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ANCHOR QEA

Memorandum

November 8, 2019

To: Cindy Kinkade, AECOM

From: David Cannon, PE

Re: Buena Vista Lagoon Enhancement Project – Engineering Analyses for the Modified Saltwater Alternative

At the request of the San Diego Association of Governments (SANDAG), Anchor QEA, LLC, (Anchor QEA) conducted engineering to evaluate the Modified Saltwater Alternative for the Buena Vista Lagoon Enhancement Project (Enhancement Project). This technical memorandum documents the methods, findings, and conclusions of the engineering analyses and fluvial and tidal hydrodynamic modeling, which supplements the engineering analyses for the Enhancement Project conducted by Everest International Consultants, Inc., (Everest) in 2014 (Everest 2014a). The Anchor QEA staff who worked on this task formerly worked on the Enhancement Project while employed at Everest.

Background

Buena Vista Lagoon (Lagoon) consists of four basins connected by three hydraulic connections. For the Enhancement Project, Everest conducted engineering analyses, tidal and fluvial hydrodynamic modeling for existing conditions, and the following four wetlands enhancement alternatives:

- Saltwater Alternative
- Freshwater Alternative
- Hybrid Alternative A (mix of saltwater and freshwater with channel in Weir Basin)
- Hybrid Alternative B (mix of saltwater and freshwater without channel in Weir Basin)

The *Buena Vista Lagoon Enhancement Project Final Environmental Impact Report* (Final EIR; AECOM 2017) that documents the environmental impacts of the alternatives listed above was completed in September 2017. During the deliberation on the certification of the Final EIR in November 2018, the SANDAG Board of Directors (BOD) heard public testimony from property owners who own land critical for the implementation of the Enhancement Project. The BOD postponed action for 6 months to provide time for development of a proposal that would reflect modifications requested by the property owners and thus avoid litigation while meeting SANDAG's project objectives. Those efforts resulted in a proposal that is a variant of the Saltwater Alternative and Hybrid Alternative A; it reflects public desire and agency input, while still achieving the stated project objectives. This proposed configuration that combines the configurations of the Saltwater Alternative and Hybrid Alternative A with some minor modifications is referred to as the "Modified Saltwater Alternative."

Overview of the Modified Saltwater Alternative

The Modified Saltwater Alternative represents an enhancement configuration that provides a saltwater hydrologic regime with expanded hydraulic connections. This alternative would achieve the enhancement objectives primarily through elimination of existing exotic vegetation, dredging to remove excess sediment, and establishment of continuous tidal exchange. A plan view of the Modified Saltwater Alternative proposed grading is presented in Figure 1.

Prominent features of the Modified Saltwater Alternative include the following:

- Existing vegetation would be removed and subsequently disposed.
- A total of 937,000 cubic yards (cy) would be excavated or dredged.
- Saltwater habitat would be created in the I-5 Basin with a subtidal channel having a bottom elevation of -2.5 feet North Geodetic Vertical Datum (NGVD). The three existing islands in the western part of the I-5 Basin would be kept at existing elevations.
- Saltwater habitat would be created in the Coast Highway Basin (CH Basin) with a subtidal channel running through the central part of the basin. The bottom elevation of the channel would be -2.5 feet NGVD.
- Saltwater habitat would be created in the Railroad Basin (RR Basin) with a bottom elevation of -2.5 feet NGVD. This area would serve as a sand trap for littoral sands entering the Lagoon through the newly created tidal inlet.
- A channel in the Weir Basin would be created by building a channel guide along the north side of the channel across the Weir Basin. The southern edge of the channel would be defined by the southern bank of the Weir Basin. The channel conveys fluvial and tidal flows between the RR Basin and tidal inlet. The area to the north of the channel guide would be a water basin with restricted tidal exchange. The crest elevation of the channel guide and a water control structure to control the water level in the western Weir Basin would be determined in a future design phase.
- The new I-5 Bridge structure being developed by the California Department of Transportation (Caltrans) was assumed to be in place for this analysis. The channel cross section would have an invert elevation of -2.5 feet NGVD. The bottom width of the channel would be 105 feet, with a slope of 1V:2H on both sides of the channel.
- A new Carlsbad Boulevard Bridge would be built as part of the Enhancement Project under this alternative or as a separate project in conjunction with this alternative. The new bridge would have adequate clearance and channel width to accommodate fluvial and tidal flows. The bottom elevation would be level with the bottom elevation of the channels upstream and downstream of the hydraulic connection, which would be -2.5 feet NGVD. The bottom width of the hydraulic connection would be 110 feet with vertical slopes on both sides of the channel.

Figure 1
Modified Saltwater Alternative Plan View

- The new North County Transit District (NCTD) Railroad Bridge structure being developed by NCTD and SANDAG was assumed to be in place for this analysis. The channel bottom elevation would be equal to the bottom elevation of the channels upstream and downstream of the hydraulic connection, which would be -2.5 feet NGVD. The bottom width of the channel would be 90 feet with an average slope of 1V:8.5H on the north side and 1V:11.5H on the south side.
- The existing 50-feet-wide weir would be replaced with a tidal inlet to provide continuous tidal exchange between the Lagoon and ocean. The tidal inlet would be stabilized with channel guides. The top width of the inlet at an elevation of 6 feet NGVD would be 100 feet. The inlet channel would be designed with an invert elevation of -2.0 feet NGVD. The slope of the channel guide would be 1V:2H.
- There would be a tidal inlet maintenance program to keep the Lagoon open to tidal exchange.
- The pedestrian boardwalk that is being planned is included in the analysis. It would run parallel to Carlsbad Boulevard, providing a pedestrian crossing over the Lagoon.

Vegetation Removal and Soil Excavation

Like the other Enhancement Project alternatives, the Modified Saltwater Alternative would involve the removal and disposal of a substantial volume of vegetation. It is estimated that approximately 211,000 cy of vegetation would be removed from the four basins under the Modified Saltwater Alternative. This is the same amount of vegetation as that of the Saltwater Alternative. Table 1 shows the volume of vegetation to be removed by basin.

Table 1
Modified Saltwater Alternative Volume of Materials to be Removed

Type of Material	Volume by Basin (cy)				Total
	Weir Basin	RR Basin	CH Basin	I-5 Basin	
Vegetation	1,000	14,000	104,000	92,000	211,000
Soil	33,500	95,000	488,000	320,500	937,000

The Enhancement Project would require the excavation of approximately 937,000 cy of soil from the four basins under the Modified Saltwater Alternative. The distribution of this earthwork between the four basins for each alternative is presented in Table 1.

Possible disposal options previously determined based on the content of sand in the excavated material would be adopted for the Modified Saltwater Alternative. Like the other Enhancement Project alternatives, two approaches to handle the soil disposal would be adopted for the Modified Saltwater Alternative. Approach 1 would dispose of the material that is suitable for beneficial reuse on nearby beaches and the nearshore and would dispose of fine-grained material offshore. Approach 2 would dispose of the material that is suitable for beneficial reuse on nearby beaches and the nearshore. Additionally, Approach 2 would dispose of fine-grained material in an overdredge pit on site where the existing material being replaced is found to be suitable for beneficial reuse within the littoral zone, on the beach, or in the nearshore. Table 2 provides the earthwork quantities under each disposal and reuse scenario for the Modified Saltwater Alternative. For Approach 2, the overdredge pit that would be constructed in the CH Basin would have an area of 1,100 feet in diameter at the existing ground surface, a side slope of 1V:5H, and a depth of 38 feet. The amount of fine-grained material that would be disposed in the overdredge pit would be about 798,000 cy. It should be noted that the previous soil characterization studies were based on composite samples of a few locations and to a limited depth below ground. Further soil characterization investigations during the future phase of the Enhancement Project would provide more precise soil characterization estimates.

Table 2
Material Disposal Approaches for the Modified Saltwater Alternative

Construction Approach	Volume of Disposal (cy)	
	Approach 1	**Approach 2**
Beach		
Oceanside	119,000	245,000
North Carlsbad	0	0
Nearshore		
Oceanside	33,000	692,000
LA-5	785,000	0
Total Export	937,000	937,000

Tidal and Fluvial Modeling

Model Scenarios

The study approach (Everest 2014a) developed for the other Enhancement Project alternatives was used to study the potential impacts of flooding associated with the Modified Saltwater Alternative and to estimate the tidally influenced wetlands habitat distributions under current (Year 2020), Year 2050, and Year 2100 mean sea level conditions. In the Everest (2014a) study, the mean sea level rise projections were based on the guidance of the California Ocean Protection Council (2013). The 2D numerical hydrodynamic model known as TUFLOW was used to conduct the numerical tidal and fluvial hydraulic modeling. The model was also used for providing information to estimate tidal prism, which would predict the inlet stability of the Modified Saltwater Alternative. Twenty scenarios were developed to achieve the study objectives. These scenarios are listed in Table 3.

Table 3
Modeling Scenarios

Lagoon Condition	Scenario Number	Sea Level Year	Flood Flow	Tide	Hydraulic Constriction Conditions							Objective
					Outlet/ Inlet	Railroad Bridge	Railroad Channel	Coast Highway Bridge	Coastal Highway Channel	I-5 Bridge	I-5 Channel	
Modified Saltwater Alternative	101	2020	2	Mean-Hi	Transition	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish max. WSE
	102	2020	5	Mean-Hi	Transition	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish max. WSE
	103	2020	10	Mean-Hi	Transition	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish max. WSE
	104	2020	50	Mean-Hi	Transition	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish max. WSE
	105	2020	100	Mean-Hi	Transition	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish max. WSE
	106	2020	None	Mean-Hi	Transition	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Tidal prism
	107	2020	100	Mean-Lo	Transition	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish max. velocity
	108	2020	None	TEA	Open	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish habitat dist.
	109	2020	None	TEA	Transition	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish habitat dist.
	110	2020	None	TEA	Closed	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish habitat dist.
	111	2050	100	Mean-Hi	Transition	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish max. WSE
	112	2050	100	Mean-Lo	Transition	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish max. velocity
	113	2050	None	TEA	Open	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish habitat dist.
	114	2050	None	TEA	Transition	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish habitat dist.
	115	2050	None	TEA	Closed	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish habitat dist.
	116	2100	100	Mean-Hi	Transition	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish max. WSE
	117	2100	100	Mean-Lo	Transition	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish max. velocity
	118	2100	None	TEA	Open	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish habitat dist.
	119	2100	None	TEA	Transition	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish habitat dist.
	120	2100	None	TEA	Closed	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Proposed Bridge	Proposed Channel	Establish habitat dist.

Notes:
Inlet proposed: 100 feet wide
Proposed Coast Highway Bridge includes the boardwalk
2020 Sea Level: 1983 to 2001 Tidal Epoch sea level
2050 Sea Level: +2.0 feet
2100 Sea Level +5.5 feet

Mean-Hi: mean tide with timing to get high water surface elevation
Mean-Lo: mean tide with timing to get high water velocity
TEA: Tidal Epoch Analysis tide used to estimate habitat distribution
WSE: Water Surface Elevation

Model Domain and Bathymetry

The TUFLOW model domain and bathymetry for the Modified Saltwater Alternative are shown in Figure 2. The proposed Lagoon grading shown in Figure 1 was used to prepare the TUFLOW model grid shown in Figure 2. The Modified Saltwater Alternative model grid was setup based on the hydraulic connections that are summarized in Table 4. In addition, the Modified Saltwater Alternative model grid included a proposed pedestrian boardwalk that would be constructed parallel to the Carlsbad Boulevard. The tidal inlet bottom elevations would vary from -2.0 feet NGVD to +2.3 feet NGVD. The transitional condition of the tidal inlet with a bottom elevation of -0.5 foot NGVD was used in the analyses as this condition represents the most prevailing and average condition of the tidal inlet in a maintenance dredging cycle. The open and closed conditions were also used in the tidal hydraulics analyses to estimate the possible ranges of inundation frequencies and corresponding habitat distributions across a full maintenance dredging cycle.

Figure 2
TUFLOW Model Domain and Bathymetry for Modified Saltwater Alternative

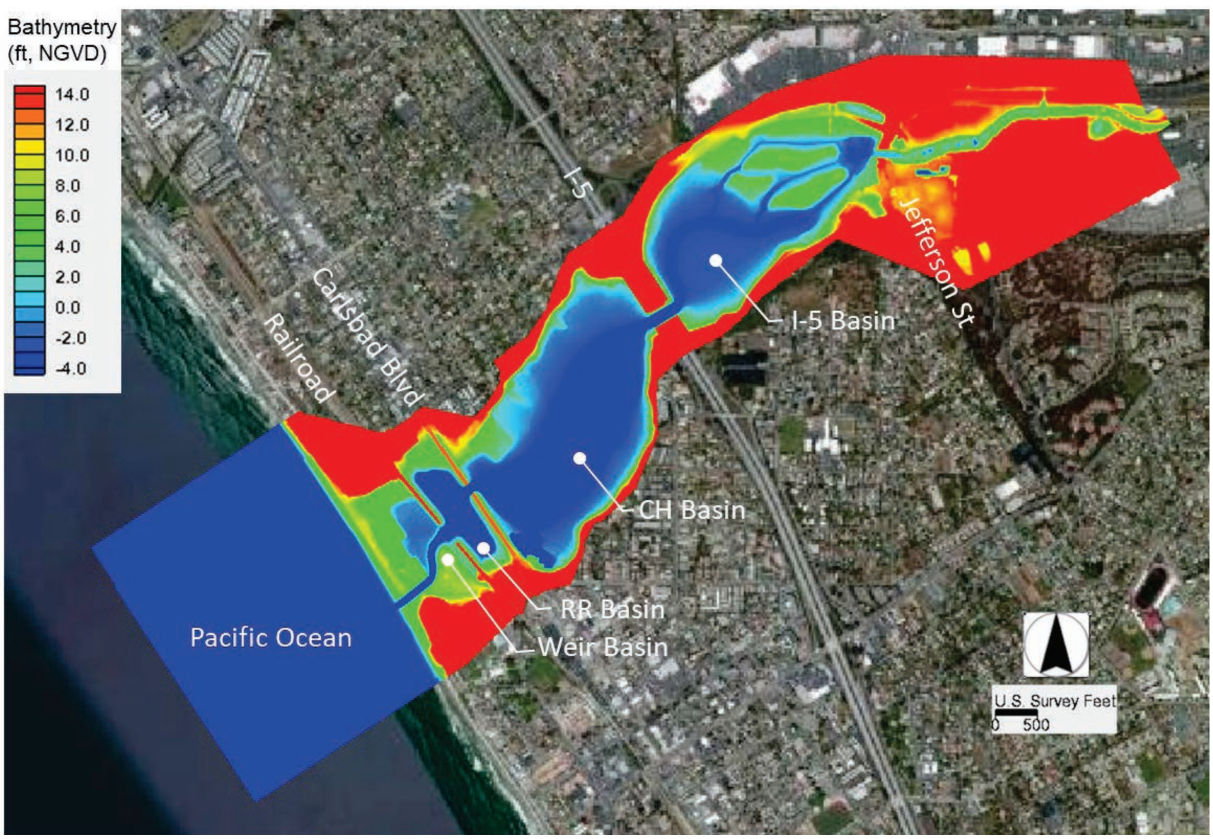


Table 4
Modified Saltwater Alternative Hydraulic Conditions

Structure	Top/Bottom Width (ft)	Bottom Elevation (ft NGVD)	Channel Side Slope (H:V)
Tidal Inlet	100 (top width)	-2.0/-0.5/+2.3*	2:1
Railroad Bridge	90 (bottom width)	-2.5	11.5:1 (S), 8.5:1 (N)
Carlsbad Boulevard Bridge	110 (bottom width)	-2.5	Vertical
I-5 Bridge	105 (bottom width)	-2.5	2:1

Notes:
* open/transition/close inlet conditions
H:V: horizontal to vertical
N: north side
S: south side

Fluvial Hydraulics

Model Boundary Conditions

The flood impact of the Modified Saltwater Alternative scenario was modeled in TUFLOW using the model grid presented in the Model Domain and Bathymetry section of this technical memorandum. The set of model input used in the Enhancement Project fluvial hydraulic analyses (Everest 2014a) was applied to the Modified Saltwater Alternative model.

Downstream Ocean Boundary: Mean Tide

The model input at the downstream ocean boundary for Year 2020 mean tide condition is shown in Figure 3. For sea level rise analysis, projected rises of the mean sea levels by 2.0 feet and 5.5 feet, respectively, for 2050 and 2100 were added to the 2020 tide water elevations (Everest 2014a). The projected tide elevations at the downstream boundary for Year 2050 and Year 2100 are shown in Figure 4.

Upstream Boundary: Flood Flows

Flood events of different magnitudes ranging from 2-year to 100-year return periods were applied at the upstream boundary. The time series of these flood flows entering the Lagoon are shown in Figure 3. The timing of the peak of the flood flow input relative to the peak tide input was set to generate the greatest flood impact to the project area.

Figure 3
Flood and Mean Tide Hydrographs

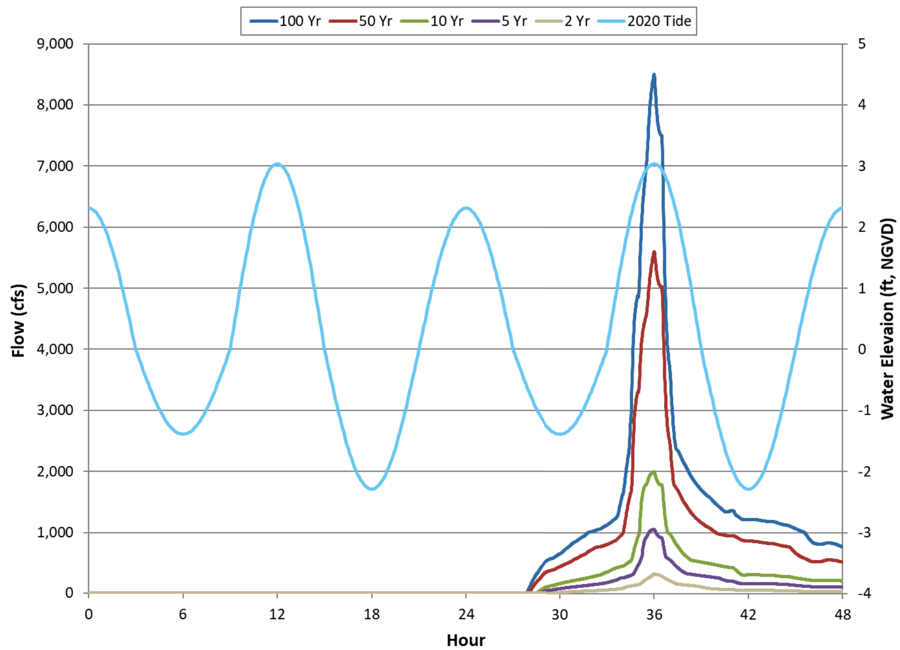
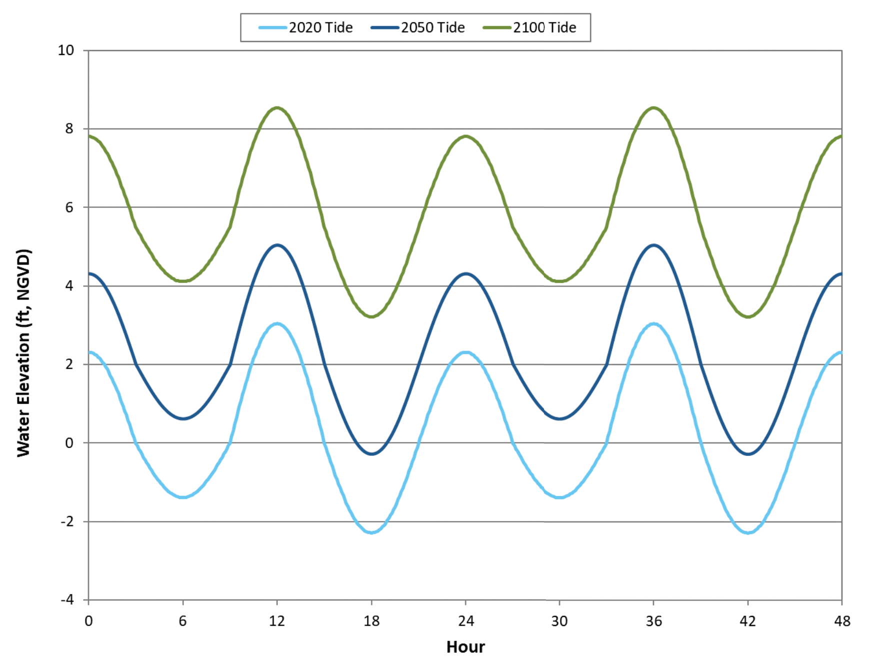


Figure 4
Projected Mean Tide Elevation Time Series for Years 2050 and 2100



Results of Fluvial Hydraulic Analysis

Results: Water Elevations

The movement of water within the Modified Saltwater Alternative project area under different flood scenarios was simulated in TUFLOW. Water elevations output from TUFLOW for the Modified Saltwater Alternative was analyzed to evaluate the potential flood impacts of storm events of various magnitudes. In Table 5, the maximum water elevations in the four basins under a 100-year storm event for the Modified Saltwater Alternative (shown in bold type) are summarized and compared with those of the "Existing/No Project" conditions.

Table 5
Results of Maximum Water Elevation by Basin Under Year 2020, Year 2050, and Year 2100 Mean Sea Level Conditions for the 100-Year Storm Event

	Maximum Water Elevation (ft NGVD)							
	Weir Basin		RR Basin		CH Basin		I-5 Basin	
Sea Level Year	Existing/ No Project	Modified Saltwater Alternative	Existing/ No Project	Modified Saltwater Alternative	Existing/ No Project	Modified Saltwater Alternative	Existing/ No Project	Modified Saltwater Alternative
2020	12.0	**7.0**	12.1	**7.4**	12.1	**7.7**	15.8	**8.1**
2050	12.7	**7.6**	12.8	**8.0**	12.9	**8.4**	16.9	**8.8**
2100	13.1	**9.7**	13.2	**10.0**	13.3	**10.6**	17.0	**10.9**

Figure 5 shows a plan view plot of the maximum water elevations of the project area during a 100-year storm event under Year 2020 mean sea level conditions. Figures 6 and 7 show the plan view plots of maximum water elevation results during the same storm under mean sea level rise conditions in Year 2050 and Year 2100, respectively. Figure 8 presents the maximum water elevation profiles for various storm and mean sea level scenarios modeled in TUFLOW. These elevation profiles for different scenarios are maximum water elevation results taken along the center line of the Lagoon that runs from the upstream boundary to the Lagoon inlet/outlet.

Figure 5
Maximum Water Elevations Under Modified Saltwater Alternative During a 100-Year Storm in Year 2020

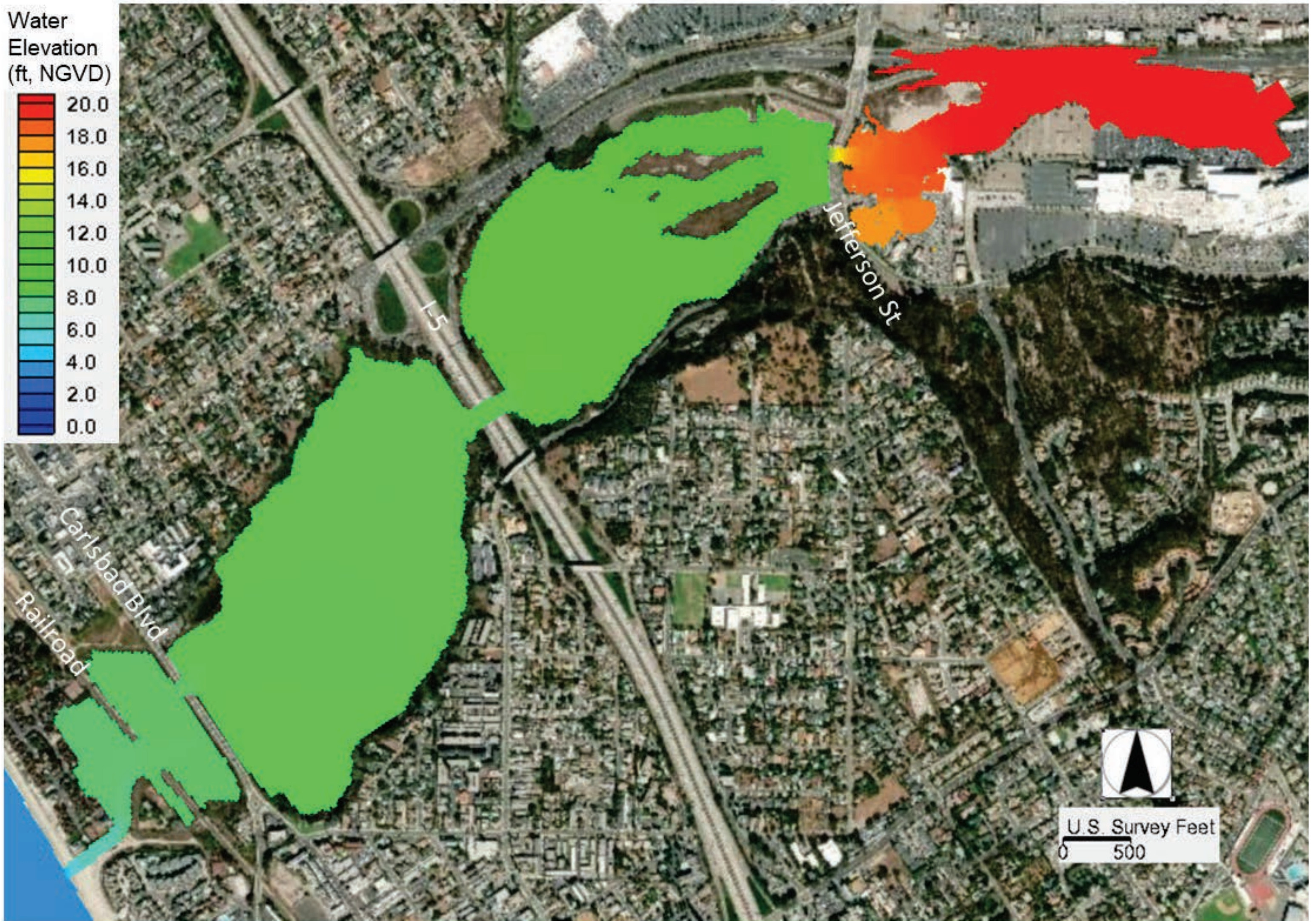
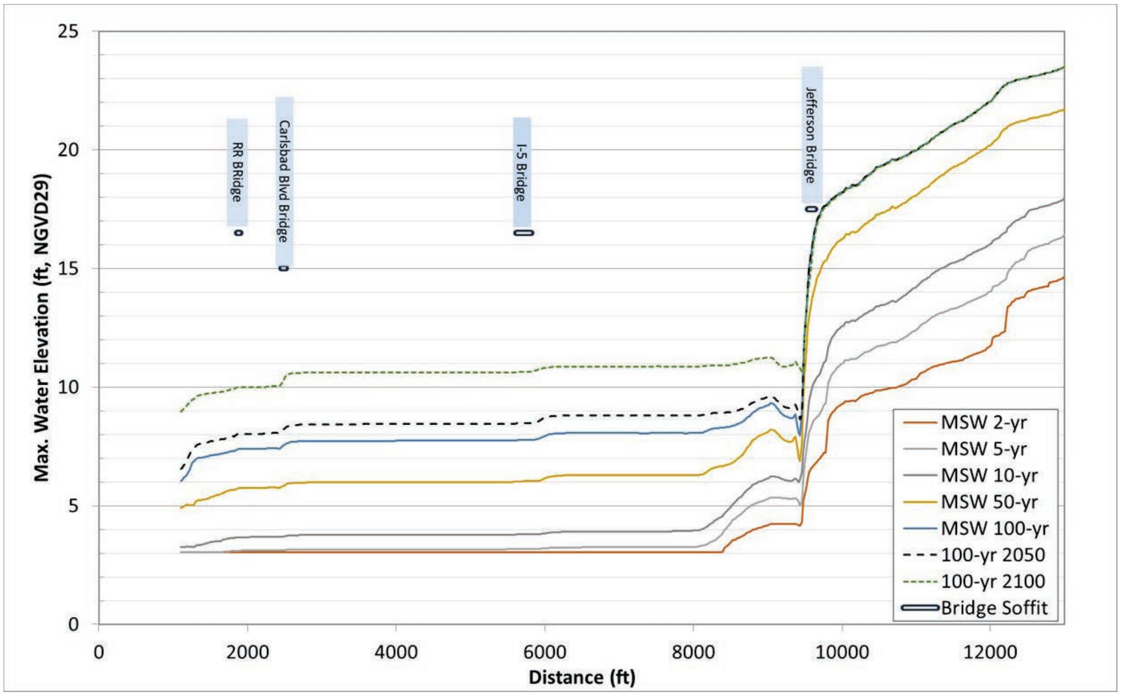


Figure 6
Maximum Water Elevations Under Modified Saltwater Alternative During a 100-Year Storm in Year 2050

Figure 7
Maximum Water Elevations Under Modified Saltwater Alternative During a 100-Year Storm in Year 2100

Figure 8
Maximum Water Elevation Profile Under Modified Saltwater Alternative



Comparison of Fluvial Results Among Alternatives

To compare the flooding results under the Modified Saltwater Alternative with the other enhancement alternatives and existing conditions (Everest 2014a), the maximum water elevation results for each enhancement alternative and the existing conditions are summarized in Table 6 for each basin for storm events of different return periods. Figure 9 compares maximum water elevation profiles along the center line of the Lagoon for all the alternatives and existing conditions during a 100-year flood event.

To compare impacts of mean sea level rise conditions on flood impacts, the maximum water elevations under current mean sea level and future mean sea level rise conditions during a 100-year storm event are presented in Table 7. The maximum water elevation results are presented for each basin for the current mean sea level (Year 2020) and future mean sea level rise conditions (Years 2050 and 2100).

Based on the model results, flood conditions would generally be improved with implementation of the Modified Saltwater Alternative since flood elevations under the Modified Saltwater Alternative are lower than or equal to flood elevations under existing conditions. Overall, the Modified Saltwater Alternative would perform similarly to the Saltwater Alternative.

Table 6
Comparison of Fluvial Results under 2020 Mean Sea Level Conditions

Storm Return Period (Year)	Alternative	Maximum Water Elevation (ft, NGVD)			
		Weir Basin	RR Basin	CH Basin	I-5 Basin
100	Existing Conditions	12.0	12.1	12.1	15.8
	Saltwater Alternative	7.0	7.3	7.7	8.2
	Modified Saltwater Alternative	**7.0**	**7.4**	**7.7**	**8.1**
	Freshwater Alternative	9.6	9.7	10.4	15.4
	Hybrid Alternative A	6.6	6.8	7.1	15.9
	Hybrid Alternative B	6.6	6.8	7.1	15.9
50	Existing Conditions	10.2	10.2	10.3	13.3
	Saltwater Alternative	5.4	5.7	6.0	6.5
	Modified Saltwater Alternative	**5.2**	**5.7**	**6.0**	**6.3**
	Freshwater Alternative	8.0	7.9	9.0	12.9
	Hybrid Alternative A	5.2	5.4	5.6	13.7
	Hybrid Alternative B	5.2	5.4	5.6	13.8
10	Existing Conditions	7.7	7.7	7.8	8.9
	Saltwater Alternative	3.5	3.6	3.8	4.0
	Modified Saltwater Alternative	**3.3**	**3.7**	**3.8**	**3.9**
	Freshwater Alternative	6.9	6.9	7.1	8.4
	Hybrid Alternative A	3.1	3.2	3.3	9.7
	Hybrid Alternative B	3.1	3.2	3.3	9.7
5	Existing Conditions	6.9	6.9	6.9	7.4
	Saltwater Alternative	3.1	3.1	3.2	3.3
	Modified Saltwater Alternative	**3.0**	**3.1**	**3.2**	**3.3**
	Freshwater Alternative	6.5	6.5	6.5	7.0
	Hybrid Alternative A	3.0	3.0	3.0	9.1
	Hybrid Alternative B	3.0	3.0	3.0	9.2
2	Existing Conditions	6.1	6.1	6.1	6.2
	Saltwater Alternative	2.8	2.8	2.9	2.9
	Modified Saltwater Alternative	**3.0**	**3.0**	**3.0**	**3.0**
	Freshwater Alternative	6.0	6.0	6.0	6.0
	Hybrid Alternative A	3.0	3.0	3.0	7.1
	Hybrid Alternative B	3.0	3.0	3.0	7.1

Figure 9
Maximum Water Elevation Profiles Comparison Among Enhancement Project Alternatives

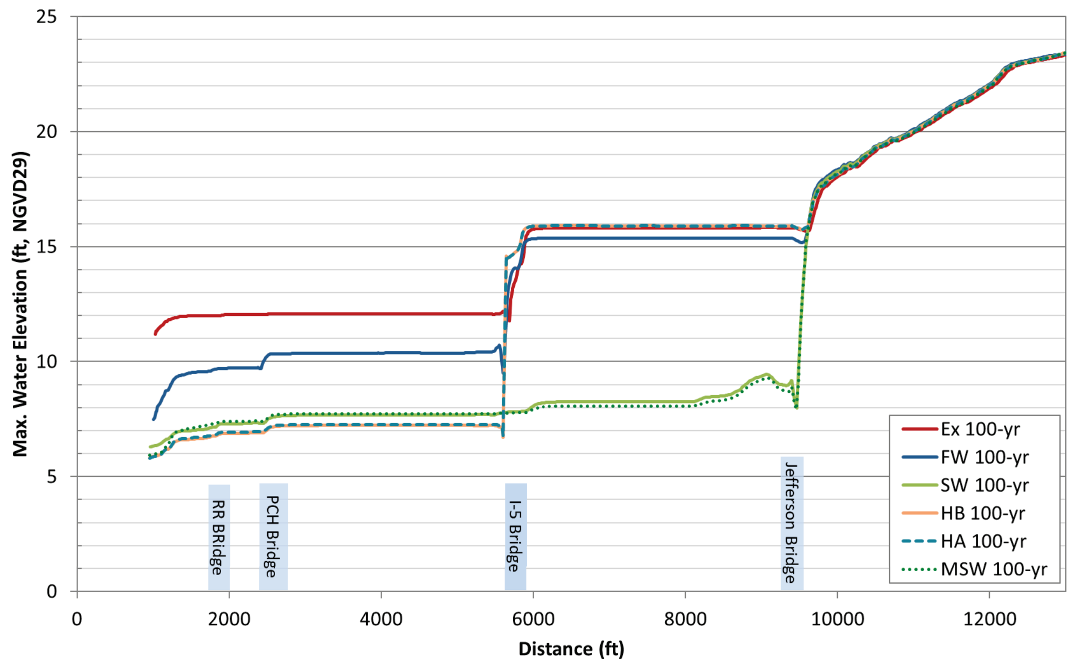


Table 7
Comparison of Fluvial Results Under Year 2020, Year 2050, and Year 2100 Mean Sea Level Conditions for the 100-yr Storm Event

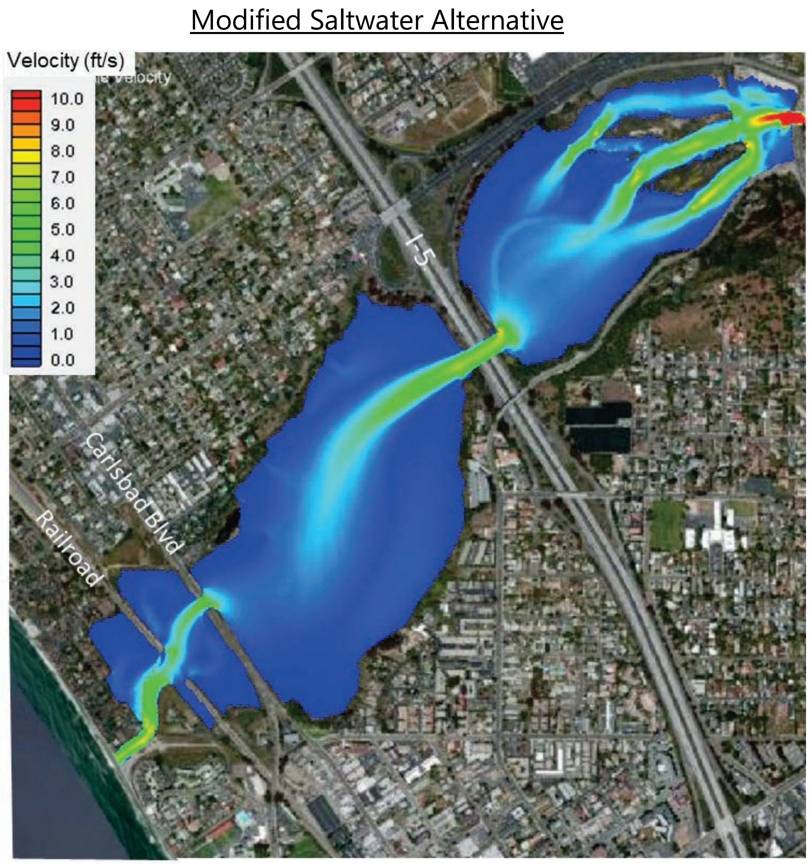
Sea Level Conditions	Alternative	Maximum Water Elevation (ft, NGVD)			
		Weir Basin	RR Basin	CH Basin	I-5 Basin
2020	Existing Conditions	12.0	12.1	12.1	15.8
	Saltwater Alternative	7.0	7.3	7.7	8.2
	Modified Saltwater Alternative	**7.0**	**7.4**	**7.7**	**8.1**
	Freshwater Alternative	9.6	9.7	10.4	15.4
	Hybrid Alternative A	6.6	6.8	7.1	15.9
	Hybrid Alternative B	6.6	6.8	7.1	15.9
2050	No-Project Conditions	12.7	12.8	12.9	16.9
	Saltwater Alternative	7.5	7.9	8.3	8.8
	Modified Saltwater Alternative	**7.6**	**8.0**	**8.4**	**8.8**
	Freshwater Alternative	9.6	9.7	10.4	15.4
	Hybrid Alternative A	7.1	7.4	7.9	16.0
	Hybrid Alternative B	7.1	7.4	7.9	16.0
2100	No-Project Conditions	13.1	13.2	13.3	17.0
	Saltwater Alternative	9.5	9.8	10.4	10.8
	Modified Saltwater Alternative	**9.7**	**10.0**	**10.6**	**10.9**
	Freshwater Alternative	10.0	10.2	10.6	15.4
	Hybrid Alternative A	9.1	9.3	9.7	16.0
	Hybrid Alternative B	9.1	9.3	9.7	16.0

Results: Velocities

The fluvial velocities were studied to evaluate the erosion potential in the Lagoon during storm events and to provide velocities at the bridge crossings for the Modified Saltwater Alternative such that adequate erosion control measures can be developed in the future. Maximum velocities were plotted for the project area during the 100-year storm event. Figure 10 shows the maximum velocities of the Enhancement Project during a 100-year storm event in Year 2020 for the Modified Saltwater Alternative. The velocity results for the Saltwater Alternative (Everest 2014a) are also shown side by side for comparison. Figures 11 and 12 show the maximum velocities during a 100-year storm event under Year 2050 and Year 2100 mean sea level rise conditions, respectively.

In general, the velocity results are similar to that of the Saltwater Alternative. The fluvial hydraulic analysis water velocity results revealed that the velocities in the basins would be below 1 foot per second (ft/s), except in the defined channel running through the basins. This suggests that erosion would be limited to the channel and would likely only occur during large storm events. The predicted velocities are higher at the hydraulic connections with velocities exceeding 3 ft/s, thereby indicating a potential for erosion. Like the Saltwater Alternative, slope protection would be required in these areas to protect the side slopes and bridge infrastructure from erosion.

Figure 10
Maximum Water Velocities Under Modified Saltwater Alternative and Saltwater Alternative During a 100-Year Storm in Year 2020



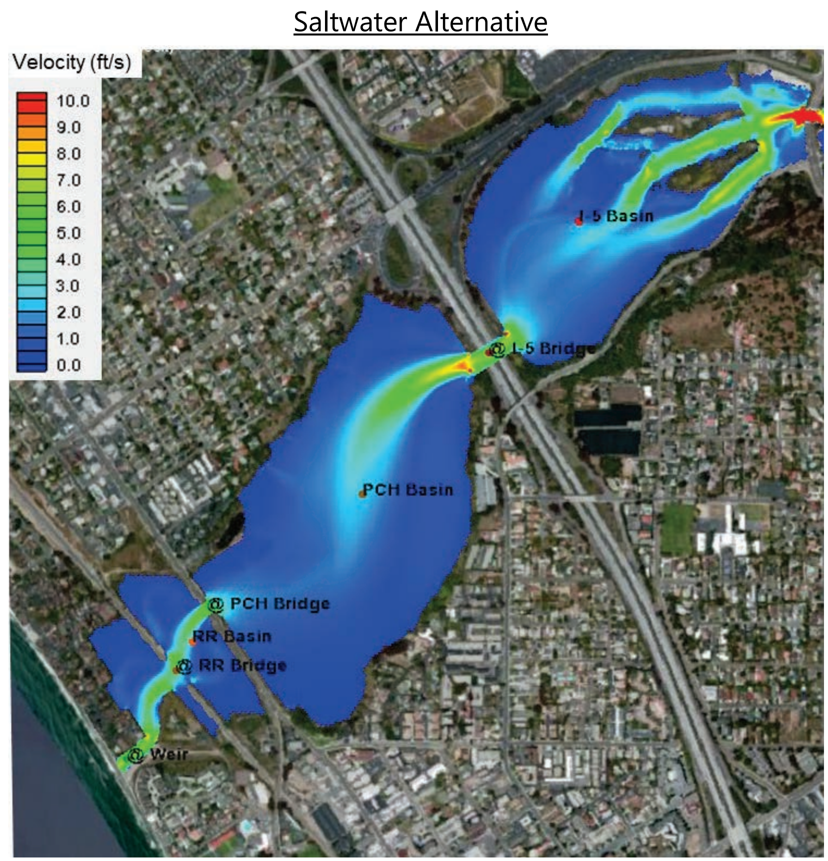
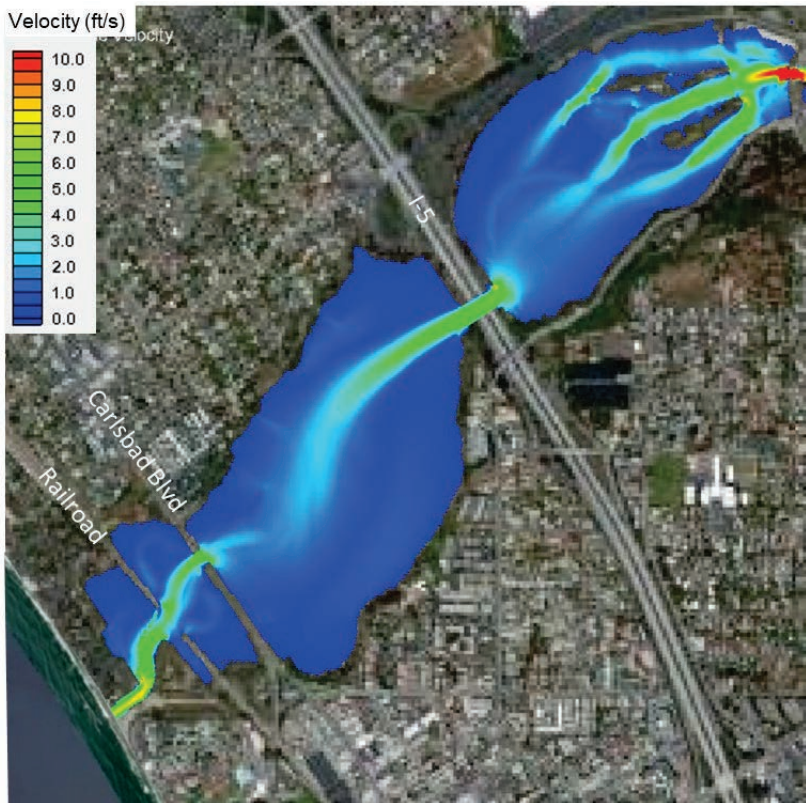


Figure 11
Maximum Water Velocities Under Modified Saltwater Alternative and Saltwater Alternative During a 100-Year Storm in Year 2050

Modified Saltwater Alternative



Saltwater Alternative

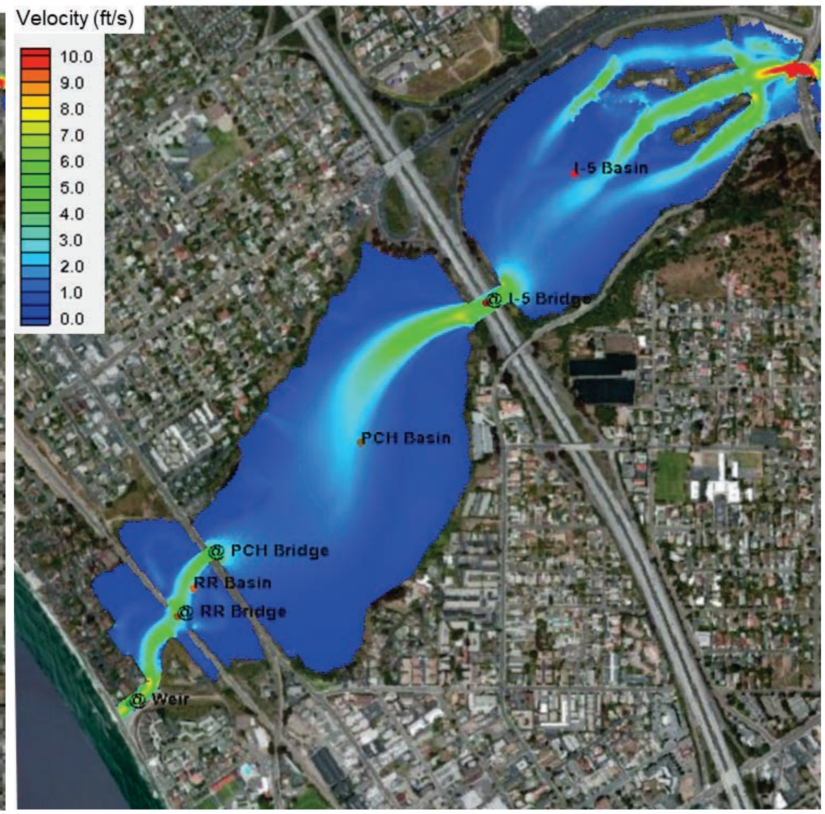
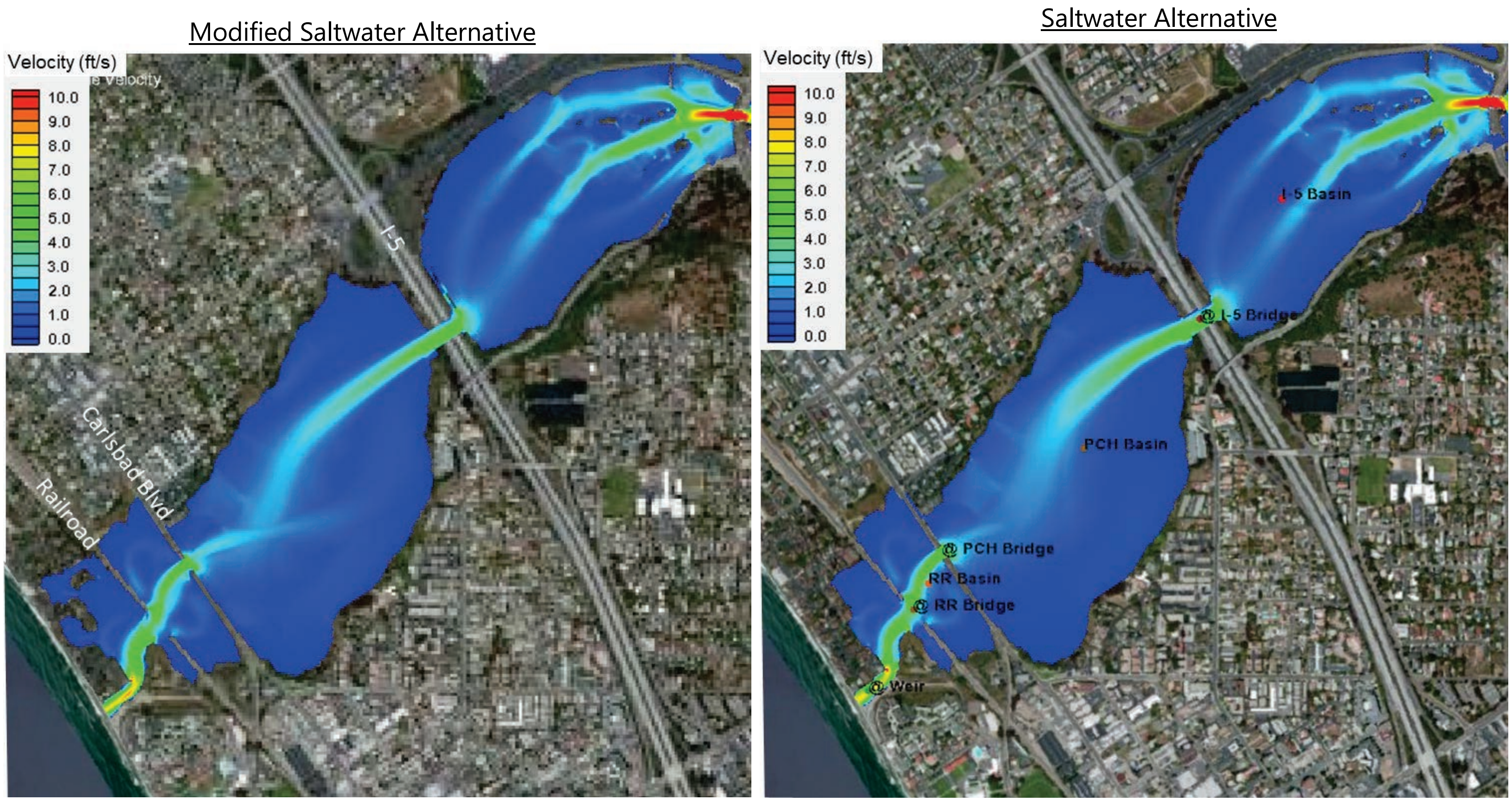


Figure 12
Maximum Water Velocities Under Modified Saltwater Alternative and Saltwater Alternative During a 100-Year Storm in Year 2100



Tidal Hydraulic Analysis

Using the TUFLOW numerical model, the tidal hydraulics analysis was conducted to simulate long-term tidal responses (water level fluctuations) in the Lagoon under the Modified Saltwater Alternative condition. This tidal response was used to determine the inundation frequencies from which habitat distribution within the Lagoon was estimated for the four basins.

Model Boundary Conditions

Downstream Ocean Boundary: Tidal Epoch Analysis Tidal Series

To simulate the long-term tidal responses in the Lagoon, a 30-day representative tidal series was used as the boundary condition at the ocean boundary of the model. This is the same input as was used in the Everest (2014a) study for other enhancement alternatives. Figure 13 shows the Tidal Epoch Analysis (TEA) tidal series for the current (2020) mean sea level condition. To evaluate habitat distribution in future sea level rise conditions, the TEA tidal series for Year 2050 and Year 2100 previously developed and applied to other alternatives were used at the ocean boundary of the Modified Saltwater Alternative. Figure 14 shows the TEA tide series for Year 2050 and Year 2100.

Figure 13
2020 TEA Tidal Series

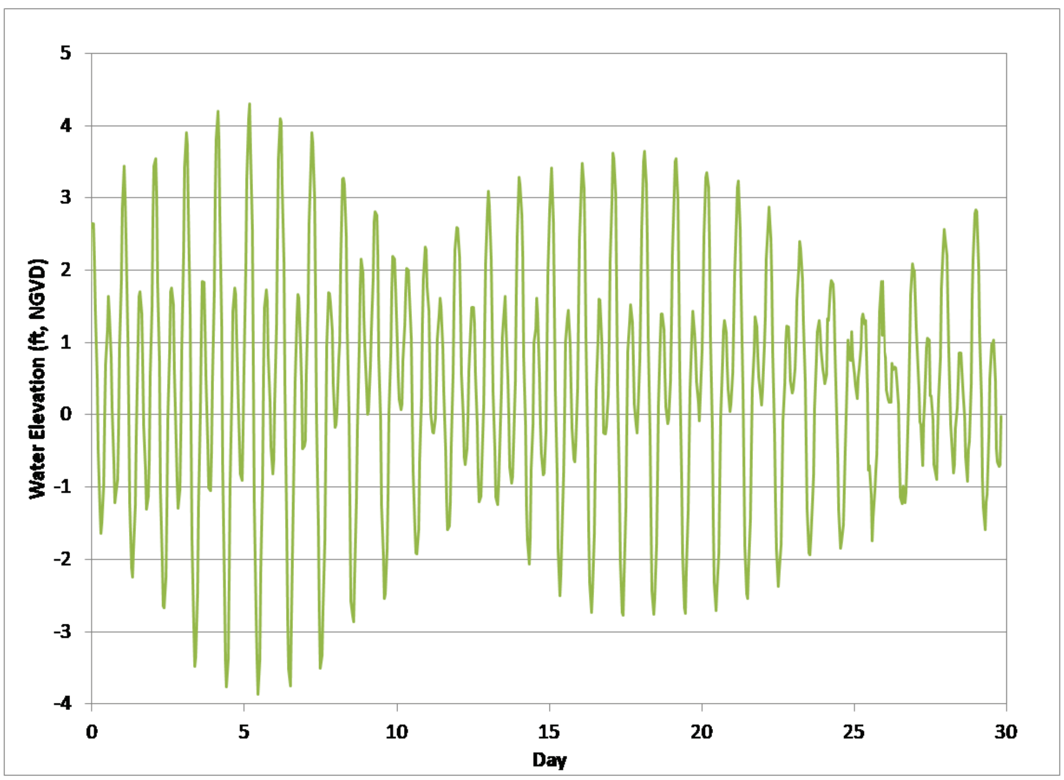
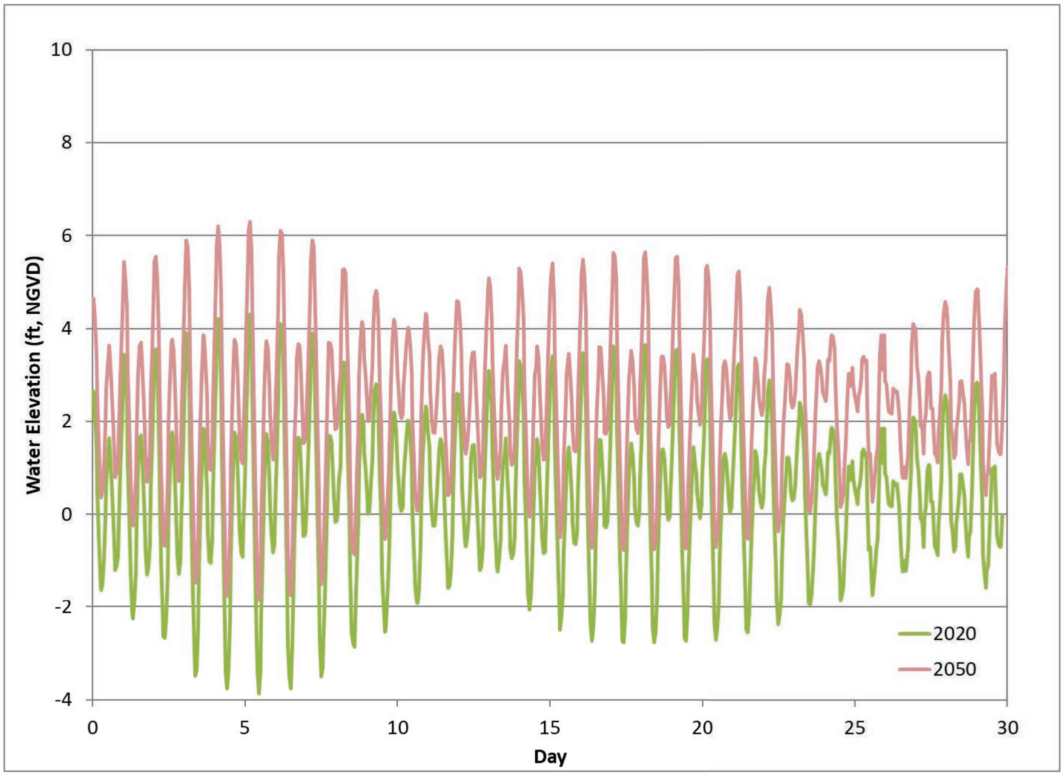
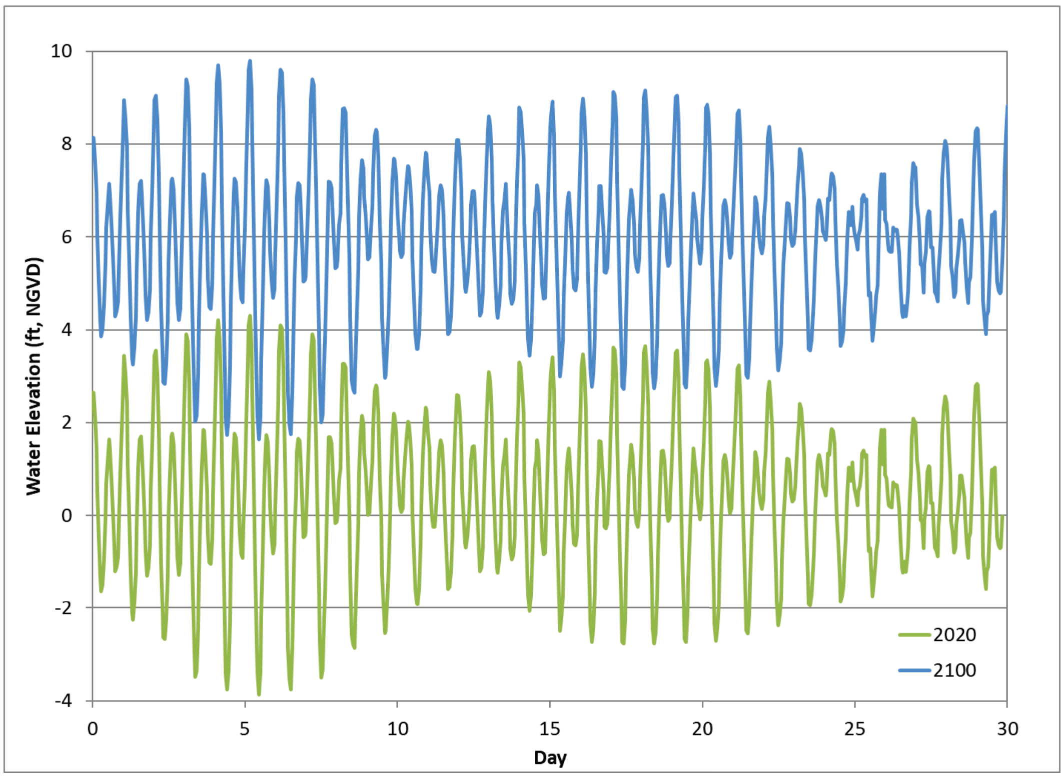


Figure 14
Year 2050 and Year 2100 TEA Tide Series Compared to Year 2020 TEA Tide Series





Upstream Boundary: No Flood Flow

For the tidal hydraulics analysis, it was assumed that no fluvial flow enters the model domain. This assumption was used in the modeling of other Enhancement Project alternatives.

Inundation Frequency

Inundation frequencies for the Modified Saltwater Alternative are shown in Figures 15, 16, and 17 for Year 2020, Year 2050, and Year 2100, respectively. Each figure shows the inundation frequency in each basin compared with the inundation frequency of the tide. Deviations from the inundation of the tide correspond to the degree of tidal muting. As expected, the results show an increase in tidal muting as the inlet cross section decreases from open to closed conditions.

Figure 15
Inundation Frequency for Modified Saltwater Alternative for Year 2020

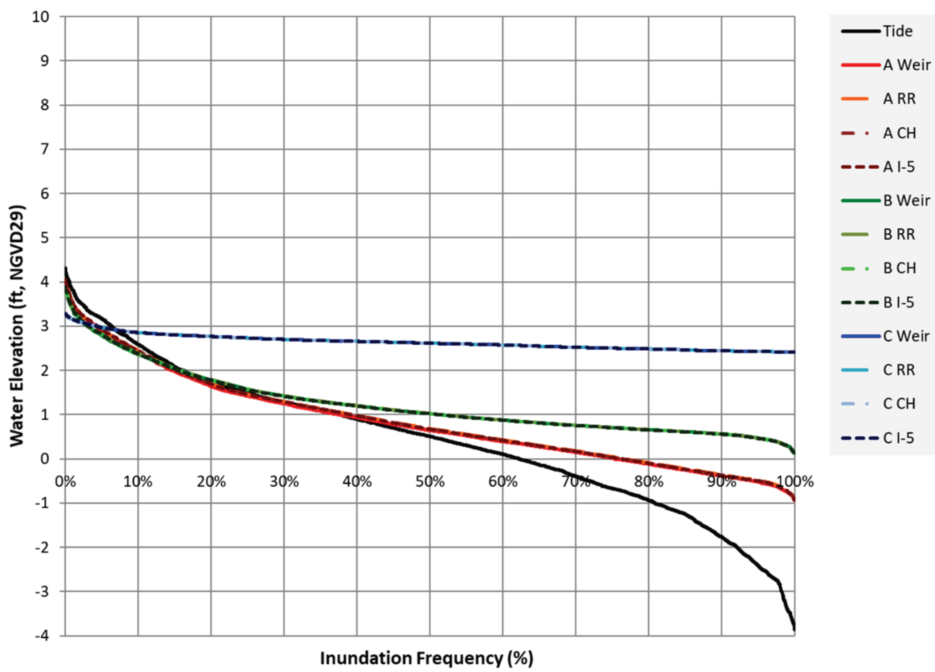


Figure 16
Inundation Frequency for Modified Saltwater Alternative for Year 2050

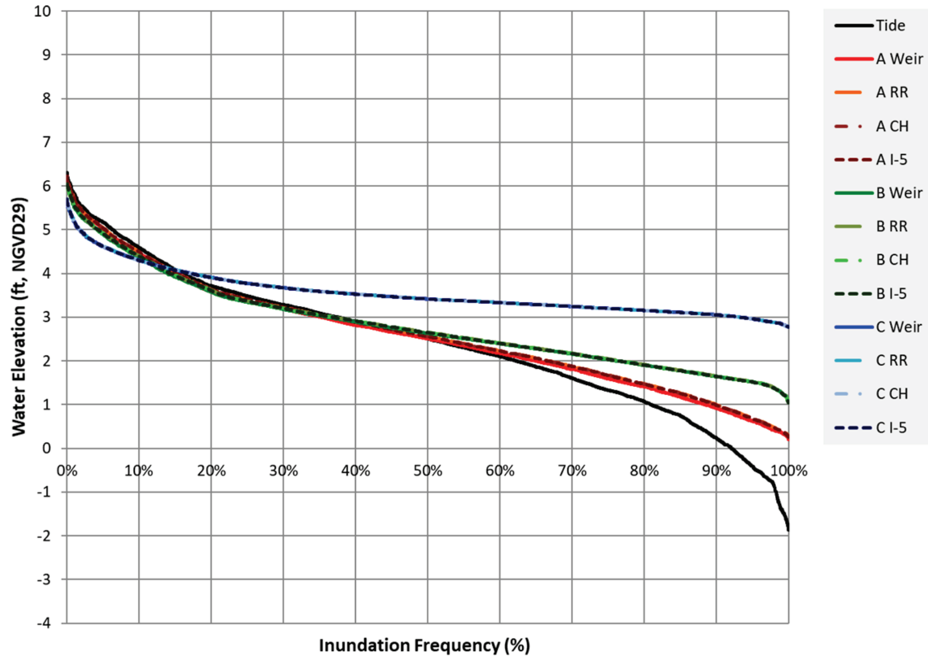
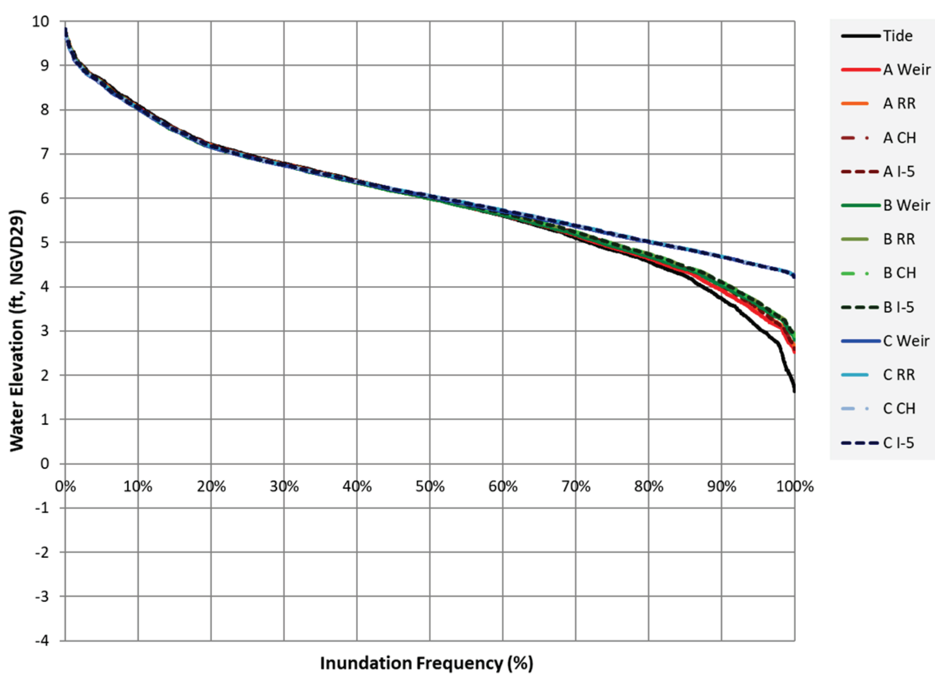


Figure 17
Inundation Frequency for Modified Saltwater Alternative for Year 2100



Habitat Distribution

The habitat elevation range predicted for each habitat type was identified based on inundation frequencies. Table 8 shows the maximum frequency for each subtidal and intertidal habitat type for the Modified Saltwater Alternative. Habitat distributions were estimated for the current mean sea level and the transitional inlet condition. While the three types of inundation frequency curves (namely, A – Open Inlet Condition, B – Transitional Inlet Condition, C – Closed Inlet Condition) capture the range of inundation frequencies expected through a maintenance dredge cycle, habitat distribution was estimated based on the transitional inlet condition since it is the most prevailing condition in the maintenance dredge cycle. The habitat acreages in each basin are summarized in Table 9 and illustrated in Figure 18 for the Modified Saltwater Alternative.

Table 8
Inundation Frequency by Habitat Type

Habitat Type	Maximum Inundation Frequency (%)
Upland	0
High Marsh	5
Middle Marsh	25
Low Marsh	45
Intertidal Unvegetated	95
Open Water Vegetated	99
Open Water Unvegetated	100

Table 9
Proposed Habitat Distribution for Modified Saltwater Alternative

Habitat	Area (Acres)				
	Weir Basin	RR Basin	CH Basin	I-5 Basin	Total
Upland/Non-Tidal	0.9	4.4	7.5	25.7	38.5
Southern Coastal Salt Marsh High (Tidal)	1.6	3.6	23.1	29.1	57.5
Southern Coastal Salt Marsh Mid	0.2	0.6	15.1	12.1	28.0
Southern Coastal Salt Marsh Low	0.1	0.3	5.9	10.5	16.9
Mudflats	0.1	0.4	6.8	6.4	13.7
Open Water (Tidal)	2.1	7.6	51.9	9.2	70.7
Subtidal Fish Area (Deeper Open Water)	-	1.1	2.0	3.2	6.4
Restricted Tidal Area (St. Malo)	5.9	-	-	-	5.9
Beach	0.8	-	-	-	0.8
Total	11.6	18.0	112.4	96.3	238.3

Notes:
Values based on GIS data prepared by AECOM
"-" = none

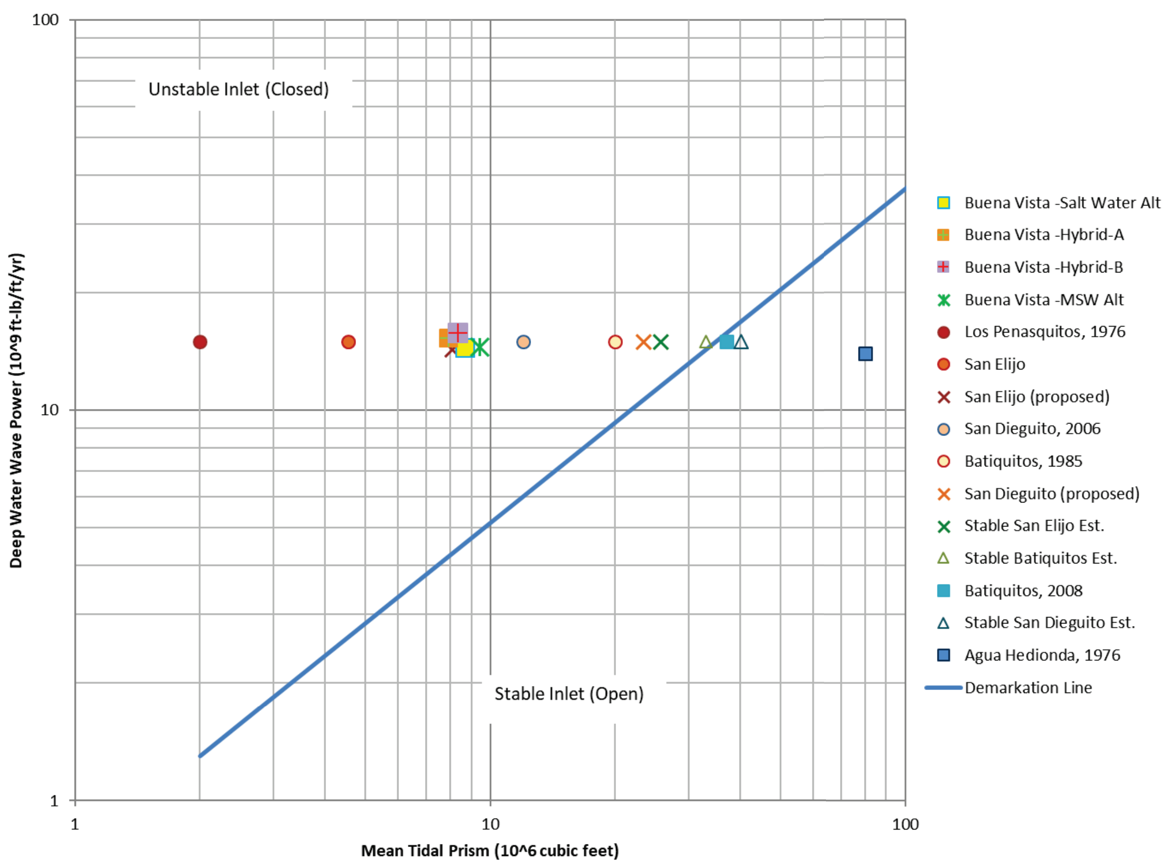
Figure 18
Habitat Distribution for the Modified Saltwater Alternative

Note: Prepared by AECOM

Inlet Stability

The estimated mean tidal prism for the current sea level tidal exchange is 9.4 million cubic feet for the Modified Saltwater Alternative. The tidal inlet stability study was documented in the Everest technical memorandum prepared for the Enhancement Project (Everest 2014b). The Modified Saltwater Alternative inlet condition was added to the inlet stability tidal prism graph (Figure 19). Figure 19 indicates that the Modified Saltwater Alternative has a very similar inlet stability condition as the other Enhancement Project alternatives—tidal prisms associated with the Enhancement Project alternatives lie far left of the separation line between stable and unstable inlet conditions. Hence, as with other Enhancement Project alternatives, the tidal inlet of Modified Saltwater Alternative would be expected to close, thereby requiring periodic opening efforts to maintain an open condition.

Figure 19
Inlet Stability Tidal Prisms



Summary

This technical memorandum documents the methods, findings of engineering analyses, and estimates of the fluvial and tidal hydraulic performance of the Modified Saltwater Alternative. The following findings were identified in this effort for the Modified Saltwater Alternative:

- The volume of excavated material to be disposed off site would be 937,000 cy. The volume of vegetation to be removed would be 211,000 cy.
- The maximum fluvial flood water elevations and water velocities of the Modified Saltwater Alternative are very similar to those of the Saltwater Alternative.
- Under the Modified Saltwater Alternative, the water velocities within the four basins during various storm events would not exceed the scour criteria (e.g., 1 ft/s), suggesting that significant levels of erosion would not be expected to occur within the Lagoon basins during storm events.
- The water velocities of the Modified Saltwater Alternative at the three hydraulic connections (I-5 Bridge, Carlsbad Boulevard Connection, NCTD Railroad Bridge) would exceed the sediment scour criteria such that slope protection would likely be needed at these locations to maintain the integrity of the bridge infrastructure and associated roadway and railway embankments.
- Tidal hydraulic analysis results provided predictions of the habitat distribution for the Modified Saltwater Alternative. The habitat distribution is summarized in Table 10.
- Based on the estimated tidal prism, the inlet for the Modified Saltwater Alternative would require periodic maintenance dredging in order to keep the inlet/outlet open for tidal exchange between the ocean and restoration area.

Table 10
Proposed Habitat Distribution Summary for Modified Saltwater Alternative

Habitat	Area (Acres)
Upland/Non-Tidal	38.5
Southern Coastal Salt Marsh High (Tidal)	57.5
Southern Coastal Salt Marsh Mid	28.0
Southern Coastal Salt Marsh Low	16.9
Mudflats	13.7
Open Water (Tidal)	70.7
Subtidal Fish Area (Deeper Open Water)	6.4
Restricted Tidal Area (St. Malo)	5.9
Beach	0.8
Total	238.3

References

AECOM, 2017. *Buena Vista Lagoon Enhancement Project Environmental Impact Report*. Prepared for SANDAG. Prepared by AECOM. September 2017.

California Ocean Protection Council, 2013. *State of California Sea-Level Rise Guidance Document*. Prepared by Coastal and Ocean Working Group of the California Climate Action Team (CO-CAT). March 2013.

Everest (Everest International Consultants, Inc.), 2014a. *Buena Vista Lagoon Enhancement Project Fluvial and Tidal Hydraulics Analyses*. Prepared for SANDAG and AECOM. Prepared by Everest International Consultants, Inc. August 29, 2014.

Everest, 2014b. Memorandum to: SANDAG and AECOM. Regarding: Buena Vista Lagoon Enhancement Project Tidal Inlet Stability Technical Memorandum. August 29, 2014.