CHAPTER 6
SURFACE WATER QUALITY

This chapter describes water quality issues in the Salton Sea and the major tributaries and potential changes that could occur due to implementation of the alternatives.

STUDY AREA

The study area is defined as the geographical area within which the large majority of potential impacts are expected. The study area for water quality issues is the Salton Sea, drains and rivers that flow into the Salton Sea, adjacent wetlands, and uplands that may influence water quality in the Salton Sea, as shown in Figure 6-1.

REGULATORY REQUIREMENTS

Federal and State regulations applicable to the Salton Sea are summarized below.

Federal Regulations

The Federal Water Pollution Control Act Amendments of 1972, also known as the Clean Water Act, established the institutional structure for the U.S. Environmental Protection Agency (USEPA) to regulate discharges of pollutants into the waters of the United States, establish water quality standards, conduct planning studies, and provide funding for specific grant projects. The Clean Water Act has been amended by Congress several times since 1972. USEPA has provided most states with the authority to administer many of the provisions of the Clean Water Act. In California, the State Water Resources Control Board (SWRCB) has been designated by USEPA along with the nine Regional Water Quality Control Boards to develop and enforce water quality objectives and implementation plans, as described below under State Regulations. The Colorado River Basin Regional Water Quality Control Board (CRBRWQCB) is the lead water quality management agency in the study area.

The Clean Water Act includes many provisions to manage water quality. Major provisions that affect water quality in the Salton Sea watershed and were considered during the development and evaluation of alternatives in the Draft Programmatic Environmental Impact Report (PEIR) are described below.

Section 401 of the Clean Water Act requires that federally authorized discharges into waters of the United States not violate state water quality standards. Section 402 of the Clean Water Act authorizes states to issue National Pollutant Discharge Elimination System (NPDES) permits for discharges to surface water both from point sources and many non-point sources in stormwater. Compliance is required for all discharges into waters of the United States, or for construction projects that would disturb one acre or more. The CRBRWQCB administers the NPDES permit program in the study area except on Tribal lands.

Section 404 of the Clean Water Act requires that an entity obtain permits before discharging dredge or fill material into navigable waters, their tributaries, and associated wetlands. Activities regulated by 404 permits include, but are not limited to, dredging, bridge construction, flood control actions, and some fishing operations.

Under section 303(d) of the Clean Water Act, states, territories, and authorized Indian tribes submit lists to USEPA describing water bodies for which existing pollution controls are insufficient to attain or maintain water quality standards. Impaired water bodies must be ranked based upon the severity of the pollution and the beneficial uses of such waters. After submitting the list of impaired waters, also referred to as a 303(d) list, states must develop a plan, called the Total Maximum Daily Load (TMDL) plan, to limit excess pollution. A TMDL represents the greatest pollutant load that a waterbody can assimilate and continue to meet water quality standards and designated beneficial uses. Generally, TMDLs are adopted for specific pollutants throughout the water body.

The California Environmental Protection Agency, SWRCB, and CRBRWQCB have identified water bodies within the Salton Sea watershed that do not comply with applicable water quality standards. The Salton Sea and all of the principal inflow sources are listed as impaired water bodies. Sedimentation/Siltation TMDLs for the New and Alamo rivers and Pathogen TMDL for the New River were adopted by the CRBRWQCB and approved by the SWRCB and USEPA. The Sedimentation/Siltation TMDL for Imperial Valley drains has been adopted by the CRBRWQCB and is being reviewed by the SWRCB and USEPA. Other TMDLs are in the development and review processes, as shown in Table 6-1.

Table 6-1
Impaired Water Bodies Within Salton Sea Watershed

Water Body	Pollutant of Concern	Type of Concern			TMDL Completion Date
		Irrigation Flows	Imported Salts	Other	
Coachella Valley Stormwater Channel (Whitewater River)	Bacteria	Source Unknown			Draft Published
Alamo River	Pesticides	X			2011
	Selenium	X	X		2010
	Sedimentation/Siltation	X			Adopted
Imperial Valley Drains	Pesticides	X			2011
	Selenium	X	X		2008
	Sedimentation/Siltation	X			Draft Published
New River	Nutrients	X		X	2010
	Pesticides	X		X	2011
	Sedimentation/Siltation	X			Adopted
	Dissolved Oxygen			X	2006
	Trash			X	Draft Published
	Chloroform			X	2011
	Toluene			X	2011
	p-Cymene			X	2009
	1,2,4-trimethylbenzene			X	2009
	m,p,-Xylene			X	2008
	o-Xylenes			X	2008
	p-DCB			X	2010
	Pathogens			X	Adopted
Salton Sea	Nutrients	X		X	Draft Published
	Salt	X	X		Not Identified
	Selenium	X	X		2010

CRBRWQCB, 2006

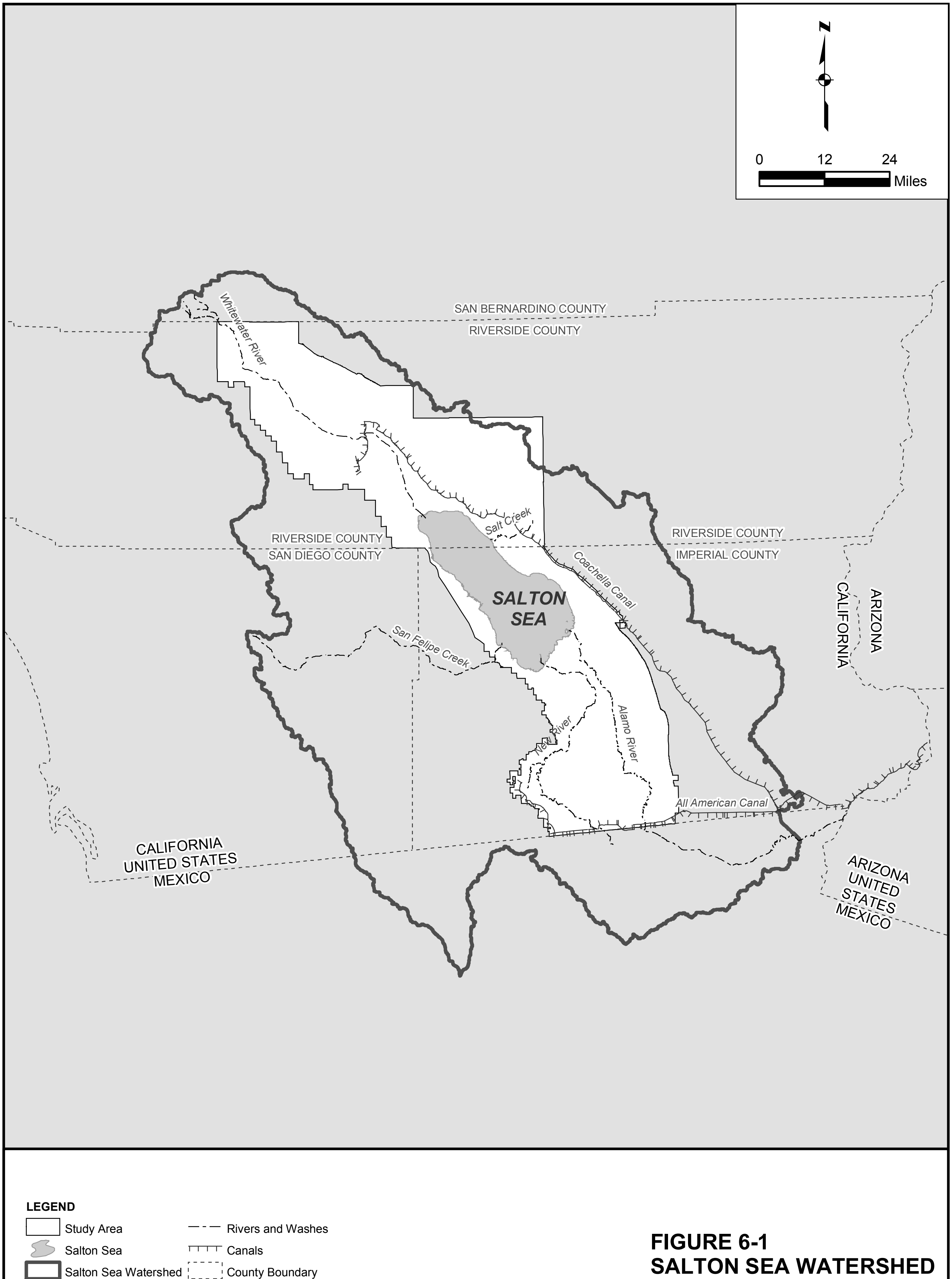

FIGURE 6-1
SALTON SEA WATERSHED

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Another federal regulation is the National Toxics Rule that established ambient water quality criteria for aquatic life and human health. California adopted related regulations under the California Toxics Rule that was promulgated by the U.S. Environmental Protection Agency for priority toxic pollutants and other provisions for water quality standards to be applied to waters in the State.

State Regulations

The Porter-Cologne Act modified the Water Code to establish the responsibilities and authorities of the SWRCB and nine Regional Water Quality Control Boards. The SWRCB formulates and adopts State policy for water quality control. The RWQCBs develop water quality objectives and Basin Plans that identify beneficial uses of water; establish water quality objectives (limits or levels of water constituents based on federal and State laws); and define implementation programs to meet water quality objectives.

The CRBRWQCB Water Quality Control Plan establishes water quality criteria and guidelines that protect human and aquatic life uses of the Lower Colorado River geographic subregion. Specifically, the Water Quality Control Plan designates beneficial uses for surface water and groundwater, establishes narrative and numerical objectives that must be attained or maintained to protect the designated beneficial uses and to conform to the State anti-degradation policy, describes implementation programs to protect the beneficial uses, and defines required monitoring activities to evaluate the effectiveness of the Water Quality Control Plan.

Additionally, the Colorado River Basin Water Quality Control Plan (CRBRWQCB, 2002a) incorporates, by reference, all applicable SWRCB and CRBRWQCB plans and policies. The beneficial uses designated for the Salton Sea area are summarized in Table 6-2.

Table 6-2
Designated Beneficial Uses for Surface Water in the Salton Sea

Beneficial Use	Description
Aquaculture (AQUA)	Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.
Industrial Service Supply (IND)	Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.
Water Contact Recreation (REC-I)	Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, and use of natural hot springs.
Non-Contact Recreation (REC-II)	Uses of water for recreational activities involving proximity to water, but not normally involving contact with water where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tidepool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.
Warm Freshwater Habitat (WARM)	Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
Wildlife Habitat (WILD)	Uses of water that support terrestrial ecosystems including, but not limited to, the preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
Rare, Threatened or Endangered Species (RARE)	Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under State or federal law as rare, threatened, or endangered.

Source: CRBRWQCB, 2005

The Policy for Implementation of Toxic Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California adopted by the SWRCB (2005) establishes procedures for discharges of priority pollutants to non-ocean surface waters of California. The policy is used in conjunction, where appropriate, with the development of TMDLs to ensure achievement of water quality standards.

The Lake or Streambed Alteration Agreement, Fish and Game Code section 1600, is required for any action that will: (1) divert, obstruct, or change the natural flow or the bed, channel, or bank of any river, stream, or lake; (2) use materials from a streambed; or (3) result in the disposal or deposition of debris, waste, or other material containing crumbled, flaked, or ground pavement where it can pass into any river, stream, or lake. The authorization requirement applies to any work undertaken in or near a river, stream, or lake that flows at least intermittently through a bed or channel. This includes ephemeral streams, desert washes, and watercourses with a subsurface flow.

HISTORICAL PERSPECTIVE

The Salton Sea was formed during 1905 to 1907, as a result of an uncontrolled diversion of the Colorado River in which the entire flow of the River rushed into the Salton Basin (Ogden, 1996, Hely et al., 1966). The water surface elevation of the Salton Sea rose to a maximum of -195 feet mean sea level (msl) by the time the diversion dike was repaired in 1907, but rapidly receded to about -250 feet msl by 1925, as evaporation exceeded the rate of agricultural drainage flows. In 1925, the elevation of the Salton Sea started to increase due to increased discharge of drainage from agricultural areas in Imperial, Coachella, and Mexicali valleys. Drainage flows from these areas have generally sustained historical water surface elevations.

The Salton Sea, like all closed-basin lakes, is saline due to the accumulation of salts due to evaporation. The Colorado River is estimated to have had an average salinity of about 500 milligrams/liter (mg/L) during 1905 to 1907 (Hely et al., 1966). However, the large amount of salts that accumulated on the Sea Bed during previous inundation events rapidly dissolved into the newly formed Salton Sea. This redissolution of salts, combined with high evaporation rates and minimal inflows, caused the salinity to quickly rise to above 40,000 mg/L total dissolved solids (TDS) by 1925. The salinity decreased in the late 1920s, as irrigated agriculture drainage flows entered the Salton Sea. During the 1930s, agricultural activity declined, and the salinity increased to more than 43,000 mg/L. As agricultural activities increased in the 1940s and 1950s, the salinity decreased to near marine, or ocean, salinity (35,000 mg/L with a range from 30,000 to 40,000 mg/L). In the past 50 years, the average Salton Sea salinity has slowly risen to over 48,000 mg/L by 2006.

In addition to the effects of increasing salinity, several other factors affect the long term water quality of the Salton Sea. The Salton Sea is a hypereutrophic water body characterized by high nutrient concentrations, high algal biomass as demonstrated by high chlorophyll concentrations, historic high fish productivity, low clarity, frequent very low dissolved oxygen (both in hypolimnetic and epilimnetic waters), fish kills, and noxious odors (Setmire et al., 2001). High levels of nutrients from agricultural drainage and municipal discharges, combined with warm temperatures, contribute to extremely high levels of productivity in the Salton Sea. The high productivity has contributed to a number of impairments to water quality, including nuisance algal blooms, anoxia, production of hydrogen sulfide and ammonia, and serious detrimental effects to fish.

DATA SOURCES

Previous investigations have characterized the water quality of the Salton Sea and have studied the mixing and nutrient dynamics that govern its high productivity (Setmire et al., 2001). Historic and current water quality characteristics of the Salton Sea have been published in a wide variety of papers, scientific articles, agency reports and publications, as well as unpublished results and communications. Existing water quality data used in this evaluation were obtained from the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) and Geological Survey (USGS) and CRBRWQCB, and a variety of technical reports prepared for public agencies. Meteorological data were obtained from the Department of Water Resources (DWR) California Irrigation Management Information System (CIMIS). A detailed summary of the data collected to support this effort is provided in Appendix D.

DATA LIMITATIONS

Despite the extensive study of the Salton Sea, limited water quality data are available for the Salton Sea. The most comprehensive survey of recent Salton Sea water quality conditions was conducted in 1999. Wind data used to assist in this assessment were obtained from CIMIS for monitoring stations near the Salton Sea. These data may not fully reflect the complex wind patterns at the Salton Sea. Other data limitations include the availability of information to determine the long term fate and sequestration of in-sea phosphorus and the effects of sediment sources on water column nutrients and oxygen demands.

EXISTING CONDITIONS

The Salton Sea is a highly saline, eutrophic water body that has been historically and is presently used as a repository for agricultural return flows from the Imperial and Coachella valleys. Agricultural drainwater from the Imperial Valley, Coachella Valley, and parts of the Mexicali Valley, as well as municipal and industrial discharges in the watershed, support the Salton Sea. As described in Chapter 5, annual inflows of about 1,300,000 acre-feet have in recent years sustained the Salton Sea water surface elevation at about -228 msl and a water surface area of about 230,000 acres (360 square miles).

Physical Characteristics

The long, or primary, axis of the Salton Sea is defined as northwest to southeast in approximate alignment with the principal axis of the Coachella Valley. The geometry of the Salton Basin and the extreme meteorological conditions (winds and temperatures) strongly influence the hydrodynamics and water quality of the Salton Sea. A bathymetric survey of the Salton Sea was conducted by Reclamation in 1995. The Salton Sea contains two subbasins separated by a shallow upraised area in the middle. The bathymetry exhibits relatively flat areas along the southern, southwestern, southeastern, and northern shorelines, with the steepest slopes along the northeastern shoreline near Salton Sea State Recreation Area. The elevation of the two deepest areas in the north and south subbasins are about -278 feet msl.

Meteorological Conditions

Meteorological conditions are extremely important to water quality conditions at the Salton Sea. The range of chemical reactions changes with temperatures. Winds move constituents in the Salton Sea and are related to stratified/stagnant or mixed water quality conditions in the Salton Sea or other water bodies.

Meteorological data for California are available from CIMIS. CIMIS currently includes over 125 active weather stations located throughout the State, as well as 61 inactive stations for which historical data are available. The stations measure a number of meteorological parameters including solar radiation, air temperature, soil temperature, relative humidity, wind speed, wind direction, and precipitation. Additional parameters are calculated based on the measured values and include net radiation, reference evapotranspiration, wind roses and wind cubed (an indicator of wind power), vapor pressure, and dew point temperature (DWR, 2005a).

Data from five CIMIS stations near the Salton Sea are available for 1999 and were used in characterizing its meteorological conditions. These stations include (from north to south) #136 (Oasis), #141 (Mecca), #154 (Salton Sea North), #127 (Salton Sea West), and #128 (Salton Sea East), as shown on Figure 6-2. The hourly wind speed, direction, and frequency at each of the CIMIS stations are illustrated through the wind rose diagrams shown in Figures 6-3 through 6-5. The frequencies of winds blowing *from* particular directions are indicated by the length of the spokes on the wind rose. The magnitude of the winds is depicted by the colors of the spokes with higher magnitudes represented by warmer colors. While the wind fields are complex at the Salton Sea, the highest winds are generally from the northwest in the north subbasin and from the west in the south subbasin. The maximum wind speeds are greater in the south subbasin.

Salton Sea Water Circulation

Water circulation patterns in the Salton Sea affect the transport and distribution of nutrients, dissolved oxygen, mixing of water layers and inflows, temperature gradients, sediments, and other water quality parameters. Energy regimes generated by circulation also have an effect on shoreline erosion and sediment deposition patterns. Modeling work by the Water Resources and Environmental Modeling Group of the Department of Civil Engineering at the University of California, Davis (Salton Sea Authority and Reclamation, 2000) found that wind velocity is the dominant factor affecting water currents in the Salton Sea. The wind pattern results in two large gyres, rotating in opposite directions. In the northern subbasin, currents rotate clockwise, and in the southern subbasin, the currents rotate counterclockwise .

Salinity

Average salinity in the Salton Sea is currently estimated at about 48,000 mg/L, but varies depending on location. Lower salinity frequently occurs near the tributaries and near the shoreline of the Salton Sea due to dilution by inflows. Higher salinity generally occurs in the center of the Salton Sea. The primary source of salts in the Salton Sea watershed is from imported Colorado River water. These salts are applied to fields with irrigation water and are carried off by tailwater or tilewater into surface drains. The annual salt load delivered to the Salton Sea is about 3,500,000 to 4,000,000 tons. Beginning in the mid-1980s to early 1990s, precipitation of significant quantities of salts (primarily gypsum and calcite) began and has been estimated to be about 1,500,000 tons/year. The primary constituents associated with salinity in the Salton Sea are sodium, calcium, chloride, and sulfate.

Freshwater is less dense than saltwater and when freshwater flows into a more saline environment, the freshwater will float for a time over the saltier water, creating a salt wedge at the point of inflow. However, in the Salton Sea, freshwater inflows from tributaries generally mix rapidly with the ambient saltwater near the confluence of the tributaries due to the prevailing wind action. This action forms an abrupt transition from freshwater to saltwater. This rapid mixing suggests that inflows attain the physiochemical characteristics of the Salton Sea water within a short distance from the confluence of the tributary, although a delta area of less saline water exists near the tributary inflows.

Selenium

Selenium enters the Salton Sea as highly soluble salt (primarily as selenate and selenite) and accumulates in the anoxic sediments on the Salton Sea floor. Waterborne selenium enters the lake from river and drain sources in the range of 5 to 10 micrograms/liter (µg/L) (0.005 to 0.01 mg/L) total selenium. In the Salton Sea, the concentration is rapidly reduced to less than 2 µg/L, mostly all as selenite or organic selenium (Schroeder et al., 2002). Waterborne concentrations are reduced as selenium rapidly assimilates into biota and settles as part of the organically rich sediments.

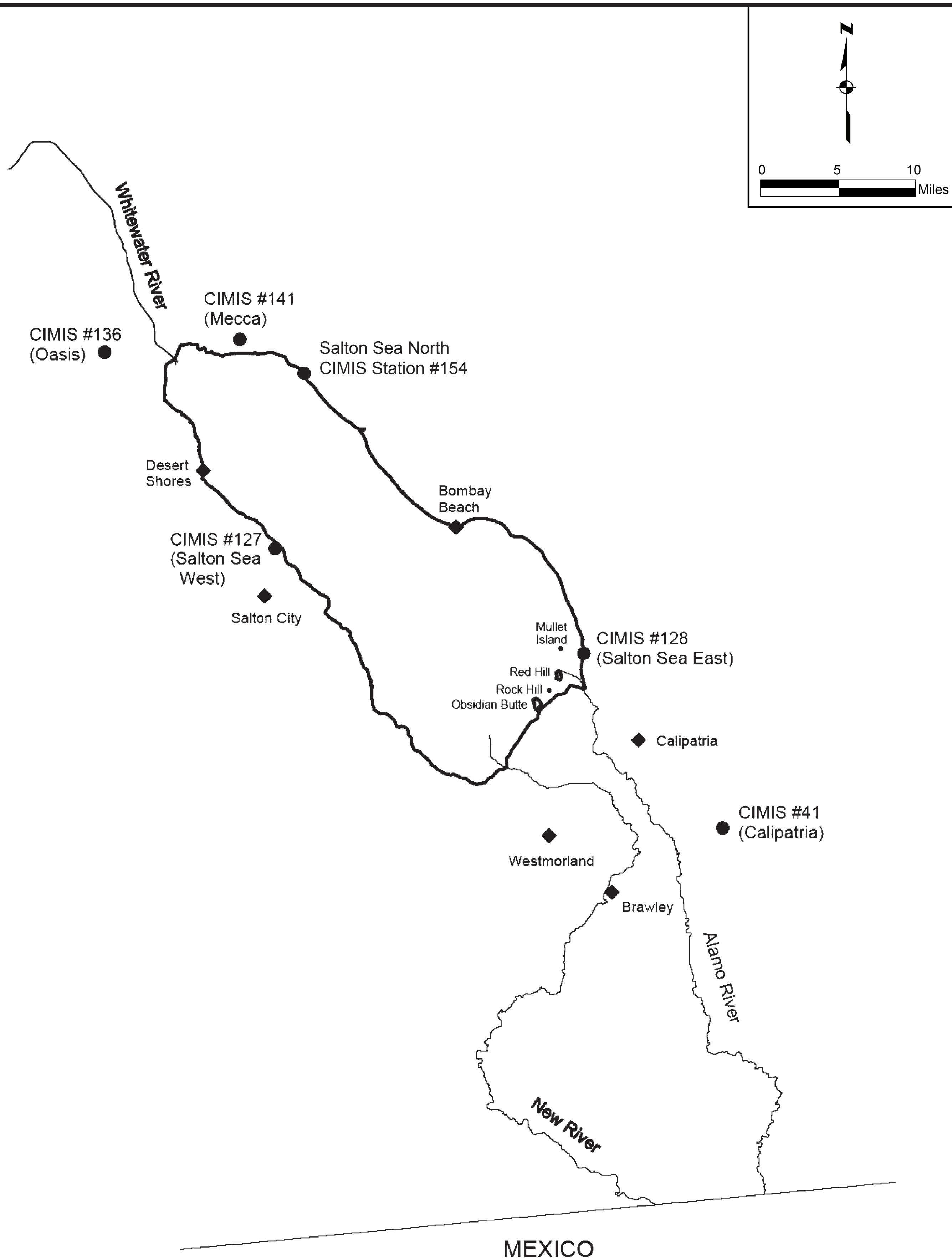
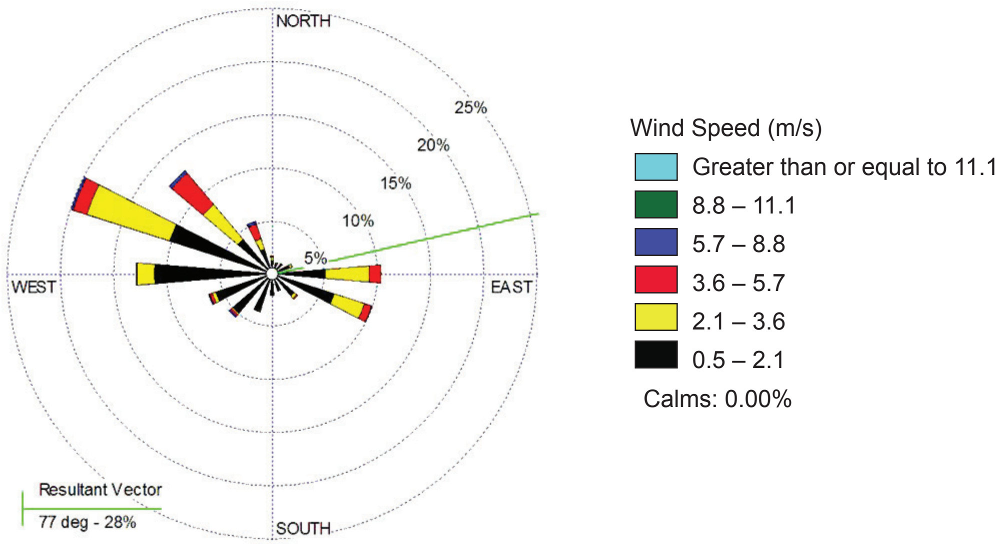


FIGURE 6-2
LOCATION OF THE SALTON SEA CIMIS STATIONS

Note: Shoreline Elevation = 228 ft below msl
Adapted from Schladow, 2004.

CIMIS #136 (Oasis)



CIMIS #141 (Mecca)

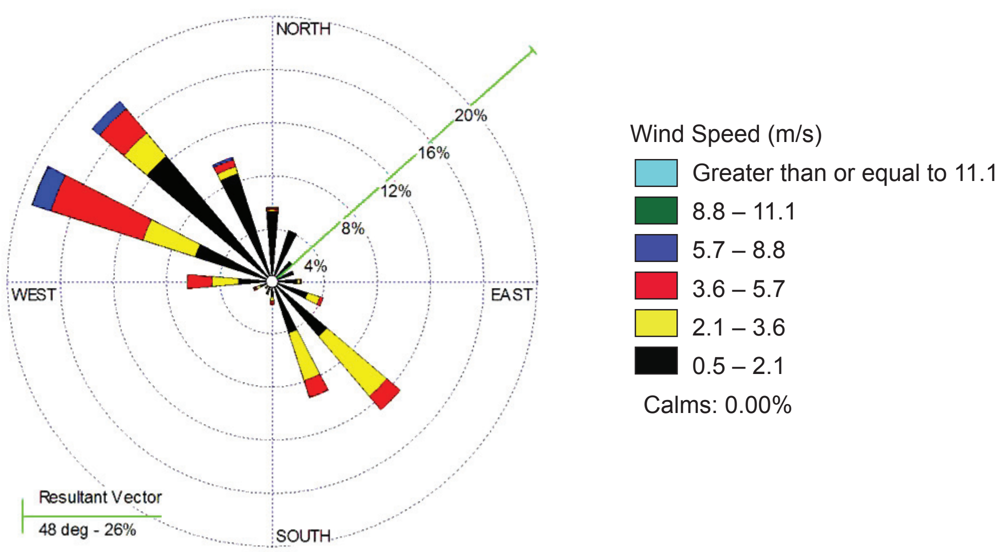
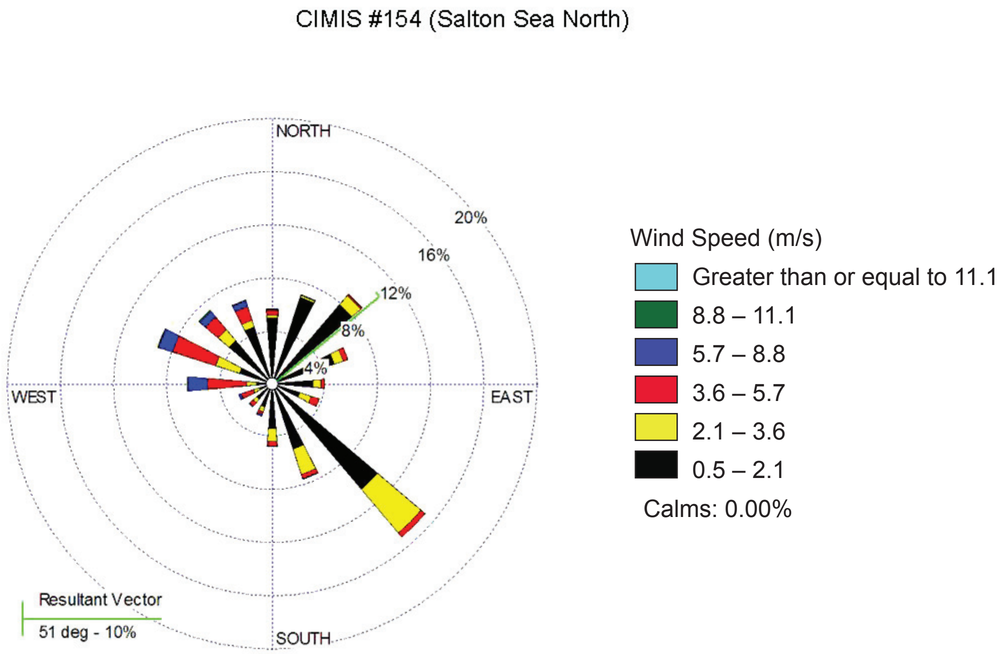


FIGURE 6-3
WIND ROSE PLOTS FOR CIMIS STATIONS #136 (OASIS) AND #141 (MECCA)



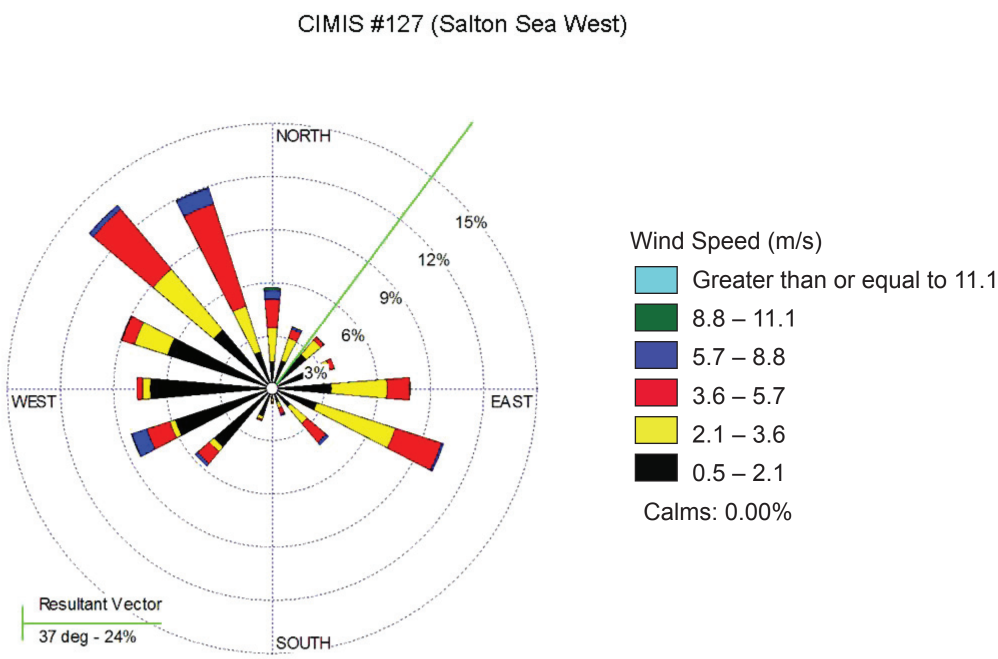


FIGURE 6-4
WIND ROSE PLOTS FOR CIMIS STATIONS #154 (SALTON SEA NORTH) AND #127 (SALTON SEA WEST)

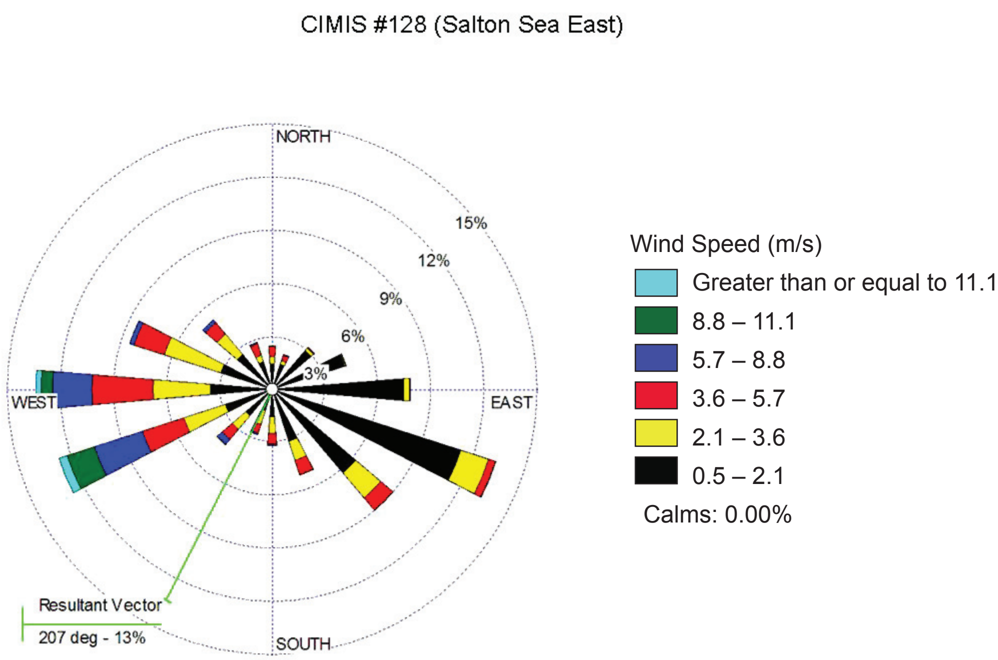


FIGURE 6-5
WIND ROSE PLOT FOR CIMIS STATION #128 (SALTON SEA EAST)

The anoxic nature of the sediments is important in trapping the selenium in insoluble, non-bioavailable fractions of selenite, elemental selenium, and selenide. If selenium was not sequestered in the sediments of the Salton Sea, the selenium concentration in the water would be as high as 400 µg/L (0.4 mg/L) (Schroeder, 2000). Selenium has accumulated in the Sea Bed surface sediments with generally higher concentrations in the northern portion of the Salton Sea as compared to the southern portion, probably as a result of circulation patterns redistributing soft, organic, and selenium rich sediments.

Temperature

A chemical and physical limnological study of the Salton Sea was performed by Holdren and Montaño (2002) for the year 1999. The measurements included temperature at various depths for three sampling sites. Monthly measurements were taken from January through March, and October through December; biweekly measurements were taken from April through September. The first site (SS-1) is near the deepest point of the northern subbasin, the second site (SS-2) is in the middle of the Salton Sea, and the third site (SS-3) is near the deepest point of the southern subbasin. Water surface temperatures ranged from 36.5 degrees Celsius (˚C) (97.7 degrees Fahrenheit [˚F]) in August to a low of 14.2 ˚C (58.1˚F) in January.

Temperature contour plots generated from the Holdren and Montaño (2002) study data are presented in Figure 6-6. The plots illustrate the typical thermal stratification pattern that is prevalent at the Salton Sea. In 1999, the Salton Sea was generally well mixed in the winter and spring, with extended stratification in the summer (June through September). The June through September time period is represented on the graphs as Days 152 to 273. It should be noted, that the Salton Sea is a polymictic lake, meaning that it may stratify and mix many times during the year.

Dissolved Oxygen

Dissolved oxygen is a particular concern at the Salton Sea because it is essential to support survival of fish and other aquatic organisms. Surface water (technically referred to as the epilimnion or epilimnetic water) is often supersaturated with respect to dissolve oxygen for several months during daylight hours, while water at the bottom of the Salton Sea near the Sea Bed (also referred to as the hypolimnion or hypolimnetic water) is virtually devoid of dissolved oxygen (Holdren and Montaño, 2002; Anderson and Amrhein, 2003). Dissolved oxygen supersaturation is often caused by photosynthetic production of oxygen during the daytime. A dissolved oxygen concentration of about 4 to 5 mg/L is generally considered necessary for most aquatic species. Species such as tilapia have been shown to be tolerant of infrequent very low dissolved oxygen concentrations, generally less than 2 mg/L (FAO, 1986).

Dissolved oxygen concentrations are a function of the geometry of the water body, wind fields, algal production, and biological and chemical oxygen demand in the water body. Frequently the geometry of a large water body is described in relation to depth and fetch. The fetch is a measure of the water surface area where the wind continues at a constant direction and speed.

Thermal stratification leads to accumulation of chemical compounds in a chemically reduced state in the hypolimnion. The anaerobic microbial community at the hypolimnion-sediment interface, as well as decomposition of organic matter in an anoxic hypolimnion, produces hydrogen sulfide and ammonia, constituents that are toxic to most aquatic life. The breakdown of stratified conditions is generally associated with mixing of hypolimnetic and surface waters. This results in the distribution of these toxic components throughout the water column and the subsequent depletion of dissolved oxygen through oxidation of these compounds. These mixing events are of particular concern, as fish and other aquatic organisms have few refugia. Events such as these have been correlated to massive fish kills (Schladow, 2004), although fish kills are observed during all seasons, including some that result from low water temperatures.

Dissolved oxygen concentrations measured in the Holdren and Montaño (2002) limnological study of the Salton Sea ranged from greater than 200 percent saturation in the surface water to zero in the bottom water. They reported that the period of severe dissolved oxygen depletion during August and September 1999 (0.21 mg/L as surface dissolved oxygen on September 8, 1999) coincided with extensive fish kills. The observed dissolved oxygen concentrations are presented in Figure 6-7.

Nutrients

The Salton Sea is a eutrophic to hypereutrophic water body characterized by high nutrient concentrations, high algal biomass as demonstrated by high chlorophyll *a* concentrations, high fish productivity, low clarity, frequent very low dissolved oxygen concentrations, massive fish kills, and noxious odors (Setmire, 2000). The eutrophic conditions appear to be controlled (i.e., limited) by phosphorus.

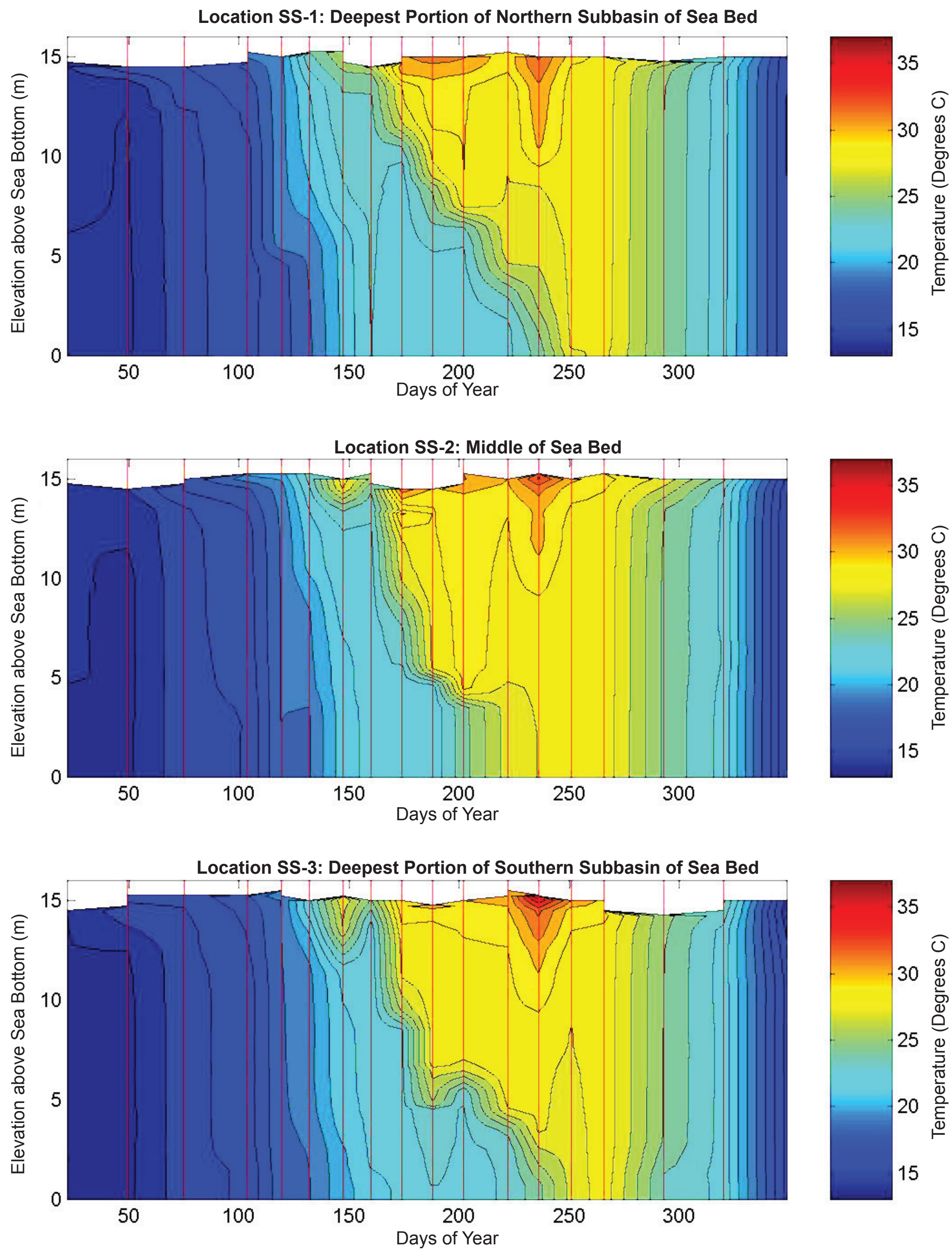
Phosphorus

Phosphorus is an essential nutrient for plant and algal growth. Setmire et al. (2001) identified phosphorus as the limiting nutrient at the Salton Sea, and others (Holdren and Montaño, 2002; Schladow, 2004) have supported this conclusion. Phosphorus is present in water bodies in many forms, including soluble and particulate organic phosphates from algae and other organisms, inorganic particulate phosphorus, polyphosphates, and soluble orthophosphates. Soluble orthophosphate is assimilated by phytoplankton and is, therefore, an important constituent to consider when assessing the productivity and quality of a water body. Total phosphorus is also measured in water quality studies, as it is an indication of the maximum level of productivity of a water body.

Holdren and Montaño's study in 1999 measured both soluble orthophosphate and total phosphorus in the Salton Sea. Soluble orthophosphate was often below detection limits. Levels of soluble orthophosphates were highest during the winter months and lowest during the spring and summer months, correlating with typical seasonal algal growth patterns. Total phosphorus concentrations were lowest in the fall and highest in the winter months, with peak concentrations as high as 200 µg/L (0.2 mg/L) (Holdren and Montaño, 2002). The concentration of phosphorus in the Salton Sea was nearly the same in 1968/69 as in 1999 despite a 100 percent increase in external phosphorus loading (Setmire, et al., 2001), which indicates there is an effective phosphorus removal mechanism in the Salton Sea. Table 6-3 presents the seasonal nutrient concentrations in the Salton Sea measured in 1999. Based on these data, an annual average total phosphorus concentration has been calculated to be about 69 µg/L (0.069 mg/L).

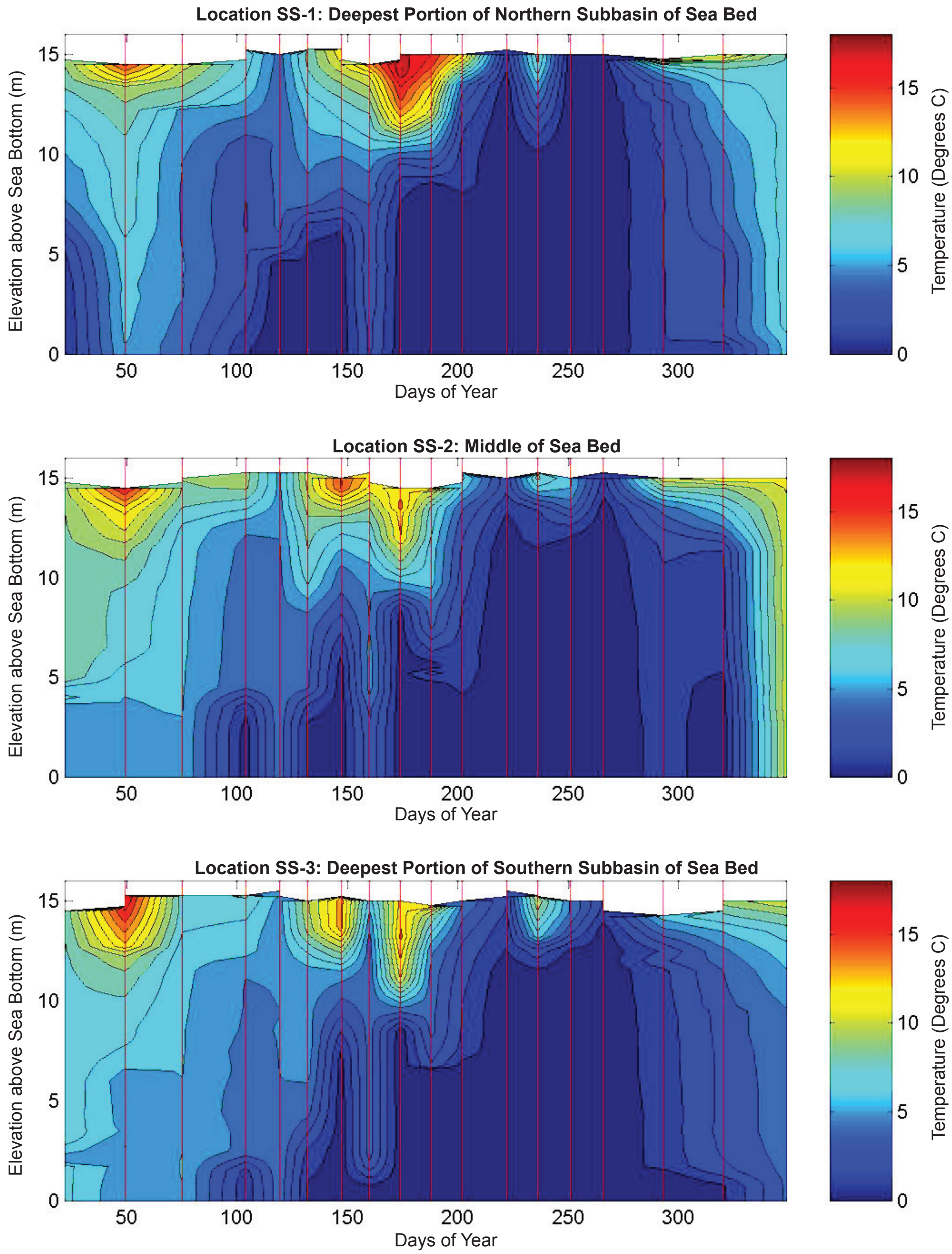
Nitrogen

Nitrogen is present in water bodies in several forms. Ammonia is the form most readily utilized by phytoplankton, and is typically found in water with low oxygen concentrations. Ammonia can be broken down by bacteria to form nitrite which, in turn, is converted to nitrate. Nitrate is commonly found in surface water. Nitrogen in the inflows to the Salton Sea is primarily in nitrate-nitrite form. The annual mean concentration of nitrates and nitrites in the Salton Sea was found to be 120 µg/L (0.12 mg/L). This is an order of magnitude lower than the concentration of nitrate-nitrite found in the tributaries to the Salton Sea. Most of the nitrogen in the Salton Sea consists of ammonia and organic nitrogen. In their chemical analysis of the Salton Sea, Holdren and Montaño (2002) found that about 32 percent of the total nitrogen was ammonia, with higher concentrations near the bottom. The Salton Sea median ammonia concentration for 1999 was about 1,180 µg/L (1.18 mg/L) and the daily maximum exceeded 2,400 µg/L (2.40 mg/L) at two locations (Holdren and Montano, 2002). High levels of ammonia indicate frequent reducing conditions in the Salton Sea, and contribute to anoxia and fish kills. Nitrogen accumulates in the sediments on the Sea Bed.



Source: Holdren and Montano, 2002.

FIGURE 6-6
CONTOURS OF OBSERVED TEMPERATURE FOR 1999



Source: Holdren and Montano, 2002.

FIGURE 6-7
CONTOURS OF OBSERVED DISSOLVED OXYGEN FOR 1999

Table 6-3
Seasonal Nutrient Concentrations in the Salton Sea and Tributaries

Constituent	Summer	Fall	Winter	Spring	Annual Mean[b]
Alamo River					
Soluble Orthophosphate[a] (mg/L)	0.23	0.456	0.492	0.454	0.408
Total Phosphorus (mg/L)	0.53	0.583	0.744	1.02	0.719
Nitrogen in the form of nitrate and nitrite (mg/L)	5	6.84	6.94	6.91	6.42
Nitrogen in the form of ammonia (mg/L)	0.89	0.629	1.57	1.97	1.26
Organic nitrogen and ammonia as measured by the Kjeldahl process (mg/L)	2.3	1.6	3.4	4	2.8
New River					
Soluble Orthophosphate[a] (mg/L)	0.548	0.928	0.773	0.537	0.697
Total Phosphorus (mg/L)	1.01	1.11	1.16	1.15	1.11
Nitrogen in the form of nitrate and nitrite (mg/L)	2.5	3.41	4.08	4.21	3.55
Nitrogen in the form of ammonia (mg/L)	3.84	3.36	3.55	2.74	3.14
Organic nitrogen and ammonia as measured by the Kjeldahl process (mg/L)	5.3	4.4	4.7	4.5	4.7
Whitewater River					
Soluble Orthophosphate[a] (mg/L)	0.632	0.709	0.823	0.675	0.71
Total Phosphorus (mg/L)	0.753	0.92	0.899	0.889	0.865
Nitrogen in the form of nitrate and nitrite (mg/L)	15.8	15.4	12.2	13.9	14.3
Nitrogen in the form of ammonia (mg/L)	0.45	0.396	1.52	0.551	0.729
Organic nitrogen and ammonia as measured by the Kjeldahl process (mg/L)	1.8	1.5	3.1	1.7	2
Salton Sea					
Soluble Orthophosphate[a] (mg/L)	0.01	0.02	0.042	0.011	0.021
Total Phosphorus (mg/L)	0.053	0.026	0.107	0.088	0.069
Nitrogen in the form of nitrate and nitrite (mg/L)	0.1	0.05	0.19	0.16	0.12
Nitrogen in the form of ammonia (mg/L)	1.45	1.27	1.17	0.76	1.16
Organic nitrogen and ammonia as measured by the Kjeldahl process (mg/L)	4.1	4.1	2.3	3.6	3.5

Source: Holdren and Montaño, 2002

[a] Soluble orthophosphate is the dissolved portion of phosphorus in a phosphate form

[b] The Annual Mean value is the title in the table as reported by Holdren and Montaño. This valued actually is the mean of the seasonal concentrations. The analysis included a higher number of data points in the summer months. Therefore, an actual annual mean of the data would provide more weight to the summer months than if the number of data points were consistent for all seasons. The last column is actually a four seasonal mean value.

Nitrogen-to-Phosphorus Ratios

The ratio of nitrogen to phosphorus (N:P) is often used to indicate which nutrient is limiting plant growth. Since healthy algal cells require about a 7:1 ratio, any body of water with a higher ratio is considered phosphorus limited, while a body of water with a lower ratio is considered nitrogen limited. The Salton Sea in 1999 exhibited very high N:P ratios (194:1 for total nitrogen to total phosphorus and 228:1 for total inorganic nitrogen to soluble orthophosphate). These results strongly suggest that phosphorus is the limiting nutrient in the Salton Sea (Setmire et al., 2001).

Chlorophyll

Chlorophyll a is measured and used to represent algal biomass in a water body. Chlorophyll a data were collected by San Diego State University (SDSU) from the Salton Sea in 1999 (Tiffany et al., 2001). Due to the limited data set, a long term trend in algal growth cannot be determined. However, chlorophyll a concentrations from the SDSU study ranged from greater than 100 µg/L (0.1 mg/L) in summer at the surface to less than 10 µg/L (0.01 mg/L) in the fall at mid-depth. The measurements were taken at 0, 3, and 6 meters (0, 9.8, and 19.4 feet) from the water surface. Concentrations were highest in February and July to August, and are likely indicative of algal blooms (Schladow, 2004).

Hydrogen Sulfide

Hydrogen sulfide is produced by decomposition of organic matter in the sediments by anaerobic sulfate-reducing bacteria especially during periods of prolonged stratification with anoxic conditions. The deep Salton Sea is characterized by prolonged periods of thermal stratification with a defined thermocline in the water column. Water above the thermocline (epilimnion) is generally sufficiently oxygenated and is similar to a shallow water body. Hydrogen sulfide generated in the sediments and diffused into the hypolimnetic water continues to accumulate in the absence of mixing. When thermal stratification is weakened or eliminated, the water column mixes and the toxic effects of hydrogen sulfide can immediately affect aquatic life in the area. Hydrogen sulfide can be toxic to aquatic life through either direct toxicity or through a rapid removal of dissolved oxygen from the water as it is oxidized.

ENVIRONMENTAL IMPACTS

Analysis Methodology

The impact assessment analyzed water quality impacts of the alternatives using the best information and tools available at the time of preparation of the PEIR. In general, the analyses should be considered screening-level due to the significant uncertainty that exists regarding surface water quality, future hydrology, and lake response to nutrient load changes. The analysis of impacts is based on estimates of future water quality, relevant significance criteria, and assumptions and approaches developed to support the PEIR. A summary of the analysis methodology for various parameters is presented below and described in more detail in Appendices D, F, and H-2.

Salinity was evaluated in the Salton Sea; Brine Sink; Saline Habitat Complex with the Shoreline Waterway, if included; Concentric Rings, Concentric Lakes, Marine Sea with and without a Marine Sea Mixing Zone; and Recreational Saltwater and Recreational Estuary lakes.

Four primary methods were used in the analysis to evaluate salinity, water quality in the deep Marine Sea water bodies, water quality in the shallower water bodies, and selenium. These methods are summarized below.

Methodology for Estimating Salinity

The Salton Sea Analysis (SALSA) hydrologic model, as described in Chapter 5 and Appendix H-2, was applied to the alternatives to determine the range of salinities in the major water bodies in each of the alternatives.

Methodology for Estimating Marine Sea Water Quality

In order to better understand the thermal regime at the Salton Sea, two distinctly different numerical models were calibrated and applied. The one-dimensional Dynamic Lake Model-Water Quality (DLM-WQ) model had been applied in previous studies of the Salton Sea and was shown to provide a reasonable simulation of the thermal structure for 1999 conditions (Schladow, 2004). To determine whether the one-dimensional assumption of the DLM-WQ model was a significant limitation for addressing future conditions at the Salton Sea, a three-dimensional hydrodynamic model, SI3D, was applied for identical conditions. The SI3D model, originally developed by the USGS (Smith and Larock, 1997) for application to the San Francisco Bay-Delta, was adapted for lakes by the University of California, Davis (UC Davis), and demonstrated to work well for large, shallow lakes, such as Clear Lake, California (Rueda and Schladow, 2003). The DLM-WQ model results for temperature were validated through a separate, independent SI3D model simulation. Then, the DLM-WQ model was applied to analyze nutrient conditions at the Salton Sea in the deeper water bodies with marine sea water quality.

The DLM-WQ model was calibrated for temperature, dissolved oxygen, phosphorus, nitrogen, and chlorophyll for 1999 conditions. The year 1999 was selected for calibration due to the relatively complete data set, including temperature and dissolved oxygen profiles, provided by Holdren and Montaño (2002).

The phosphorus concentrations in the water bodies of the alternatives are based upon inflows and internal sources. Internal sources such as sediment resuspension and release are significant contributors to water column phosphorus concentrations. Model simulations were developed for the Salton Sea under Existing Conditions and No Action Alternative, the Marine Sea in Alternatives 6 and 8, and the Recreational Saltwater Lake in Alternative 7. The Marine Sea in Alternative 5 is assumed to behave similarly to the Marine Sea in Alternative 6. Using 1999 meteorological conditions, the DLM-WQ model was simulated for two snapshot scenarios. The first scenario assumes phosphorus loads are reduced due to a reduction in inflows without a reduction in concentration or changes in internal sources of phosphorus. The second scenario assumes that phosphorus concentrations in the inflows are reduced by 50 percent and that internal sources also are reduced by 50 percent. Reduction in phosphorus in the inflows is assumed based on reductions in flows into the New River from Mexico and implementation of the Sedimentation/Siltation TMDL that would reduce phosphorus adsorbed to the soil particles. The exact reduction of influent phosphorus concentrations due to these actions is not known. Therefore, for the purposes of the PEIR analyses, these two snapshots were developed to bookend the future conditions.

Another DLM-WQ model simulation was performed for Alternative 7 with an assumed 90 percent reduction in phosphorus concentrations in both the inflows and the pore water controlling the internal loads. A detailed discussion of the model calibration and application to the alternatives is included in Appendix D.

Methodology for Estimating Saline Habitat Complex, Concentric Rings, and Concentric Lakes Water Quality

Two models were applied to better understand the water quality effects on the Saline Habitat Complex, Concentric Rings, and Concentric Lakes. The DLM-WQ model, as described above, was applied to a one-mile square cell with 6-foot and 10-foot water depths. The 6-foot water depth scenario was used to describe potential thermal conditions in the Saline Habitat Complex cells and also in the Concentric Lakes Alternative. A 10-foot water depth scenario was used to describe the Concentric Rings Alternative.

The characteristics of the Saline Habitat Complex cells were also described using the EUTROMOD model (Reckhow, 1996), which includes a large, comparative lake and pond database for North America. The empirical model consists of a series of regression relationships that use influent nutrient chemistry, hydraulic retention time, and average lake depth to predict average summer water quality conditions such as chlorophyll *a* concentrations, in-lake phosphorus and nitrogen concentrations, water clarity, and lake Trophic State Index (TSI), as described in Appendix D. The TSI is a single number that incorporates various water quality values on a scale from 1 to 100, where higher values indicate more enriched, eutrophic conditions.

The EUTROMOD model was applied for these shallow cells to confirm the general findings of the DLM-WQ analysis. EUTROMOD Results indicated that the Saline Habitat Complex cells would likely be hypereutrophic in character. Water clarity would be expected to be less than a foot, with high chlorophyll values (greater than 22 µg/L (0.022 mg/L) and TSI values in the hypereutrophic range (greater than 70) if the inflows to the cells are any combination of water from the rivers and drains. EUTROMOD results also suggest the cells have some potential for high oxygen demand and dissolved oxygen depletion during overnight and windless periods. Such cells typically experience a high degree of daily oxygen and pH fluctuations (with lowest pH and dissolved oxygen levels at night due to the biological activity).

Methodology for Estimating Selenium Impacts

Selenium loss from the water column and associated transfer to the sediments (as historically and recently observed in the current Salton Sea) were assumed to continue as primary processes that would determine water column concentrations. As a result, waterborne concentrations were assumed to average less than 2 µg/L (0.002 mg/L) as total selenium. The Ecological Risk Assessment (Appendix F) based much of the evaluation of selenium risk on variations in estimated sediment and biota concentrations rather than variations in waterborne concentrations in the habitats. River and drain inflows to these habitats were assumed to be blended concentrations.

Significance Criteria

The following significance criteria were based on CEQA and used to determine if changes as compared to Existing Conditions and the No Action Alternative would:

- Violate any water quality standards or waste discharge requirements; and
- Substantially degrade water quality.

Application of Significance Criteria

Significance criteria have been applied to the alternatives considered in the PEIR. The following discussion summarizes the overall methodology in the application of the criteria to the alternatives:

- **Violate any water quality standards or waste discharge requirements -** The CRBRWQCB Water Quality Control Plan, including the TMDLs, establish the following water quality standards or requirements for the Salton Sea.
  - **Salinity:** The CRBRWQCB Water Quality Control Plan identifies a salinity objective of 35,000 mg/L for the Salton Sea to support fish and wildlife, and states that it will be difficult to meet this objective in the Salton Sea. The Imperial County General Plan includes a

provision to maintain the salinity in the Salton Sea at 40,000 mg/L or less to support habitat and recreation uses, as described in Chapter 11.

- Selenium: The CRBRWQCB Water Quality Control Plan identifies a selenium objective of 5 µg/L (0.005 mg/L) based on a four-day average and 2 µg/L (0.002 mg/L) on a one-hour average as measured in the Salton Sea. As previously described, the existing waterborne concentrations in the Salton Sea are less than 2 µg/L (0.002 mg/L). Because there are no specific actions that would decrease selenium concentrations in the inflows during the study period, it is anticipated that the inflow selenium loads would not change unless tile drainage flows, and related selenium loads, decline due to water conservation. Determination of the risk of selenium toxicity in the alternatives was evaluated considering selenium concentrations and exposure pathways related to sediment, surface water inflows, biota, and soil in each of the major components, as described in Appendix F. This analysis recognizes that selenium concentrations in water could be greater than 5 µg/L (0.005 mg/L) in some components especially in areas with soils characterized by high selenium concentrations. The impact assessment associated with meeting a selenium objective is presented in Chapters 8 and 14 and not in this chapter.
- Phosphorus: The CRBRWQCB Draft Nutrient TMDL for the Salton Sea identifies an average annual phosphorus target of 35 µg/L (0.035 mg/L) as measured in the Salton Sea. As previously described, the existing waterborne phosphorus concentration in the Salton Sea is about 69 µg/L (0.069 mg/L). The following analysis compares phosphorus in all of the alternatives to the Draft TMDL target for the Marine Sea, however, this target may not be applicable to the shallow water bodies.

- **Substantially degrade water quality** - Degradation of Salton Sea water quality is related to the reduction in the ability to support aquatic species and recreation. For the Salton Sea, this category is used to describe general water quality conditions related to lake eutrophication. The water quality analysis includes determinations of dissolved oxygen and hydrogen sulfide concentrations. Since these indicator parameters are dependent on the level of nutrient source control and lake response, they are presented for the same two influent scenarios as those described above for phosphorus concentrations. The thermal structure of the Salton Sea plays a dominant role in the vertical mixing and associated exchange of hypolimnetic water (often anoxic) with epilimnetic water (usually oxic). Frequent and deep vertical mixing, characterized by a relatively homogeneous temperature profile, allows dissolved oxygen to penetrate the water column and prevents prolonged periods of anoxia at the sediment-water interface. Conversely, a stratified Salton Sea could allow for prolonged periods of hypolimnetic anoxia, and high hydrogen sulfide and ammonia concentrations which, upon mixing, could deplete the water column of dissolved oxygen. Hydrogen sulfide concentrations in each alternative are presented in the following analysis.

Summary of Assumptions

The assumptions related to the descriptions of the alternatives are described in Chapter 3. The specific assumptions related to the analysis of water quality are summarized in Table 6-4.

Table 6-4
Summary of Assumptions for Water Quality Analysis

Assumptions Common to All Alternatives	
1. Discharges into the New River from facilities in Mexico would be reduced as described under the No Action Alternative. The reduction in flows would also reduce the amount of constituents, including phosphorus, that would enter the New River. 2. Point-source discharges into the New, Alamo, and Whitewater rivers would comply with specific National Pollutant Discharge Elimination System permits. 3. Objectives of the TMDLs would be achieved by the end of Phase IV. 4. Water quality in the Sedimentation/Distribution Basins would be the same as in the New, Alamo, and Whitewater rivers. Therefore, these facilities are not considered in the water quality impact assessment. 5. Waterborne selenium concentrations would be similar to Existing Conditions in all alternatives and is not considered in the water quality impact assessment. 6. Water quality in conveyance channels would be consistent with the related water bodies and are not considered separately in the water quality impact assessment. 7. The modeling scenarios should be considered preliminary analyses. Fundamental nutrient cycling processes and rates are not sufficiently understood at this time and, therefore, the results should be used in a comparative manner rather than as absolute predictions. In addition, due to limited understanding of the processes, time frames for achieving water quality goals cannot be determined.	
Assumptions Specific to the Alternatives	
No Action Alternative and Alternatives 1 and 6	Water quality, including salinity, in the Pupfish Channels would be the same as Existing Conditions in the drains.
Alternatives 2, 3, 4, 5, 7, and 8	No additional assumptions were made.

Summary of Impact Assessment

The impacts shown in Table 6-5 assume implementation of the Next Steps to reduce the adverse impacts.

No Action Alternative

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basins, Air Quality Management, Pupfish Channels, and Salton Sea. The construction activities would be identical under the No Action Alternative-CEQA Conditions and the No Action Alternative-Variability Conditions. However, the Salton Sea would be substantially different in each condition. Therefore, both conditions are described below.

The salinity of the Salton Sea in the No Action Alternative-CEQA Conditions would be less than salinity in the No Action Alternative-Variability Conditions because the inflows would be greater under the No Action Alternative-CEQA Conditions. Salinity under No Action Alternative-CEQA Conditions and the No Action Alternative-Variability Conditions would be greater than under the Existing Conditions.

In the No Action Alternative-CEQA Conditions and the No Action Alternative-Variability Conditions, the Salton Sea would be sufficiently large in area and deep to maintain many of the physical and water quality characteristics of the Existing Conditions in Phase I. The Salton Sea becomes a shallower water body after 2020. Therefore, the Salton Sea conditions were evaluated for the end of Phase I (at 2020), end of Phase III (at 2040), and at the end of Phase IV (2078).

Table 6-5
Summary of Benefit and Impact Assessments to Surface Water Quality

Alternative	Basis of Comparison	Changes by Phase				Comments	Next Steps
		I	II	III	IV		
Criterion: Violate water quality standard.							
No Action Alternative	Existing Conditions	O	O	O	O	Salinity would continue to exceed CRBRWQCB and Imperial County limits. Total phosphorus in the Salton Sea would continue to exceed the proposed TMDL.	Additional studies of influent nutrient concentrations and relationships between nutrients in the inflows, sediment, and water column needed.
	No Action Alternative	NA	NA	NA	NA		
Alternatives 1 - 2	Existing Conditions	L	L	L	L	Water quality conditions in the Brine Sink would be similar to the Salton Sea under the No Action Alternative. Salinity in a portion of the Saline Habitat Complex would be less than 40,000 mg/L. Phosphorus in the Saline Habit Complex would be higher than under Existing Conditions and No Action Alternative.	Same as No Action Alternative
	No Action Alternative	L	L	L	L		
Alternative 3	Existing Conditions	L	L	L	L	Water quality conditions in the Brine Sink would be similar to the Salton Sea under the No Action Alternative. Salinity in the Rings would be less than 40,000 mg/L. Phosphorus conditions in the Rings anticipated to be similar those described under Alternative 1.	Same as No Action Alternative
	No Action Alternative	L	L	L	L		
Alternative 4	Existing Conditions	L	L	L	L	Water quality conditions in the Brine Sink would be similar to the Salton Sea under the No Action Alternative. Salinity in the First and Second lakes would be less than 40,000 mg/L. Phosphorus conditions in the Lakes anticipated to be similar those described under Alternative 1.	Same as No Action Alternative
	No Action Alternative	L	L	L	L		
Alternatives 5, 6, and 8	Existing Conditions	L	L	L	L	Water quality conditions in the Brine Sink would be similar to the Salton Sea under the No Action Alternative. Water quality conditions in the Saline Habitat Complex would be similar as described under Alternative 1. Salinity in the Marine Sea would be less than 40,000 mg/L. Total phosphorus in the Marine Sea probably would exceed 35 µg/L unless phosphorus sources were reduced by at least 50 percent.	Same as No Action Alternative
	No Action Alternative	L	L	L	L		

Table 6-5
Summary of Benefit and Impact Assessments to Surface Water Quality

Alternative	Basis of Comparison	Changes by Phase				Comments	Next Steps
		I	II	III	IV		
Alternative 7	Existing Conditions	L	L	L	L	Water quality conditions in the Brine Sink would be similar to the Salton Sea under the No Action Alternative. Water quality conditions in the Saline Habitat Complex would be similar as described under Alternative 1. Salinity in the Marine Sea would be greater than 40,000 mg/L at an average inflow of 717,000 acre-feet/year. Total phosphorus in the Marine Sea probably would exceed 35 µg/L unless phosphorus sources were reduced by at least 50 percent.	Same as No Action Alternative.
	No Action Alternative	L	L	L	L		
Criterion: Substantially degrade water quality.							
No Action Alternative	Existing Conditions	S	S	S	S	Periods of thermal stratification would be shorter than under the Existing Conditions. Dissolved oxygen concentrations at the water surface at 6 a.m. would be less than 2 mg/L for an equal or less number of days than under Existing Conditions during Phase I. However, as the Salton Sea becomes more shallow under Phases II through IV, the number of days with dissolved oxygen concentrations in the early morning that would be less than 2 mg/L would become greater than under the Existing Conditions.	Additional studies of influent nutrient concentrations and relationships between nutrients in the inflows, sediment, and water column could identify methods to improve water quality.
	No Action Alternative	NA	NA	NA	NA		
Alternatives 1 - 4 and 6	Existing Conditions	L	L	L	L	Thermal stratification in the Brine Sink and Saline Habitat Complex would occur less frequently than under Existing Conditions and similar to No Action Alternative conditions under Phase II through IV. Dissolved oxygen concentrations in the Saline Habitat Complex at the water surface at 6 a.m. would be less than 2 mg/L for more days than under Existing Conditions and the No Action Alternative under Phase I, and for less days than under No Action Alternative under Phases II through IV.	Same as No Action Alternative.
	No Action Alternative	L	B	B	B		

Table 6-5
Summary of Benefit and Impact Assessments to Surface Water Quality

Alternative	Basis of Comparison	Changes by Phase I	II	III	IV	Comments	Next Steps
Alternatives 5 and 8	Existing Conditions	L	L	L	L	Thermal stratification and dissolved oxygen concentrations in the Brine Sink and Saline Habitat Complex are similar to conditions under Alternative 1. Thermal stratification of the Marine Sea would occur more frequently than in the Salton Sea under Existing Conditions and No Action Alternative. This could cause higher potential for anoxic conditions throughout the water column. Dissolved oxygen concentrations in the Marine Sea at the water surface at 6 a.m. would be less than 2 mg/L for fewer days than under Existing Conditions and No Action Alternative.	Same as No Action Alternative.
	No Action Alternative	L	L	L	L		
Alternative 7	Existing Conditions	L	L	L	L	Thermal stratification and dissolved oxygen concentrations in the Brine Sink and Saline Habitat Complex are similar to conditions under Alternative 1. Thermal stratification of the Marine Sea would occur more frequently than in the Salton Sea under Existing Conditions and No Action Alternative. This could cause higher potential for anoxic conditions throughout the water column. However, with additional water treatment, these conditions could be reduced. The degree of reduction and the timing of this occurrence is not known at the time of preparation of the PEIR. Dissolved oxygen concentrations in the Marine Sea at the water surface at 6 a.m. would be less than 2 mg/L for fewer days than under Existing Conditions and No Action Alternative.	Same as No Action Alternative.
	No Action Alternative	L	L	L	L		

Legend for Types of Benefits or Impacts in Each Phase:
S = Significant Impact
O = No Impact
L = Less Than Significant
B = Beneficial Impact
NA = Not Analyzed

At the end of Phase I, the water column would be expected to stratify in the spring and early summer. Based on the water quality modeling results presented in Appendix D, water column stratification would occur in the summer months. This would allow an anoxic zone to form in the hypolimnion. The anoxic conditions and prolonged stratification would cause the production and accumulation of hydrogen sulfide and ammonia in these deeper waters. The deep waters also would be characterized by extremely low dissolved oxygen. When cooler temperatures and winds break the thermal stratification, the water column would become fully mixed. This condition would occur in late summer/early fall and would result in a serious degradation of water quality that would be toxic to aquatic life in the vicinity of this mixing event.

In Phases II through IV, less wind energy would be required to mix the water and dissolved oxygen would extend to a larger portion of the water column in the shallower water body than under Existing Conditions. Therefore, the Salton Sea would be subject to greater and more frequent mixing events, less thermal stratification, and less accumulation of hydrogen sulfide and ammonia, as described in Appendix D.

The number of consecutive days with thermal stratification would be greater under the No Action Alternative-CEQA Conditions in Phases II through IV than under the No Action Alternative-Variability Conditions because the Salton Sea would be deeper, as described in Appendix D.

There is considerably more orthophosphate throughout the water column in the No Action Alternative at 2040 and 2078 simulations than in the No Action Alternative at 2020 simulation. This result is influenced by the model assumption that for the shallower Sea there is increased resuspension of orthophosphate from the bottom sediments and release of orthophosphate in the pore water.

The large algal community would likely reduce dissolved oxygen levels. The most critical time would be in the early morning hours due to nighttime algal respiration. Model results indicate that early morning dissolved oxygen would be less than 2 mg/L (a value where many fish and wildlife would be stressed). However, the dissolved oxygen concentrations are anticipated to not cause long term anoxic effects in the shallow Salton Sea.

Alternative 1 – Saline Habitat Complex I

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basins, Air Quality Management, Pupfish Channels, Saline Habitat Complex, and Brine Sink.

Under Alternative 1, the Saline Habitat Complex would be designed to provide salinities ranging from 20,000 to 200,000 mg/L. The salinity in the Brine Sink would continue to increase over the study period and would be greater than salinity under the Existing Conditions and No Action Alternative.

Thermal stratification, phosphorus, and dissolved oxygen condition in the Brine Sink would be similar to those described for the Salton Sea under No Action Alternative.

Aeration and reaeration of the Saline Habitat Complex cells were evaluated using the local wind field and temperature data. The temperature modeling results indicated that the Saline Habitat Complex cells with a 1-mile fetch would be fully mixed. Water temperatures would be the same over all depths at most times of the year (modeling suggests only 9 days of stratification). Windless periods could produce partial dissolved oxygen depletion in the deeper areas of the cells. The most critical period for this condition would be during the summer because dissolved oxygen saturation decreases with increased temperature, and biological activity of algae and other aquatic species increases in the warm water. However, the summer months are characterized by relatively windy periods.

The DLM-WQ model results indicate that the small, shallow cells with high phosphorus would be extremely productive. These results are based upon the assumption in the model that phosphorus continues to be provided by the New and Alamo rivers inflows, and that the phosphorus concentrations are the same in the rivers and the Saline Habitat Complex cells.

The EUTROMOD results also suggest the cells have some potential for high oxygen demand and dissolved oxygen depletion during overnight and windless periods. Such cells typically experience a high degree of daily oxygen and pH fluctuations (with lowest pH and dissolved oxygen levels at night due to the biological activity) with the potential for fish kills because of the low dissolved oxygen.

Due to the uncertainty, information from on-going pilot studies by USGS and potentially from Early Start Habitat should be considered prior to design and construction of all the Saline Habitat Complex area in this alternative.

Construction of the Saline Habitat Complex cells would temporarily increase suspended sediment and nutrient cycling in waters near active construction. Resuspended bottom sediments would release previously deposited nutrients, particularly phosphorus, and temporarily stimulate local algae production and reduce water quality conditions. This would be a short term effect during construction. However, construction during Phase I would affect tilapia and pupfish.

Alternative 2 – Saline Habitat Complex II

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basins, Air Quality Management, Saline Habitat Complex, Shoreline Waterway, Saltwater Conveyance, and Brine Sink.

Under Alternative 2, the Saline Habitat Complex would be designed to provide salinities ranging from 20,000 to 200,000 mg/L. The salinity in the Brine Sink would continue to increase over the study period, and would be greater than salinity under the Existing Conditions and No Action Alternative.

Thermal stratification, phosphorus, and dissolved oxygen condition in the Brine Sink would be similar to those described for the Salton Sea under No Action Alternative.

Water quality conditions in the Saline Habitat Complex cells would be similar to those described under Alternative 1.

Water quality conditions during construction would be similar to those described under Alternative 1.

Alternative 3 – Concentric Rings

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basins, Air Quality Management, First and Second rings, and Brine Sink.

The First Ring would be designed to provide salinity between 20,000 and 30,000 mg/L, and the Second Ring would provide salinity from 30,000 to 40,000 mg/L. The salinity in the Brine Sink would be greater than salinity under the Existing Conditions or No Action Alternative.

Water quality characteristics of the Brine Sink would be similar to those described for the Salton Sea under the No Action Alternative.

The First and Second rings in Alternative 3 were modeled with DLM-WQ in a similar manner as the Saline Habitat Complex cells with deeper water. It is recognized that the Concentric Rings would have long areas that would increase fetch, as compared to small cells; and, therefore, the assumptions are not completely appropriate for the Concentric Rings. Because the model should only be used in a comparative manner, it was determined that the model results for the smaller shallow cells could be used to be as indicative of conditions in the Concentric Rings. However, the model values should not be used for design criteria.

The model results indicate that the Concentric Rings primarily would be well mixed, with numerous episodes of significant stratification. Algal productivity and daily variations in dissolved oxygen probably would be similar to conditions in the Saline Habitat Complex. The algal biomass would cause excessive dissolved oxygen concentrations during the daylight hours and extremely low dissolved oxygen concentrations in the early morning hours.

Water quality conditions during construction would be similar to those described under Alternative 1.

Alternative 4 – Concentric Lakes

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basins; First, Second, Third, and Fourth lakes; and Brine Sink.

Salinity would be 20,000 to 30,000 mg/L in the First Lake, 35,000 mg/L in the Second Lake, 45,000 mg/L in the Third Lake, and 60,000 mg/L in the Fourth Lake.

Water quality characteristics of the Brine Sink would be similar to those described for the Salton Sea under the No Action Alternative.

The water quality conditions of the Concentric Lakes would be similar to that described for the Saline Habitat Complex cells under Alternative 1.

Water quality conditions during construction would be similar to those described under Alternative 1.

Alternative 5 – North Sea

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basins, Air Quality Management, Saline Habitat Complex, Shoreline Waterway, Saltwater Conveyance, Marine Sea, Marine Sea Recirculation Canal, and Brine Sink.

Salinity of the Marine Sea would be between 30,000 to 40,000 mg/L. Salinity of the Saline Habitat Complex would be as described under Alternative 1.

Water quality characteristics of the Brine Sink and Saline Habitat Complex would be similar to conditions described under Alternative 1.

Thermal stratification in the Marine Sea is anticipated to be more pronounced and to extend for a longer period of time as compared to the Salton Sea under Existing Conditions and Phase I of the No Action Alternative. Prolonged periods of stratification would create anoxic conditions in the hypolimnion and contribute to production and accumulation of hydrogen sulfide and ammonia. When the thermocline breaks down in fall, low dissolved oxygen may be expected throughout much of the water column as hypolimnetic water mixes with surface water. Stratification also allows significant algal growth in the surface layers above the stratification.

The DLM-WQ model is limited with respect to the simulation of the actual mechanisms for permanent burial, or sequestration, of phosphorus in deep sediments and resuspension into the water column. The model results indicated that the Marine Sea would be characterized by mechanisms for sequestration of phosphorus in deep areas and within the sediments, as is currently believed to be occurring in the Salton Sea under Existing Conditions.

Depending on the effectiveness of phosphorus reduction in the inflows as TMDLs are implemented and sequestration of phosphorus in the sediments, the water quality objective for phosphorus probably could be achieved in the Marine Sea in Phases II through IV. This would require at least 50 percent reduction in phosphorus external loadings and 50 percent reduction in phosphorus sources from within the Salton Sea.

Water quality conditions during construction would be similar to those described under Alternative 1.

Alternative 6 – North Sea Combined

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basin, Air Quality Management, Pupfish Channels, Saline Habitat Complex, Shoreline Waterway, Saltwater Conveyance, Marine Sea, Marine Sea Mixing Zone, Marine Sea Recirculation Canal, and Brine Sink.

Salinity of the Marine Sea would be between 30,000 to 40,000 mg/L. Salinity of the Saline Habitat Complex would be as described under Alternative 1.

Water quality characteristics of the Brine Sink and Saline Habitat Complex would be similar to conditions described under Alternative 1. Water quality of the Marine Sea would be similar to conditions described for the Marine Sea under Alternative 5.

The Marine Sea Mixing Zone would be located along the southern and a portion of the western shoreline in the same location as the First Ring described under Alternative 3. This component would be formed by a Perimeter Dike and would have similar salinity and water depths as the First Ring. Therefore, water quality in the Marine Sea Mixing Zone is expected to be similar in water quality to that described for the First Ring under Alternative 3.

Water quality conditions during construction would be similar to those described under Alternative 1.

Alternative 7 – Combined North and South Lakes

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basin, Air Quality Management using Protective Salt Flat on Exposed Playa below -255 feet msl, Exposed Playa without Air Quality Management above -255 feet msl, Saline Habitat Complex, Recreational Saltwater Lake, Recreational Estuary Lake, Marine Sea Recirculation Canal, IID Freshwater Reservoir, two Treatment Plants, and Brine Sink.

Salinity of the Marine Sea would be between 30,000 to 40,000 mg/L. Salinity of the Saline Habitat Complex would be between 30,000 and 200,000 mg/L.

Water quality characteristics of the Brine Sink and Saline Habitat Complex would be similar to conditions described under Alternative 1.

Placement of the Barrier affects potential for thermal stratification. Under Alternative 7, the Barrier is close to the mid-point of the Sea Bed. This provides for a large surface water area and associated fetch, and provides more areas with shallow depths than if the Barrier is located to the north of the mid-point. Thermal stratification in the Recreational Saltwater Lake is anticipated to be more pronounced and to extend for a longer period of time as compared to Existing Conditions and Phase I of the No Action Alternative. During the periods of stratification, anoxic conditions in the hypolimnion would develop and contribute to production of hydrogen sulfide and ammonia. When the thermocline breaks down in the fall months, low dissolved oxygen may be expected throughout much of the water column as hypolimnetic water mixes with surface water, as described under Alternative 5.

It is anticipated that the phosphorus cycling and sequestration processes would continue in the Recreational Saltwater Lake as in the Marine Sea description under Alternative 5. Alternative 7 also includes water treatment facilities to reduce phosphorus loadings from the inflows and in the recycled water between the Recreational Saltwater Lake and the Recreational Estuary Lake. It is anticipated that the water treatment plants would remove more than 90 percent of the phosphorus loadings in the inflows and other constituents in the Recreational Saltwater Lake discharges. This would improve water quality in the Recreational Saltwater Lake more rapidly than just implementation of the TMDLs. However, due to the limited understanding of nutrient cycling in the Recreational Saltwater Lake and uncertainty of the mechanical functioning of the outlet structure to withdraw water from the Recreational Saltwater Lake, the actual reduction in time to achieve the phosphorus TMDL is not known at the time of preparation of the PEIR.

Conditions in the Recreational Estuary Lake would be similar to those described for the Marine Sea Mixing Zone under Alternative 6.

Water quality conditions during construction would be similar to those described under Alternative 1.

Alternative 8 – South Sea Combined

As described in Chapter 3, this alternative would involve construction and operations and maintenance activities for the Sedimentation/Distribution Basins, Air Quality Management, Saline Habitat Complex, Shoreline Waterway, Marine Sea, Marine Sea Recirculation Canal, and Brine Sink.

Salinity of the Marine Sea would be between 30,000 to 40,000 mg/L. Salinity of the Saline Habitat Complex would be as described under Alternative 1.

Water quality characteristics of the Brine Sink and Saline Habitat Complex would be similar to conditions described under Alternative 1. Water quality of the Marine Sea would be similar to conditions described for the Marine Sea under Alternative 5.

Thermal stratification in the Marine Sea is anticipated to be more pronounced and to extend for a longer period of time as compared to Existing Conditions and the early phases of the No Action Alternative. The southern Sea Bed has larger shallower areas than the northern Sea Bed. In addition, average wind speeds are about 20 percent higher in the southern Sea Bed than the northern Sea Bed. The shallower water depths and higher wind speeds would allow greater mixing of the Marine Sea as compared to North Seas in other alternatives. However, thermal stratification would occur. Thermal stratification in the southern Marine Sea is anticipated to be more pronounced and to extend for a longer period of time as compared to Existing Conditions and the early phases of the No Action Alternative. Conditions would be similar to those described under Alternative 5 when the thermal stratification is disrupted.

The DLM-WQ model predicted higher dissolved oxygen concentrations in the surface water under Alternative 8 as compared to the Salton Sea in Existing Conditions and No Action Alternative during Phase I.

Water quality conditions during construction would be similar to those described under Alternative 1.

Next Steps

During the project-level analysis, detailed water quality and sediment assessments would need to be conducted to determine specific locations for facilities and better understand the fundamental processes of nutrient dynamics and external/internal source contributions in the current Salton Sea. The importance of internal processes and spatial representation of these parameters must be considered. The timing and extent of the Salton Sea response to load reductions also must be determined.

Despite significant uncertainty, the models used in the PEIR analysis can serve as a useful tool for comparative analysis, incorporating the best understanding of the physical system. The model also can guide and focus future data collection efforts, including the following items:

- Long term water quality monitoring of the Salton Sea and tributary sources at a frequency useful for capturing system dynamics, including weekly monitoring of Salton Sea nutrients and chlorophyll *a* and real-time temperatures;
- Focused data collection to better understand the role of sediment resuspension, sediment release, nutrient sequestration, and sediment oxygen demand;
- Pilot studies of shallow water cells on recently exposed Sea Bed to determine the rate of nutrient fluxes to the water column and other biological parameters that may be different on the Sea Bed materials as compared to pilot studies being conducted on lands adjacent to the Sea Bed; and
- Development of a multi-dimensional hydrodynamic and water quality model, with coupled sediment pool, for the Salton Sea that could be used, in tandem with data collection efforts, to provide more detailed analysis of specific facility locations.

Long term monitoring programs also should be considered to determine the effectiveness of water quality improvements in the watershed and the ability of the Sedimentation/Distribution Basins to remove nutrients.

During project-level analyses, the additional information collected for the modeling efforts described above can be used to identify specific design criteria of the habitat facilities, including the following items:

- Habitat design criteria to maximize full mixing in the water column, such as orientation of islands parallel to the prevailing winds or orientation of the open water to take advantage of wind fields;
- Consider construction methods that would limit the potential to re-suspend bottom sediments that are rich in nutrients;
- Identify construction periods to avoid periods of high algal growth and periods critical to the well-being of invertebrates, fish, and wildlife;
- Determine the technical feasibility and need for methods to reduce internal nutrient loads; and
- Determine the appropriate depth of deep pools to balance temperatures and water quality.