3.2 HYDROLOGY

This section describes existing conditions related to hydrologic features and patterns of Buena Vista Lagoon and associated inland surface waters. This section also identifies pertinent policies and regulations governing hydrology in the designated project areas and evaluates the impacts associated with implementation of the Enhancement Project and its alternatives. The dynamics of the adjacent coastline are discussed in Section 3.3 Coastal Processes, which further describes the effects of storms and waves on the Enhancement Project. Section 3.3 also addresses coastal inlet protection, ocean wave energy effects, and ebb bar formations affecting the lagoon. Off-site materials placement/disposal is proposed for area beaches/nearshore and offshore sites, which are also primarily affected by coastal processes rather than the internal hydrology of the lagoon. Materials placement/disposal sites (beach, nearshore, and offshore) are located outside the lagoon; lagoon hydrology would not be affected by materials placement at disposal sites. Therefore, this section does not address hydrology impacts associated with materials placement or disposal.

Also refer to Section 3.4 Water and Aquatic Sediment Quality for a description of the lagoon's water and sediment quality characteristics and the potential changes anticipated from the various project alternatives.

This section, including the baseline condition for project analysis, is based on information from the *Buena Vista Lagoon Enhancement Project Draft Shoreline Report* (Everest 2014a), the *Buena Vista Lagoon Enhancement Project Tidal Inlet Maintenance Plan Technical Memorandum* (Everest 2014e), the *Buena Vista Lagoon Enhancement Project Fluvial and Tidal Hydraulics Analyses Report* (Appendix C), *Carlsbad Watershed Management Plan* (CWN 2002), *Carlsbad Watershed* (PCW 2014), *Carlsbad Watershed Management Area Water Quality Improvement Plan* (CWMA WQIP; CWMA Responsible Agencies 2014), the *Limited Geotechnical Investigation and Input to Buena Vista Lagoon Restoration Project* (TerraCosta Consulting Group 2008), and the *Buena Vista Lagoon Restoration Feasibility Study* (Everest and Battelle 2003). Sources dating from before the publication of the NOP reflect information that was still applicable at the time of NOP publication. From these technical studies and information, hydrology characteristics within Buena Vista Lagoon are discussed relative to the following:

- Surface hydrology/drainage
- Groundwater hydrology
- Water circulation
- Flooding
- Flood control

3.2.1 EXISTING CONDITIONS

The relevant policies and regulations dictating hydrology at the project site are discussed within this section. Additional regulatory requirements pertaining to other specific topic areas, such as noise, air quality, water quality, etc., are discussed in their respective analysis sections.

Certain regulatory approvals related to hydrology would be required by various regulatory agencies prior to project initiation. The project would be required to implement project design elements and construction and post-construction best management practices (BMPs) to address hydrology-related impacts. After certification of the EIR, but prior to implementation of the Enhancement Project, the project design and construction approach for the selected alternative must comply with applicable regulatory requirements (e.g., Municipal Permit, General Construction Permit) for hydrology management during construction activities. The project would also be required to comply with applicable regulations (e.g., Municipal Permit, Carlsbad WQIP, Standard Urban Storm Water Mitigation Plan/Hydromodification Management Plan [SUSMP/HMP]), to properly control erosion, provide sufficient flood protection, and incorporate suitable low-impact development (LID) BMPs to provide sufficient post-construction storm water management (e.g., infiltration and minimize impervious area). Compliance with SUSMP and HMP requirements minimizes hydrology and water quality impacts because SUSMP and HMP measures both control quantity and patterns of runoff as well as post-development runoff water quality. Note that the Watershed Management Area Analysis (WMAA) of the Carlsbad WQIP recommends exempting Buena Vista Lagoon from hydromodification management requirements. However, the final WQIP is currently in progress and is planned for submittal to the Regional Water Quality Control Board (RWQCB) no later than June 27, 2015. Therefore, compliance with hydromodification requirements will be included in the analysis. In addition, if the project would, upon construction, negatively affect the hydrologic or hydraulic characteristics of a flooding source, and thus would result in the modification of the existing regulatory floodway, or effective Base Flood Elevations, a Conditional Letter of Map Revision (CLOMR) and Letter of Map Revision (LOMR) would be prepared by the City of Carlsbad and the City of Oceanside, which would require approval by Federal Emergency Management Agency (FEMA) prior to project construction activities. However, this is not anticipated to occur under any of the alternatives.

<u>Regulatory Setting</u>

A full description of the regulatory setting for this document can be found in Appendix B. The following laws, regulations, policies, and plans are applicable to this resource area:

- Executive Order 11988 – Floodplain Management
- National Flood Insurance Act
- Construction General Permit
- Carlsbad Watershed Management Plan
- Carlsbad Watershed Management Area Water Quality Improvement Plan
- San Diego Municipal Storm Water Permit

Surface Hydrology and Drainage Patterns

Buena Vista Lagoon is a coastal lagoon that occupies approximately 220 acres, dominated by freshwater due to historical weir and levee improvements and operation. The lagoon is traversed by I-5, Carlsbad Boulevard, and the NCTD railroad tracks. Buena Vista Lagoon was originally ~~a tidal system~~influenced by both tidal and fluvial inputs; however, during ~~most summers~~much of the year, the lagoon was closed to the sea (CWN 2002; Beller et al. 2014). The current weir at the mouth of the lagoon, constructed in 1971, restricts tidal flow, and Buena Vista Lagoon currently functions as a freshwater lagoon.

Buena Vista Lagoon is located within the Buena Vista Creek Hydrologic Area (HA) of the Carlsbad Hydrologic Unit (HU). Figure 3.2-1 shows the study area within the hydrology of the region. The Carlsbad HU encompasses approximately 210 square miles and extends from the headwaters above Lake Wohlford in the east, to the Pacific Ocean to the west, and from the Cities of Vista and Oceanside in the north, to Solana Beach and Escondido in the south. There are numerous important surface hydrologic features within the Carlsbad HU, including four ecologically sensitive coastal lagoons, four creeks, and two large water storage reservoirs (Lake Wohlford and Dixon Lake).

The Carlsbad HU is composed of six HAs: Loma Alta, Buena Vista Creek, Agua Hedionda, Encinas, San Marcos, and Escondido Creek. The largest jurisdictional area in the Carlsbad HU is the unincorporated San Diego County areas, with the remaining areas associated with the Cities of Carlsbad, San Marcos, and Escondido. The majority of the Carlsbad HU is urbanized (48 percent), with residential (29 percent), commercial/industrial (6 percent), freeways and roads (12 percent), agriculture (12 percent), and vacant/undeveloped (32 percent) composing the dominant land uses (PCW 2014).

The Buena Vista Creek watershed, which is the watershed tributary to Buena Vista Lagoon, is approximately 14,400 acres and comprises 11 percent of the Carlsbad HU (CWN 2004; CWMA Responsible Agencies 2014). Buena Vista Creek begins on the western slopes of the San Marcos

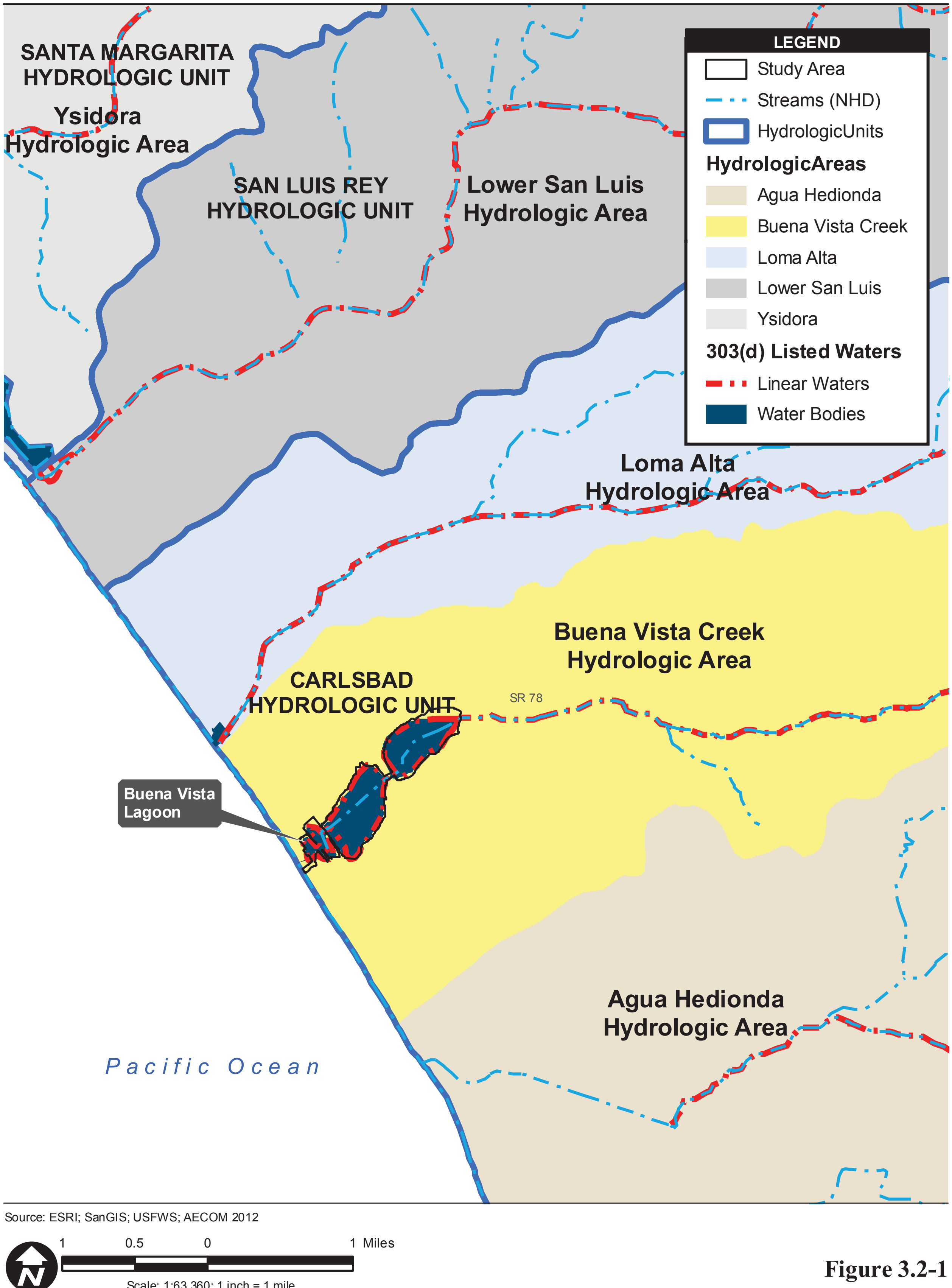


Figure 3.2-1
Surface Hydrology of the Buena Vista Lagoon

Mountains and ends in Buena Vista Lagoon and the Pacific Ocean. The primary receiving waters in the HA are Buena Vista Creek, Buena Vista Lagoon, and the Pacific Ocean. Elevations within the watershed range from sea level to 1,217 feet on the ridges of the San Marcos Mountains. Large sections of the creek have been channelized to reduce the chance of flooding private property. Approximately 80 percent of the watershed is developed primarily with commercial and residential uses, and some agricultural uses (CWN 2002).

The lagoon receives runoff from Buena Vista Creek as well as from storm drains along the perimeter of the lagoon. Buena Vista Creek drains approximately 20 square miles of the Buena Vista Creek HA into the Pacific Ocean (Figure 3.2-1). Average annual precipitation is approximately 11 inches.

Surface hydrology within the lagoon plays a large role in determining the habitat distribution that develops and is maintained. As discussed above, the lagoon is currently functioning as a freshwater system as a result of the weir at the mouth of the lagoon that restricts tidal exchange and maintains a constant surface water elevation of at least 5.6 feet. The increased freshwater influence and general impoundment since installation of the weir has led to predominantly freshwater conditions, resulting in a dominant freshwater marsh habitat (e.g., cattails) throughout the lagoon.

Groundwater Hydrology

The Enhancement Project is located within the South Coast Groundwater Hydrologic Region as identified in California's Groundwater Bulletin 118 (DWR 2004). Groundwater in the region consists of water within underground aquifers that is recharged from the land surface. Natural recharge of the groundwater underlying Buena Vista Lagoon is primarily from percolation in Buena Vista Creek, with smaller amounts contributed by direct precipitation into the lagoon and on lagoon shores. Infiltration from agricultural and residential uses contributes additional groundwater recharge. Groundwater is believed to be unconfined and characterized by exchange with the overlying lagoon. There is no identified groundwater basin underlying Buena Vista Lagoon.

Due to the weir that impounds runoff from Buena Vista Creek, groundwater levels are estimated to remain relatively constant between 6 and 9 feet mean sea level (MSL) around the borders of the lagoon (TerraCosta Consulting Group 2008).

Circulation

The hydrology within Buena Vista Lagoon is largely driven by freshwater supplied from the upstream Buena Vista Creek HA watershed and less so by ocean tidal fluctuations along the coast. The water level in the lagoon is maintained primarily by storm water runoff from Buena Vista Creek upstream of the I-5 Basin. The lagoon also receives minor inflows from several local storm drains along the perimeter of the lagoon, including nuisance flows and irrigation runoff. Storm-related storm surges in the ocean can also provide lagoon replenishment when seawater overtops the weir and beach berm. Primary loss of water in the lagoon occurs via evapotranspiration and seepage. Outflow from the lagoon also occurs when the beach berm is periodically lowered by the City of Oceanside or during high flood events, allowing lagoon water higher than the existing weir to exit the lagoon. The hydrologic water balance and the circulation dynamics of the lagoon are dependent on the surrounding landform topography and the lagoon bathymetry, as well as conditions that vary seasonally relative to the following:

- Precipitation (watershed drainage and direct rainfall to the lagoon);
- Tidal prism (the total volume of water exchanging between the ocean and lagoon over the weir);
- Groundwater level and groundwater/surface flow relationships (e.g., groundwater mounding or springs and seepage);
- Urban dry weather runoff;
- Evaporative water loss due to combinations of temperature, humidity, and wind; and
- Aquatic and wetland plant transpiration water loss.

Buena Vista Creek experiences seasonal flows typical of coastal slope drainages in San Diego County. Natural surface flows in Buena Vista Creek are dominated by urban and agricultural runoff during the dry season, but artesian springs provide for some surface flow even during the summer dry season (CWN 2002). Surface flow increases substantially during wet weather or flood events due to precipitation and storm water runoff from the Buena Vista Creek watershed into the creek.

Several human modifications, in addition to increased runoff flows, affect the water balance and overall circulation within the lagoon. These modifications include the railroad tracks, Carlsbad Boulevard, and I-5, each of which is set on an embankment where it crosses the lagoon, and the weir located at the lagoon mouth. These developments reduce lagoon circulation, increase water residence times, and contribute to sediment accumulation, excess vegetation, and degrading water quality in the lagoon. Residence time (i.e., the average length of time during which water is in a given location) is used as an index of lagoon-wide water circulation. Reduced circulation can lead to increased residence times. Long residence times are indicative of stagnant water with poor flushing, while short residence times are indicative of good water circulation and flushing. Water and sediment transport through each basin is limited by the constrictions defining each basin (i.e., weir channel, railroad bridge, Carlsbad Boulevard bridge, and I-5 bridge) and the absence of deep channels to direct flow (Everest 2014a). Residence time calculated at the lagoon or basin level does not necessarily reflect localized water circulation conditions. Rather, in addition to these systemic constrictions, circulation within specific areas can be influenced by more localized conditions, including the presence or absence of vegetation and the ability of wind-driven waves to form on the surface of the water outside of channels and deep areas within the lagoon.

The four major basins are connected by relatively narrow weir and bridge channels, which trap nearly all sediment that enters the lagoon basins. Accumulation of coarse beach sand deposits brought into the mouth of the lagoon from incoming (flood) high tidal flows has created a beach berm across the lagoon inlet on the beach side of the weir. This beach berm develops to an elevation higher than the weir and controls the water level in the lagoon, precluding tidal exchange when present. This berm also retains freshwater entering the lagoon from the watershed until the beach berm is breached by human-induced mechanical movement or natural flood flows. When the berm is breached, the weir retains freshwater and precludes tidal exchange, but the weir elevation is lower than the berm elevation when the berm is fully formed. Under strong storm events, freshwater flows from the watershed can have sufficient momentum and hydraulic force to erode the beach berm and induce tidal exchange over and/or through the existing weir until the beach berm rebuilds via natural sand accretion. Historically, the beach berm was breached more readily by storm flows and tidal action; however, since the weir at the mouth of the lagoon was constructed, the weir precludes tidal exchange that would occur following large storm events that erode the beach berm. The existing weir regulates water level, impounds freshwater, and reduces the ability for tidal flushing to occur (resulting in essentially no tidal exchange) thereby increasing freshwater impounding and subsequent sedimentation within the lagoon. Consequently, lagoon-ocean water exchange only occurs when the lagoon water level exceeds the weir and beach berm elevation or when astronomic tide conditions (spring and neap tides) or maintenance occurs and the beach berm is breached.

These hydraulic inefficiencies within Buena Vista Lagoon have led to inefficient drainage patterns, decreased circulation and water fluctuations, long residence times, and a consistent degradation of water quality throughout the lagoon. As part of the PWP/TREP preparation, Caltrans completed a set of lagoon optimization studies, including the I-5 Bridge Study at Buena Vista Lagoon (Everest 2012), which included all of the infrastructure crossings in the lagoon.

Channel cross-sections, optimized from a hydraulic perspective, are identified in that study at each of the different infrastructure crossings within the lagoon (e.g. railroad, Highway 101, I-5). These optimized cross sections are incorporated into the Enhancement Project. This section addresses circulation, while effects on water quality and biological resources are discussed in more detail in Sections 3.4 Water and Aquatic Sediment Quality and 3.5 Biological Resources, respectively.

Flooding, Erosion, and Siltation

During large storm events, freshwater flood flows from the watershed entering the lagoon can overtop the weir and beach berm with erosive outflow to the ocean and erode the beach berm, leading to periods of ocean water entering the lagoon over the weir during high tide events. However, such natural flushings happen infrequently, and throughout most of the year (and often during low-rainfall winter seasons), tidal flushing remains essentially nonexistent because it is prevented by both the berm and the weir. The narrow channels currently connecting the four basins entrap sediment and cannot sustain sufficient water velocities to allow adequate or constant circulation for sediment transport. Additionally, the existing weir prevents lagoonal sediments from depositing on the beaches near the inlet.

The potential for flooding within areas adjacent to the lagoon remains a concern during large storm events (e.g., 100-year storms). Formal mapping of the 100-year floodplain is described below and shown in Figure 3.2-2, but flooding can currently occur in some areas (e.g., St. Malo community) under smaller storm events (e.g., 50-year storms) due to the present hydraulic constrictions within the lagoon.

Historically, activities occurring throughout the watershed, such as road development, agriculture, and construction, have resulted in erosion and consequential fine sediment transport that settled out in the lagoon. Buena Vista Creek is the principal transporter of alluvial sediment to the lagoon. Much of the lagoon sedimentation is directly related to urban runoff and stream channel modification that have historically occurred throughout the Buena Vista Creek and lagoon watershed (CWN 2002). Sedimentation within Buena Vista Lagoon continues as a result of upland erosion sources; however, it is anticipated that current rates of sediment accumulation are lower than historic rates due to hardscape urbanization of the watershed that reduces available sediment for transport in runoff.

Source: SANDAG 2012; SANGIS; FEMA; AECOM 2014

600 300 0 600 Feet

Scale: 1:7,200; 1 inch = 600 feet

Figure 3.2-2
FEMA Flood Zones

Path: P:\2013\60288954_BVLEP_EIR\06GIS\6.3_Layout\Reports\EIR\FEMA.mxd, 12/22/2014, steinb

This page intentionally left blank.

Exacerbating the sediment fallout and entrapment caused by the weir, railroad, Carlsbad Boulevard, and I-5, narrow channel configurations within the lagoon also contribute to reduced flow and sedimentation. As a result of decades of poor circulation, persistent sedimentation, and essentially no tidal prism (i.e., closed lagoon mouth), substantial deposits of primarily sand-sized sediments have accumulated in the lagoon basins. In general, the lagoon consists of a thin layer of fine-grained material (silts and clays) that overlays a thick, relatively homogenous layer of sandy materials (>80 percent sand). Small percentages of gravel-sized particles (shell material) were measured in the Railroad Basin (Everest and Battelle 2003).

Flood Control

The need for controlling floodwaters is based on geographic flood zone areas that FEMA defines according to varying levels of flood risk. These zones are depicted on Flood Insurance Rate Maps or Flood Hazard Boundary Maps. Each zone reflects the severity or type of flooding in the area. A large percentage of the lagoon and some adjacent areas, particularly to the west and north of the Weir Basin, and north, south, and east of the I-5 Basin, are located within the FEMA 100-year flood zone (Figure 3.2-2). Buena Vista Lagoon is a part of the Buena Vista Creek floodplain.

Because the weir, railroad, Carlsbad Boulevard, and I-5 restrict the movement and release of flood flows through the lagoon to the Pacific Ocean, Carlsbad Boulevard is subject to flooding during relatively large flood events (e.g., 50-year and 100-year storms). In addition, flooding is also a concern for the low-lying residential community of St. Malo that is located on the beach on the northern side of the Weir Basin (Appendix C, Section 5). The areas to the north and west of the Weir Basin are located within the FEMA 100-year flood zone (Figure 3.2-2). Low-lying areas along the floodplains of Buena Vista Creek are also likely to experience flooding during 100-year events. Flooding also regularly affects the informal public trails located near the Nature Center. High flood levels occur in the I-5 Basin, indicating that the I-5 bridge provides a significant constriction to flood flow conveyance from Buena Vista Creek through the lagoon to the ocean (Appendix C, Section 5).

Inundation Conditions

Inundation can be caused by seiche or mudflow. The interior of the lagoon and structures along its perimeter are currently protected from high wave energy along the beaches during some coastal storm wave events by the presence of the weir and the relatively narrow inlet channel.

Seiches are oscillations generated in enclosed bodies of water usually as a result of earthquake-related ground shaking. A seiche wave has the potential to overflow the sides of a containing basin to inundate adjacent or downstream areas. Seiches can also occur in conjunction with a tsunami event. Tsunami is a condition that is influenced by coastal processes, and is addressed in Section 3.3, Coastal Processes.

Mudflows are shallow water-saturated landslides that travel rapidly down slopes carrying rocks, brush, and other debris. Mudflows occur in areas containing slopes composed of high clay-bearing soils. They are often triggered by unusually heavy rains that cause the slope stability to fail and the mud, water, and debris to flow like a flood. As further discussed in Section 3.8 Geology and Soils, the terraces in the area where construction and maintenance activities would occur are not considered steep slopes that would be susceptible to stability failure.

3.2.2 Significance Criteria

A significant impact to hydrology would occur if implementation of the Enhancement Project would result in any of the following:

A. Substantial depletion of groundwater supplies or interference with groundwater recharge, such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of preexisting nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted);

B. Substantial alteration of the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river or increase in river flow velocities, in a manner that would result in substantial scour or erosion that causes instability of slopes, river control berms, adjoining roadway embankments, or bridge abutments;

C. Substantial increase in the flow rate or amount (volume) of surface runoff in a manner that would result in flooding on- or off-site, causing damage to structures or exposing the public to substantial risk;

D. Creation or contribution to runoff water that would exceed the capacity of existing or planned storm water drainage systems; or

E. Placement within a 100-year flood hazard area of structures that would substantially impede or redirect flood flows.

F. Increase risks of damage from inundation by seiche or mudflow.

These thresholds are derived from the CEQA Guidelines Appendix G sample questions.

3.2.3 Impact Analysis

A two-dimensional numerical hydrodynamic model (TUFLOW) was used to estimate water surface elevations and water velocities associated with extreme storm events (e.g., 100-year return period storm event) and small storm events (e.g., 10-year return period storm event) (Appendix C). Table 3.2-1 illustrates maximum water elevations for each alternative compared to existing conditions under different storm events (e.g., 10-, 50-, 100-year). Maximum water elevations during a 100-year storm event are shown for existing conditions and each of the alternatives in Figure 3.2-3. Table 3.2-2 identifies the acreage within the flood plain for the modeled 100-year storm events.

Table 3.2-1
Maximum Flood Elevations under 2015 Mean Sea Level Conditions

Storm Return Period (Year)	Alternative	Maximum Water Elevation (ft, NGVD)			
		Weir Basin	Railroad Basin	Coast Highway Basin	I-5 Basin
100	Existing Conditions	12.0	12.1	12.1	15.8
	Freshwater Alternative	9.6	9.7	10.4	15.4
	Saltwater Alternative	7.0	7.3	7.7	8.2
	Hybrid A	6.0	6.7	7.0	16.0
	Hybrid B	6.0	6.7	7.0	16.0
50	Existing Conditions	10.2	10.2	10.3	13.3
	Freshwater Alternative	8.0	7.9	9.0	12.9
	Saltwater Alternative	5.4	5.7	6.0	6.5
	Hybrid A	4.5	5.4	5.6	13.7
	Hybrid B	4.5	5.3	5.6	13.8
10	Existing Conditions	7.7	7.7	7.8	8.9
	Freshwater Alternative	6.9	6.9	7.1	8.4
	Saltwater Alternative	3.5	3.6	3.8	4.0
	Hybrid A	3.0	3.2	3.3	9.7
	Hybrid B	3.0	3.2	3.3	9.7
5	Existing Conditions	6.9	6.9	6.9	7.4
	Freshwater Alternative	6.5	6.5	6.5	7.0
	Saltwater Alternative	3.1	3.1	3.2	3.3
	Hybrid A	3.0	3.0	3.0	9.1
	Hybrid B	3.0	3.0	3.0	9.2
2	Existing Conditions	6.1	6.1	6.1	6.2
	Freshwater Alternative	6.0	6.0	6.0	6.0
	Saltwater Alternative	2.8	2.8	2.9	2.9
	Hybrid A	3.0	3.0	3.0	7.1
	Hybrid B	3.0	3.0	3.0	7.1

ft NGVD = feet National Geodetic Vertical Datum
Source: Appendix C

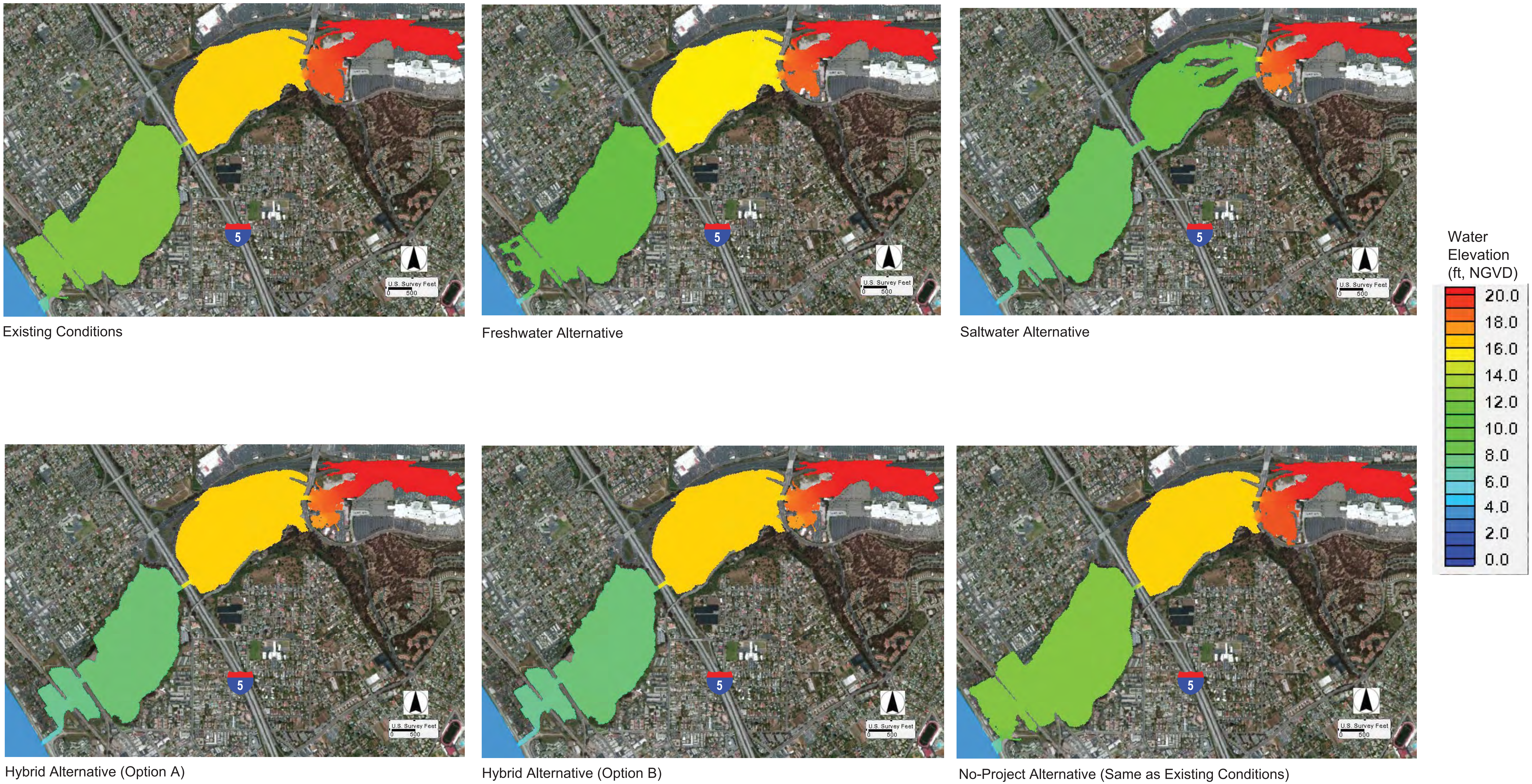
Table 3.2-2
Floodplain Acreage for Modeled 100-year Storm Events

	Existing Conditions	Freshwater Alternative	Saltwater Alternative	Hybrid Alternative Option A	Hybrid Alternative Option B
Acreage within floodplain (100-year storm event)	318	303	263	285	285

Freshwater Alternative

<u>Temporary Impacts</u>

The Freshwater Alternative would involve the least amount of initial vegetation and sediment removal and would not require periodic maintenance at the lagoon inlet. During the construction process, the lagoon’s mouth would remain closed, and there would be only minor changes to the lagoon’s water balance, circulation, and surface hydrology. Construction activities would be conducted in a phased approach: vegetation removal would occur first starting at the I-5 Basin and moving downstream until reaching the Weir Basin. Dredging work would then occur, starting in the Coast Highway Basin and moving to the I-5 Basin, then the Railroad and Weir Basins. The weir work would be conducted last. Minor alterations to lagoon circulation would occur during weir replacement from the use of temporary cofferdams and dewatering activities; however, these changes would be temporary and localized around the weir location. Water levels within the lagoon would not increase during construction activities relative to existing conditions, and flow regimes would remain primarily unaltered since the weir would remain in place. Open water areas of the lagoon would continue to be subject to slow velocities, so increased erosion and flow rates would not be anticipated during construction activities. Some increases in localized circulation would occur due to dredge and support equipment movement and wind wave-driven circulation resulting from vegetation removal. Additionally, a temporary staging area would be created adjacent to the lagoon and next to the Nature Center for staging of construction activities in the Coast Highway Basin. This staging area would be created through the temporary placement of fill material. Compliance with applicable regulations (i.e., Construction General Permit, Municipal Permit) would be required to ensure impacts during construction activities are minimized. Erosion control would be addressed in the project Storm Water Pollution Prevention Plan (SWPPP) required under the Construction General Permit. Erosion-control BMPs (e.g., riprap, hydraulic mulch, soil binders, hydroseed) would be developed and implemented by the contractor in compliance with existing regulations to minimize scour and impacts on surface drainage patterns and existing drainage systems. **Compliance with applicable regulatory requirements and implementation of appropriate**



Source: Everest International Consultants, Inc. & Battelle Memorial Institute 2003

0 1000 2000 Feet

Figure 3.2-3
Year 2015 100-year Storm Inundation

This page intentionally left blank.

BMPs would ensure construction of the Freshwater Alternative would not result in a substantial alteration to existing drainage patterns that would cause substantial scour or erosion, increased runoff flow rates or volume resulting in flooding or an exceedance of drainage system capacity, increased exposure to water-related hazards, or placement of structures that would impede flood flows. Temporary impacts would be less than significant (Criteria B, C, D, and E).

Groundwater is believed to be unconfined and characterized by an ongoing exchange with the overlying lagoon. Although the lagoon's channels would undergo vegetation removal and dredging, and the water level is expected to be lower in the active work area during replacement of the weir, the existing level of hydrologic connectivity between groundwater and the lagoon would not be expected to change as a result of work activities, and no substantial decrease in recharge characteristics should occur during construction. **Construction work for the Freshwater Alternative would not result in substantial depletion of groundwater supplies or interference with groundwater recharge, and temporary impacts would be less than significant (Criterion A).**

Seiche hazards would not be increased over existing conditions for both wind-driven and seismic seiche (Appendix N). As stated above, construction and maintenance activities would not occur on steep slopes that would be susceptible to stability failure from a mudflow. As discussed in Section 3.2.1, the terraces in the area where construction activities would occur are not considered steep slopes that would be susceptible to mudflow. **No increased risk of inundation from seiche or mudflow would result from construction of the Freshwater Alternative and temporary impacts would be less than significant (Criterion F).**

<u>Permanent Impacts</u>

The Freshwater Alternative would slightly increase localized hydraulic efficiency of Buena Vista Lagoon over existing conditions by removing vegetation and sediment in open water areas to improve inter-basin flow exchange, as well as flood protection. Vegetation removal in open water areas and from central portions of the basins would enhance localized circulation by decreasing vegetation density; 129,000 cy of vegetation would be removed under the Freshwater Alternative. Removal of excess sediment would also increase localized water circulation throughout the basins; 562,000 cy of sediment would be removed. Refer to Table 2-4 for amounts of vegetation and sediment to be removed from each basin. Localized circulation within the lagoon would slightly improve following construction due to the creation of larger expanses of open water and less dense vegetation that does not allow water movement. However, overall circulation within the lagoon would decrease under the Freshwater Alternative. With deeper basins and no tidal flushing, residence times would increase in all basins compared to existing conditions (Table 3.2-3). The hydrologic regime of the lagoon would remain a freshwater system influenced primarily by upstream watershed drainage into the I-5 Basin at the east end of the lagoon.

Table 3.2-3
Average Residence Time during Dry Weather for Year 2015

Alternative	Basins	Residence Time (Days)
Existing Conditions	I-5	8
	Coast Highway	36
	Railroad	75
	Weir	82
Freshwater	I-5	33
	Coast Highway	82
	Railroad	116
	Weir	118
Saltwater	I-5	3
	Coast Highway	3
	Railroad	1
	Weir	1
Hybrid A	I-5	23
	Coast Highway	18
	Railroad	1
	Weir	2
Hybrid B	I-5	22
	Coast Highway	17
	Railroad	1
	Weir	1

Source: Appendix D

In addition, the deep, open water area located just downstream from the Jefferson Street bridge, which acts as a sediment trap for fluvial runoff into the lagoon, would remain. The existing 50-foot weir at the ocean outlet would be replaced with a wider, 80-foot weir to improve flood protection. The channel extending under I-5 would remain at existing dimensions. The Carlsbad Boulevard bridge would remain in place; however, accumulated sediment and vegetation would be removed to return the channel to the original design dimensions (no channel expansion would occur). The channel under the Railroad bridge would be deepened from existing conditions as part of the Enhancement Project; the channel bottom would be narrower than existing conditions, while the width at +3 feet NGVD would remain at 200 feet as existing, as identified in the I-5 Bridge Study at Buena Vista Lagoon (Everest 2012). Railroad bridge construction would be conducted by others as part of the LOSSAN project as described in Chapter 2. See Table 2-3 for channel dimensions under each alternative.

Overall, alterations to drainage patterns and circulation within the lagoon would benefit hydraulic efficiency, biological resources and reduce vector concerns in the lagoon. Localized circulation would increase with vegetation and sediment removal and channel deepening. The new, larger weir would enable the lagoon to drain incoming freshwater more efficiently and improve flood control during large storm events, leading to less potential in general for flooding hazards. The wider weir would provide a larger area for storm flows to exit the lagoon. A greater volume of water would be able to exit the lagoon during wet weather conditions and less water would be confined within the lagoon, thereby reducing flooding. As shown in Table 3.2-1, water elevations in all four basins would be lower than existing conditions under all storm events (i.e., 2-, 5-, 10-, 50-, and 100-year). Table 3.2-2 shows that the overall area within the floodplain under a 100-year storm event would decrease. The new weir would be built in the same location at the same elevation (+5.6 feet NGVD) as the existing weir, which would result in no substantial change to infiltration characteristics and no substantial change in surface runoff in the lagoon.

The Freshwater Alternative is not anticipated to increase impervious area compared to existing conditions. The proposed Boardwalk deck would be constructed of timber planks with spacing between and would require proper drainage designs per applicable regulatory requirements (i.e., Municipal Permit, SUSMP, HMP, LID BMPs) to eliminate or minimize increases in discharge flow rate, runoff volume, or erosion potential. By complying with the regulatory requirements and properly implementing appropriate BMPs, no significant changes to surface runoff patterns or sedimentation loads into the lagoon would occur. In a post-construction setting, temporary staging areas would be uncompacted, revegetated, and restored to pre-construction conditions.

Hydrologic improvements associated with the Freshwater Alternative would offer some improvement to the existing constrictions within the lagoon that are currently causing water flow and circulation problems (i.e., excess vegetation and sediment). This alternative would also improve the ability of the lagoon to drain more efficiently and improve flood protection with the new, wider weir. The proposed Boardwalk deck elevation would be located above the 100-year flood water surface elevation (approximately 12 feet NGVD) to avoid impeding flood flows. Improved drainage would generally reduce the potential for flooding to occur within the lagoon and along adjacent areas during large storm events. Water surface elevations in all basins under all storm events would be lower than existing conditions under the Freshwater Alternative (Table 3.2-1), thereby reducing flooding impacts over existing conditions. However, Carlsbad Boulevard and portions of the St. Malo community would still be flooded during some storm events (i.e., 100-year storm) under the Freshwater Alternative, similar to existing conditions but to a slightly smaller degree (Appendix C and Figure 3.2-3). Flooding of adjacent infrastructure and/or roadways and the potential for exposure of people or property to flooding hazards would be reduced over existing conditions. The floodplain for a 100-year storm event would be reduced from 318 acres under existing conditions to 303 acres, as shown in Table 3.2-2. In addition, the Freshwater Alternative would not require a CLOMR, which is needed if a proposed project causes an increase in flood elevation of greater than 1 foot and is within a flood area designated as Zone A.

Based on hydraulic analyses of water velocities conducted within the lagoon, velocities in the basins would be below 1 foot per second (ft/s), with higher velocities (exceeding 3 ft/s) in the hydraulic connections (channels), which could suggest erosive forces within the channels during large storm events (Appendix C, Section 5). However, much of the lagoon channel cross sections would be protected with erosion control products (i.e., riprap) and vegetated material to stabilize soils and foster natural recruitment from restoration planting, as described in Table 2-9, Standard Construction Practices. These efforts would limit the time that erosive soils would be exposed and would not result in substantial long-term erosion. **Compliance with applicable regulatory requirements and implementation of appropriate BMPs would ensure the Freshwater Alternative would not result in a substantial alteration to existing drainage patterns that would cause substantial scour or erosion, increased runoff flow rates or volume resulting in flooding or an exceedance of drainage system capacity, increased exposure to water-related hazards, or placement of structures that would impede flood flows. Permanent impacts would be less than significant (Criteria B, C, D, and E).**

Although the lagoon's channels would undergo vegetation removal and dredging, and placement of some riprap, the existing level of hydrologic connectivity between groundwater and the lagoon would not be expected to be altered, and substantial reduction in recharge characteristics is not anticipated. The new weir would be at the same level as the existing weir, keeping water levels within the lagoon consistent with existing levels. **The Freshwater Alternative would not result in substantial depletion of groundwater supplies or interference with groundwater recharge, and permanent impacts would be less than significant (Criterion A).**

Similar to the discussion under temporary impacts, the potential for seiche hazard would not increase under the Freshwater Alternative (Appendix N). The long periods of seiche oscillations fall outside of the period range where earthquake ground motion carry the most energy, and wave-driven seiche hazards would also decrease compared to existing conditions because of proposed changes in depth. As discussed in Section 3.2.1, the terraces in the area where maintenance activities would occur are not considered steep slopes that would be susceptible to mudflow. **The Freshwater Alternative would not result in an increased risk of inundation from seiche or mudflow and permanent impacts would be less than significant (Criterion F).**

Long-term Benefits

The Freshwater Alternative would reduce water elevations compared to existing conditions in all basins during all storm events (i.e., 2-, 5-, 10-, 50-, and 100-year), thereby reducing flooding impacts. The extent of that improvement would be reduced compared to the Saltwater or Hybrid Alternatives, reducing elevations in each basin by between 2.4 and 0.4 feet. The floodplain for a 100-year storm event would be reduced from 318 acres under existing conditions to 303 acres. Increased circulation would result from the Freshwater Alternative, but on a localized basis and not to the extent of the Saltwater or Hybrid Alternatives. Long-term circulation and drainage improvements may not persist because long-term sediment removal is anticipated only every 25 years, and only some continued vegetation removal is planned.

Saltwater Alternative

Temporary Impacts

Temporary impacts as a result of the implementation of the Saltwater Alternative would be greater than those discussed for the Freshwater Alternative. The Saltwater Alternative would require more vegetation removal (all existing vegetation within dredging limits would be removed) and sediment removal for initial implementation than the Freshwater Alternative and would require periodic annual maintenance (every 12 to 20 months) to remove sediment from the inlet and lagoon basins. The Saltwater Alternative would require replacement of the weir with an open tidal inlet to create a saltwater system. In addition, the Carlsbad Boulevard bridge would be improved and channels under the Carlsbad Boulevard bridge and I-5 would be expanded. Similar to the Freshwater Alternative, the channel under the Railroad bridge would be deepened.

Similar to the Freshwater Alternative, phased construction would occur: vegetation removal would occur first starting at the I-5 Basin and moving downstream until reaching the Weir Basin; dredging work would then occur, starting in the Coast Highway Basin and moving to the I-5 Basin, then the Railroad and Weir Basins; the weir/inlet work would be conducted last, and the lagoon would be opened once this work is complete. During construction, the lagoon mouth would remain closed, and there would be only minor changes to the lagoon’s water balance, circulation, and surface hydrology. Minor alterations to lagoon circulation would occur during weir replacement from the use of temporary cofferdams and dewatering activities; however, these changes would be temporary and localized around the weir and structure locations. Water levels within the lagoon would not increase during construction activities relative to existing conditions, and flow regimes would remain primarily unaltered since the weir would remain in place. Open water areas of the lagoon would continue to experience slow velocities, so increased erosion and flow rates would not be anticipated during construction activities. Some increases in localized circulation would occur due to dredge and support equipment movement and wind wave-driven circulation resulting from vegetation removal. In addition, areas identified as sensitive to erosion (channel slopes under infrastructure and bridge abutments) would be structurally protected as described in Chapter 2 and erosion control would be further addressed in the project SWPPP to minimize scour and impacts on surface drainage patterns and existing drainage systems.

A temporary staging area would be created adjacent to the lagoon and next to the Nature Center for staging of construction activities in the Coast Highway Basin. This staging area would be created through the temporary placement of fill material. Erosion-control BMPs (e.g., riprap, hydraulic mulch, soil binders, hydroseed) would be implemented by the contractor in compliance with existing regulations requiring preparation of the SWPPP to minimize scour and impacts on surface drainage patterns and existing drainage systems. **Compliance with applicable regulatory requirements and implementation of appropriate BMPs would ensure construction of the Saltwater Alternative would not result in a substantial alteration to existing drainage patterns that would cause substantial scour or erosion, increased runoff flow rates or volume resulting in flooding or an exceedance of drainage system capacity, increased exposure to water-related hazards, or placement of structures that would impede flood flows. Temporary impacts would be less than significant (Criteria B, C, D, and E).**

Although the lagoon’s channels would undergo vegetation removal and dredging, and the water level is expected to be lower in the active work area during construction of the tidal inlet, the existing level of hydrologic connectivity between groundwater and the lagoon would not be altered, and no substantial reduction in recharge characteristics would occur. **The construction of the Saltwater Alternative would not result in substantial depletion of groundwater supplies or interference with groundwater recharge, and temporary impacts would be less than significant (Criterion A).**

Similar to the discussion under the Freshwater Alternative, the potential for seiche hazard would not increase under the Saltwater Alternative (Appendix N). The long periods of seiche oscillations fall outside of the period range where earthquake ground motion carry the most energy, and wave-driven seiche hazards would also decrease compared to existing conditions because of proposed changes in depth. As discussed in Section 3.2.1, the terraces in the area where construction activities would occur are not considered steep slopes that would be susceptible to mudflow. **The Saltwater Alternative would not result in a temporary increased risk of inundation from seiche or mudflow and permanent impacts would be less than significant (Criterion F).**

Permanent Impacts

The Saltwater Alternative, when completed (the lagoon would be open to the ocean following weir removal and inlet construction), would change the hydrologic regime of the lagoon from the existing freshwater system to a saltwater system, influenced primarily by seawater entering the lagoon through an open tidal inlet during flood tides. Freshwater input would continue relative to the upstream watershed flow entering the lagoon as well as from along the perimeter of the lagoon during storm events. Water exiting the lagoon under the Saltwater Alternative would primarily occur during ebb (outgoing) tides, with evapotranspiration and seepage providing additional output.

All existing freshwater vegetation within the dredging limits would be removed and existing freshwater marsh and open water areas would be replaced with coastal salt marsh and open marine water areas. A new channel in the Weir Basin would be created and existing channels would be expanded, and infrastructure would be improved to minimize constrictions and allow tidal exchange and enhanced circulation. The existing weir at the ocean outlet would be replaced with an open inlet to provide tidal exchange. A subtidal, stabilized channel running from the southern side of the tidal inlet inside the Weir Basin seaward to the existing stone revetment running along the St. Malo complex on the northern side of Weir Basin would be created to provide tidal exchange, thereby improving circulation throughout the Weir Basin. The existing channel under Carlsbad Boulevard would be expanded to improve hydraulic connectivity between the Coast Highway Basin and the Railroad Basin. In addition, the channel under I-5 would be expanded to further improve circulation and exchange throughout the lagoon basins. The channel under the Railroad bridge would be deepened from existing conditions; the channel bottom would be narrower than existing conditions, while the width at +3 feet NGVD would remain 200 feet as existing. Railroad and I-5 bridge structure improvements would be conducted by others as described in Chapter 2, although channel improvements under those structures would be completed by the Enhancement Project. See Table 2-3 for channel dimensions under each alternative.

Drainage patterns would be altered and circulation within the lagoon would increase with the open inlet, improved channel network and flow regimes, and increased tidal flow. With tidal flushing, residence times would decrease in all basins under the Saltwater Alternative compared to existing conditions (Table 3.2-3). Hydrology throughout the lagoon would be enhanced through improved infrastructure (i.e., open inlet, new bridge) and expanded channels (i.e., Carlsbad Boulevard and I-5 channels) that would allow freshwater to flow out of the lagoon and promote improved tidal exchange further east into the lagoon basins. The new tidal inlet would enable the lagoon to drain incoming freshwater more efficiently and improve flood control during large storm events, leading to less potential in general for flooding hazards. The tidal inlet would be wider than the existing weir at a slightly lower elevation (+4.0 feet NGVD); however, there would be no anticipated change in surface runoff amounts into the lagoon as a result of the tidal inlet.

The increase in impervious area is expected to be minimal under the Saltwater Alternative and would include the Boardwalk and a stone revetment under the Carlsbad Boulevard bridge extending approximately 300 feet from the channel to the north and south to help stabilize the bridge abutments (PDF-1 and PDF-2) and meet applicable design and engineering requirements. The stone revetment and proposed Boardwalk would require proper drainage designs per applicable regulatory requirements (i.e., Municipal Permit, SUSMP, HMP, LID BMPs) to eliminate or minimize increases in discharge flow rate, runoff volume, or erosion potential. By complying with the regulatory requirements and properly implementing appropriate BMPs, no significant changes to surface runoff patterns would occur. In a post-construction setting, temporary staging areas would be uncompacted, revegetated, and restored to pre-construction conditions.

The Saltwater Alternative would reduce the flood potential compared to existing conditions (Table 3.2-1). Water elevations in all four basins would be lower than existing conditions under design storm events (i.e., 2-, 5-, 10-, 50-, and 100-year) (Table 3.2-1). Table 3.2-2 shows that the overall area within the floodplain under a 100-year storm event would decrease. The lagoon channel network and infrastructure improvements would enhance hydraulic connectivity between the lagoon and ocean, and allow fluvial flows to drain from the lagoon more efficiently. The new 100-foot-wide tidal inlet would improve flood performance over existing conditions.

The proposed Boardwalk deck elevation would be located above the 100-year flood water surface elevation at approximately 12 feet NGVD to prevent flooding. To accommodate flood flows under the Carlsbad Boulevard bridge, including a 1-foot freeboard, the roadway elevation would be raised to 14 feet NGVD from the existing 9.6-foot NGVD elevation, which would also eliminate flooding of the roadway during design storm conditions (Table 3.2-1 and Figure 3.2-3). Improved circulation and drainage would generally reduce the potential for flooding to occur within the lagoon and along adjacent infrastructure during large storm events. Flood conditions would be greatly improved throughout the lagoon compared to existing conditions, as maximum water surface elevations would substantially decrease in all basins under each storm return period as shown in Table 3.2-1. The 100-year storm event floodplain would be reduced from 318 acres under existing conditions to 263 acres (Table 3.2-2). Water elevations and inundation during 100-year storm events would be reduced in flood-prone areas (Carlsbad Boulevard; St. Malo community; and north, south, and east of the I-5 Basin) (Table 3.2-1 and Figure 3.2-3), minimizing hazards to people, structures, and facilities within these areas.

Flooding of adjacent infrastructure and/or roadways and the potential for exposure of people or property to flooding hazards would be reduced over existing conditions. Channel and infrastructure improvements would be reviewed by SANDAG, the City of Carlsbad, and the City of Oceanside, as appropriate, prior to approval of project grading plans (PDF-4) to ensure flooding hazards would be minimized and meet requirements of the various jurisdictions. In addition, the Saltwater Alternative would not require a CLOMR, which is needed if a proposed project causes an increase in flood elevation of greater than 1 foot and is within a flood area designated as Zone A.

Flow volumes and velocities through the lagoon would be expected to increase due to the open tidal inlet, creating the potential for erosion, but only within the defined channel connecting the basins. Based on hydraulic analyses of water velocities conducted within the lagoon, velocities in the basins would be below 1 ft/s; however, velocities within the hydraulic connections (i.e., channels) would be higher (exceeding 3 ft/s), thereby indicating a potential for channel scour and erosion, but would be limited to the channels and likely only occur during large storm events (Appendix C, Section 5). However, slope protection would be required in these channels to protect the side slopes and bridge infrastructure from erosion. Lagoon channel cross sections would be protected with erosion control products (i.e., riprap) and vegetated material to stabilize soils and foster natural recruitment from restoration planting, thus managing erosion during higher-velocity storm flows and preventing damage, as described in Table 2-9, Standard Construction Practices. These efforts would limit the time that erosive soils would be exposed and would not result in substantial long-term erosion. In addition, it is expected that a flood shoal would form within the enhanced lagoon with the addition of the open tidal inlet and large tidal prism (Everest 2014e). Longshore transport of sand can become trapped behind coastal structures and inlets, and would potentially create a sand bar formation (flood shoal) in the lagoon that can ultimately close the mouth. This flood shoal would form in response to changes in the tidal inlet configuration and lagoon tidal prism. The flood shoal would be removed during regular inlet maintenance to maintain an open inlet condition; approximately 27,000 cy of sediment is anticipated to be removed every 12 to 20 months (Everest 2014e). **Compliance with applicable regulatory requirements and implementation of appropriate BMPs would ensure the Saltwater Alternative would not result in a substantial alteration to existing drainage patterns that would cause substantial scour or erosion, increased runoff flow rates or volume resulting in flooding or an exceedance of drainage system capacity, increased exposure to water-related hazards, or placement of structures that would impede flood flows. Permanent impacts would be less than significant (Criteria B, C, D, and E).**

The Saltwater Alternative would enlarge the tidal channel network throughout the lagoon and enhance the ability of the lagoon to drain incoming freshwater flows more efficiently. Although the lagoon's channels would undergo vegetation removal and dredging, the existing level of hydrologic connectivity between groundwater and the lagoon would not be expected to substantially decrease recharge characteristics. **The Saltwater Alternative would not result in substantial depletion of groundwater supplies or interference with groundwater recharge, and permanent impacts would be less than significant (Criterion A).**

Similar to the discussion under temporary impacts, the potential for seiche hazard would not increase under the Saltwater Alternative (Appendix N). The long periods of seiche oscillations fall outside of the period range where earthquake ground motion carry the most energy, and wave-driven seiche hazards would also decrease compared to existing conditions because of proposed changes in depth. As discussed in Section 3.2.1, the terraces in the area where maintenance activities would occur are not considered steep slopes that would be susceptible to mudflow. **The Saltwater Alternative would not result in an increased risk of inundation from seiche or mudflow and permanent impacts would be less than significant (Criterion F).**

Long-term Benefits

Under the Saltwater Alternative, water elevations would be reduced in all basins during all storm events (i.e. 2-, 5-, 10-, 50-, and 100-year), thereby reducing flooding impacts. This alternative would reduce water elevations by between 7.6 and 4.4 feet in each basin—more than the Freshwater Alternative would, but slightly less than the Hybrid Alternative. The 100-year storm event floodplain would be reduced from 318 acres under existing conditions to 263 acres, the greatest reduction of all the alternatives. Long-term benefits of circulation and drainage pattern improvements and decreased residence times are more likely to persist due to increased tidal flow and enhanced circulation from the open tidal channel. The new tidal inlet would also enable the lagoon to drain incoming freshwater more efficiently.

Hybrid Alternative

Temporary Impacts

Temporary impacts as a result of the implementation of the Hybrid Alternative would be similar to those discussed for the Saltwater Alternative. The Hybrid Alternative would require slightly more sediment removal but less vegetation removal for initial implementation than the Saltwater Alternative and would require periodic annual maintenance (every 12 to 18 months) to remove sediment from the inlet and lagoon basins, similar to the Saltwater Alternative. The Hybrid Alternative would require replacement of the existing weir with an open tidal inlet to provide tidal exchange and create a system influenced by both saltwater and freshwater. Additionally, the

Hybrid Alternative would include construction of a new weir (spillway) at the I-5 bridge to maintain a freshwater hydrologic regime in the portion of the lagoon east of I-5.

Similar to the Saltwater Alternative, phased construction would occur with vegetation removal occurring first, followed by dredging, and the weir/inlet work. The lagoon would be opened once the inlet work is complete. Some minor disruption to lagoon circulation (e.g., reduced flows) would be expected from temporary cofferdam and dike work and dewatering activities during the construction of the tidal inlet, and installation of the new I-5 weir; however, these changes would be localized and temporary. In addition, areas identified as sensitive to erosion (channel slopes under infrastructure, bridge abutments) would be structurally protected as described in Chapter 2, and erosion control would be further addressed in the project SWPPP to minimize scour and impacts on surface drainage patterns and existing drainage systems. Erosion-control BMPs (e.g., riprap, hydraulic mulch, soil binders, hydroseed) would be implemented by the contractor in compliance with existing regulations to minimize scour and impacts on surface drainage patterns and existing drainage systems. **Compliance with applicable regulatory requirements and implementation of appropriate BMPs would ensure construction of the Hybrid Alternative would not result in a substantial alteration to existing drainage patterns that would cause substantial scour or erosion, increased runoff flow rates or volume resulting in flooding or an exceedance of drainage system capacity, increased exposure to water-related hazards, or placement of structures that would impede flood flows. Temporary impacts would be less than significant (Criteria B, C, D, and E).**

Similar to the Saltwater Alternative, the existing level of hydrologic connectivity between groundwater and the lagoon would not be expected to be altered, and no substantial reduction in recharge characteristics would occur as a result of construction activities. **The Hybrid Alternative would not result in substantial depletion of groundwater supplies or interference with groundwater recharge, and temporary impacts would be less than significant (Criterion A).**

Similar to the discussion under the Saltwater Alternative, the potential for seiche hazard would not increase under the Hybrid Alternative (Appendix N). The long periods of seiche oscillations fall outside of the period range where earthquake ground motion carry the most energy, and wave-driven seiche hazards would also decrease compared to existing conditions because of proposed changes in depth. As discussed in Section 3.2.1, the terraces in the area where construction activities would occur are not considered steep slopes that would be susceptible to mudflow. **The Hybrid Alternative would not result in an increased risk of inundation from seiche or mudflow and permanent impacts would be less than significant (Criterion F).**

Permanent Impacts

The Hybrid Alternative would change the hydrologic regime of the lagoon from the existing freshwater system to a hybrid system influenced by both seawater and freshwater, with a saltwater system created west of I-5 and a freshwater system maintained east of I-5. The hydrologic system west of I-5 would be influenced primarily by saltwater entering the system from an open tidal inlet during high tides, as well as freshwater entering the lagoon just downstream from I-5 and along the boundary of the lagoon. Under the Hybrid Alternative, water would exit the western portion of the lagoon primarily during ebb tides, with evapotranspiration and seepage providing additional output. The hydrologic system east of I-5 would be controlled primarily by freshwater entering the system from upstream and along the boundary of the lagoon, and outputs via evapotranspiration and seepage, or overflow at the I-5 weir.

Under the Hybrid Alternative, new channels would be created, existing channels would be expanded, and infrastructure would be improved to minimize constrictions and allow tidal exchange and enhanced circulation. Similar to the Saltwater Alternative, the existing weir would be removed and replaced with an open tidal inlet to provide tidal exchange. Residence times would decrease in basins with tidal flushing (i.e., Weir, Railroad, and Coast Highway) compared to existing conditions (Table 3.2-3). A channel would be constructed to connect the tidal inlet from the ocean area through the Weir Basin and into the Railroad Basin (Option A). Option B would be similar to the Saltwater Alternative, and would achieve tidal exchange via an open tidal inlet connecting the ocean to the Weir Basin, thereby improving tidal circulation and residence times throughout the basins west of I-5. Residence time for the I-5 Basin under the Hybrid Alternative would increase compared to existing conditions (Table 3.2-3). Similar to the Saltwater Alternative, the existing channel under Carlsbad Boulevard would be expanded to improve hydraulic connectivity between the Coast Highway Basin and the Railroad Basin and the Railroad bridge channel would be deepened. In addition, a new weir (spillway) would be constructed in the channel under the I-5 bridge to maintain a freshwater hydrologic regime in the portion of the lagoon east of I-5.

Drainage patterns would be altered and saltwater circulation within the lagoon would increase in the western portion of the lagoon (west of I-5) with the open inlet, improved channel network and flow regimes, and increased tidal flow. Hydrology throughout the lagoon would be enhanced through sediment and vegetation removal; 148,500 cy of vegetation and 833,000 cy of sediment would be removed from the lagoon under the Hybrid Alternative (Table 2-4). The eastern portion of the lagoon (east of I-5) would be dominated by freshwater entering the system from upstream and along the boundary of the lagoon. Sediment accumulation in the eastern portion of the lagoon is anticipated to be lower than historic rates due to urbanization of the watershed, leading to a decrease in sediment contained in runoff entering the lagoon from the upstream watershed.

The new tidal inlet would enable the lagoon to drain incoming freshwater more efficiently and improve flood performance in most basins during large storm events, leading to less potential in general for flooding hazards. Maximum water elevations under design storm events (i.e., 2-, 5-, 10-, 50-, and 100-year) would be lower than existing conditions in all basins west of I-5 (Table 3.2-1). Water levels in the I-5 Basin would remain similar to existing conditions or would increase, particularly under relatively small storm event conditions (Table 3.2-1). Table 3.2-2 shows that the overall area within the floodplain under a 100-year storm event would decrease. This increase would be due to the placement of the proposed weir under I-5, which would continue to control water drainage from the I-5 Basin.

Similar to the Saltwater Alternative, the increase in impervious area is expected to be minimal under the Hybrid Alternative and would include the Boardwalk and a stone revetment under the Carlsbad Boulevard bridge extending approximately 300 feet from the channel to the north and south to help stabilize the bridge abutments (PDF-1 and PDF-2) and meet required design and engineering standards. The stone revetment and proposed Boardwalk would require proper drainage designs per applicable regulatory requirements (i.e., Municipal Permit, SUSMP, HMP, LID BMPs) to eliminate or minimize increases in discharge flow rate, runoff volume, or erosion potential. By complying with the regulatory requirements and properly implementing appropriate BMPs, no significant changes to surface runoff patterns would occur. In addition, the new I-5 weir would be the same width as the existing channel under the bridge (36 feet) and would have the same elevation as the existing weir in the Weir Basin (+5.6 feet NGVD). The new I-5 weir would slightly increase water elevations in the I-5 Basin as compared to existing conditions (Table 3.2-1); however, increases would be minimal and would not be expected to substantially alter drainage patterns or surface runoff amounts. Therefore, there would be no anticipated substantial change in surface runoff amounts in the lagoon as a result of the Boardwalk, stone revetment, the tidal inlet, or the new I-5 weir. In a post-construction setting, temporary staging areas would be uncompacted, revegetated, and restored to pre-construction conditions.

The Hybrid Alternative would provide flood reduction potential compared to existing conditions. The lagoon channel network improvements would enhance hydraulic connectivity between the lagoon and ocean in the western portion of the lagoon (west of I-5), and allow fluvial flows to drain from the lagoon more efficiently. The new 100-foot-wide tidal inlet would improve flood performance over existing conditions. The proposed Boardwalk deck elevation would be located above the 100-year flood water surface elevation to prevent flooding, and the Carlsbad Boulevard bridge roadway elevation would be raised to accommodate flood flows under the bridge and eliminate flooding of the roadway during design storm conditions.

Improved circulation and drainage would generally reduce the potential for flooding to occur within the lagoon and along adjacent infrastructure during large storm events. Flood conditions would be greatly improved throughout the lagoon compared to existing conditions, as maximum water surface elevations would significantly decrease in all basins, with the exception of the I-5 Basin, under each storm return period as shown in Table 3.2-1. Water elevations in the I-5 Basin would increase slightly compared to existing conditions. The 100-year storm event floodplain would be reduced from 318 acres under existing conditions to 285 acres (Table 3.2-2). Water elevations and inundation during 100-year storm events would be reduced in flood-prone areas (Carlsbad Boulevard, north and west of the Weir Basin, including the St. Malo community, and east of the I-5 Basin) (Table 3.2-1 and Figure 3.2-3), minimizing hazards to people, structures, and facilities within these areas. Areas to the north and south of the I-5 Basin would still be flooded under 100-year storm events similar to existing conditions (Figure 3.2-3).

Flooding of adjacent infrastructure and/or roadways and the potential for exposure of people or property to flooding hazards would be reduced over existing conditions throughout the majority of the lagoon. Channel and infrastructure improvements would be reviewed by SANDAG, the City of Carlsbad, and the City of Oceanside, as appropriate, prior to approval of project grading plans to ensure flooding hazards would be minimized and requirements of the various jurisdictions are appropriately satisfied. In addition, the Hybrid Alternative would not require a CLOMR, which is needed if a proposed project causes an increase in flood elevation of greater than 1 foot and is within a flood area designated as Zone A.

Flow volumes and velocities through the lagoon may increase due to the open tidal inlet, creating the potential for erosion in western lagoon channels. Based on hydraulic analyses of water velocities conducted within the lagoon, velocities in the basins would be below 1 ft/s; however, velocities within the channels would be higher (exceeding 3 ft/s), thereby indicating a potential for channel scour, but would be limited to the channels and likely only occur during large storm events (Appendix C, Section 5). However, the lagoon channel cross sections (e.g., Carlsbad Boulevard channel and channel from tidal inlet to Railroad Basin) would be protected with erosion control products (i.e., riprap) and vegetated material to stabilize soils and foster natural recruitment from restoration planting, thus managing erosion during higher-velocity storm flows and preventing damage, as described in Table 2-9, Standard Construction Practice. These efforts would limit the time that erosive soils would be exposed and would not result in substantial long-term erosion. In addition, similar to the Saltwater Alternative, it is expected that a flood shoal would form within the enhanced lagoon with the addition of the open tidal inlet and large tidal prism (Everest 2014e). This flood shoal would be removed during regular inlet maintenance to maintain an open inlet condition; approximately 27,000 cy of sediment is anticipated to be removed every 12 to 20 months (Everest 2014e). **Compliance with applicable regulatory requirements and implementation of appropriate BMPs would ensure the Hybrid Alternative would not result in a substantial alteration to existing drainage patterns that would cause substantial scour or erosion, increased runoff flow rates or volume resulting in**

flooding or an exceedance of drainage system capacity, increased exposure to water-related hazards, or placement of structures that would impede flood flows. Permanent impacts would be less than significant (Criteria B, C, D, and E).

Similar to the Saltwater Alternative, the Hybrid Alternative would enlarge the tidal channel network in the western portion of the lagoon and enhance the ability of the lagoon to drain incoming freshwater flows more efficiently. The existing level of hydrologic connectivity between groundwater and the lagoon would not be expected to substantially decrease recharge characteristics. **The Hybrid Alternative would not result in substantial depletion of groundwater supplies or interference with groundwater recharge, and permanent impacts would be less than significant (Criterion A).**

Similar to the discussion under temporary impacts, the potential for seiche hazard would not increase under the Hybrid Alternative (Appendix N). The long periods of seiche oscillations fall outside of the period range where earthquake ground motion carry the most energy, and wave-driven seiche hazards would also decrease compared to existing conditions because of proposed changes in depth. As discussed in Section 3.2.1, the terraces in the area where maintenance activities would occur are not considered steep slopes that would be susceptible to mudflow. **The Hybrid Alternative would not result in an increased risk of inundation from seiche or mudflow and permanent impacts would be less than significant (Criterion F).**

Long-term Benefits

Under the Hybrid Alternative options, water elevations would be reduced in all basins except the I-5 Basin during all storm events (i.e., 2-, 5-, 10-, 50-, and 100-year), thereby reducing flooding impacts. This alternative would reduce water elevations in all basins except the I-5 Basin to a greater extent than either the Saltwater Alternative or the Freshwater Alternative, with a reduction of between 5 and 6 feet during a 100-year storm event. The 100-year storm event floodplain would be reduced from 318 acres under existing conditions to 285 acres. The Hybrid Alternative would also result in long-term circulation and drainage pattern improvements and decreased residence times due to the open inlet, improved channel network and flow regimes, increased tidal flow, and continued vegetation and sediment removal. These benefits would not occur in the I-5 Basin, which would remain relatively similar to the Freshwater Alternative.

No Project Alternative

Under the No Project Alternative, tidal flows would continue to be restricted due to the existing weir at the ocean outlet and the lagoon would remain a freshwater-dominated system. No vegetation or sediment removal would occur and no improvements to infrastructure would occur to minimize constrictions at crossings to create better flow throughout the basins. Narrow channels under I-5 and Carlsbad Boulevard would continue to constrict flows throughout the basins. The condition of stormflows being constricted by narrow channels and bottlenecks at the weir and under the I-5 bridge would continue under the No Project Alternative.

It is anticipated that the overall hydrological functions of the lagoon would continue to degrade under the No Project Alternative as the lagoon continues to experience sedimentation and expansion of vegetation. In addition, as open water in the lagoon continues to decrease, existing flood water elevations would continue to rise compared to existing conditions (0.5 to 1 foot increase at a minimum). Decreased flood water elevations that would be provided under the various Enhancement Project alternatives (with the exception of the I-5 Basin in the Hybrid Alternative) would not occur under the No Project Alternative. The extent to which flood risks would increase is speculative, and would depend on the rate and pattern of sedimentation and vegetation encroachment. Flooding performance would worsen under the No Project Alternative, and **impacts to hydrology would be significant (Criteria A through E).**

3.2.4 Mitigation Measures

Given the compliance with required storm water permits (i.e., Municipal Permit, Construction General Permit, SUSMP, HMP), as well as conformance to proper BMP design, implementation, and maintenance mandated by permits and associated regulations, no substantial impacts to hydrology would be expected as a result of the proposed implementation and impacts would be less than significant. No additional mitigation measures are required.