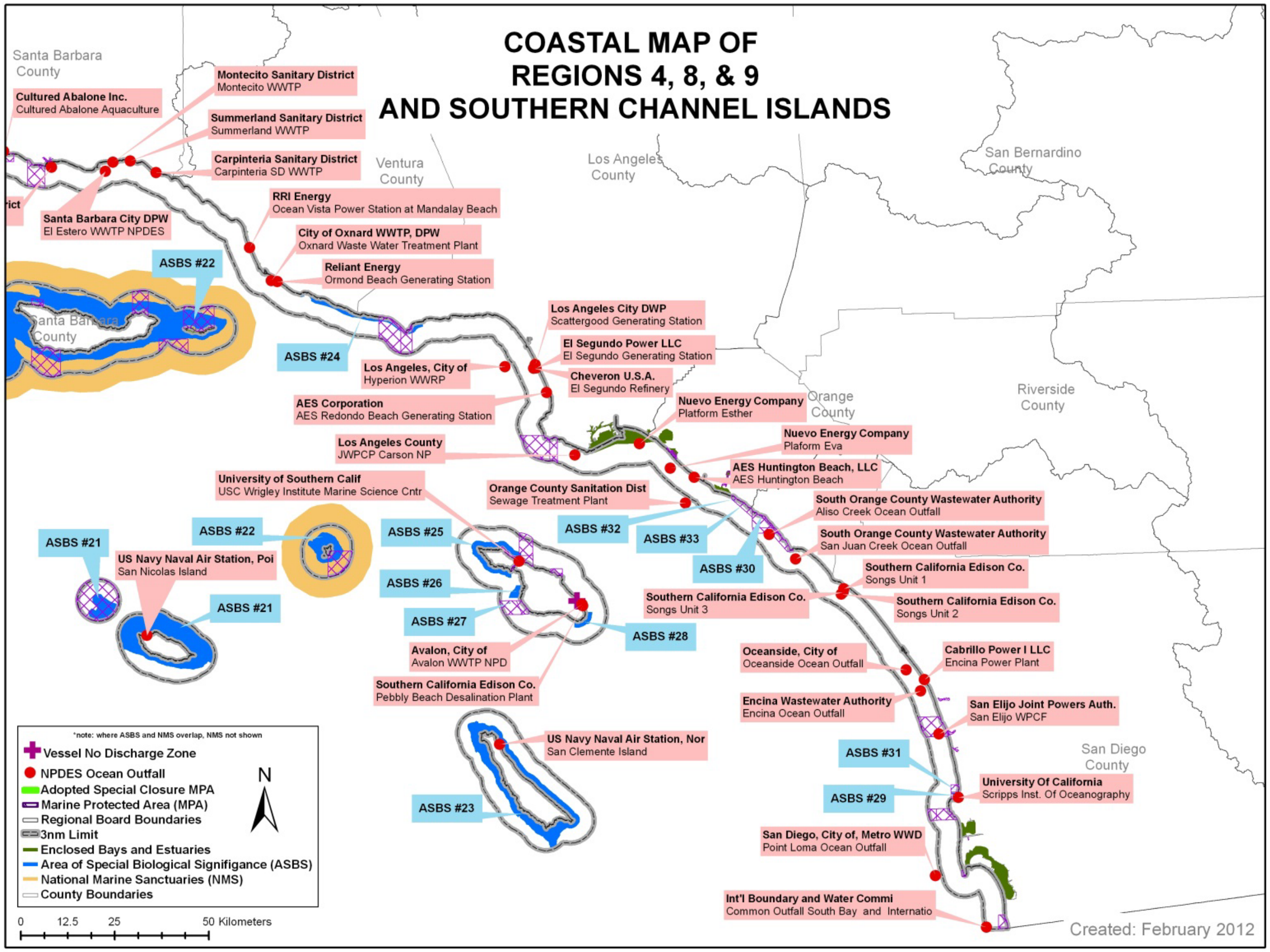

Figure VIII-5. ASBS Boundaries, MPA Boundaries, Wastewater Outfall Points, Marine Sanctuary Boundaries, and Enclosed Bays in southern Channel Islands and Regions 4, 8 and 9.

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* See Appendix I for definition of terms.

Appendix V
CORRESPONDENCE

Renewal of NPDES CA0107409

Request for Determination of Compliance
Regional Water Quality Control Board

Renewal of NPDES CA0107409

THE CITY OF SAN DIEGO

January 2, 2015

Mr. Dave Gibson
Executive Officer
Regional Water Quality Control Board
San Diego Region
2735 Northside Drive, Suite 100
San Diego, CA 92108-2700

Dear Mr. Gibson:

Subject: Request for Determinations of Compliance City of San Diego 301(h) Waiver Application

Regional Water Board Order No. R9-2009-0001 (NPDES CA0107409) regulates the treatment and discharge of wastewater from the City of San Diego E.W. Blom Point Loma Wastewater Treatment Plant to the Pacific Ocean via the Point Loma Ocean Outfall (PLOO). The purpose of this letter is to request a determination from the Regional Water Board, as required by 40 CFR 125.61(b)(2), that the PLOO discharge complies with applicable provisions of State Law and State of California water quality standards.

Purpose of Requested Compliance Determination. Order No. R9-2009-0001 expires on July 31, 2015, and the City of San Diego is required to submit a report of waste discharge in application for renewal of the Order 180 days in advance of this expiration date. As part of this application, the City will be requesting that the U.S. Environmental Protection Agency renew modified secondary treatment standards for the PLOO discharge pursuant to provisions of Section 301(h) and 301(j)(5) of the Clean Water Act. The City's 301(h) application is being developed in accordance with the format established in 40 CFR 125, Subpart G. As part of the 301(h) application, Section III.B.8 of Appendix B of 40 CFR 125, Subpart G, requires 301(h) applicants to:

> *Provide the determination required by 40 CFR 125.61(b)(2) for compliance with applicable provisions of State law, including water quality standards, or, if the determination has not yet been received, a copy of a letter to the appropriate agency(s) requesting the required determination.*

Section III.G.2 of Appendix B of 40 CFR 125, Subpart G, also requires the City of San Diego to obtain a determination from the State that the PLOO does not cause additional treatment or control requirements on other regional point or non-point discharges.

PUBLIC UTILITIES DEPARTMENT
9192 Topaz Way • San Diego, CA 92123
(858) 292-6401

For inclusion in our 301(h) renewal application, the City requests that the Regional Water Board provide updated determinations that the Point Loma ocean outfall discharge (1) is in compliance with NPDES permit limits and provisions of the California Ocean Plan, and (2) does not affect treatment or control requirements on other regional point or non-point discharges. For your reference, enclosed is a copy of the Water Board's compliance determination letter from the City's prior NPDEs application.

Compliance Background. In June 2010, EPA issued a renewed NPDES permit to the City of San Diego that included a Clean Water Section 301(h) waiver from secondary treatment requirements for total suspended solids (TSS) and biochemical oxygen demand. EPA's 2010 decision was based on 15 years of comprehensive receiving water and habitat monitoring that demonstrating that the discharge of chemically enhanced primary treated wastewater 23,760 feet offshore at a depth of 320 feet was not having a detrimental effect on the ocean environment. Monitoring information submitted by the City to the Regional Water Board pursuant to Order No. R9-2009-0001 demonstrates that the PLOO discharge has achieved 100 percent compliance with all effluent concentration standards and California Ocean Plan-based performance goals established within Order No. R9-2009-0001. The submitted monitoring information further demonstrates that receiving waters near the outfall comply with all applicable federal water quality criteria recommended by EPA for the protection of aquatic habitat and human health.

Since receiving its initial 301(h) NPDES permit in 1995, the City has embarked on a progressive series of facilities improvements that have resulted in a systematic reduction in discharged pollutants. Since 1995, TSS mass emissions discharged from the Point Loma outfall have been reduced within each successive NPDES permit period. Additionally, within the past several years the City has implemented an integrated system-wide proprietary chemical additional technology that has resulted in the reduction in discharge concentrations of TSS to levels that approach (and in 2014 were often below) the federal secondary treatment standard of 30 mg/l.

As noted, monitoring data submitted by the City to the Water Board has documented 100 percent compliance with effluent standards and other provisions of the California Ocean Plan established in Order No. R9-2009-0001.

The City looks forward to submitting the NPDES permit renewal application for the PLOO in January 2015. This application will also include the City's commitment to implementation of the *Pure Water San Diego* program that is a joint water/wastewater facilities plan to generate 83 mgd of potable reuse water upstream of the Pt. Loma WWTP and thereby further reduce flow and loads discharged thru the PLOO.

Please contact Alan Langworthy of my staff at (858) 292-6401 or alangworthy@sandiego.gov if you need any additional information in order to make the required determinations that the PLOO discharge (1) complies with applicable State of California water quality standards, and (2) does not cause additional treatment or control requirements on other regional point or non-point discharges.

Thank you for your assistance.

Sincerely,

Halla Razak, P.E.
Director of Public Utilities

AL/slc

Enclosure: Water Board's compliance determination letter from the City's prior NPDEs application

California Regional Water Quality Control Board
San Diego Region
Over 50 Years Serving San Diego, Orange, and Riverside Counties
Recipient of the 2004 Environmental Award for Outstanding Achievement from USEPA

Linda S. Adams
Secretary for Environmental Protection

Arnold Schwarzenegger
Governor

9174 Sky Park Court, Suite 100, San Diego, California 92123-4353
(858) 467-2952 • Fax (858) 571-6972
http:// www.waterboards.ca.gov/sandiego

March 23, 2010

In reply refer to:
248796:jcofrancesco
WDID: 9 000000275

Jim Barrett
Director of Public Utilities
City of San Diego
600 B Street, Suite 400
San Diego, CA 92101-4514

Dear Mr. Barrett:

SUBJECT: REQUEST FOR DETERMINATIONS OF COMPLIANCE, 301(H) and (J)(5) WAIVER APPLICATION FOR THE CITY OF SAN DIEGO E.W. BLOM POINT LOMA METROPOLITAN WASTEWATER TREATMENT PLANT DISCHARGE TO THE PACIFIC OCEAN THROUGH THE POINT LOMA OCEAN OUTFALL

Attached is an Action on Request for Clean Water Act Section 401 Water Quality Certification as required by 40 CFR 125.61(b)(2) and 40 CFR 125.64(b) for the City of San Diego's (City's) 301(h) and (j)(5) waiver application. It has been determined that the proposed wastewater discharge from the City's Point Loma Ocean Outfall to the Pacific Ocean:

1. Complies with applicable water quality standards for waters of the Pacific Ocean included in the 2005 California Ocean Plan and the 1994 Water Quality Control Plan for the San Diego Basin (Basin Plan), including any amendments to date, and

2. Will not result in additional treatment, pollution control, or other requirement on any other existing point or non-point sources.

In the subject line of any response, please include the requested "**In reply refer to:**" information located in the heading of this letter. For questions pertaining to the subject matter, please contact Joann Cofrancesco at (858) 637-5589 or jcofrancesco@waterboards.ca.gov.

Respectfully,

DAVID W. GIBSON
Executive Officer
DWB:dtb:bdk:jlc

Enclosure: Water Quality Certification

cc (with enclosure):

David W. Smith, Chief
U.S. Environmental Protection Agency, Region 9
NPDES Permits Office (WTR-5)
75 Hawthorne Street
San Francisco, CA 94105

State Water Resources Control Board
Division of Water Quality

THE CITY OF SAN DIEGO · STATE OF CALIFORNIA
SEMPER VIGILANS

Request for Comments
Endangered Species
National Marine Fisheries Service

Renewal of NPDES CA0107409

THE CITY OF SAN DIEGO

January 2, 2015

Mr. Will Stelle
West Coast Regional Administrator
National Marine Fisheries Service
501 West Ocean Boulevard, Suite 4200
Long Beach, CA 90802-4213

Dear Mr. Stelle:

Subject: Request for Comments on Endangered Species - Application for Modified Secondary Treatment Requirements

City of San Diego Point Loma Ocean Outfall

The City of San Diego is preparing an application to the U.S. Environmental Protection Agency and San Diego Regional Water Quality Control Board requesting renewal of its' NPDES permit for the discharge of treated wastewater to the Pacific Ocean via the 23,760-foot-long, 320-foot deep Point Loma Ocean Outfall. The City's application requests renewal of modified secondary treatment requirements for the Point Loma discharge in accordance with provisions of Section 301(h) and Section 301(j)(5) of the Clean Water Act. The City's Section 301 renewal application does not request any increase in currently permitted discharge flows or mass emissions. In fact, a decrease in permitted suspended solids mass emissions is proposed. Treatment and discharge operations at Point Loma have complied with all applicable state and federal standards for the protection water quality, habitat quality, marine organisms, and beneficial uses of the ocean. The proposed discharge will continue to meet or exceed these standards.

In June 2010, EPA issued a renewed NPDES permit to the City of San Diego that included a Clean Water Section 301(h) waiver from secondary treatment requirements for total suspended solids (TSS) and biochemical oxygen demand (BOD). The EPA's 2010 decision was based on 15 years of comprehensive receiving water and habitat monitoring demonstrating that the discharge of chemically enhanced primary treated wastewater 23,760 feet offshore at a depth of 320 feet was not having a detrimental effect on the ocean environment. Since issuance of the current NPDES permit in 2010, the City's extensive monitoring program continues to verify that the Point Loma discharge protects San Diego's ocean waters and marine life. The City's comprehensive monitoring program demonstrates that the discharge complies (by significant margins) with all applicable state and federal receiving water standards established for the protection of marine aquatic habitat and human health. The monitoring further demonstrates that receiving waters near the outfall comply with all applicable federal water quality criteria recommended by EPA for the protection of aquatic habitat and human health.

PUBLIC UTILITIES DEPARTMENT
9192 Topaz Way • San Diego, CA 92123
(858) 292-6401

DIVERSITY

Since receiving its' initial 301(h) NPDES permit in 1995, the City has embarked on a progressive series of facilities improvements that have resulted in a systematic reduction in discharged pollutants. Since 1995, TSS mass emissions discharged from the Point Loma outfall have been reduced within each successive NPDES permit period. In recent years, chemically enhanced treatment improvements have resulted in discharge concentrations of TSS that approach (and in 2014 were typically below) the federal secondary treatment standard of 30 mg/l.

As part of applying for renewed NPDES 301(h) requirements, the City is committing to continuing this trend of reduced solids mass emissions during the upcoming five-year NPDES permit period. Additionally, the City is committing to implementing a 20 year comprehensive water and wastewater facilities plan called Pure Water San Diego. The Pure Water San Diego program has a goal of reducing future Point Loma discharge flows by implementing 15 mgd of potable reuse by 2024, a cumulative 30 mgd of potable reuse by 2028, and a cumulative 83 mgd of potable reuse by 2036.

NPDES permits need to be renewed every five years, and the City is required to submit an application for renewal of its NPDES permit and 301(h) modified discharge requirements by January 31, 2015. As part of Section II.D.3 of the Applicant Questionnaire, the Section 301 application requires the City to identify:

- Any threatened or endangered species which may inhabit or obtain nutrients from waters affected by the discharge;
- Whether the discharge is consistent with the Endangered Species Act; and
- Whether the discharge will affect threatened or endangered species or their critical habitat.

In this letter, use of the term "endangered species" includes threatened species as well.
***Previous* Findings:** As part of the Section 301 applications submitted to EPA in 1979 and 1983, the City and EPA contacted the National Marine Fisheries Service (NMFS) for a determination of impacts from the City's original Point Loma discharge approximately 11,500 feet offshore at a depth of 220 feet. In response to these contacts, G. Howard, NMFS Regional Director noted in a February 6, 1980 letter that the following species may migrate through or occasionally visit California coastal waters.

Gray whale, *Eschrichtius robustus*
Humpback whale, *Megaptera novaeangliae*
Right whale, *Balaena glacialis*
Blue whale, *Balaenoptera musculus*
Fin whale, *Balaenoptera physalus*
Sei whale, *Balaenoptera borealis*
Sperm whale, *Physter macrocephalus*
Leatherback sea turtle, *Dermochelys coriacea*

Pacific hawksbill sea turtle, *Eretmochelys imbricata*
Green sea turtle, *Chelonia mydas*
Pacific Ridley sea turtle, *Lepidochelys olivacea*
Loggerhead sea turtle, *Caretta caretta*

In a May 15, 1980, letter from F. Anders (NMFS Acting Regional Director), NMFS expressed principal interest in the gray whale, but noted that no sewage-related disease or contamination of whales had occurred in California. Mr. Anders' letter also stated that compliance with California Ocean Plan water quality objectives would be sufficient for protecting the species from adverse effects. The letter concluded that granting a 301 variance would not jeopardize the continued existence of any threatened or endangered species which visit or migrate through California coastal waters. In a letter dated December 7, 1983, Mr. Anders further stated that the gray whale was the only listed species for which NMFS had management responsibility that would likely occur in the vicinity of Point Loma.

In 1991 NMFS conducted an informal Section 7 consultation under the Endangered Species Act as part of environmental planning efforts to extend the Point Loma outfall to its present length of 23,760 feet. In a July 3, 1991, letter, NMFS concluded that populations of marine mammals and endangered species under NMFS jurisdiction would not be adversely affected by the outfall extension.

In a letter dated March 27, 1995, regarding the City's 1995 Section 301 application, Ms. Hilda Diaz-Soltero, NMFS Regional Director, commented that no Federally listed under the jurisdiction of the NMFS are likely to be affected by the modified discharge at the Point Loma outfall. The list of endangered species was found to be accurate, except that gray whale is no longer listed under the Endangered Species Act (although it continues to receive protection under the U.S. Marine Mammal Protection Act).

In a letter dated August 10, 1999, Mr. Rodney McInnis, Acting Regional Administrator, NMFS, Southwest Region, commented that based on the offshore distance and depth of the discharge of the wastewater and available scientific information, the National Marine Fisheries Service concludes that there are no Federally listed species under our jurisdiction that are likely to be affected by the modified discharges at the Point Loma outfall. The letter also indicated that the list of endangered species under NMFS's jurisdiction that may be found off Point Loma is current and correct.

In a letter dated November 29, 2009, Mr. Rodney McInnis, Regional Administrator NMFS Southwest Regional Office, provided the following comments:

> "There is no new information available that would indicate that the discharge of primary-treated wastewater 4.5 miles offshore of Point Loma at a depth of 97.5 meters is having direct impacts on any ESA-listed species under the jurisdiction of NMFS. The range of influence of the discharge on the local benthic environment is about 300 meters from the outfall, according to annual reports released by the San Diego Metropolitan Wastewater Department. This area is

sufficiently small that any ESA-listed species with mobility (marine mammals, sea turtles, and fish) that might migrate through the area would easily be able to avoid or escape the influence of the discharge plume. NMFS expects that the presence of listed species in the vicinity of the discharge would typically be ephemeral. The depth of the outfall is also located well below the depth range in which the more sedentary ESA-listed abalone would be expected to be found. At this time, NMFS is not aware of any information that suggests potential indirect impacts associated with long-term bioaccumulation of discharged sediments and constituents by Point Loma's primary-treated wastewater discharge are affecting ESA-listed species. However, these processes are generally not well understood or easily attributed to specific point sources given the migratory nature of many marine organisms.

NMFS recommends the following updates to the list of endangered or threatened species that maybe found off Point Loma: Right whale (*Eubalaena japonica*) should be changed to North Pacific right whale; Hawksbill turtles (*Eretmochelys imbricata*) can be removed from the list; Although there is a small nesting population which persists off the southern Baja coast of Mexico, there have been no reports of this species as far north as San Diego and it is therefore unlikely that they would be found off the California coast; The Central California Coastal evolutionary significant unit (ESU) of coho salmon (*Oncorhynchus kistuch*) is listed as endangered. As with the other salmonids, they are uncommon to waters as far south as Point Loma; Three ESUs of chinook salmon (*Oncorhynchus tshawytscha*) in California have been listed. The Sacramento River winter-run unit is considered endangered, and both the Central Valley Spring and California Coastal units are considered threatened. NMFS still considers them uncommon to waters as far south as Point Loma; The southern California distinct population segment (DPS) of steelhead (*Oncorhynchus mykiss*) should be referenced as endangered; Other California steelhead DPSs listed as threatened include South-Central California, Central California Coast, California Central Valley, and Northern California. None of these would be commonly found off of Point Loma; the southern DPS of green sturgeon (*Acipenser medirostris*) is currently listed as threatened (71 FR 17757). Although it is possible that this species may occur in coastal waters as far south as Point Loma, it would be considered very uncommon; Black abalone (*Haliotis cracherodii*) was listed as endangered in January, 2009 (74FR 1937).

As defined under the ESA, take means "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in such conduct." Incidental take means any take that occurs which "is not the purpose of an otherwise lawful activity." If the City believes the discharge of wastewater at this location is or has the potential to negatively affect ESA-listed species in a manner which may constitute take, the City is encouraged to contact the SWR for further information and guidance on compliance with ESA regulations (16 U.S.C. 1536 and 1539)."

Current Conditions: An Endangered Species Assessment is being prepared as a part of the City of San Diego's current Section 301 renewal application. The assessment, presented in the following enclosure, evaluates the potential effects of the discharge of treated wastewater from the Point Loma Ocean Outfall on endangered species and their critical habitat. It includes a description of: the action to be considered; the specific area that may be affected by the action; listed species or critical habitat that may be affected by the action; how the action may affect any listed species or critical habitat; an analysis of any cumulative effects; and, other relevant available information on the action, the affected listed species, or critical habitat.

The City of San Diego monitors ocean conditions over space and time, and assesses any impacts of wastewater discharge or other man-made or natural influences on the local marine environment. There is no indication of change in any physical or chemical water quality parameter attributable to wastewater discharge off Point Loma. Instead, fluctuations in oceanographic parameters have historically been associated with varying climate regimes and with natural events such as storm activity and the presence of plankton blooms.

Conditions on the seafloor off Point Loma show some changes that may be expected near large ocean outfalls, though restricted to a relatively small, localized region near the discharge site. Other measures of environmental impact such as concentrations of sediment contaminants show no patterns related to wastewater discharge. Marine communities in the Point Loma region remain characteristic of natural conditions with no suggestion of ecologically-significant changes.

Fish and invertebrates assemblages reveal no spatial or temporal patterns that can be ascribed to effects of wastewater discharge. Contaminants in fish tissues in the Point Loma area are similar to those at reference sites beyond the influence of the discharge. The lack of physical anomalies and other symptoms of disease in local fish, as well as the low level of contaminants in fish tissues, reflect a healthy marine environment.

Extensive monitoring and scientific studies indicate little or no alteration of physical, chemical, or biological conditions of the waters or substrates. Impacts on marine organisms, prey species, their habitat, and other ecosystem components are minimal. The discharge of treated wastewater at Point Loma will make an insignificant contribution to regional cumulative impacts on endangered species and their critical habitat.

The Endangered Species Assessment concludes that there is no indication of adverse impacts from operation of the Point Loma Ocean Outfall on environmental conditions or biological communities that could affect the health and well-being of endangered species or threaten their critical habitat. Future flows and contaminant concentrations from the Point Loma Ocean Outfall would be at or below currently permitted levels. Thus, the proposed, future discharge of treated wastewater from the Point Loma Ocean Outfall is not likely to adversely affect endangered species or their critical habitat. The purpose of this letter is to solicit concurrence from your agency that the proposed discharge will not adversely affect endangered species and is consistent with the federal Endangered Species Act.

The City is including the information and conclusions in the Endangered Species Assessment in its Section 301 application for renewal of discharge requirements for the Point Loma Ocean Outfall. We would appreciate any comments you may have on the City's Section 301 application and on our determination that the Point Loma Ocean Outfall is not likely to adversely impact endangered species.

We would also appreciate your updating us on any new species listings or other pertinent information not reflected in the current Endangered Species Assessment or in previous correspondence noted above. For your information, we are also contacting the U. S. Fish and Wildlife Service for comments on endangered species under their jurisdiction.

Please call or email Alan Langworthy (858) 292-6401 or alangworthy@sandiego.gov if you or your staff members need any additional information in order to make a determination.

Thank you for your assistance.

Sincerely,

Halla Razak, P.E.
Director of Public Utilities

AL/slc

Enclosure: Endangered Species Assessment for City of San Diego

NOTE: See Appendix J in Volume VII for the Endangered Species Assessment transmitted to the National Marine Fisheries Service

Request for Comments
Endangered Species
U.S. Fish and Wildlife Service

Renewal of NPDES CA0107409

THE CITY OF SAN DIEGO

January 2, 2015

Mr. G. Mendel Stewart
Field Supervisor
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Avenue, Suite 250
Carlsbad, California 92008-7385

Dear Mr. Stewart:

Subject: Request for Comments on Endangered Species - Application for Modified Secondary Treatment Requirements

City of San Diego Point Loma Ocean Outfall

The City of San Diego is preparing an application to the U.S. Environmental Protection Agency and San Diego Regional Water Quality Control Board requesting renewal of its' NPDES permit for the discharge of treated wastewater to the Pacific Ocean via the 23,760-foot-long, 320-foot deep Point Loma Ocean Outfall. The City's application requests renewal of modified secondary treatment requirements for the Point Loma discharge in accordance with provisions of Section 301(h) and Section 301(j)(5) of the Clean Water Act. The City's Section 301 renewal application does not request any increase in currently permitted discharge flows or mass emissions. In fact, a decrease in permitted suspended solids mass emissions is proposed. Treatment and discharge operations at Point Loma have complied with all applicable state and federal standards for the protection water quality, habitat quality, marine organisms, and beneficial uses of the ocean. The proposed discharge will continue to meet or exceed these standards.

In June 2010, EPA issued a renewed NPDES permit to the City of San Diego that included a Clean Water Section 301(h) waiver from secondary treatment requirements for total suspended solids (TSS) and biochemical oxygen demand (BOD). The EPA's 2010 decision was based on 15 years of comprehensive receiving water and habitat monitoring demonstrating that the discharge of chemically enhanced primary treated wastewater 23,760 feet offshore at a depth of 320 feet was not having a detrimental effect on the ocean environment. Since issuance of the current NPDES permit in 2010, the City's extensive monitoring program continues to verify that the Point Loma discharge protects San Diego's ocean waters and marine life. The City's comprehensive monitoring program demonstrates that the discharge complies (by significant margins) with all applicable state and federal receiving water standards established for the protection of marine aquatic habitat and human health. The monitoring further demonstrates that

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receiving waters near the outfall comply with all applicable federal water quality criteria recommended by EPA for the protection of aquatic habitat and human health.
Since receiving its' initial 301(h) NPDES permit in 1995, the City has embarked on a progressive series of facilities improvements that have resulted in a systematic reduction in discharged pollutants. Since 1995, TSS mass emissions discharged from the Point Loma outfall have been reduced within each successive NPDES permit period. In recent years, chemically enhanced treatment improvements have resulted in discharge concentrations of TSS that approach (and in 2014 were typically below) the federal secondary treatment standard of 30 mg/l.

As part of applying for renewed NPDES 301(h) requirements, the City is committing to continuing this trend of reduced solids mass emissions during the upcoming five-year NPDES permit period. Additionally, the City is committing to implementing a 20 year comprehensive water and wastewater facilities plan called Pure Water San Diego. The Pure Water San Diego program has a goal of reducing future Point Loma discharge flows by implementing 15 mgd of potable reuse by 2024, a cumulative 30 mgd of potable reuse by 2028, and a cumulative 83 mgd of potable reuse by 2036.

NPDES permits need to be renewed every five years, and the City is required to submit an application for renewal of its NPDES permit and 301(h) modified discharge requirements by January 31, 2015. As part of Section II.D.3 of the Applicant Questionnaire, the Section 301 application requires the City to identify:

- Any threatened or endangered species which may inhabit or obtain nutrients from waters affected by the discharge;

- Whether the discharge is consistent with the Endangered Species Act; and

- Whether the discharge will affect threatened or endangered species or their critical habitat.

In this letter, use of the term "endangered species" includes threatened species as well.

Previous Findings: As part of Section 301 applications submitted to EPA in 1979 and 1983, the City contacted the U.S. Fish and Wildlife Service (USFWS) for a determination of impacts from the City's original Point Loma discharge approximately 11,500 feet offshore at a depth of 220 feet. In response to these contacts, in a letter dated April 27, 1980, W. Sweeney, Area Manager for USFWS, noted that the California least tern may occur in the San Diego area. In a letter dated August 28, 1981, EPA requested that USFWS evaluate EPA's conclusion that the approval of a Section 301 waiver would have no impact on the California least tern population in the San Diego area. In a response letter dated April 30, 1982, USFWS Area Manager concluded that approval of a Section 301 waiver for the Point Loma discharge would not affect the California least tern population.

In 1991, the City prepared and distributed an Environmental Impact Report which assessed impacts associated with moving the Point Loma outfall discharge from 11,500 feet offshore and a depth of 220 feet to 23,760 feet offshore and a depth of 320 feet. City records indicate that USFWS received either a copy of the draft EIR or a notice of the EIR; USFWS was invited to comment on the accuracy and sufficiency of the EIR. USFWS offered no comments on the discharge relocation project and did not request a Section 7 consultation under the Endangered Species Act.

After approval of the EIR and construction of the extended outfall, the City terminated the discharge through the old outfall and initiated the discharge of advanced primary effluent from the extended outfall in November 1993, in accord with an Administrative Order issued by EPA. In a letter to Mr. Jim Bartel, Field Supervisor, U.S. Fish and Wildlife Service, Carlsbad, California dated October 29, 2007, the City requested comments on endangered species for the Point Loma Ocean Outfall Section 301 application. In response, Ms. Cara McGary, Fish and Wildlife Biologist, Carlsbad Fish and Wildlife Office, Carlsbad, California replied in an email to Mr. Tim Bertch, Director, Metropolitan Wastewater Department, City of San Diego dated December 10, 2007 (Reference Number 2008-B-0187/2008-I-0186). Ms. McGary stated in the email: "We agree with the City's assessment that the project may affect but is not likey to adversely affect threatened or endangered species. There are no newly listed species in the project vicinity that would be impacted by this project."

Current Conditions: An Endangered Species Assessment is being prepared as a part of the City of San Diego's current Section 301 renewal application. The assessment, presented in the following enclosure, evaluates the potential effects of the discharge of treated wastewater from the Point Loma Ocean Outfall on endangered species and their critical habitat. It includes a description of: the action to be considered; the specific area that may be affected by the action; listed species or critical habitat that may be affected by the action; how the action may affect any listed species or critical habitat; an analysis of any cumulative effects; and, other relevant available information on the action, the affected listed species, or critical habitat.

The City of San Diego monitors ocean conditions over space and time, and assesses any impacts of wastewater discharge or other man-made or natural influences on the local marine environment. There is no suggestion of change in any physical or chemical water quality parameter attributable to wastewater discharge off Point Loma. Instead, fluctuations in oceanographic parameters have historically been associated with varying climate regimes and with natural events such as storm activity and the presence of plankton blooms.

Conditions on the seafloor off Point Loma show some changes that may be expected near large ocean outfalls, though restricted to a relatively small, localized region near the discharge site. Other measures of environmental impact such as concentrations of sediment contaminants show no patterns related to wastewater discharge. Marine communities in the Point Loma region remain characteristic of natural conditions with no suggestion of ecologically-significant changes.

Fish and invertebrates assemblages reveal no spatial or temporal patterns that can be ascribed to effects of wastewater discharge. Contaminants in fish tissues in the Point Loma area are similar to those at reference sites beyond the influence of the discharge. The lack of physical anomalies and other symptoms of disease in local fish, as well as the low level of contaminants in fish tissues, reflect a healthy marine environment.

Extensive monitoring and scientific studies at Point Loma indicate little or no alteration of physical, chemical, or biological conditions of the waters or substrates. Impacts on marine organisms, prey species, their habitat, and other ecosystem components are minimal. The discharge of treated wastewater at Point Loma will make an insignificant contribution to regional cumulative impacts on endangered species and their critical habitat.

The Endangered Species Assessment concludes that there is no indication of adverse impacts from operation of the Point Loma Ocean Outfall on environmental conditions or biological communities that could affect the health and well-being of endangered species or threaten their critical habitat. Future flows and contaminant concentrations from the Point Loma Ocean Outfall would be at or below currently permitted levels. Thus, the proposed, future discharge of treated wastewater from the Point Loma Ocean Outfall is not likely to adversely affect endangered species or their critical habitat. The purpose of this letter is to solicit concurrence from your agency that the proposed discharge will not adversely affect endangered species and is consistent with the federal Endangered Species Act.

The City is including the information and conclusions in the Endangered Species Assessment in its Section 301 application for renewal of discharge requirements for the Point Loma Ocean Outfall. We would appreciate any comments you may have on the City's Section 301 application and on our determination that the Point Loma Ocean Outfall is not likely to adversely impact endangered species.

We would also appreciate your updating us on any new species listings or other pertinent information not reflected in the current Endangered Species Assessment or in previous correspondence noted above. For your information, we are also contacting the U. S. National Marine Fisheries Service for comments on endangered species under their jurisdiction.

Please call or email Alan Langworthy (858) 292-6401 or alangworthy@sandiego.gov if you or your staff members need any additional information in order to make a determination.

Thank you for your assistance.

Sincerely,

Halla Razak

Halla Razak, P.E.
Director of Public Utilities

AL/slc

Enclosure: Endangered Species Assessment for City of San Diego

NOTE: See Appendix J in Volume VII for the Endangered Species Assessment transmitted to the U.S. Fish and Wildlife Service

Request for Comments
Essential Fish Habitat Assessment
National Marine Fisheries Service

Renewal of NPDES CA0107409

THE CITY OF SAN DIEGO

January 2, 2015

Mr. Will Stelle
West Coast Regional Administrator
National Marine Fisheries Service
501 West Ocean Boulevard, Suite 4200
Long Beach, CA 90802-4213

Dear Mr. Stelle:

Subject: Request for Comments on Essential Fish Habitat Assessment - Application for Modified Secondary Treatment Requirements

City of San Diego Point Loma Ocean Outfall

The City of San Diego is preparing an application to the U.S. Environmental Protection Agency and San Diego Regional Water Quality Control Board requesting renewal of its' NPDES permit for the discharge of treated wastewater to the Pacific Ocean via the 23,760-foot-long, 320-foot deep Point Loma Ocean Outfall. The City's application requests renewal of modified secondary treatment requirements for the Point Loma discharge in accordance with provisions of Section 301(h) and Section 301(j)(5) of the Clean Water Act. NPDES permits need to be renewed every five years, and the City is required to submit an application for renewal of its NPDES permit and 301(h) modified discharge requirements by January 31, 2015.

The City's Section 301 renewal application does not request any increase in currently permitted discharge flows or mass emissions. In fact, a decrease in permitted suspended solids mass emissions is proposed. Treatment and discharge operations at Point Loma have complied with all applicable state and federal standards for the protection water quality, habitat quality, marine organisms, and beneficial uses of the ocean. The proposed discharge will continue to meet or exceed these standards.

In June 2010, EPA issued a renewed NPDES permit to the City of San Diego that included a Clean Water Section 301(h) waiver from secondary treatment requirements for total suspended solids (TSS) and biochemical oxygen demand (BOD). The EPA's 2010 decision was based on 15 years of comprehensive receiving water and habitat monitoring demonstrating that the discharge of chemically enhanced primary treated wastewater 23,760 feet offshore at a depth of 320 feet was not having a detrimental effect on the ocean environment. Since issuance of the current NPDES permit in 2010, the City's extensive monitoring program continues to verify that the Point Loma discharge protects San Diego's ocean waters and marine life. The City's

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comprehensive monitoring program demonstrates that the discharge complies (by significant margins) with all applicable state and federal receiving water standards established for the protection of marine aquatic habitat and human health. The monitoring further demonstrates that receiving waters near the outfall comply with all applicable federal water quality criteria recommended by EPA for the protection of aquatic habitat and human health.

Since receiving its' initial 301(h) NPDES permit in 1995, the City has embarked on a progressive series of facilities improvements that have resulted in a systematic reduction in discharged pollutants. Since 1995, TSS mass emissions discharged from the Point Loma outfall have been reduced within each successive NPDES permit period. In recent years, chemically enhanced treatment improvements have resulted in discharge concentrations of TSS that approach (and in 2014 were typically below) the federal secondary treatment standard of 30 mg/l.

As part of applying for renewed NPDES 301(h) requirements, the City is committing to continuing this trend of reduced solids mass emissions during the upcoming five-year NPDES permit period. Additionally, the City is committing to implementing a 20 year comprehensive water and wastewater facilities plan called Pure Water San Diego. The Pure Water San Diego program has a goal of reducing future Point Loma discharge flows by implementing 15 mgd of potable reuse by 2024, a cumulative 30 mgd of potable reuse by 2028, and a cumulative 83 mgd of potable reuse by 2036.

The marine environment in the vicinity of Point Loma supports a wide variety of commercial fisheries. These fisheries are protected and managed by the Magnuson-Stevens Fishery Conservation and Management Act and the Sustainable Fisheries Act through their "Essential Fish Habitat" provisions.

As a part of the City of San Diego's current Section 301 renewal application, an Essential Fish Habitat Assessment is being prepared. The assessment, presented in the following enclosure, evaluates the potential effects of the discharge of treated wastewater from the Point Loma Ocean Outfall on Essential Fish Habitat. It includes a description of: the project area, the Point Loma Ocean Outfall, the environmental setting, commercial fisheries, the regulatory background, fishery management plans, species descriptions, life history profiles, designated Essential Fish Habitat (EFH), and potential impacts of the discharge of treated wastewater from the Point Loma Ocean Outfall on EFH.

The City of San Diego monitors ocean conditions over space and time, and assesses any impacts of wastewater discharge or other man-made or natural influences on the local ecosystem and environment.

There is no indication of change in any physical or chemical water quality parameter attributable to wastewater discharge off Point Loma. Instead, fluctuations in oceanographic parameters have historically been associated with varying climate regimes and with natural events such as storm activity and the presence of plankton blooms.

Conditions on the seafloor off Point Loma show some changes that may be expected near large ocean outfalls, though restricted to a relatively small, localized region near the discharge site. Other measures of environmental impact such as concentrations of sediment contaminants show no patterns related to wastewater discharge. Marine communities in the Point Loma region remain characteristic of natural conditions with no suggestion of ecologically-significant changes.

Fish and invertebrates assemblages reveal no spatial or temporal patterns that can be ascribed to effects of wastewater discharge. While significant natural variations in fish populations are observed (in response to factors such as water temperature), the Point Loma wastewater discharge is not having any significant effect on fish communities off Point Loma. Fish populations lack physical abnormalities such as fin erosion or tumors. Levels of trace metals, chlorinated hydrocarbons, pesticides, and polyaromatic hydrocarbons are relatively low, with concentrations within the range found throughout the Southern California Bight.

No outfall-related effects are evident from bioaccumulation data. Contaminants in fish tissues in the Point Loma area are similar to those at reference sites beyond the influence of the discharge. The absence of physical anomalies and other symptoms of disease in local fish, as well as the low level of contaminants in fish tissues, reflect a healthy marine environment.

The proposed operation of the Point Loma Ocean Outfall will not reduce the quality or quantity of Essential Fish Habitat. Extensive monitoring and scientific studies indicate little or no alteration of physical, chemical, or biological conditions of the waters or substrates. Impacts on marine organisms, prey species, their habitat, and other ecosystem components are minimal. Wastewater discharged from the outfall will make an insignificant contribution to regional cumulative impacts on EFH or fisheries species.

The Essential Fish Habitat Assessment concludes that the discharge of treated wastewater from the Point Loma Ocean Outfall will not have an adverse effect on Essential Fish Habitat. The purpose of this letter is to solicit concurrence from your agency that the proposed discharge will not adversely affect Essential Fish Habitat and is consistent with the Magnuson-Stevens Fishery Conservation and Management Act.

The City is including the information and conclusions of the Essential Fish Habitat Assessment in its Section 301 application to EPA for renewal of discharge requirements for the Point Loma Ocean Outfall. We would appreciate any comments you may have on the City's Section 301 application and on our determination that the Point Loma Ocean Outfall is not likely to adversely affect Essential Fish Habitat.

We would also appreciate your updating us on any new information not reflected in the current Essential Fish Habitat Assessment or in previous correspondence noted above.

Please call or email Alan Langworthy (858) 292-6401 or alangworthy@sandiego.gov if you or your staff members need any additional information in order to make a determination.

Thank you for your assistance.

Sincerely,

Halla Razak, P.E.
Director of Public Utilities

AL/slc

Enclosure: Essential Fish Habitat Assessment for City of San Diego

NOTE: See Appendix K in Volume VII for the Essential Fish Habitat Assessment transmitted to the National Marine Fisheries Service

Request for Determination of Compliance
California Coastal Commission

Renewal of NPDES CA0107409

California Coastal Commission
Compliance Determination

To be provided after
Regional Water Quality Control Board
Adoption of NPDES CA0107409