Los Peñasquitos Lagoon Restoration

Phase 1C – 90% Design Hydrologic and Hydraulic Report – Final
Salt Marsh Restoration

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1.0 Introduction

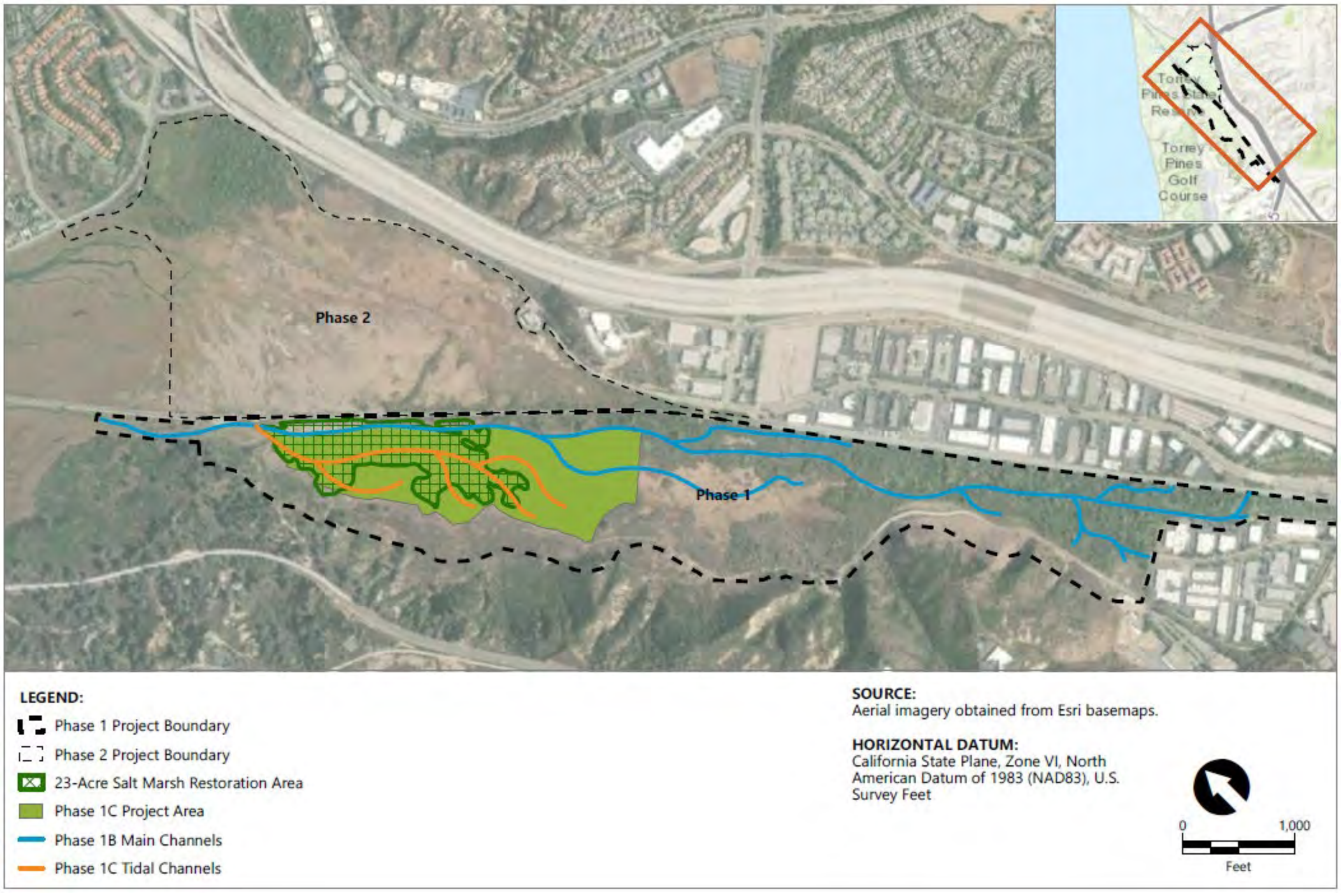
Phase 1 of the Los Peñasquitos Lagoon Restoration Project proposes constructing floodplain enhancements, a network of channels to improve conveyance of freshwater, and restoration of a portion of the upper lagoon with increased tidal influence in that area. Phase 1 will be implemented in the following three phases:

- Phase 1A: Upstream floodplain enhancements and adjacent low flow channel improvements
- Phase 1B: Freshwater and fine-grained sediment conveyance improvements from Phase 1A to the Phase 1 downstream extents
- Phase 1C: Restoration of degraded salt marsh currently not subject to tidal flow and dominated with non-native ryegrass (Festuca perennis) in the downstream portion of Phase 1 to both tidal and non-tidal salt marsh

This report summarizes the findings from the tidal hydraulic and salinity modeling performed to develop and evaluate design refinements to optimize the performance of the salt marsh restoration. Additional details of the tidal hydraulic and salinity modeling are provided in Appendix A and B.

2.0 Phase 1C Hydraulic Design Refinements

Phase 1C involves the restoration of degraded salt marsh dominated by non-native ryegrass, as shown in Figure 2.1. These areas are currently not subject to tidal influence. The pre-design concept targeted 23-acres for tidal salt marsh. This targeted acreage was assessed and refined through the design process and the hydrodynamic modeling summarized in this report. Degraded non-tidal salt marsh outside of the planned tidal salt marsh was also targeted for habitat enhancement toward the Total Maximum Daily Load (TMDL) goal. These non-tidal salt marsh areas will provide for future transition zones for sea level rise (SLR). Freshwater and sediment management measures will be implemented to sustain both the tidal and non-tidal salt marsh restoration areas. The salt marsh restoration will be constructed after completion of Phase 1A Floodplain Enhancements 1 and 2 and the Phase 1B primary freshwater management channel (Phase 1B channel). Construction of Phase 1C will include creating tidal channels that branch off at the downstream end of the Phase 1B channel and revegetating both Phase 1B and 1C areas. Floodplain Enhancement 3 will be constructed following completion of Phase 1C because this area will be used as a temporary stockpile area for all three phases.



SOURCE:
Aerial imagery obtained from Esri basemaps.

HORIZONTAL DATUM:
California State Plane, Zone VI, North American Datum of 1983 (NAD83), U.S. Survey Feet

Figure 2.1. Phase 1C Salt Marsh Restoration Project Overview

2.1 Approach

Refinement of the salt marsh restoration design was based on a numerical hydrodynamic model, herein referred to as the 2020 Environmental Fluid Dynamics Code (EFDC) Model, that simulates water and salinity levels under existing and proposed conditions. The 2020 EFDC Model's purpose was to evaluate if target habitats can be established and maintained in the salt marsh restoration area. Tidal hydraulics and salinity modeling were used to determine water levels and salinity levels, respectively, as well as to evaluate impacts of the lagoon inlet and tidal channel conditions on water and salinity levels in the salt marsh restoration area. The hydrodynamic modeling approach consisted of the following:

- Update the conceptual-level 2018 EFDC Model based on new bathymetry data.
- Develop a design-level EFDC Model that improves the model predictions of water and salinity levels.
- Verify the 2020 EFDC Model using measured water and salinity level data from 2016 and 2020.
- Simulate water and salinity levels under existing conditions and proposed restoration conditions based on the Phases 1B and 1C 30% design.
- Evaluate water and salinity levels with a range of lagoon inlet and tidal channel conditions.
- Evaluate salinity recovery in the salt marsh restoration area following a flood event.
- Evaluate water and salinity levels with projected SLR at Year 2035 when the TMDL targets are to be achieved, and at Year 2100 to assess longer term effects on the salt marsh restoration area.
- Develop design refinements for the Phase 1C 60% and 90% design to improve tidal inundation in the salt marsh restoration area.

Appendix A describes the prior EFDC modeling and the 2020 EFDC model development.

2.2 30% Design Evaluation

2.2.1 Overview

The salt marsh restoration conceptual design refinements recommended greater excavation in the lower portion of the Phase 1C project area to increase tidal exchange and associated influence of saltwater to maintain the restored salt marsh (Figure 2.1). The upper portion of the Phase 1C project area would be excavated to a lesser depth to increase saltwater influence and naturally replace non-salt marsh vegetation with salt marsh vegetation (i.e., without replanting of salt marsh vegetation) as SLR moves the tidal inundation upstream. This approach allows the establishment of tidal salt marsh restoration within the anticipated schedule, while enabling transition areas for future SLR adaptation and increasing the amount of salt marsh restoration to achieve the long-term goal of restoring 84 acres of salt marsh. Areas of degraded non-tidal salt marsh outside of the tidal influence will undergo enhancement activities that include removal of invasive rye grass and seed bank and revegetation with salt marsh species. In these areas, freshwater management will be implemented that includes diversion of dry weather flow away from these areas and reduction in storm flow retention. These freshwater management measures will be implemented as part of Phases 1A and 1B. Both tidal and non-tidal salt marsh restoration will also be sustained by the upstream sediment management measures that will reduce the coarse sediment loading to the restored areas by the floodplain enhancements. Both tidal and non-tidal restored salt marsh will achieve the TMDL goal.

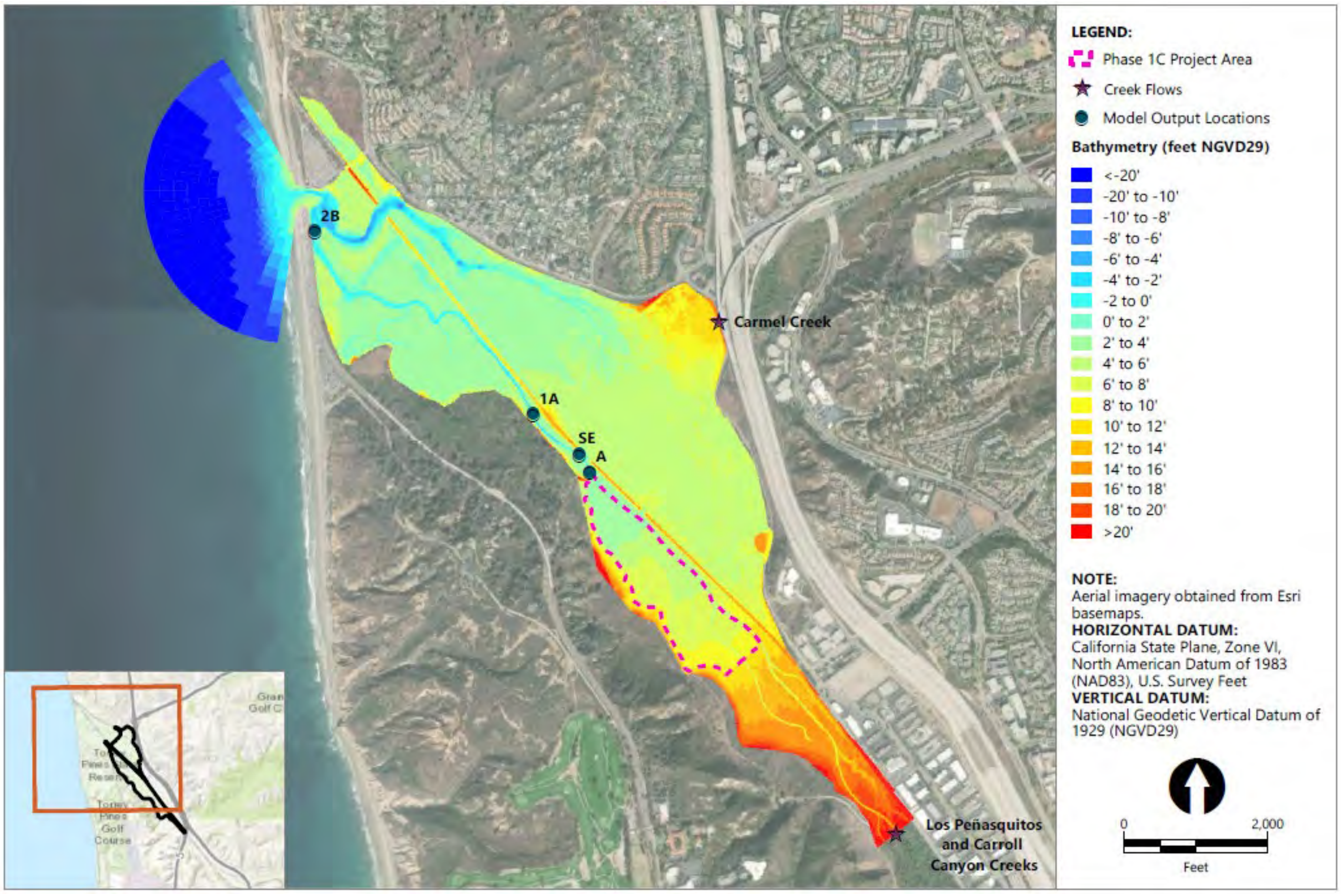
2.2.2 Design Changes

The Phase 1C 30% design detailed refinements of the concept design. Design changes from the conceptual design for the 30% design included the following:

- Tidal channels were realigned to extend farther into the restoration area to include a former wastewater pond and removal of the existing berm surrounding the former wastewater pond.
- The Phase 1B channel and Phase 1C main tidal channel were separated to improve freshwater management and minimize dry weather flows into the restoration area.
- Grading of Phase 1C was integrated with the Phase 1B channel. The Phase 1C main tidal channel was graded to be 2 feet above the Phase 1B channel bottom to prevent dry weather flows from backing up into the salt marsh restoration area.
- The connection between the Phase 1B and 1C channels was moved downstream to account for extension of the Phase 1B channel farther downstream to the pinch point.
- Wetland benches were widened between the tidal channels connecting the Phase 1B and 1C channels.
- Dredging of the existing tidal channel sill identified from the 2020 survey will be considered to improve tidal exchange to the restoration area.

2.2.3 Results

The 2020 EFDC Model was used to simulate water and salinity levels based on the Phase 1C 30% design, as shown in Figure 2.2.



NOTE:
Aerial imagery obtained from Esri basemaps.
HORIZONTAL DATUM:
California State Plane, Zone VI, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM:
National Geodetic Vertical Datum of 1929 (NGVD29)

Figure 2.2. 2020 EFDC Model for Phase 1C 30% Design

Three model scenarios, as summarized in Table 2.1, were used to evaluate water and salinity levels over a 20-day period, which covers a range of spring, mean, and neap tidal conditions. Scenarios 1 to 3 were designed to determine impacts of the inlet and tidal channel bathymetry in order to identify physical features that could limit tidal exchange to the salt marsh restoration area. The partially closed inlet and 2020 tidal channel bathymetry configurations were established based on the July 2020 bathymetry survey. The open inlet configuration was determined using the April 2020 bathymetry survey that was taken following a wet weather event. The tidal channel configuration with the sill removed was based on dredging of the tidal channel to an elevation of -3 feet NGVD29. For comparison purposes, the Scenario 1 inlet and tidal channel configuration was also simulated for existing conditions.

Table 2.1. Phase 1C 30% Design Model Scenarios

Scenario	Inlet Configuration	Tidal Channel Configuration	Purpose
Scenario 1	Partially closed inlet	2020 tidal channel bathymetry	Determine the range of water and salinity levels in the salt marsh restoration area.
Scenario 2	Open inlet	2020 tidal channel bathymetry	Determine changes in water and salinity levels with open inlet conditions.

Scenario	Inlet Configuration	Tidal Channel Configuration	Purpose
Scenario 3	Open inlet	Tidal channel sill removed	Determine changes in water and salinity levels with open inlet conditions and the tidal channel sill removed.

Partially closed inlet based on July 2020 bathymetry survey.
Open inlet bathymetry based on April 2020 pre-dredge bathymetry survey taken following a wet weather event.
Removal of tidal channel sill assumes dredging to -3 feet NGVD29.

2.2.3.1 Scenario 1

Water levels and salinity were simulated for a 20-day period covering a wide range of tide conditions including neap, mean, spring, and extreme spring tidal conditions, as shown in Figure B.1 in Appendix B. The 20-day period corresponds to tide conditions from June 1 to 19, 2020. The ocean tide on the last day was obtained from tides on November 25, 2015, which was selected to represent an extreme spring high tide during a significant El Niño Southern Oscillation (ENSO) event.

Time series of water levels and salinity at four locations were compared between existing conditions and Scenario 1 with a partially closed inlet. Water levels at the downstream (Location 2B) and upstream (Location 1A) ends of the tidal channel are similar between existing conditions and Scenario 1, as shown in Figure B.2 in Appendix B. Water level comparisons between existing conditions and Scenario 1 near the salt marsh restoration site are provided in Figure B.2 in Appendix B. At Location SE, the low tide water levels are lower under Scenario 1 due to the larger channel. At Location A, water levels for existing conditions are not shown because this location does not receive tidal inundation under existing conditions due to high ground elevations. The salt marsh restoration would lower existing ground elevations and create new tidal channels to allow tidal inundation of the salt marsh restoration area. Scenario 1 results in tidal inundation of the salt marsh restoration area during high tides above 2.0 feet NGVD29.

Salinity concentrations at the downstream (Location 2B) and upstream (Location 1A) ends of the tidal channel are shown in Figure B.3 in Appendix B for existing conditions and Scenario 1. Daily salinity fluctuations corresponding to the tides are similar between existing conditions and Scenario 1 at the downstream end of the tidal channel (Location 2B). Upstream at Location 1A, spikes in salinity concentrations during spring high tides occur for Scenario 1, indicating an increase in tidal exchange compared to existing conditions. Figure B.4 in Appendix B shows salinity concentrations near the salt marsh restoration area at Locations SE and A. High salinity concentrations only occur during extreme spring high tides.

To better illustrate the extent of saltwater influence, spatial plots of the tidal inundation and salinity at spring low tide, spring high tide, and extreme spring high tide were compared between existing conditions and Scenario 1. The timing of the spatial plots is illustrated in Figure B.1 in Appendix B. Spatial plots of the tidal inundation based on water depth are shown in Figure B.5 in Appendix B. The corresponding salinity spatial plots are provided in Figure B.6 in Appendix B. Under Scenario 1, dry weather flows are contained within the Phase 1B channel. At low tide, flows are contained within the tidal channel and salinity along the entire tidal channel is low, indicating a greater amount of freshwater. However, during high tides, dry weather flows would enter the salt marsh restoration area because the Phase 1B channel bank elevation is lower than spring high tide. While the salinity in the salt marsh restoration area is low, saltwater does extend into the salt marsh restoration area, as previously indicated by the water levels at Location A. Saltwater also extends farther upstream toward the east end of the salt marsh restoration area because the Phase 1B channel is about 1 foot deeper than the existing channel. The salinity spatial plots also show that high tides are restricted from extending upstream toward the salt marsh restoration area (tidal channel high tide restriction). At this location, the tidal channel banks are higher and keep high tides within the tidal channel.

2.2.3.2 Scenario 2

Scenario 2 was conducted to evaluate the effects of the lagoon inlet bathymetry on water and salinity levels. Water level comparisons of the Phase 1C 30% design with a partially closed and open inlet were made at two locations along the tidal channel, as shown in Figure B.7 in Appendix B, and two locations near the salt marsh restoration area, as shown in Figure B.8 in Appendix B. The open inlet results in lower water elevations at Location 2B during low tides, downstream of the tidal channel sill. The open inlet does not affect low tide water levels at the other three locations because the tidal channel sill prevents draining of water upstream of the sill. At all four locations, high tide water levels are increased with the open inlet because more saltwater enters the lagoon, thus improving tidal exchange. Time series of salinity at the four comparison locations are shown in Figures B.9 and B.10 in Appendix B. Under Scenario 2, salinity near the salt marsh restoration area is greater than Scenario 1 during high tide because of the improvement in tidal exchange.

Spatial plots of the tidal inundation and salinity are provided in Figures B.11 and B.12 in Appendix B, respectively. For both Scenarios 1 and 2, salt and freshwater flows are contained within the tidal channel. During high tides, tidal inundation near the salt marsh restoration area is greater with an open inlet (Scenario 2). The salinity spatial plot at spring high tide illustrates a greater amount of saltwater reaching the restoration area and moving the freshwater interface farther upstream.

2.2.3.3 Scenario 3

With an open inlet, the tidal channel sill becomes the limiting factor for tidal exchange to the salt marsh restoration area. Scenario 3 was developed to evaluate the effects of removing the tidal channel sill on water and salinity levels. Scenarios 2 and 3 water levels are compared in Figures B.13 and B.14 in Appendix B and salinity in Figures B.15 and B.16 in Appendix B. The removal of the tidal channel sill (Scenario 3) improves the draining of water levels during low tides, thereby increasing the tide range at the upstream end of the tidal channel near the salt marsh restoration area. This increase in tidal exchange is needed to sustain the salt marsh restoration, however, the existing tidal channel elevation provides an additional restriction of flow as discussed below.

Spatial plots of the tidal inundation and salinity are shown in Figures B.17 and B.18 in Appendix B, respectively. The results show that even without restrictions of the inlet bathymetry and tidal channel sill, tidal exchange may not be enough to offset freshwater flows. Based on the salinity spatial plot at spring high tide, Scenario 3 does not move the freshwater interface farther upstream despite the improvement in tidal exchange because of the pinch point, where the tidal channel bottom increases from -2 to -1 feet NGVD29. This increase in channel bottom restricts tidal exchange even with an open inlet and removal of the sill.

2.2.4 Conclusions

The tidal hydraulic and salinity modeling showed that tidal exchange to the salt marsh restoration area is limited by the following physical features:

- Lagoon inlet
- Tidal channel sill
- Tidal channel high tide constriction
- Pinch point

Both the inlet bathymetry and tidal channel sill can limit tidal exchange. Scenario 2 showed that maintaining a deeper inlet bathymetry increases tidal exchange to the salt marsh restoration area. Removing the tidal channel sill will also increase tidal exchange but may not be enough to maintain high salinity levels in the restoration area due to freshwater flows.

At the tidal channel high tide constriction location, high tides are restricted from extending farther upstream toward the salt marsh restoration area due to higher bank elevations of the existing tidal channel.

Widening of the pinch point would increase tidal exchange at the downstream portion of the salt marsh restoration area. However, this increase in saltwater would not be large enough to maintain high salinity concentrations in the salt marsh restoration area. The higher channel bottom elevation above the pinch point also limits tidal exchange. Therefore, in addition to keeping the inlet open and removing the tidal channel sill, bottom elevations in the existing tidal channel through the pinch point and into Phase 1C need to be lowered to -2 feet NGVD29 to achieve sufficient tidal exchange to sustain the salt marsh restoration.

For the 30% design, the Phase 1C channel was graded higher than the Phase 1B channel to minimize freshwater entering the salt marsh restoration area. However, the higher Phase 1C channel elevation does not prevent freshwater from entering the salt marsh restoration area because high tides overtop the Phase 1B channel. In addition, the higher Phase 1C channel elevation reduces tidal exchange to the salt marsh restoration area.

2.2.5 Recommendations

The following were recommendations for the 60% design:

- Analyze removal of the tidal channel sill to determine if such action could yield substantial improvements in tidal exchange and salinity to the salt marsh restoration area.

- Analyze improvements (e.g., deepening and/or widening) to the Phase 1C channel connection to the Phase 1B channel to determine if such action would allow a greater amount of saltwater into the salt marsh restoration area.
- Analyze improvements (e.g., deepening and/or widening) to the Phase 1C tidal channels to determine if such action would facilitate better salinity exchange within the salt marsh restoration area.

2.3 60% Preliminary Design Evaluation

2.3.1 Overview

Salt marsh restoration refinements for the 60% preliminary design, as shown in Figure 2.3, were developed based on recommendations from the tidal hydraulic and salinity modeling of the 30% design. The 2020 EFDC Model was used to conduct simulations to evaluate the effectiveness of these refinements at improving tidal exchange (water levels) and salinity within the restoration area. Additional model simulations were conducted to assess salinity recovery following a flood event, as well as evaluating transition areas for future SLR adaptation.

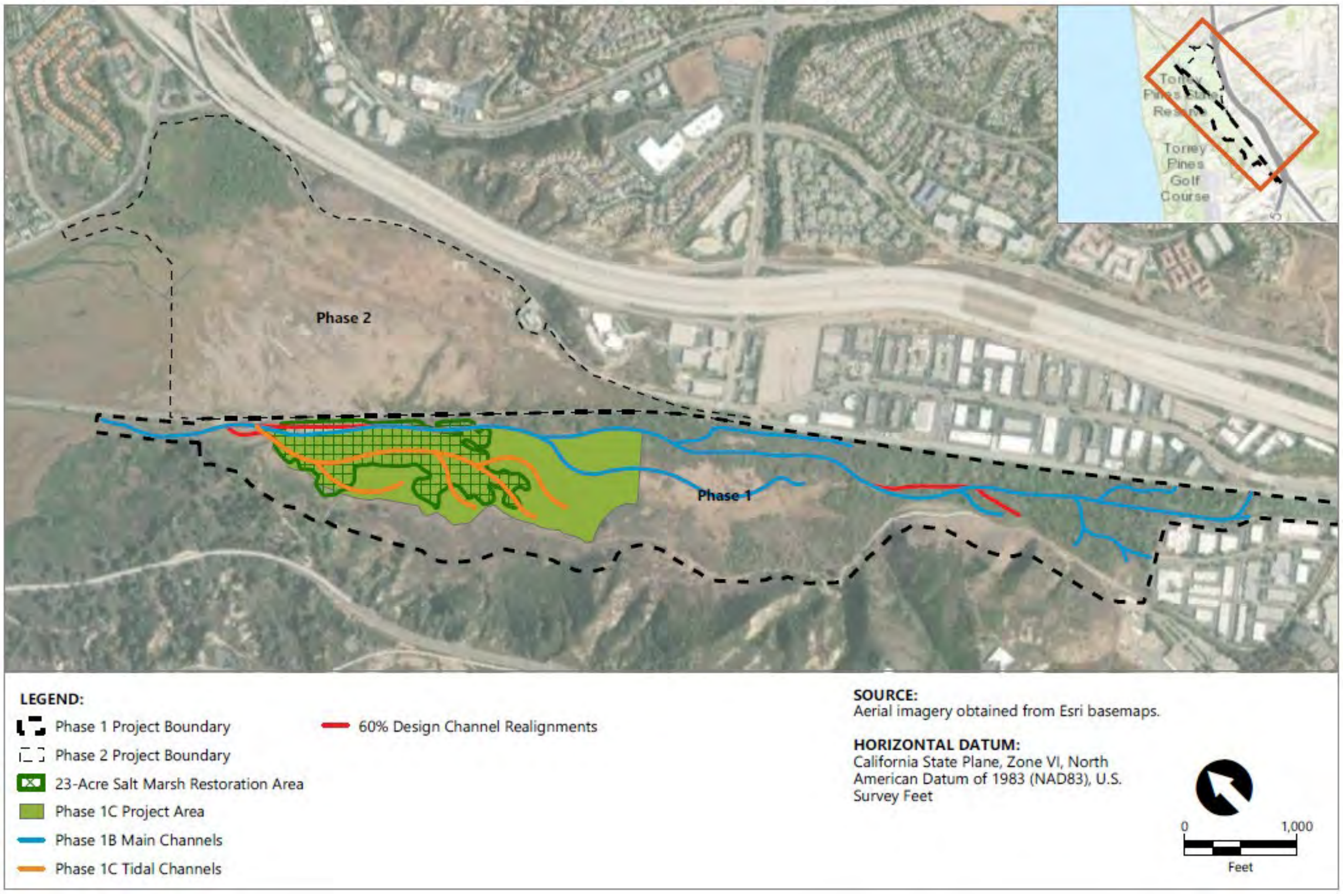


Figure 2.3. Phase 1C 60% Preliminary Design Overview

2.3.2 Design Changes

The 60% preliminary design focused on increasing tidal exchange and salinity in the salt marsh restoration with the following design changes:

- The Phase 1B channel was realigned closer toward the existing channel to minimize dry weather flows into the salt marsh restoration area during high tide.
- The Phase 1C channel was realigned to connect to the Phase 1B channel farther downstream, enabling a deeper channel with a bottom elevation of -1 foot NGVD29 to increase tidal exchange to the salt marsh restoration area.
- The tidal channel sill was removed to determine if such action could yield substantial improvements in tidal exchange and salinity to the salt marsh restoration area.
- The Phase 1C tidal channels were improved by deepening and widening the downstream portion of the channel to determine if such action would facilitate better salinity exchange within the salt marsh restoration area.

2.3.3 Results

The 2020 EFDC Model was used to simulate water and salinity levels based on the Phase 1C 60% preliminary design, as shown in Figure 2.4.

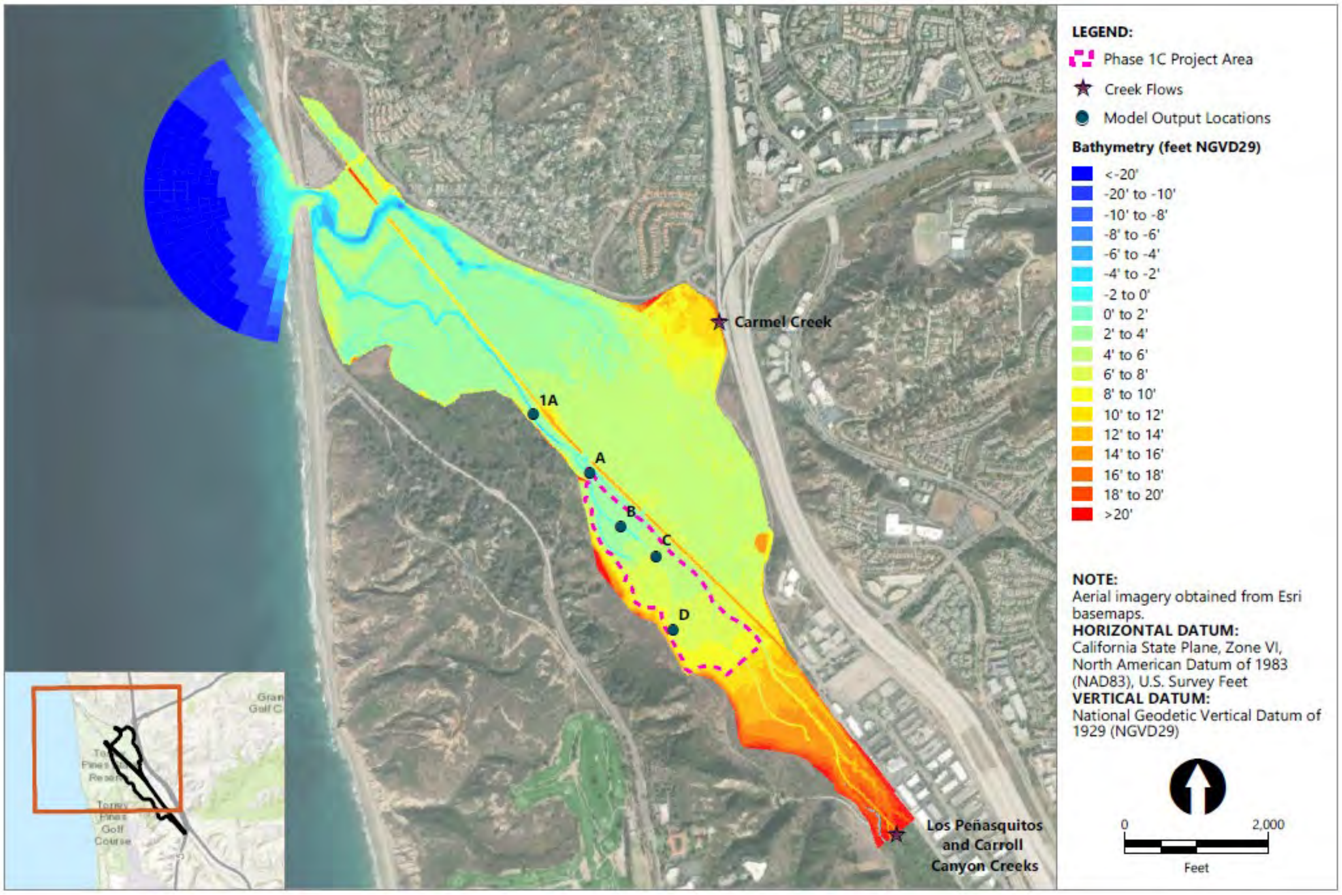


Figure 2.4. 2020 EFDC Model for Phase 1C 60% Preliminary Design

Five model scenarios, as summarized in Table 2.2, were used to evaluate water and salinity levels over a 20-day period. Scenarios 4 and 5 were conducted to determine if changes for the 60% preliminary design would improve tidal exchange and salinity to the salt marsh restoration area. To illustrate the deeper channel connection for the Phase 1C channel, the existing tidal channel profile was compared to the Phase 1B channel profile in Figure 2.5. The Phase 1C channel connection to the Phase 1B Channel was moved downstream with a deeper channel bottom at -1 foot NGVD29.

Additional model scenarios were conducted to assess salinity recovery following a flood event and to evaluate transition areas for future SLR adaptation. Scenario 6 simulated a 2-year flood event to evaluate salinity recovery in the salt marsh restoration area following a flood event. This scenario assumed an open inlet configuration based on the April 2020 bathymetry survey that was taken following a wet weather event and tidal channel sill removed. Scenarios 7 and 8 were developed to assess projected SLR for Year 2035 and Year 2100, respectively. Both SLR scenarios were conducted based on a partially closed inlet and 2020 tidal channel bathymetry for comparison with Scenario 4.

Table 2.2. Phase 1C 60% Preliminary Design Model Scenarios

Scenario	Inlet Configuration	Tidal Channel Configuration	Purpose
Scenario 4	Partially closed inlet	2020 tidal channel bathymetry	Determine the range of water and salinity levels in the salt marsh restoration area.
Scenario 5	Open inlet	Tidal channel sill removed	Determine changes in water and salinity levels with open inlet conditions and the tidal channel sill removed.
Scenario 6	Open inlet	Tidal channel sill removed	Evaluate salinity recovery in the salt marsh restoration area following a 2-year flood.
Scenario 7	Partially closed inlet	2020 tidal channel bathymetry	Assess water and salinity levels with Year 2035 SLR.
Scenario 8	Partially closed inlet	2020 tidal channel bathymetry	Assess water and salinity levels with Year 2100 SLR.

Partially closed inlet based on July 2020 bathymetry survey.
Open inlet bathymetry based on April 2020 pre-dredge bathymetry survey taken following a wet weather event.
Removal of tidal channel sill assumes dredging to -3 feet NGVD29.

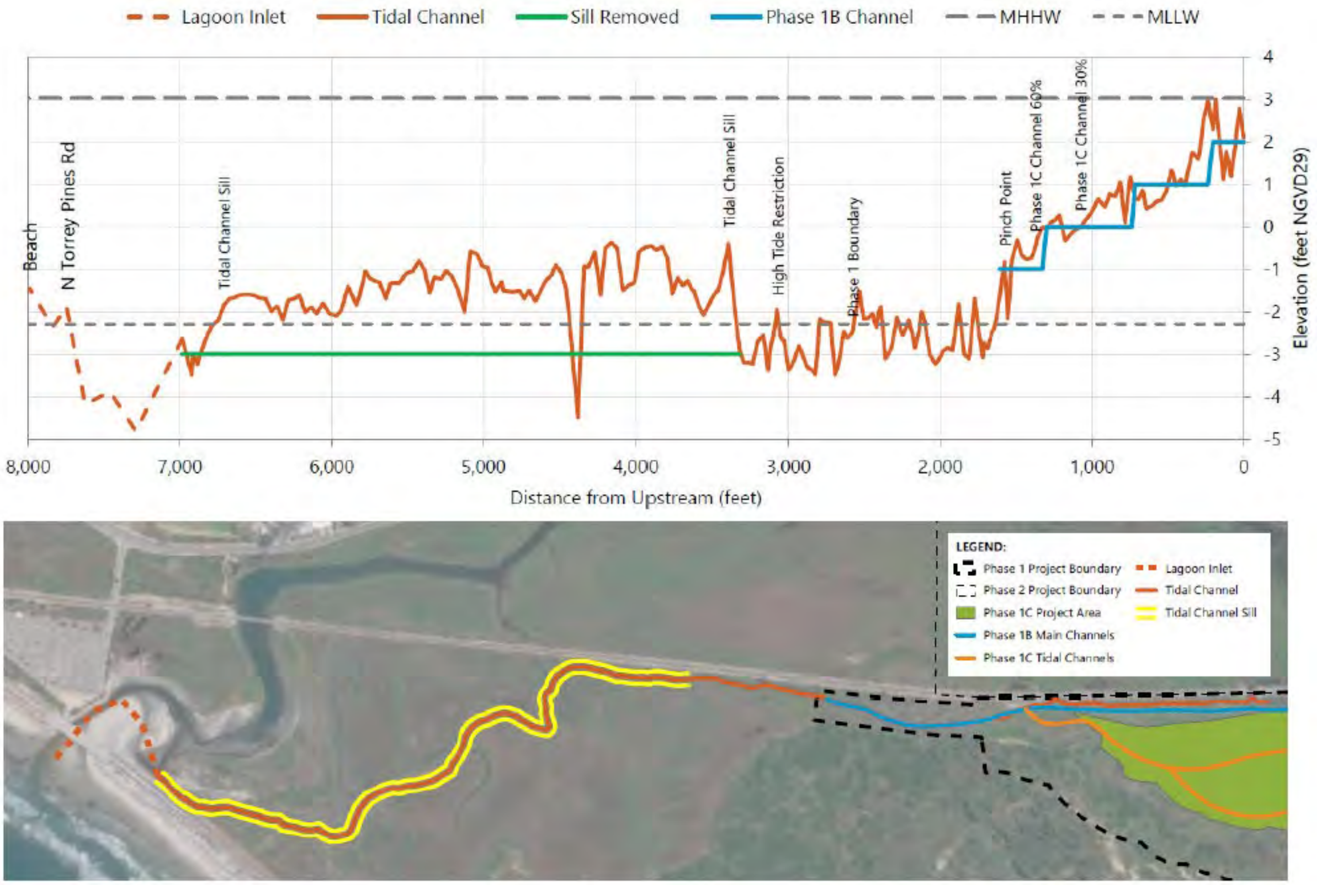


Figure 2.5. Tidal Channel Profiles

2.3.3.1 Scenarios 4 and 5

Scenarios 1, 4, and 5 are compared at Locations A and B in Figure B.19 in Appendix B for water levels and in Figure B.20 in Appendix B for salinity. Scenario 4 shows the increase in tidal exchange based on water levels due to the deeper Phase 1C channel, with tidal influence reaching farther upstream at Location B, where tidal influence barely reached under Scenario 1. Scenario 5 shows less muting at low tide (i.e., lower water levels) compared to Scenario 4 because of lower bottom elevations at the inlet and along the tidal channel with the sill removed. The deeper channel also results in higher salinity farther into the salt marsh restoration area. Scenarios 4 and 5 show higher salinity compared to Scenario 1 at both locations. At Location A, the high salinity increases coincide with spring high tides.

Spatial plots of the salinity at spring high tide are provided in Figure B.21 in Appendix B, which shows that tidal exchange to the salt marsh restoration area would be improved with a deep Phase 1C channel. In comparing Scenarios 4 and 5, tidal inundation extends farther into the salt marsh restoration area with an open inlet and tidal channel sill removed. The relatively higher channel bottom elevation at the pinch point limits tidal exchange to the salt marsh restoration area.

2.3.3.2 Scenario 6

The 2-year flood event was simulated to evaluate salinity recovery in the salt marsh restoration area following a flood event. The flood flows from the three creeks and tide conditions for Scenario 6 are shown in Figure B.22 in Appendix B. The resulting water levels and salinity at Locations A and B are shown in Figure B.23 in Appendix B. Water levels increase above tide elevation in response to the flood flows and return to tide conditions after the flood ends. Salinity recovery occurs within 3 days after the flood at Location A. Salinity recovery at Location B would take longer than 10 days after the flood.

Water inundation and salinity spatial plots are shown in Figure B.24 in Appendix B. At peak flow, flood waters completely inundate the lagoon. At the end of the flood, freshwater remains throughout the lagoon. Five days following the flood, salinity levels in the lagoon have returned to pre-storm conditions, although some ponding occurs above tidal influence.

2.3.3.3 Scenarios 7 and 8

The SLR impacts were evaluated using the low risk aversion SLR scenario projections for Year 2035, when the TMDL targets are to be achieved, and for Year 2100 to assess longer term effects on the salt marsh habitat. The tidal ranges for Year 2035 and Year 2100 are summarized in Table 2.3. In the table, SLR elevations are based on the low risk aversion scenario projections of 0.8 foot SLR for Year 2035 and 3.6 feet SLR for Year 2100.

Table 2.3. Year 2035 and Year 2100 Projections for Sea Level Rise Assessment

SLR Projections	Elevation (feet NGVD29)
Year 2035 extreme spring high	6.32
Year 2035 spring high	5.28
Year 2035 MHHW	3.83
Year 2035 MLLW	-1.50
Year 2035 spring low tide	-2.76
Year 2100 extreme spring high	9.12
Year 2100	8.08
Year 2100 MHHW	6.63
Year 2100 MLLW	1.30
Year 2100 spring low tide	0.04

Scenario 7 water levels and salinity at Locations A, B, and C are shown in Figure B.25 in Appendix B. Based on the Year 2035 projected SLR, tidal influence would extend into the lower half of the Phase 1C project area near Location C. Tidal inundation and salinity spatial plots for Scenario 7 at spring low, spring high, and extreme high tides are shown in Figure B.26 in Appendix B. At spring low tide, flows will still be confined within the tidal channel. The results show a greater extent of tidal influence with the Year 2035 SLR.

Water levels and salinity at Locations A, B, C, and D under Scenario 8 are provided in Figure B.27 in Appendix B. Tidal influence based on the Year 2100 projected SLR would extend into the upper portion of the Phase 1C project area near Location D. The Scenario 8 tidal inundation and salinity spatial plots at spring low, spring high, and extreme high tides are shown in Figure B.28 in Appendix B. Based on the Year 2100 SLR, tidal influence would cover a significant portion of the lagoon and extend toward the upper boundary of the Phase 1C project area.

2.3.4 Conclusions

The tidal hydraulic and salinity modeling for the 60% preliminary design showed that deepening of the Phase 1C channel would improve tidal exchange to the salt marsh restoration area. The amount of tidal exchange is controlled by the tidal channel bottom elevation, and salinity is controlled by tidal exchange and the amount of dry weather flow. High salinity would be achieved during high tides when the restoration area is inundated, while low salinity would occur during lower tides, but be confined within the Phase 1C channel.

Higher salinity occurs more frequently in the existing tidal channel downstream of the Phase 1C channel, indicating tidal exchange is limited by the existing tidal channel high tide constriction and pinch point. The relatively higher channel bottom elevation at the pinch point also limits the amount of saltwater entering the salt marsh restoration area.

In general, flood flows will pass through the salt marsh restoration area and return to pre-storm conditions when high tides bring in saltwater. Following the flood, ponding of freshwater could occur in the SLR transition areas because of the relatively flat grading.

With projected SLR for the Year 2035, higher salinity would occur over the lower portion of the salt marsh restoration area. The grading in the upper portion of the Phase 1C project area allows for the transition of salt marsh based on the Year 2100 projected SLR.

2.3.5 Recommendations

The following were recommendations for the 60% design refinement salt marsh restoration design:

- The tidal channel sill should be removed to prevent the tidal channel bathymetry from limiting tidal exchange and associated saltwater (saline) influence to the salt marsh restoration area. Without the removal of the sill, tidal exchange will be limited in the salt marsh restoration impacting the establishment and sustainability of the restoration. This will extend the limits of the Phase 1 project.
- Due to the continuous and significant dry weather flows from both Carroll Canyon and Los Peñasquitos Creeks, greater tidal mixing is needed at the downstream segment of the Phase 1B freshwater management channel to increase salinity in the salt marsh restoration area. To achieve an increased tidal exchange and offset reductions in salinity, it is recommended that the existing channel within the downstream end of the Phase 1 Project (approximately Station 1800 on Figure 2.5) be graded to a minimum elevation of -2 feet NGVD and extend upstream beyond the connection to the new Phase 1C tidal channel (approximately Station 1200 on Figure 2.5). The channel width should be maintained at least 10 feet across and the channel sides benched to allow for greater tidal exchange.

Significant Dry Weather Flows – Existing Channel - Lower Downstream Trestle

- At the revised downstream connection (moved farther downstream from the 30% design location) of the new Phase 1C tidal channel with the existing channel (approximately Station1200 on Figure 2.5), the bottom elevation of the Phase 1C tidal channel is recommended to be deepened to -2 feet NGVD, matching the bottom elevation of the Phase 1B channel and allowing a greater amount of saltwater into the salt marsh restoration area. The Phase 1C tidal channel bottom width is to be maintained at 10 feet wide from this connection point through the salt marsh restoration.

- During low tide conditions, freshwater flows predominate the tidal channel even at the downstream location of the new Phase 1C tidal channel (Station 1200 on Figure 2.5). Under low tide conditions freshwater may enter the new tidal channel and should be designed to contain these freshwater flows within the channel and minimize freshwater overtopping the berms and adjacent restored salt marsh by deepening the channel. As high tides then bring saltwater into this channel, tidal mixing should increase salinity.
- The model results indicate that achieving saline influence into the salt marsh restoration area will depend on inundation primarily from high tide conditions. To increase the salinity outside of the tidal channels, grading of the salt marsh restoration should include benches maintained below the high tide elevation. An option that was further evaluated in the 60% and 90% design is the implementation of small berms placed parallel but farther away from the new tidal channel to pond higher tidal flows within the salt marsh restoration. Ponding of higher salinity waters on these benches will maintain salinity and provide greater sustainability of the restored marsh.
- The model results also illustrate a high tide constriction located downstream of the Phase 1 boundary (approximately Station 3100 on Figure 2.5), where high ground elevations confine tidal flow into the existing channel. In order to improve tidal exchange to the 23-acre salt marsh restoration which will be limited to higher tide conditions, the wider channel and benching of the Phase 1B channel should be extended farther down to the high tide constriction area. As shown in the two photographs below of the existing tidal channel (approximately between Stations 1500 and 3000 on Figure 2.5), the channel has steep banks that limit the tidal flow and exchange capacity of channel. By benching this channel, greater tidal exchange and saltwater influence would be achieved into the tidal salt marsh, particularly at high tide. This would provide a more reliable method of increasing tidal exchange because bathymetry conditions at the lagoon inlet and along the tidal channel can vary significantly. Extending the benching from the current Phase 1 boundary (approximately station 2600 on Figure 2.5) down to the high tide restriction (approximately station 3100 on Figure 2.5) would require conducting additional biological and cultural surveys and including the temporary impacts in environmental documents. These could be done with the surveys for the segment of the channel that is recommended for removal of the sill farther downstream of this location. These surveys and assessment of impact is currently not in the scope as it is outside of the current Phase 1 boundary.
- In the SLR transition areas, grading of the Phase 1C benches between the restoration tidal channels should have a greater slope to minimize ponding of freshwater following a flood event.

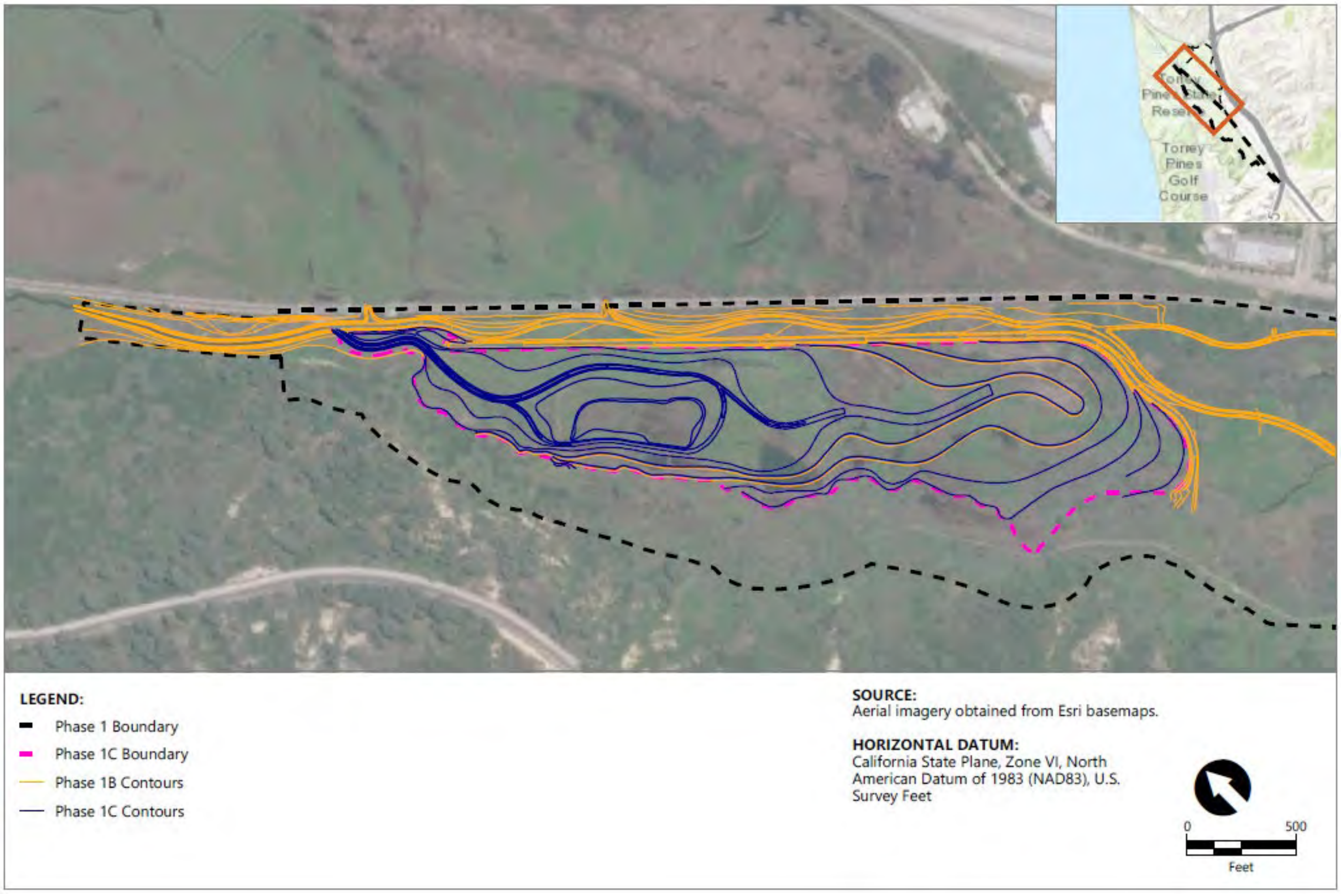
Tidal Channel – Looking Upstream - Steep Banks

Tidal Channel - Looking Downstream

2.4 60% Refined Design Evaluation

2.4.1 Overview

Refinements to the Phase 1B freshwater channel and Phase 1C 60% preliminary design were made for the 60% refined design, as shown in Figure 2.6. Changes to the Phase 1C grading considered the hydraulic and salinity conditions needed to support salt marsh vegetation. In general, the salt marsh restoration refinements focus on establishing high salt marsh vegetation and aim to inundate the lower portion of the Phase 1C area with saline water during spring high tides.



SOURCE:
Aerial imagery obtained from Esri basemaps.

HORIZONTAL DATUM:
California State Plane, Zone VI, North American Datum of 1983 (NAD83), U.S. Survey Feet

Figure 2.6. Phase 1C 60% Refined Design Overview

2.4.2 Design Changes

Modifications to the Phase 1B freshwater channel for the 60% refined design included the following:

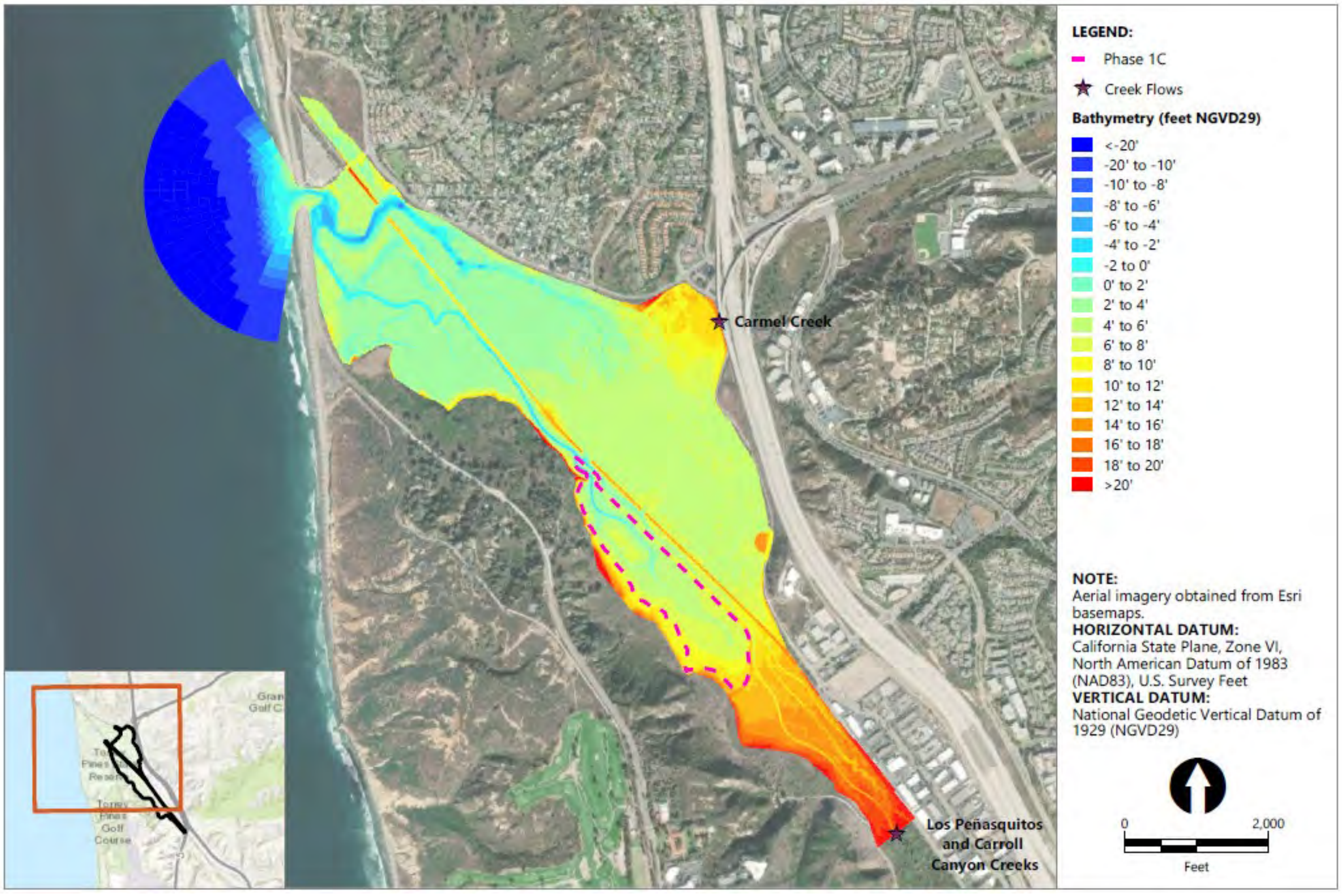
- Realigned the freshwater channel closer toward the existing channel and railroad embankment
- Separated the Phase 1B freshwater channel and Phase 1C restoration area
- Deepened channel bottom to -2 feet NGVD29 from the railroad trestle downstream to the Phase 1 boundary
- Revised the channel bench grading downstream of the Phase 1C connection; the width at an elevation of 4 feet NGVD was reduced from approximately 150 feet to 75 feet

Modifications to the Phase 1C grading for the 60% refined design included the following:

- Deepened and widened the tidal channel with a bottom width of 10 feet at -2 feet NGVD29 (at the downstream end) and side slope of 2:1 (horizontal:vertical)
- Lowered ground elevations to be inundated during high spring tides and King tides
- Preserved some existing salt marsh vegetation with a circular channel to reduce drainage of saltwater
- Provided area for expansion of salt marsh habitat in response to future projected SLR

2.4.3 Results

The 2020 EFDC Model grid was revised for the 60% refined design, as shown in Figure 2.7, and used to conduct simulations to evaluate the effectiveness of the design changes at improving tidal exchange (water levels) and salinity within the restoration area.



NOTE:
Aerial imagery obtained from Esri basemaps.
HORIZONTAL DATUM:
California State Plane, Zone VI, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM:
National Geodetic Vertical Datum of 1929 (NGVD29)

Figure 2.7. 2020 EFDC Model for Phase 1C 60% Refined Design

Five model scenarios, as summarized in Table 2.4, were used to evaluate water and salinity levels over a 20-day period that covered a range of tidal conditions. Results of the tidal hydraulic and salinity modeling are shown based on the model-predicted salinity at spring high tide and King tide.

Table 2.4. Phase 1C 60% Refined Design Model Scenarios

Scenario	Inlet Configuration	Tidal Channel Configuration	Purpose
Scenario 9	Partially closed inlet	2020 tidal channel bathymetry	Determine the range of water and salinity levels in the salt marsh restoration area.
Scenario 10	Partially closed inlet	Tidal channel sill removed	Determine changes in water and salinity levels with the tidal channel sill removed.
Scenario 11	Open inlet	Tidal channel sill removed	Determine changes in water and salinity levels with open inlet conditions and the tidal channel sill removed.

Scenario	Inlet Configuration	Tidal Channel Configuration	Purpose
Scenario 12	Partially closed inlet	Tidal channel sill removed	Assess water and salinity levels with Year 2035 SLR.
Scenario 13	Partially closed inlet	Tidal channel sill removed	Assess water and salinity levels with Year 2100 SLR.

Partially closed inlet based on July 2020 bathymetry survey.
Open inlet bathymetry based on April 2020 pre-dredge bathymetry survey taken following a wet weather event.
Removal of tidal channel sill assumes dredging to -3 feet NGVD29.

2.4.3.1 Scenarios 9 to 11

Scenarios 9 to 11 were modeled to determine if refinements to the Phase 1B and Phase 1C 60% design would improve tidal exchange and salinity to the salt marsh restoration area under current ocean tide conditions. Salinity spatial plots at spring high tides and King tides for Scenarios 9, 10, and 11 are provided in Figure B.29. The results show that there is not enough saltwater reaching the restoration area at spring high tide because the saltwater interface is downstream of the Phase 1C connection. At King tide (previously referred to as extreme spring high tide), the lower portion of the restoration area would be inundated with saltwater.

The changes from the 30% design to the 60% refined design are shown in Figure B.30 based on the salinity spatial plots for Scenarios 4 and 9. Scenario 4 represents the 30% design with a partially closed inlet and the 2020 tidal channel bathymetry. The comparison shows that the saltwater interface reached farther upstream under the 30% design. Under the 60% refined design, there is insufficient saltwater to offset the freshwater dry weather flows, mainly due to the grading changes along the Phase 1B channel downstream of the Phase 1C connection, as indicated in the upper right panel in Figure B.30. The overall Phase 1B channel bench width was reduced to avoid impacts to an existing Torrey pine (*Pinus torreyana*). This design change reduces the amount of saltwater reaching the Phase 1C connection during high tides. The comparison between the 30% and 60% refined design also shows that the lower ground elevations in the Phase 1C grading enable water to reach farther into the restoration area.

2.4.3.2 Scenarios 12 and 13

Scenarios 12 and 13 simulated the projected SLR for Year 2035 and Year 2100, respectively. Both SLR scenarios were conducted with a partially closed inlet and tidal channel sill removed for comparison with Scenario 10. The projected SLR of 0.8 foot for Year 2035 and 3.6 feet for Year 2100 were based on the 2018 California Coastal Commission SLR guidance using the low risk aversion scenario, which has an approximately 17% chance of being exceeded. This is a conservative assumption of SLR for the restoration design because higher sea levels would expand the potential coastal salt marsh area.

Salinity spatial plots for Scenarios 12 and 13 are compared to Scenario 10 in Figure B.31. The results show that salinity conditions within the restoration area would be improved with the projected SLR. In Year 2035, high tides are expected to range from about 5 to 6 feet NGVD and there would be an increase in the saltwater inundation under high tides. By the Year 2100, high tides would range from about 8 to 9 feet NGVD and the entire Phase 1C restoration area would be inundated by saltwater on a regular basis.

2.4.4 Conclusions

The tidal hydraulic and salinity modeling for the 60% refined design showed that the Phase 1C design changes improved the hydraulics for the restoration area, but that some of the design changes to the Phase 1B freshwater channel did not improve tidal exchange to the salt marsh restoration area. The salinity is controlled by the amount of tidal exchange (saltwater) and dry weather freshwater flow. To provide sufficient salinity for coastal salt marsh, the saltwater interface needs to be upstream of the Phase 1C connection. This is accomplished by providing enough saltwater at high tide to offset dry weather flows, thereby facilitating mixing of saltwater and freshwater within the Phase 1B channel prior to entering the restoration area.

In the Phase 1B 60% refined design, the channel bench widths were reduced. At the downstream Phase 1 boundary, the width of the 4-foot NGVD29 contours was reduced from 128 feet to 115 feet. At the location of the existing Torrey pine, the channel bench width was narrowed from 150 feet to 75 feet. In general, the Phase 1B channel bench needs to be widened to provide sufficient saltwater to the restoration area, and design changes are needed to compensate for the narrowing of the channel bench to accommodate the existing, lone Torrey pine tree. Key features for the salt marsh restoration design are as follows:

- Maintain separation of the Phase 1B and Phase 1C channels for spring high tide water elevations to allow mixing of saltwater and freshwater flows before entering the Phase 1C restoration area.
- Provide channel dimensions of 10 feet wide at -2 feet NGVD29 with side slope of 2H:1V to a top elevation of 3 feet NGVD29.
- Provide wetland bench elevations between 3 and 5 feet NGVD29.

2.4.5 Recommendations

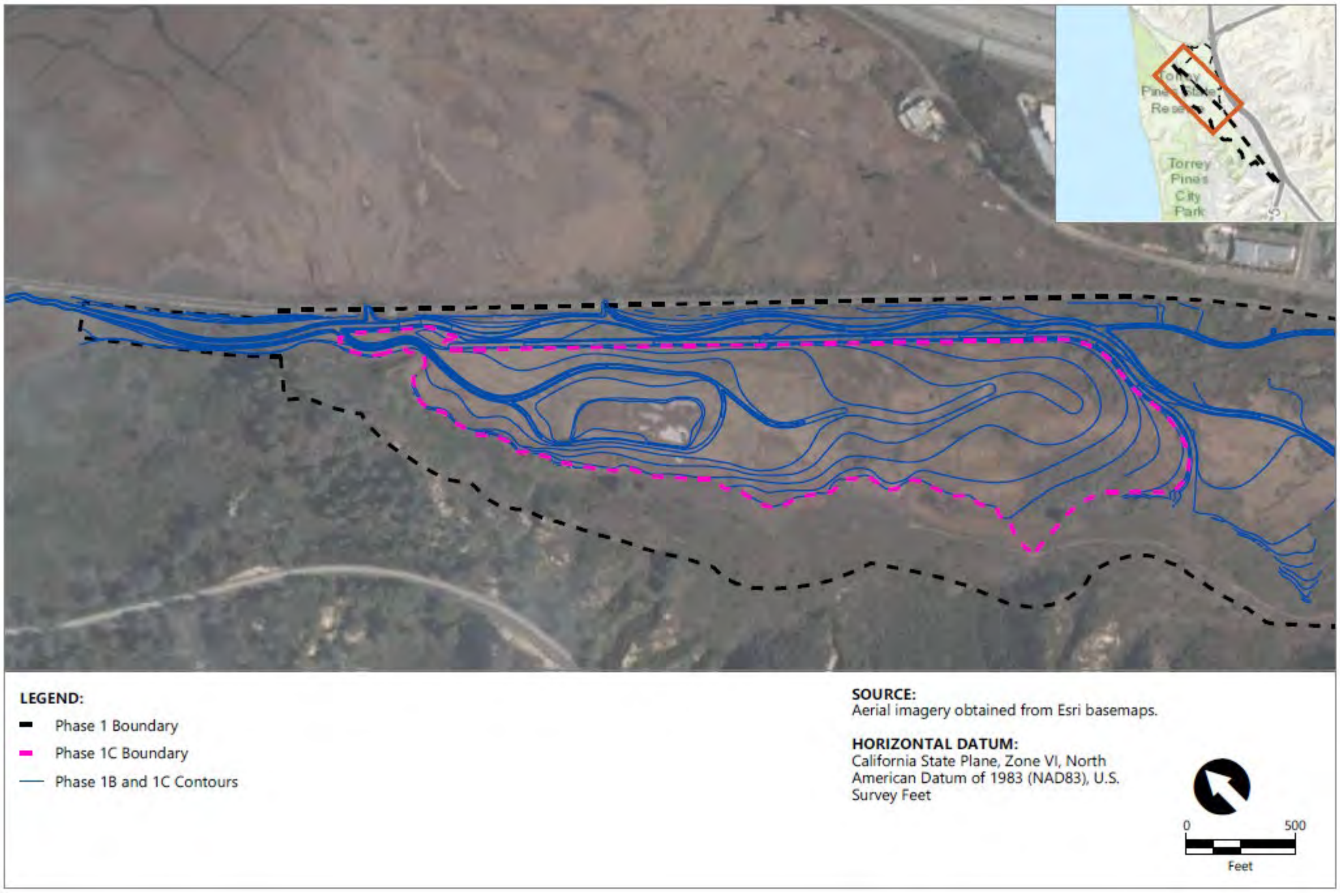
The following were recommendations to improve the salt marsh restoration design to be incorporated into the further refined 60% design:

- Maximize the Phase 1B channel bench width between the Phase 1 boundary and Phase 1C connection to increase tidal exchange at high tides. This would be accomplished by widening the 4-foot and 5-foot NGVD29 contours between the downstream end of the Phase 1 boundary and the Phase 1C connection.
- Modifications to the downstream Phase 1B channel benches should be verified with tidal hydraulic and salinity modeling.
- Marsh plain hummocks (e.g., small berms with a height of approximately 3 to 6 inches) may be added to the edges of the Phase 1C channel to pond saltwater at the higher tide elevations if additional salt is needed in the soil to keep freshwater/brackish water plants from becoming established, thereby maintaining salt marsh vegetation.

2.5 60% Final Design Evaluation

2.5.1 Overview

Salt marsh restoration refinements for the 60% final design, as shown in Figure 2.8, were developed based on recommendations from the tidal hydraulic and salinity modeling of the 60% refined design. The effectiveness of these changes for the 60% final design at improving tidal exchange (water levels) and salinity within the restoration area was evaluated with the 2020 EFDC Model. Additionally, model simulations were conducted to assess salinity recovery following a flood event as well as to evaluate SLR.



SOURCE:
Aerial imagery obtained from Esri basemaps.

HORIZONTAL DATUM:
California State Plane, Zone VI, North American Datum of 1983 (NAD83), U.S. Survey Feet

Figure 2.8. Phase 1C 60% Final Design Overview

2.5.2 Design Changes

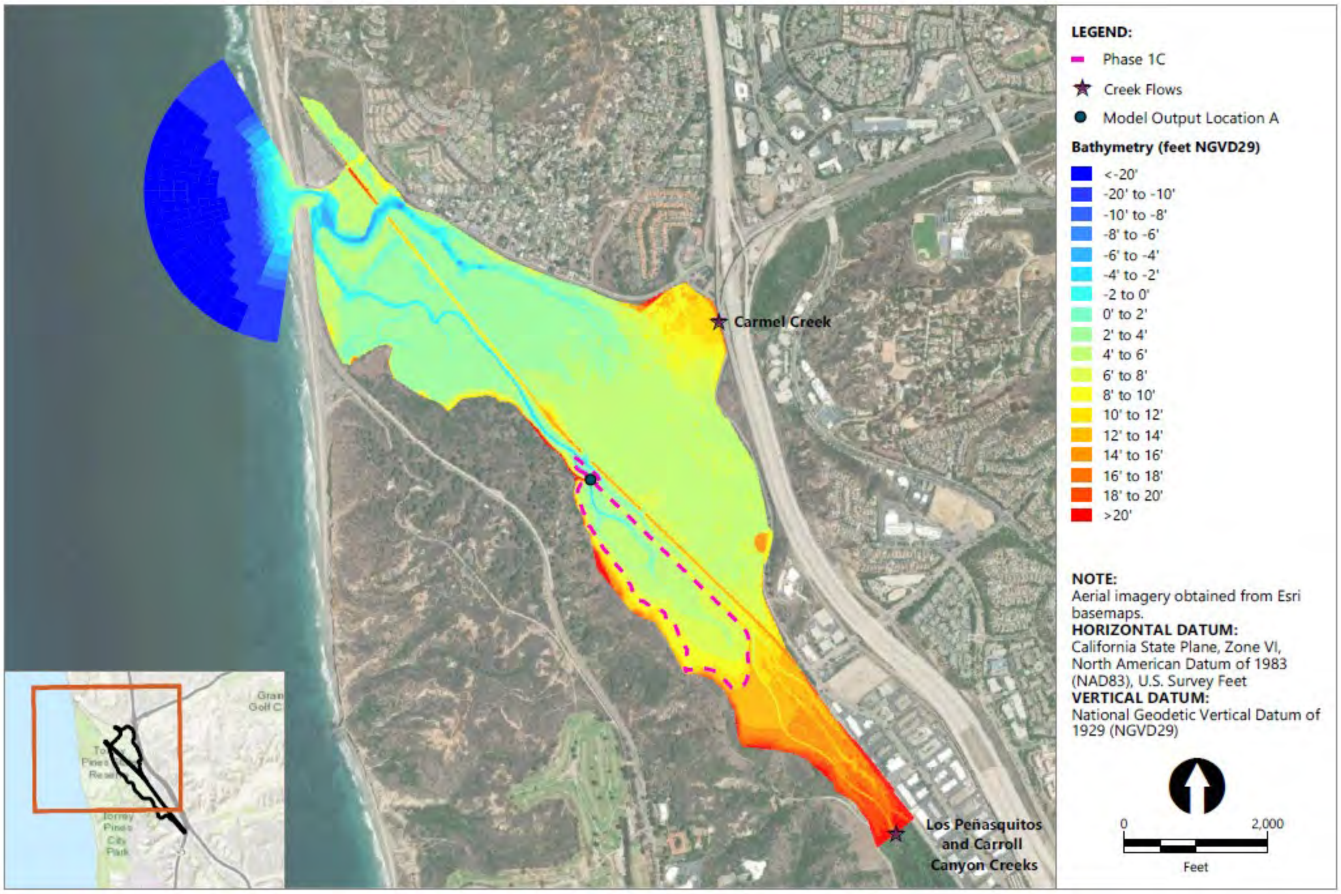
The 60% final design focused on increasing tidal exchange and salinity during spring high tide and King tide along the Phase 1B freshwater channel from the Phase 1 boundary to the Phase 1C restoration area, with the following design changes:

- Widened the freshwater channel bench grading downstream of the Phase 1C connection at an elevation of 4 feet NGVD to approximately 150 feet to increase tidal exchange during spring high tide and King tide.

- Widened the freshwater channel bench grading near the Phase 1C connection at an elevation of 4 feet NGVD to increase tidal exchange during spring high tide and King tide.
- Extend the tidal channel sill removal to a depth of -3 feet NGVD29 upstream to the Phase 1 boundary to improve tidal exchange and salinity to the salt marsh restoration area.
- Reduce dry weather flows to account for the planned dry weather flow diversion of Carroll Canyon Creek.

2.5.3 Results

The 2020 EFDC Model grid was revised for the 60% final design, as shown in Figure 2.9. The six model scenarios summarized in Table 2.5 were used to evaluate the effectiveness of the design changes at improving tidal exchange (water levels) and salinity within the restoration area. Scenarios 14 to 16 simulated water and salinity levels covering ranges in tidal range, dry weather flows, and inlet conditions. Scenario 17 was conducted to assess salinity recovery following a flood event. Transition areas for future SLR adaptation were assessed based on Scenarios 18 and 19 with projected SLR for Year 2035 and Year 2100, respectively.



NOTE:
Aerial imagery obtained from Esri basemaps.
HORIZONTAL DATUM:
California State Plane, Zone VI, North American Datum of 1983 (NAD83), U.S. Survey Feet
VERTICAL DATUM:
National Geodetic Vertical Datum of 1929 (NGVD29)

Figure 2.9. 2020 EFDC Model for Phase 1C 60% Final Design

Table 2.5. Phase 1C 60% Final Design Model Scenarios

Scenario	Inlet Configuration	Tidal Channel Configuration	Purpose
Scenario 14	Partially closed inlet	Tidal channel sill removed to Phase 1 boundary	Determine the range of water and salinity levels in the salt marsh restoration area with the tidal channel sill removed to the Phase 1 boundary and Carroll Canyon Creek dry weather flow diversion.
Scenario 15	Partially closed inlet	Tidal channel sill removed to Phase 1 boundary	Determine changes in water and salinity levels with minimum dry weather flow.
Scenario 16	Open inlet	Tidal channel sill removed to Phase 1 boundary	Determine changes in water and salinity levels with minimum dry weather flow and open inlet conditions.
Scenario 17	Open inlet	Tidal channel sill removed to Phase 1 boundary	Evaluate salinity recovery in the salt marsh restoration area following a 2-year flood.
Scenario 18	Partially closed inlet	Tidal channel sill removed	Assess water and salinity levels with Year 2035 SLR.
Scenario 19	Partially closed inlet	Tidal channel sill removed	Assess water and salinity levels with Year 2100 SLR.

Partially closed inlet based on July 2020 bathymetry survey.
Open inlet bathymetry based on April 2020 pre-dredge bathymetry survey taken following a wet weather event.
Removal of tidal channel sill assumes dredging to -3 feet NGVD29.

2.5.3.1 Scenarios 14 to 16

The salinity in the restoration area is dependent primarily on the amount of tidal exchange (saltwater) and dry weather freshwater flow. The 60% design changes have focused on maximizing saltwater at high tide to offset dry weather flows. Scenarios 14 to 16 were developed to assess ranges in tidal range, dry weather flows, and inlet conditions that affect salinity in the restoration area. The model simulations were conducted for a 20-day period that included mean, spring, neap, and King tide conditions. A range of dry weather flows and inlet conditions was evaluated due to the model sensitivity in estimating salinity. Scenario 14 represents conditions with average dry weather flows with diversion of the Carroll Canyon Creek dry weather flows and a partially closed inlet. Scenario 15 was used to determine changes in water levels and salinity based on the minimum dry weather flow used in the model verification process (Appendix A). Scenario 16 was used to evaluate an open inlet condition relative to Scenario 15.

Results of the tidal hydraulic and salinity modeling for Scenarios 14 to 16 are shown based on the model predicted salinity during spring high tide and King tide, as shown in Figure B.32. The results for Scenario 14 show that during spring high tide, there is not enough saltwater reaching the restoration area, and during King tide (previously referred to as extreme spring high tide) the lower portion of the restoration area would be inundated with saltwater. However, based on the model verification, the 2020 EFDC Model underestimates salinity due to various uncertainties, especially the dry weather flow and inlet conditions. The salinity spatial plots for Scenario 15 show higher salinity throughout the restoration area and best illustrate the extents of tidal inundation. At spring high tide and King tide, high salinity waters extend into the restoration area surrounding the existing salt marsh vegetation. Based on Scenario 16, higher salinity reaching farther into the restoration area would occur with open inlet conditions.

2.5.3.2 Scenario 17

Scenario 17 simulated a 2-year flood event to evaluate salinity recovery in the salt marsh restoration area following a flood event. This scenario assumed an open inlet configuration with the minimum dry weather flow after the flood event. The flood flows from the three creeks and tide conditions were previously shown in Figure B.22. The resulting water levels and salinity at Location A are shown in Figure B.33. Water levels increase above tide elevation in response to the flood flows and return to tide conditions after the flood ends. Salinity recovery occurs within 5 days after the end of the flood at Location A (Figure 2.9).

Water inundation and salinity spatial plots during the 2-year flood event are shown in Figure B.34. At peak flow, flood waters completely inundate the lagoon. At the end of the flood, freshwater remains throughout the lagoon. At the end of the storm, most of the flood waters have drained from the restoration area. Five days following the flood, salinity levels in the salt marsh restoration area have returned to pre-storm conditions. The separation of the freshwater and tidal channels for the 60% final design shows improved drainage of the flood waters in comparison to the 60% preliminary design (Figure B.24).

2.5.3.3 Scenarios 18 and 19

The projected SLR for Year 2035 and Year 2100 were simulated with Scenarios 18 and 19, respectively. Both SLR scenarios were conducted with a partially closed inlet for comparison with Scenario 15. The projected SLR of 0.8 foot for Year 2035 and 3.6 feet for Year 2100 were based on the 2018 California Coastal Commission SLR guidance using the low risk aversion scenario, which has an approximately 17% chance of being exceeded. This is a conservative assumption of SLR for the restoration design because higher sea levels would expand the potential coastal salt marsh area.

Salinity spatial plots for Scenarios 18 and 19 are compared to Scenario 15 in Figure B.35. The results show that higher salinity conditions would extend farther into the restoration area with the projected SLR. In Year 2035, high tides are expected to range from about 5 to 6 feet NGVD, and there would be an increase in the saltwater inundation throughout the lower portion of the restoration area. By the Year 2100, high tides would range from about 8 to 9 feet NGVD and the entire restoration area would be inundated by saltwater on a regular basis.

2.5.4 Conclusions

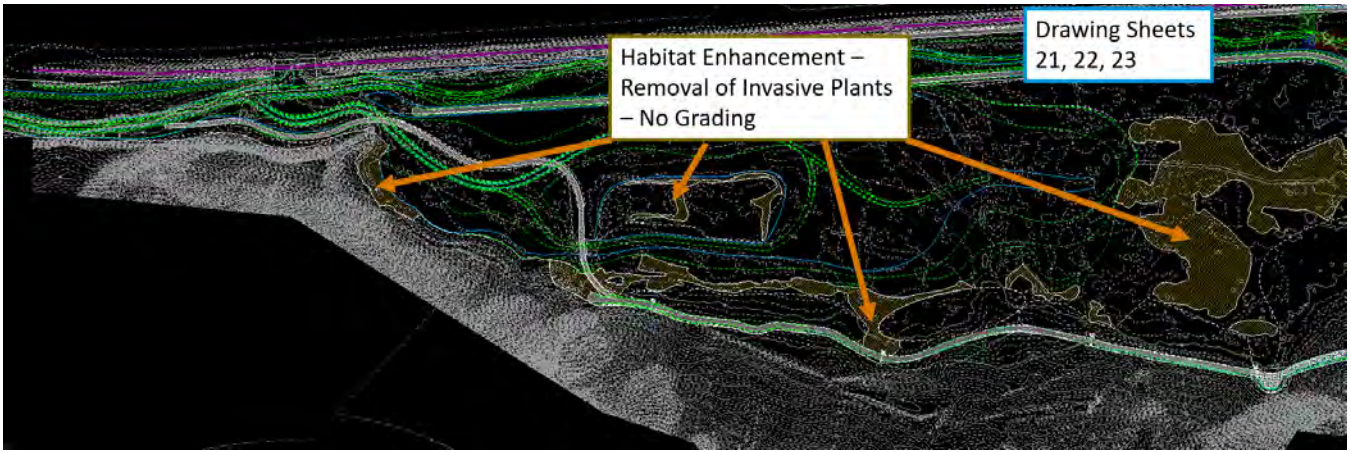
The Phase 1C salt marsh restoration 60% final design was based on the 2020 EFDC Model predictions of water and salinity levels. The grading in the Phase 1C area and downstream portion of the Phase 1B area was designed to provide the hydraulic and salinity conditions needed to preserve existing salt marsh vegetation and to establish and sustain high salt marsh vegetation. Overall, the tidal hydraulics and salinity modeling showed that salt marsh habitats can be established and maintained within the salt marsh restoration area. Tidal exchange and salinity in the restoration area are controlled by the elevation and width of the tidal channel, freshwater flow management, lagoon inlet conditions, tidal channel sill, and tidal channel high tide restriction downstream of the Phase 1 area. The 60% design refinements focused on the sustainability of coastal salt marsh based on the following changes:

- Increased and reliable tidal exchange between the lagoon and restoration area by:
  - Removing the tidal channel sill and lowering the tidal channel bottom to -3 feet NGVD29
  - Lowering the existing and new Phase 1B channel to -3 feet NGVD29 and widening the channel bottom width to 10 feet
  - Widening the tidal channel bench to 150 feet and lower elevation below spring high tide (3 and 5 feet NGVD29)
- Create conditions for greater salinity within the restoration area by:
  - Separating the freshwater channel and new tidal channel
  - Minimizing new tidal channels for higher retention of saline waters
  - Containing freshwater flows and low tides within the new tidal channel
  - Using opportunities to create salt panne and transitional zones for SLR
  - Potentially using marsh plain hummocks (e.g., small berms with a height of approximately 3 to 6 inches) at a distance from the Phase 1C channel to pond saltwater at the higher tide elevations if additional salt is needed in the soil to keep freshwater/brackish water plants from becoming established, thereby maintaining salt marsh vegetation

2.6 90% Design Evaluation

2.6.1 Overview

Salt marsh restoration refinements for the 90% design, as shown in Figure 2.10, were developed based on grading changes western and southern portions of the Phase 1C restoration area. The salinity within the restoration area that was evaluated with the 2020 EFDC Model for the 60% final design was used to support the planned vegetation communities.



Source: Burns and McDonnell 2023

Figure 2.10. Phase 1C 90% Design Overview

2.6.2 Design Changes

The 90% design focused on minimizing impacts to existing salt marsh vegetation mainly in the upstream portion of the Phase 1C restoration area, with the following design changes:

- Reduce limits of grading with no grading or stockpiles in habitat enhancement areas.
- Refine limits of disturbance to leave intact non-tidal salt marsh (i.e., identify "no disturbance areas").

2.6.3 Results

The grading changes made for the 90% design would not modify the results and conclusions of the modeling completed for the 60% final design. The 2020 EFDC Model salinity was overlain with the planned vegetation communities. Figures 2.11 to 2.13 compare the planned vegetation communities with the model predicted salinity under current water levels and with projected SLR for Year 2035 and Year 2100.

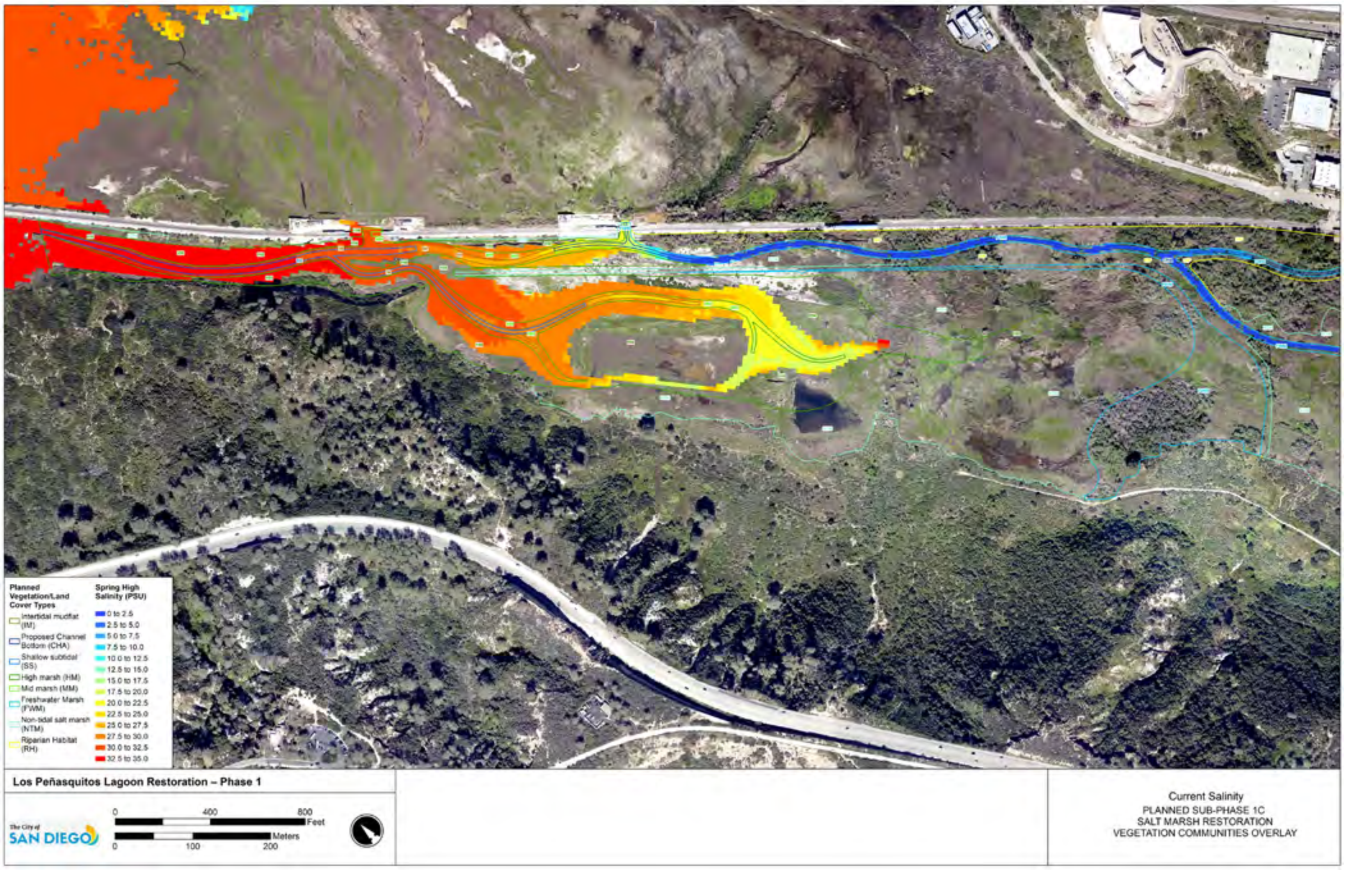


Figure 2.11. Current Salinity and Planned Vegetation Communities

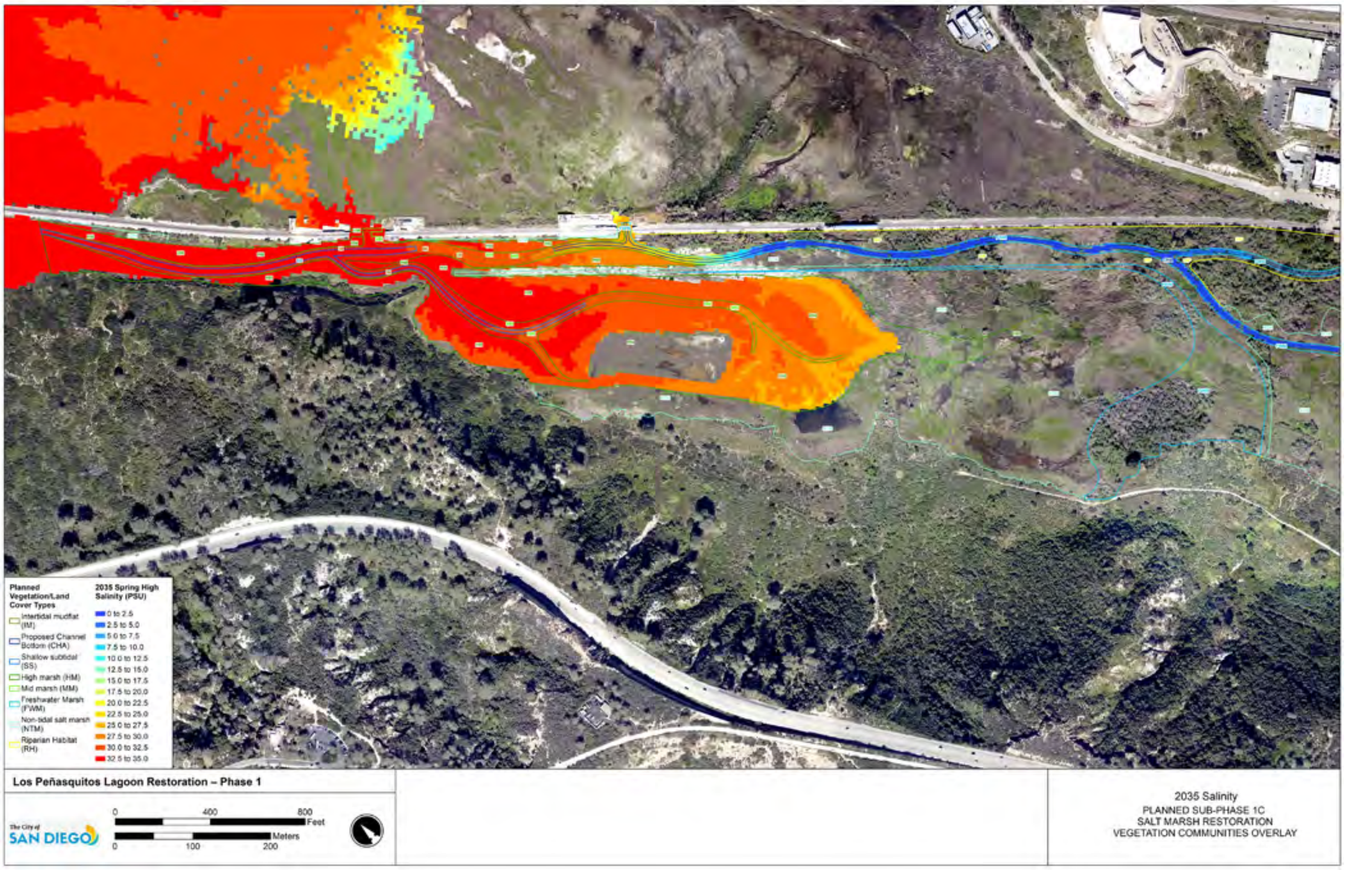


Figure 2.12. 2035 Salinity and Planned Vegetation Communities

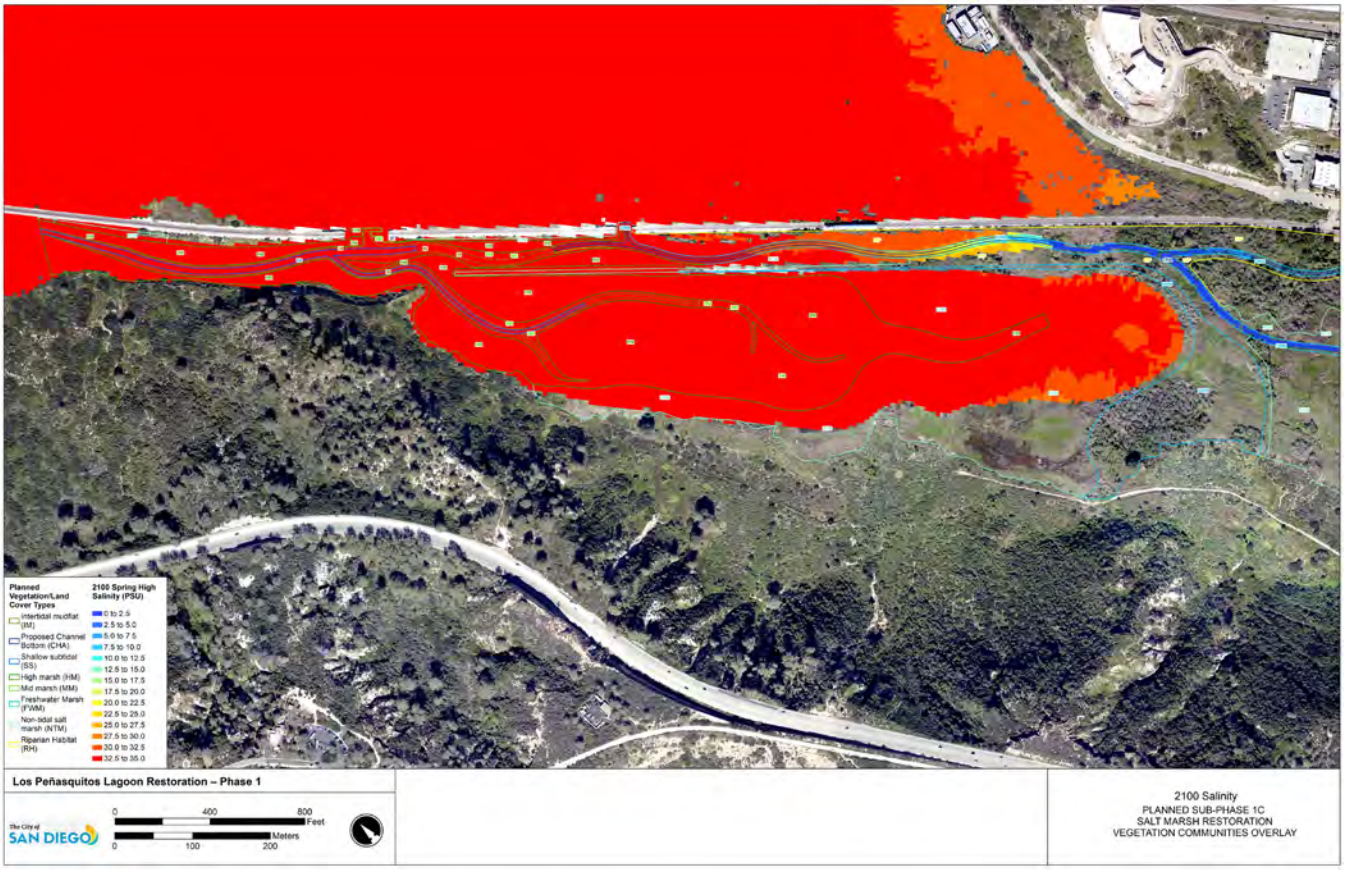


Figure 2.13. 2100 Salinity and Planned Vegetation Communities

2.6.4 Conclusions

The Phase 1C salt marsh restoration 90% design was based on the 2020 EFDC Model predictions of water and salinity levels. The grading in the Phase 1C area and downstream portion of the Phase 1B area was designed to provide the hydraulic and salinity conditions needed to preserve existing salt marsh vegetation and to establish and sustain high salt marsh vegetation. Overall, the tidal hydraulics and salinity modeling showed that salt marsh habitats can be established and maintained within the salt marsh restoration area. Tidal exchange and salinity in the restoration area are controlled by the elevation and width of the tidal channel, freshwater flow management, lagoon inlet conditions, tidal channel sill, and tidal channel high tide restriction downstream of the Phase 1 area.

3.0 Reference

Burns and McDonnell (Burns and McDonnell Engineering, Inc.), 2023. *Los Peñasquitos Lagoon Restoration Phase 1 Technical Advisory Committee Meeting – 90% Design.* July 24, 2023.

A. EFDC Model Development

1. Prior EFDC Modeling

The salt marsh restoration design was based on a numerical hydrodynamic model to simulate water levels and salinity under existing conditions. A two-dimensional numerical hydrodynamic model of the lagoon was previously developed by Tetra Tech, Inc. (Tetra Tech 2016a), herein referred to as the 2016 EFDC Model, using the Environmental Fluid Dynamics Code (EFDC) modeling platform. EFDC is a surface water modeling system developed and distributed by the U.S. Environmental Protection Agency Center for Exposure Assessment Modeling that was designed to simulate hydrodynamics and water quality transport in lake, river, estuarine, and coastal environments (USEPA 2007). The 2016 EFDC Model was subsequently modified by Geosyntec in 2018, herein referred to as the 2018 EFDC Model, for use in preparing the salt marsh restoration conceptual design and watershed master plan/integrated drainage and engineering analysis.

2016 EFDC Model Summary

The 2016 EFDC Model (Tetra Tech 2016a) simulated the ocean tide and freshwater flows from Los Peñasquitos, Carroll Canyon, and Carmel Creeks. The model grid was a cartesian grid with a grid resolution of 16.4 by 16.4 feet (5 by 5 meters) that extended from the lagoon inlet through the Phase 1 and 2 project areas. The model was calibrated based on measured water levels and salinity recorded over a 6-day period in 2016, which included a wet weather event on the last 2 days. The model calibration period (January 1 to 7, 2016) had an average dry weather flow of 15.4 cubic feet per second (cfs) and a wet weather event with a peak flow of 9,735 cfs. The 2016 EFDC Model calibration compared measured and modeled water levels and salinity in the lagoon. Water levels were compared at three locations, while salinity was compared at four other locations.

The model topography was based on 2014 Light Detection and Ranging (LiDAR) data, while the tidal channel bathymetry was defined using limited cross section surveys taken in 2008, 2015, and 2016 (ESA 2016). The ocean tide boundary used verified tide data from the National Oceanic and Atmospheric Administration (NOAA) La Jolla tide gauge. Simulated flows for the combined flow from Los Peñasquitos and Carroll Canyon Creeks and Carmel Creek were based on measured flows (AMEC 2016). The 2016 EFDC Model included a 2-day spin-up period prior to the calibration period that used an initial water level of 0 feet North American Vertical Datum of 1988 (NAVD88) and uniform initial conditions for salinity (32.5 practical salinity units [PSU]).

For the 2016 EFDC Model calibration, measured water levels were available from three locations in the lagoon, but bathymetry data were not available to properly define the tidal channels leading to two of the locations (NW and NE); therefore, the model cannot accurately simulate tide water levels at these two locations. Hence, only the modeled water levels at the SE station near the salt marsh restoration are suitable for evaluating the capability of the model to simulate tidal water levels. At the SE station, the model was not able to capture the water level variations observed in the measured data. During wet weather conditions, the modeled water levels at the three locations showed a corresponding increase in water levels from the freshwater flows, but the modeled water levels were significantly higher than the measured water levels.

The 2016 EFDC Model salinity calibration compared modeled and measured salinity at four locations. In general, the model salinity remained constant over the first 2 to 3 days before showing salinity fluctuations due to tidal effects as observed in the measured salinities. The constant salinity corresponded to neap tide conditions, and tidal effects on salinity occurred during mean tide conditions. The 2016 EFDC Model salinity levels indicated an issue with the initial conditions for the model setup and insufficient spin-up time in the model simulation. During wet weather, the modeled salinities showed a significant decrease in salinity corresponding to the freshwater flows, but the salinity spatial plots showed the freshwater flows reaching the ocean model boundary. These salinity results, in combination with the overpredicted water levels, indicated that the model ocean domain could be too small to dissipate freshwater flows after leaving the lagoon.

The 2016 EFDC Model was used to evaluate the effectiveness of dredging the main tidal channel through the Phase 1 project area and farther downstream under dry and wet weather conditions. It was concluded that a deeper and wider tidal channel would confine and convey freshwater flows through the lagoon, and that freshwater flows have a significant impact on salinity levels. The major limitation of the 2016 EFDC Model was the lack of tidal channel bathymetry.

2018 EFDC Model Summary

As part of the watershed master plan integrated drainage and engineering analysis, the 2016 EFDC Model was updated to the 2018 EFDC Model by expanding the model grid to include the Carmel Creek sediment delta fan and extending the upstream end of the Los Peñasquitos and Carroll Canyon Creeks into Sorrento Valley. The 2018 EFDC Model was used to reproduce water and salinity levels of the 2016 calibration period, but it did not improve the model predictions of water and salinity levels.

The 2018 EFDC Model was used to evaluate the conceptual design of channel modifications, removing a portion of the railroad berm, and SLR. Compared to existing conditions, the conceptual design channels slightly increased salinity at the upstream end of tidal inundation under dry weather conditions and improved freshwater conveyance under wet weather conditions. The removal of the railroad berm downstream of the second railroad trestle near the Phase 1 project area was intended to allow more tidal exchange in the salt marsh restoration area. However, removal of the railroad berm showed little effect on water levels and salinity compared to existing conditions.

Discussion

The 2018 EFDC Model was previously developed as a planning-level tool and was used in preparing the conceptual restoration design and watershed management plan (Michael Baker et al. 2018). As a planning-level tool, the 2018 EFDC Model was adequate for relative comparisons between existing and conceptual-level alternatives. However, updates to the 2018 EFDC Model were required to develop a design-level tool for the salt marsh restoration design.

As a first step in updating the 2018 Model, Geosyntec modified the model for existing conditions. The goals of the model modifications were to incorporate the more recent bathymetry data, expand the model grid (particularly the ocean boundary), and improve model predictions of water levels and salinity near the salt marsh restoration area.

An updated digital elevation model (DEM) with a 1-foot resolution was created by merging the available cross section, LiDAR, and ocean bathymetry data. Available cross section data were prioritized over the LiDAR data to ensure channels were properly represented in the DEM, and newer data were prioritized over older data where both were available. Datasets utilized for the updated DEM creation included the following:

- 2020 cross section data collected by Rick Engineering
- 2019 LiDAR data collected by the City of San Diego
- 2016 cross section collected by Environmental Science Associates
- 2014 LiDAR data from City of San Diego
- 2016 cross section data collected by Environmental Science Associates
- 2015 cross sectional information from Coastal Environments
- 2009 ocean bathymetry from National Ocean and Atmospheric Agency (NOAA)
- 2008 cross section data collected by Weston Solutions

An updated model grid was developed that incorporated a radial boundary at the ocean boundary of the model domain. This allowed the model ocean boundary to be moved farther offshore. The updated boundary allowed coarser cells to be used farther from the lagoon while maintaining high resolution in and near the lagoon. The updated model grid consists of 93,388 cells. In addition to the modifications described above, increasing the resolution of the model grid to a 3.28-foot by 3.28-foot (1-meter by 1-meter) grid resolution was considered, but it was determined that model simulation times would be prohibitively long.

Effects of these model modifications to improve model predictions were evaluated based on the 2016 validation period. The updated DEM was interpolated onto both the 2018 EFDC Model and the modified model grids. Within the tidal channels, the minimum value of the DEM within the grid cell was used to ensure channel connectivity was maintained. Outside the tidal channels, the average DEM value within the grid cell was used.

Model-data comparisons for the 2016 validation period were conducted using both the 2018 EFDC Model and modified model grids (incorporating the radial ocean boundary). Additionally, revised dry weather flows were simulated and showed that lower dry weather flows for Los Peñasquitos and Carroll Canyon Creeks may be more accurate because model-data agreement improved in the southern portion of the lagoon. However, the modified model overall performance was similar to the 2018 EFDC Model. In general, the model modifications of the bathymetry and ocean boundary resulted in a more updated and accurate representation of the lagoon bathymetry and an improved boundary condition, while also providing a more complete understanding of the strengths and limitations of the model, specifically the sensitivity to dry weather flows.

2. 2020 EFDC Model Development

Overview

Capabilities of the 2020 EFDC Model to simulate water levels and salinity were evaluated by comparing modeled and measured water levels and salinity from 2016 and 2020. The 2020 EFDC Model, as shown in Figure A.1, was used to simulate the 2016 EFDC Model calibration period to demonstrate the model improvements, which included the following:

- Expanding the ocean boundary
- Extending the model spin-up period from 2 to 8 days to start water levels at mean tide conditions
- Refining the model grid along the tidal channel

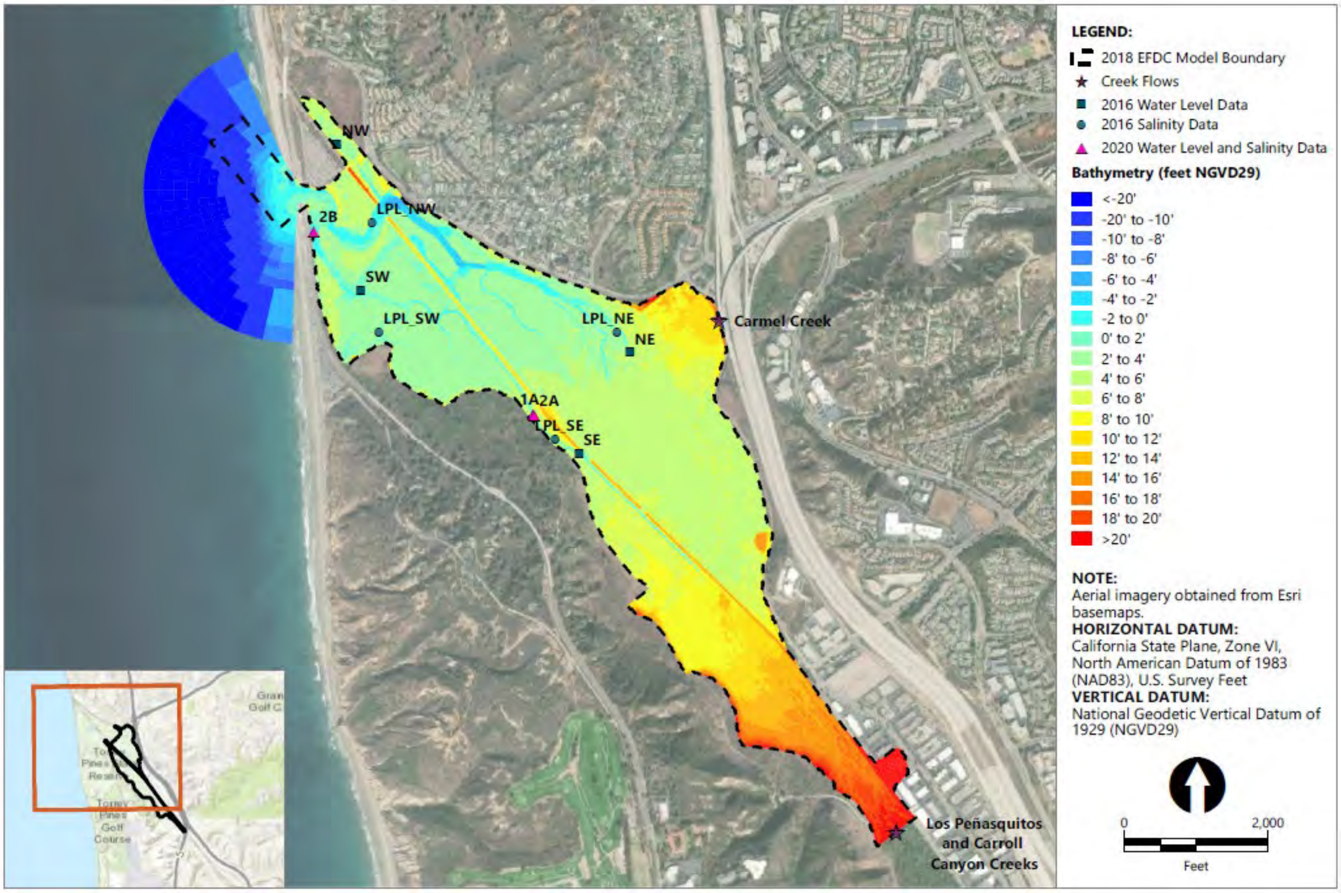


Figure A.1. 2020 EFDC Model for Existing Conditions

Input Data

Numerous data sources were used to define the physical conditions of the lagoon in the hydrodynamic model and to verify the model capabilities to simulate water and salinity levels based on the varying lagoon conditions. Table A.1 is a comprehensive summary of data available for model development, boundary conditions, and model verification. An overview of monitoring locations for available data is shown in Figure A.2.

Table A.1 Data Summary for Model Inputs

Data Type	Description	EFDC Model Application
Topography	2009 U.S. Army Corps of Engineers Southern California Bathy LiDAR	EFDC Model ocean bathymetry
	2014 LiDAR for Phase 1 and 2 project areas by City of San Diego	EFDC Model lagoon bathymetry outside tidal channels
	2020 LiDAR for Phase 1 project area, from City of San Diego	2020 EFDC Model lagoon bathymetry outside tidal channels for existing conditions
Bathymetry	2008 tidal channel cross sections by Weston Solutions (2009)	2016 and 2018 EFDC Model tidal channel bathymetry
	2015 inlet and tidal channel cross sections by Coastal Environments	2016 and 2018 EFDC Model inlet and tidal channel bathymetry
	2016 inlet and tidal channel cross sections (ESA 2016)	2016 and 2018 EFDC Model inlet and tidal channel bathymetry
	2011 to 2019 inlet maintenance summary reports with periodic cross section information available (LPLF 2020a)	Characteristics of inlet bathymetry for existing conditions
	2019 and 2020 pre- and post-dredge survey reports with cross sections (LPLF 2020b)	2020 EFDC Model open inlet bathymetry conditions
	2020 inlet and tidal channel cross sections by Rick Engineering	2020 EFDC Model inlet bathymetry for existing conditions
Watershed Inflows	September 1996 to June 2010 monthly, single-sample flow at three creeks from the LPL Monitoring Program	Data comparison for dry weather baseflow
	January 1 to 7, 2016, continuously measured watershed flows from three creeks (ESA 2016)	2016 EFDC Model calibration creek inflows
	January 20 and February 17, 2016, dry weather single-sample flow at three creeks (ESA 2016)	2018 EFDC Model constant dry weather baseflow for model scenarios
	January 1990 to December 2014 predicted flows from Los Peñasquitos Watershed LSPC Model from Bacteria TMDL Reopener (Tetra Tech 2016b and Geosyntec 2020)	2020 EFDC Model 2-year flow event determined from statistical analysis of LSPC modeled flows
Water Levels	Ocean tides at La Jolla monitored by NOAA	EFDC Model ocean water level boundary
	May 2014 to April 2016 lagoon water levels at three locations (NE, NW, and SE; Tetra Tech 2016a)	2018 EFDC Model water level calibration period January 1 through 6, 2016
	May 22 to June 26, 2020, water levels near salt marsh restoration area (1A) by Pi Environmental	2020 EFDC Model Round 1 verification period from June 6 to 16, 2020
	September 17 to October 30, 2020, water levels near salt marsh restoration (2A) and at the downstream end of the tidal channel (2B) by Pi Environmental	2020 EFDC Model Round 2 verification period from September 21 to October 7, 2020
Salinity	May 2014 to April 2016 lagoon salinity at four locations (LPL__NE, LPL__NW, LPL__SE, and LPL__SW; Tetra Tech 2016a)	2018 EFDC Model salinity calibration period January 1 through 6, 2016
	May 22 to June 26, 2020 salinity near salt marsh restoration area (1A) by Pi Environmental	2020 EFDC Model Round 1 verification period from June 6 to 16, 2020
	September 17 to October 30, 2020, salinity near salt marsh restoration area (2A) by Pi Environmental	2020 EFDC Model Round 2 verification period from September 21 to October 7, 2020

Note: Three creeks: Carmel Valley Creek, Los Peñasquitos Creek, and Carroll Canyon Creek.

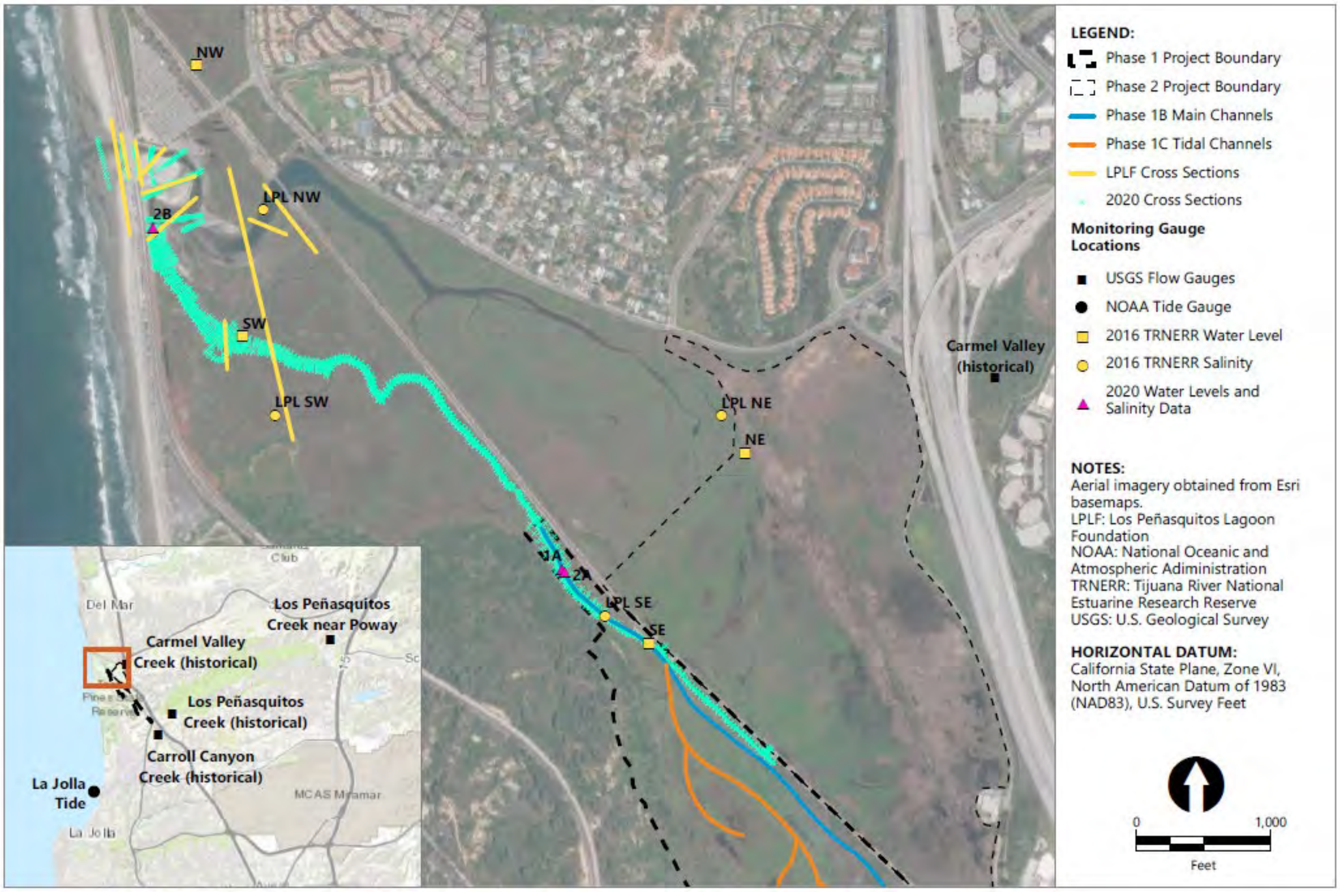


Figure A.2. Data Overview

Lagoon Topography

The LiDAR data used to develop the model bathymetry provided topographic information for most of the lagoon, but these data do not provide bathymetry of the lagoon inlet and existing tidal channels. The model topography was defined by LiDAR data from 2020 in the Phase 1 project area and from 2014 for the remaining area.

Tidal Channel Bathymetry

The spatial extent of tidal inundation at the salt marsh restoration area is strongly dependent on the dimensions (width and bottom elevation) of the lagoon inlet and tidal channel, which carries tidal flows between the ocean and restoration site. The tidal channel also facilitates drainage of freshwater flows (dry weather and storm) from the upper portions of the lagoon out to the ocean. As identified during the initial model development (Tetra Tech 2016a), higher resolution bathymetry data are needed within the tidal channel to improve the accuracy of the model results because water and salinity levels are dependent on the lagoon inlet and tidal channel conditions. To address these data gaps, bathymetric surveys (i.e., channel cross sections) by Rick Engineering were conducted at the lagoon inlet and along the tidal channel in July 2020, as shown in Figure A.2. The data were used to determine the lagoon conditions when water and salinity data near the salt marsh restoration area were collected from May to June 2020.

The 2020 tidal channel bathymetry survey channel cross sections were used to generate contours of the tidal channel. The profile of the tidal channel thalweg is provided in Figure A.3. The downstream end of the existing main tidal channel starts near Location 2B with a bottom elevation of -2.6 feet National Geodetic Vertical Datum of 1929 (NGVD29) and extends upstream approximately 7,000 feet near the salt marsh restoration area. The channel bottom becomes relatively higher, fluctuating from -2.0 to -0.4 feet NGVD29 (3,300 to 7,000 feet from upstream end). This relatively high portion of the tidal channel, referred to as the tidal channel sill, could limit draining and filling during tidal ebbing and flooding, respectively, and impair the ability for saltwater to reach the salt marsh restoration area to support the target vegetation. The tidal channel sill could also reduce the ability of the entire Phase 1 area to drain freshwater following storms. The Los Peñasquitos Lagoon Enhancement Plan (Enhancement Plan; ESA et al. 2018) suggested that excavation of the tidal channel upstream of the sill and into the Phase 1C restoration area would improve the drainage of freshwater and bring tidal waters farther upstream into the lagoon.

Upstream of the sill, the tidal channel deepens, with bottom elevations ranging from -3.5 to -1.5 feet NGVD29 up to the Phase 1 project boundary (3,300 to 1,700 feet from upstream end). At approximately 1,700 feet from the upstream end, the bottom of the tidal channel rapidly increases from -3.1 to 0.0 feet NGVD29 at the salt marsh restoration area (1,700 to 1,000 feet from upstream end). This portion of the tidal channel, referred to as the pinch point, narrows from about 16 to 8 feet at -1.0 feet NGVD29.

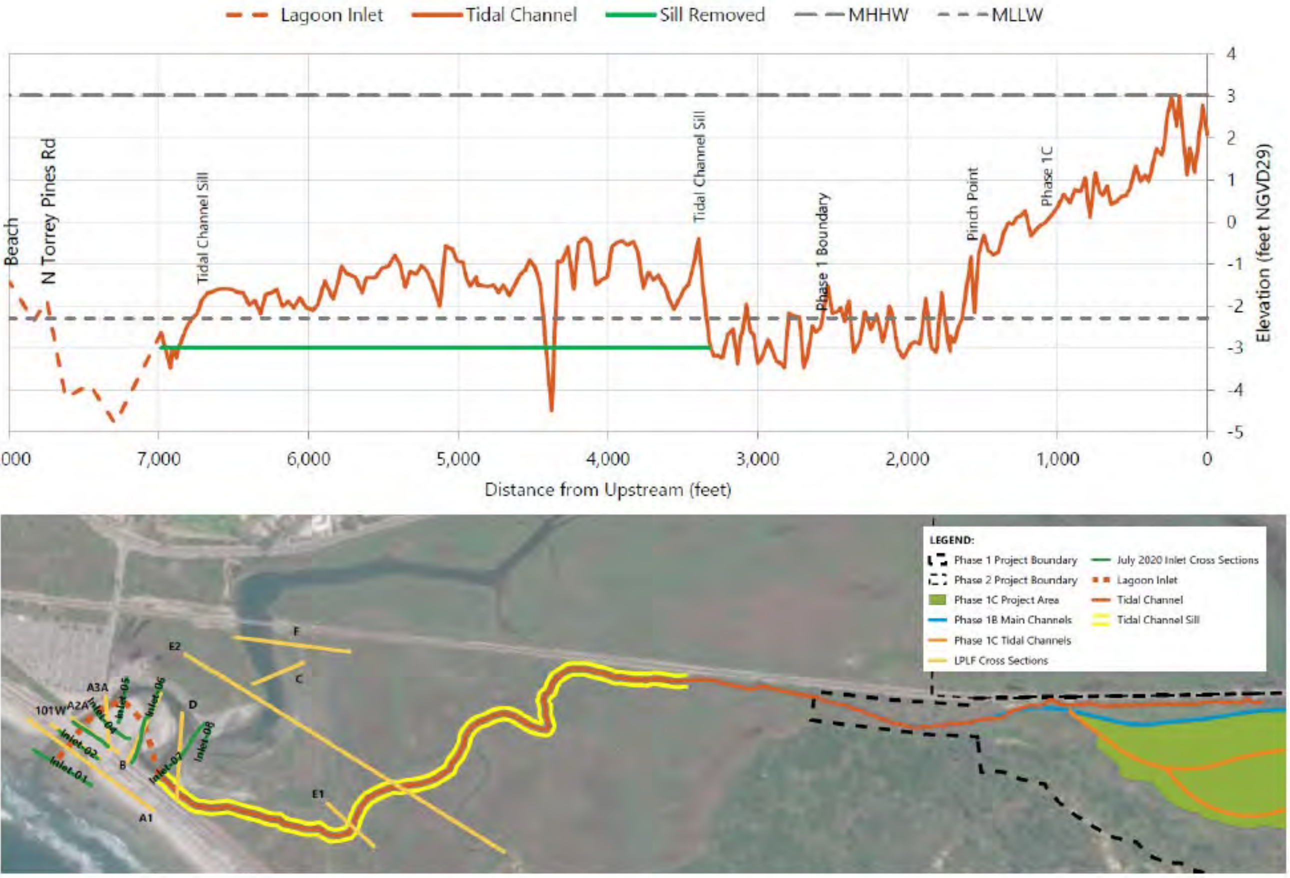


Figure A.3. July 2020 Tidal Channel Profile and Inlet Cross Sections

Lagoon Inlet Bathymetry

Historically, the lagoon inlet became more susceptible to inlet closure from marine sedimentation due to significant alterations to the lagoon system, such as the construction of the railroad and Highway 101, as summarized in the Enhancement Plan (ESA et al. 2018). The 1888 railroad alignment, constructed on an elevated berm on the eastern side of the lagoon near Interstate 5, cut off storm flows from Carmel Creek. This berm was abandoned in 1925 with the construction of the present railroad alignment through the middle of the lagoon. Freshwater flows are limited to only three railroad trestles. Construction of the 1925 railroad alignment also moved the lagoon inlet farther south from its historic location. In 1932, the construction of Highway 101 (currently referred to as North Torrey Pines Road) and the North Beach parking lot in 1968 fixed the lagoon inlet at its present location.

Since 1985, the Los Peñasquitos Lagoon Foundation (LPLF) has periodically dredged the lagoon inlet to maintain tidal exchange between the lagoon and ocean and preserve water quality conditions in the lagoon to support aquatic organisms. In 2005, the Highway 101 bridge was reconstructed with fewer support columns; this has reduced the frequency of inlet closures but it has not reduced the amount of marine sedimentation east of the Highway 101 bridge (ESA et al. 2018). A chronological summary of mechanical openings of the lagoon inlet since 2006 is provided in Table A.2. Typically, approximately 25,000 cubic yards (cy) of sand is mechanically removed in May each year. The amount of sand removed increased dramatically in 2013 and 2014 due to the Regional Beach Sand Project (RBSP II), which placed 300,000 cy of sand on beaches north of the lagoon. Sand grain size analysis showed that dredged sand from 2013 did not match typical lagoon sand, but it was likely the coarser material used in the RBSP II (ESA et al. 2018).

Table A.2 Mechanical Openings of Lagoon Inlet Since 2006

Year	Description
2006	Small mechanical opening from February 20 to 24.
2007	Four small mechanical openings on January 3, March 20, April 16, and May 14 to 19.
2008	Mechanical opening from April 30 to May 9.
2009	Mechanical opening from May 16 to 26.
2010	Mechanical opening from May 3 to 8 (24,837 cy).
2011	Mechanical opening from May 6 to 13 (26,085 cy).
2012	RBSP II placed over 300,000 cy of sand on beaches north of the lagoon in spring 2012. One mechanical opening in May (14,637 cy).
2013	Two mechanical openings on May 13 to 17 (5,000 cy) and June 12 to 21 (35,000 cy). Frequency of dredging and total volume of sand removed (40,000 cy) augmented by RBSP II.
2014	Three mechanical openings on April 7 to 11 (30,180 cy), April 21 to 28 (21,184 cy), and May 19 to 26 (4,170 cy). Frequency of dredging and total volume of sand removed (55,534 cy) augmented by RBSP II.
2015	Mechanical opening from April 22 to May 1 (25,575 cy).
2016	Six mechanical openings from March 3 to 4 (2,500 cy), April 1 (2,500 cy), May 18 to 27 (30,690 cy), June 9 (3,500 cy), August 25 to September 2 (27,300 cy), and November 14 to 18 (10,000 cy). Frequency of dredging and total volume of sand removed (76,490 cy) augmented by RBSP II and El Niño conditions.
2017	Mechanical opening from April 13 to 21 (22,700 cy).
2018	Mechanical opening from May 4 to 14 (34,534 cy).
2019	Mechanical opening from May 6 to 17 (36,090 cy). Volume of sand removed augmented by sand placed on Fletcher’s Cove in Solana Beach (140,000 cy) which was lost to coastal erosion during winter 2018-2019.
2020	Mechanical opening from May 11 to 22 (34,620 cy).

Source: LPLF 2020a

The lagoon inlet bathymetry has been documented based on periodically taken cross sections. In conjunction with maintenance dredging conducted by the LPLF, cross sections at fixed locations (Figure A.2) are routinely taken before and after dredging events. Pre- and post-dredge cross sections were measured in April and May 2020 (LPLF 2020b). The April pre-dredge survey was taken after a storm event that scoured the inlet bottom to -4 feet NGVD29. The May post-dredge survey showed that the inlet bottom was higher at 0 foot NGVD29. The higher post-dredge inlet condition was due to the dredging method, which mechanically closes the inlet to conduct dredging operations with land-based equipment. After dredging, the inlet was mechanically re-opened but not to pre-dredge conditions. In July 2020, the lagoon inlet bathymetry was measured with six cross sections (Figure A.3) to support water and salinity level monitoring. At the time of the survey, the tidal inlet was partially closed due to the beach berm with an invert elevation of -1.4 feet NGVD29 (Inlet-01), as shown in Figure A.4. The invert elevation decreased into the lagoon to about -2 feet NGVD29 beneath North Torrey Pines Road (Inlet-02 and Inlet-03) to approximately -4 feet NGVD29 toward the existing main channel (Inlet-04, Inlet-05, and Inlet-06).

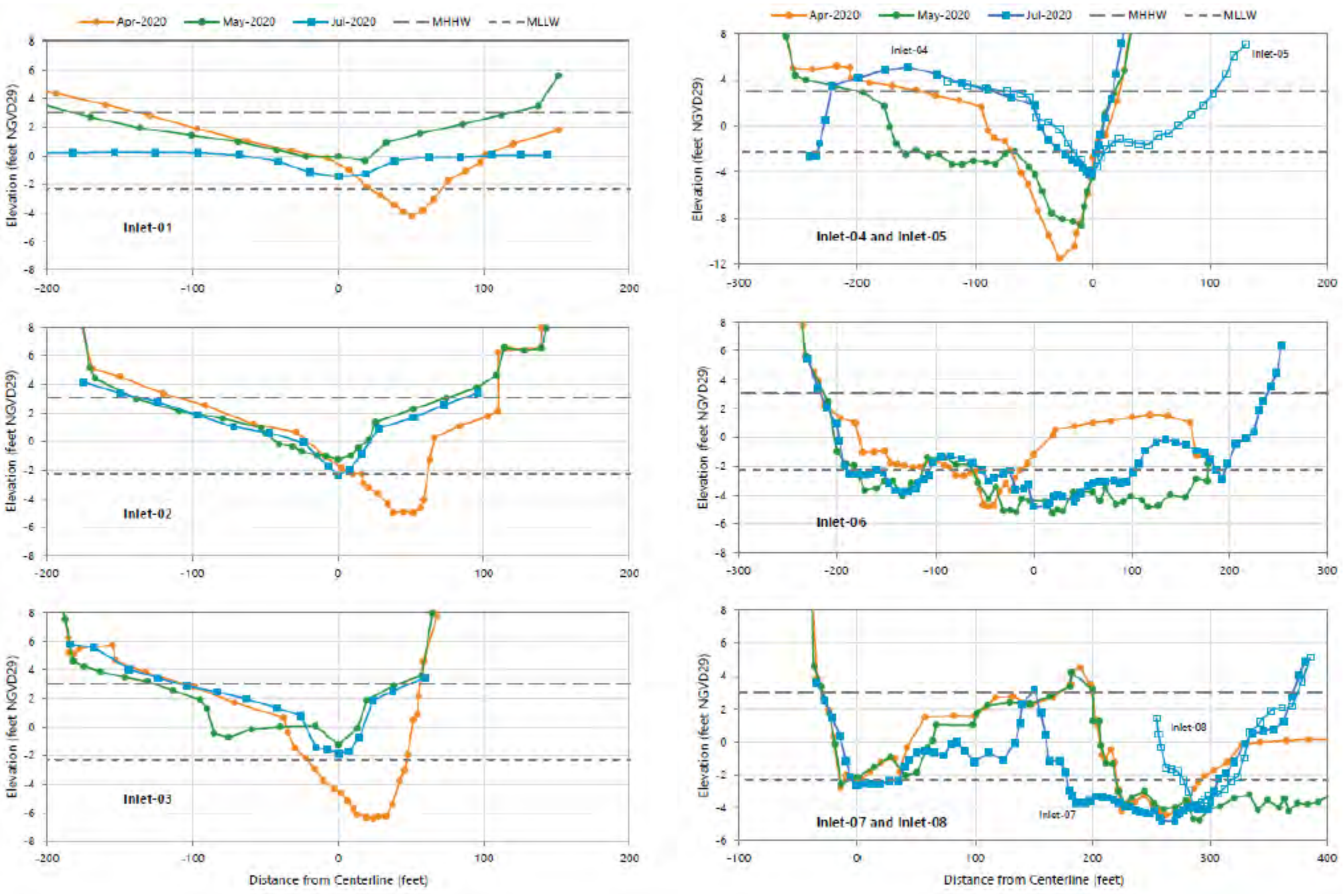


Figure A.4. 2020 Inlet Cross Sections

Creek Inflows

Three creeks flow into the lagoon: Los Peñasquitos Creek, Carroll Canyon Creek, and Carmel Creek. Historically, the LPLF and U.S. Geological Survey (USGS) monitored flows from the three creeks, but only for a 1-year period from 1985 to 1986. Currently, there are no permanent flow gauges at the downstream end of the three creeks. In the upper watershed of Los Peñasquitos Creek, there is an active USGS flow gauge near Poway (11023340) that has been in operation since 1964.

Dry Weather Flows

Dry weather flows from the three creeks were periodically monitored between September 1996 and June 2010 using a simplified single-sample method that measures the flow rate at a single point in time (like a grab sample). Monthly, single-sample flows from the three creeks were monitored as part of the LPL Biological and Physical Monitoring Program. Flow monitoring of the LPL Biological and Physical Monitoring Program was suspended because the single-sample flow method on a monthly basis did not capture flow data for specific storms or fluctuations in perennial flows. It was decided that establishing patterns in freshwater inputs would be better accomplished with continuous, telemetered flow monitoring at fixed locations (i.e., permanent flow gauges). In addition, continuous flow monitoring of the three creeks would provide flow data to characterize freshwater inputs to support the development of hydrologic and sediment loading models of existing conditions and restoration alternatives. Hence, flow monitoring was suspended in 2010 to improve the data collection methods and acquire funding for installing, operating, and maintaining permanent flow gauges (ESA et al. 2018). Additional single-sample flows at the three creeks were collected on January 20 and February 17, 2016 (ESA 2016).

Table A.3 compares the dry weather flow data and flow rates used in the previous EFDC modeling. The 2018 EFDC Model used a constant dry weather baseflow for model scenarios. The baseflow was selected as the lower measured flow on February 17, 2016, of 0.2 cfs for Carroll Canyon; 3.2 cfs for Los Peñasquitos Creek; and 0.4 cfs for Carmel Creek (ESA 2016).

Table A.3. Data Summary for Dry Weather Flows

Creek	**2016 and 2018 EFDC Model**		**January 20, 2016**	**February 17, 2016**	**1996 to 2010 Average Flow**
	Calibration	**Dry Weather**			
Carmel Creek	0.5 cfs	0.4 cfs	0.6 cfs	0.4 cfs	1.4 cfs
Los Peñasquitos Creek	14.9 cfs	3.2 cfs	5.5 cfs	3.2 cfs	3.6 cfs
Carroll Canyon Creek		0.2 cfs	1.6 cfs	0.2 cfs	2.0 cfs

Notes:2018 EFDC Model dry weather baseflow from lower of two flow samples taken in 2016 (Michael Baker et al. 2018).
January and February 2016 flow from ESA 2016.
1996 to 2010 average flow of flow data without high flows (Tetra Tech 2016a).

Wet Weather Flows

Flood hydrographs for the three creeks were available from the Loading Simulation Program in C++ (LSPC) watershed model developed to support the HEC-RAS modeling for the Los Peñasquitos Watershed Management Plan (Michael Baker et al. 2018). The LSPC model was originally developed and calibrated as part of the Bacteria TMDL Reopener (Tetra Tech 2016b). The watershed model was used to produce continuous time series of creek flows using precipitation data from water years 1991 to 2014. Return period hydrographs were determined from a statistical analysis of the LSPC modeled flows.

The approximate 2-year recurrence interval based on storm volume for Los Peñasquitos Creek, which has a 50% chance of occurring annually, was selected for the EFDC hydrodynamic modeling to evaluate salinity recovery following a flood event. The 2-year event was selected to be consistent with the prior EFDC modeling and because this size flood event is expected to inundate the entire lagoon (Michael Baker et al. 2018).

The 2-year event for Los Peñasquitos Creek was a flood event that occurred on February 15 to 19, 1998; it had a peak flow of 3,268 cfs and total volume of 198 million cubic feet (ft3) over a 4-day period. The peak flow for Carroll Canyon Creek was 3,366 cfs with a total volume of 83.4 million ft3 corresponding to a 2.27-year recurrence interval. Carmel Creek had a peak flow of 1,743 cfs and total volume of 4.91 million ft3 corresponding to a 2.27-year recurrence interval.

Ocean Tides

Ocean water levels off the coast of the lagoon are mixed, semidiurnal tides with daily variations between two unequal highs and two unequal lows. NOAA monitors water levels at the La Jolla tide gauge (9410230). Tidal datums based on the 1983 to 2001 National Tidal Datum Epoch are provided in Table A.4. The highest observed water level corresponds to the extreme spring high tide of 5.52 feet NGVD29 that occurred on November 25, 2015, during El Niño conditions.

Table A.4 Tidal Datums for La Jolla

Tidal Datum	Elevation (feet NGVD29)	Elevation (feet NAVD88)
Highest observed water level (11/25/2015)	5.52	7.62
Mean higher high water (MHHW)	3.03	5.14
Mean high water (MHW)	2.30	4.41
Mean sea level (MSL)	0.46	2.54
NGVD29	0.00	2.11
Mean low water (MLW)	-1.39	0.72
NAVD88	-2.11	0.00
Mean lower low water (MLLW)	-2.30	-0.19
Lowest observed water level (12/17/1933)	-5.16	-3.06

Source: NOAA 2017
Note: Tidal datums for National Tidal Datum Epoch 1983 to 2001

TRNERR Water Levels

The Los Peñasquitos Lagoon Real-Time Remote Monitoring is a collaborative project between the Los Peñasquitos Lagoon Foundation and Tijuana River National Estuarine Research Reserve (TRNERR). This project provides water level and water quality monitoring data to manage actions at the lagoon mouth and to ensure tidal flushing. There are four monitoring locations where data are collected every 15 minutes. Water levels are measured as water depth. Water quality measurements include water temperature, salinity, pH, specific conductance, dissolved oxygen, and turbidity (ESA 2016).

The 2016 EFDC Model used the TRNERR measured water levels and salinity for the 2016 calibration period from January 1 to 7, 2016. Because the TRNERR depth measurements are not tied to a vertical elevation datum, the tide gauges were surveyed on January 22, 2016, after each water level gauge was serviced (ESA 2016).

2020 Water Levels and Salinity

The measured water levels used for the 2016 EFDC Model calibration did not capture the full tide range near the salt marsh restoration area because the SE monitoring gauge is located at a relatively high elevation and is only tidally inundated at high tides. Without measuring a full tide range and obtaining accurate tidal channel bathymetry, it would be difficult to evaluate how far tidal inundation extends into the lagoon, how well the lagoon drains during low tide, or if there is a sill along the existing tidal channel that would limit the tidal range at the restoration area. Hence, a field program was conducted to collect water level and salinity data.

Pi Environmental deployed a tide gauge (1A shown in Figure A.1) within the tidal channel to measure water depth, water temperature, and water salinity between May 22 and June 25, 2020. The tide gauge was deployed in a deeper portion of the tidal channel downstream of the TRNERR SE monitoring location and the tidal channel “pinch point.” A second round of measurements was made at two locations (2A and 2B shown in Figure A.1) from September 17 to October 30, 2020. To facilitate numerical modeling and to support habitat design, the measured water depths were converted to water elevations (i.e., water levels) relative to a vertical datum.

Sea Level Rise Projections

The best available science on SLR in California is the 2018 Ocean Protection Council's SLR guidance (CNRA and COPC 2018), which includes SLR projections along the California coastline. A range of SLR projections are provided for three scenarios: low risk aversion, medium-high risk aversion, and extreme risk aversion. The SLR projections for La Jolla are summarized in Table A.5. The low risk aversion projections are the upper values of the likely range in SLR with a 66% probability of occurrence and provide an appropriate projection for adaptive projects (CNRA and COPC 2018).

Table A.5 Projected Sea Level Rise for La Jolla

Year	Projected SLR (feet)		
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
2030	0.6	0.9	1.1
2035	0.8*	1.1*	1.5*
2040	0.9	1.3	1.8
2050	1.2	2.0	2.8
2060	1.6	2.7	3.9
2070	2.0	3.6	5.2
2080	2.5	4.6	6.7
2090	3.0	5.7	8.3
2100	3.6	7.0	10.2

Source: CCC 2018
*Year 2035 calculated as average of Years 2030 and 2040 projections.
Low Risk Aversion: Upper limit of "likely range" (approximately 17% probably SLR exceeds).
Medium-High Risk Aversion: 1-in-200 chance (0.5% probability SLR exceeds).
Extreme Risk Aversion: Single scenario (no associated probability).

Verification Process

The 2016 calibration period was based on a wide range of input data taken at different times, such as the tidal channel bathymetry that was based on data from 2008, 2009, and 2016. In addition, the 2016 inlet and tide gauge surveys were taken after the calibration period. These data may not reflect the physical conditions of the lagoon during the 2016 calibration period. The 2020 inlet survey, tidal channel survey, and water level monitoring provided a more comprehensive data set; thus the 2020 EFDC Model verification focused on the 2020 data.

The model-predicted water levels and salinity for the 2016 calibration period are shown in Figures A.5 and A.6, respectively. The figures compare the 2020 EFDC Model with the 2018 EFDC Model predicted and measured water levels and salinity. The 2020 EFDC Model shows improvement in the modeled water levels compared to the measured water levels. For salinity, improvements were shown mainly for the NW location. The results illustrate that salinity can be sensitive to creek flows, which were further evaluated with the 2020 model verification.

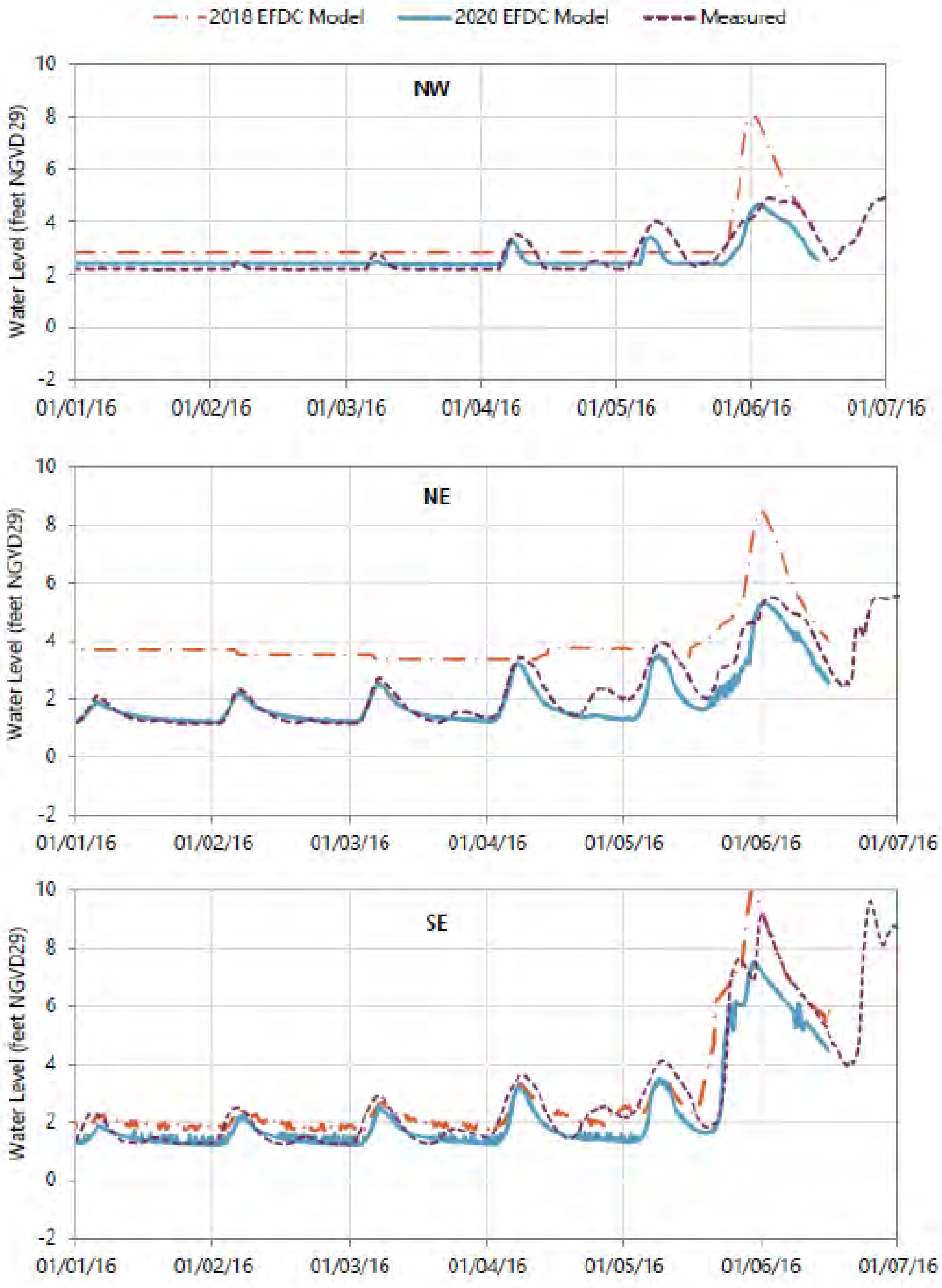


Figure A.5. 2016 Water Levels

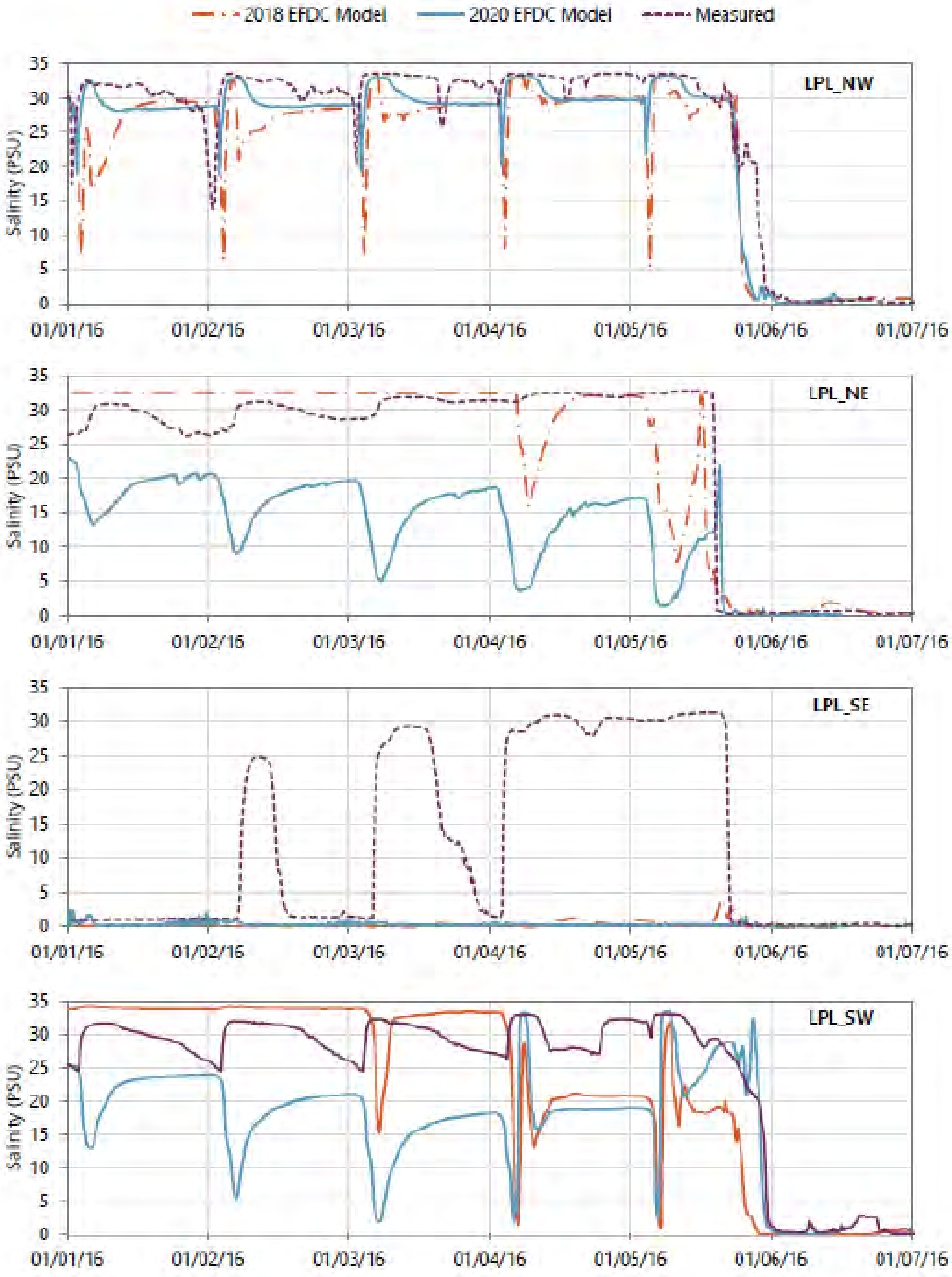


Figure A.6. 2016 Salinity

Data collected in 2020 provided the most comprehensive data set to define the physical conditions of the lagoon inlet and tidal channel. A chronological summary of the 2020 data is provided in Table A.6. Round 1 of the water and salinity monitoring occurred following the May 2020 inlet dredging. A 10-day period from June 6 to 16, 2020, was selected for the 2020 verification Round 1 comparison period. The Round 2 water and salinity monitoring collected data from two locations at the downstream and upstream ends of the tidal channel. The 2020 verification Round 2 comparison period was selected as the 16-day period from September 21 to October 7, 2020. Both 2020 verification periods were preceded by a 5-day spin-up period.

The greatest uncertainty in simulating water levels and salinity was the freshwater flows from the three creeks. Therefore, the 2020 verification periods were simulated with high, low, and minimum dry weather flow estimates to capture the possible range of dry weather flows. The higher estimate of dry weather flows was determined by scaling flow data from the USGS flow gage located in the upper Los Peñasquitos Creek watershed based on drainage area. The low estimate of dry weather flows was based on the lowest dry weather flows measured. The minimum dry weather flow was 25% of the lowest measured dry weather flows.

Table A.6 2020 Data Summary

Date	Data Type	Description
January	Inlet near closure	Spring tides between January 10 and 12 prevented inlet closure.
February	Inlet near closure	Spring tides between February 8 and 9 prevented inlet closure.
Early April	Heavy rain event	Heavy rain event scoured channels observed along Traverses A1, 101W, A2A, and A3A.
April 30	Pre-dredge survey	10 traverses surveyed. Traverse E3 was partially surveyed due to Belding's Savannah Sparrow nesting.
May 11 to 22	Inlet dredging	34,620 cy dredged from inlet.
May 22 to June 26	Water and salinity levels	Round 1 water and salinity levels monitored at one location (1A) downstream of the salt marsh restoration area.
May 28	Post-dredge survey	6 traverses surveyed. Traverses E1, E2, C, and F were not surveyed due to Belding's Savannah Sparrow nesting.
June 6	Small rain event	A 0.11-inch rain event.
July	Inlet and tidal channel surveys	Six cross sections surveyed at inlet and tidal channel cross sections along the tidal channel from downstream end to the salt marsh restoration area.
September 17 to October 30	Water and salinity levels	Round 2 water and salinity levels monitored at two locations, one near the salt marsh restoration area and one at the downstream end of the tidal channel.

For the Round 1 data, modeled and measured comparisons were made at two locations near the salt marsh restoration area. Location 1A used data from the 2020 survey and Location SE was based on the TRNERR data. The Round 1 water levels and salinity are provided in Figures A.7 and A.8, respectively. Results show that both water levels and salinity near the salt marsh restoration area are sensitive to dry weather flows. Water levels are most sensitive at low tide when dry weather flows dominate water in the tidal channel, and higher dry weather flows would result in higher minimum water levels. The modeled range of dry weather flows covers the range in measured salinity. Both the measured and modeled salinity show lower salinity during neap tide conditions.

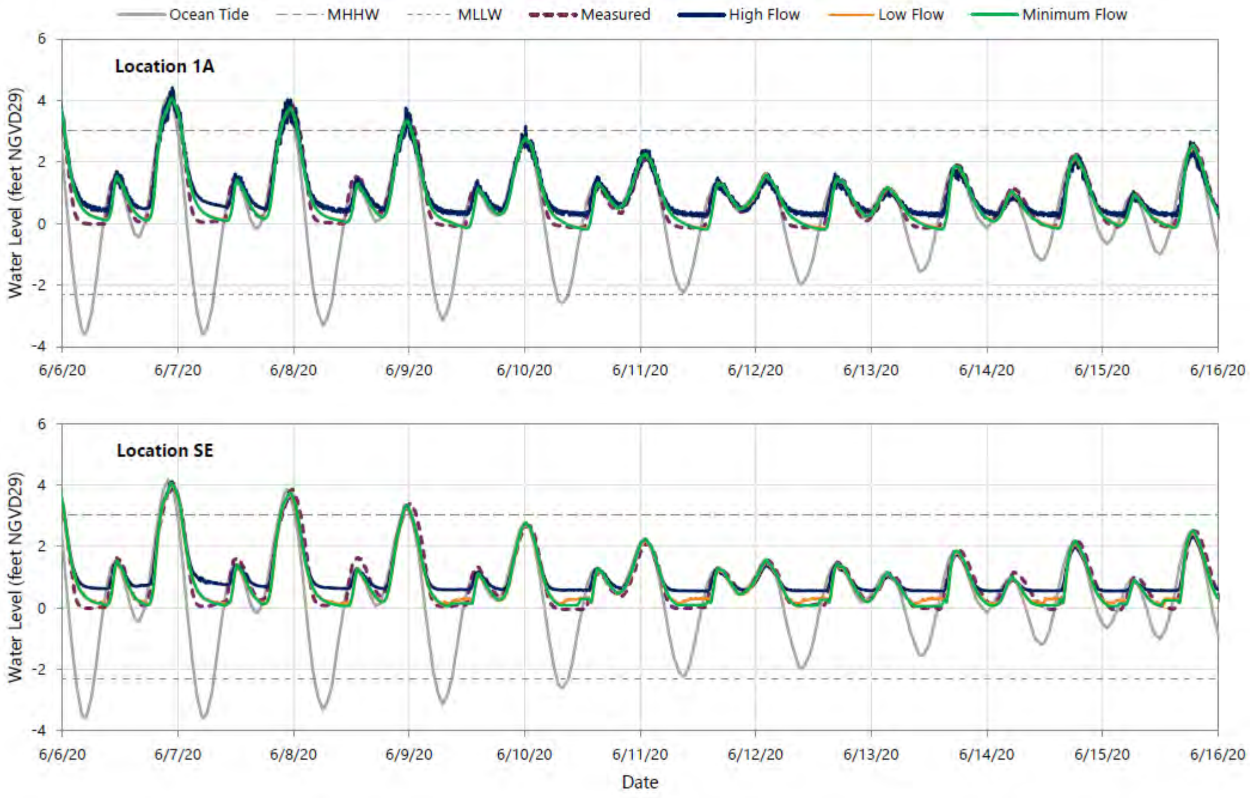


Figure A.7. 2020 Verification Round 1 Water Levels

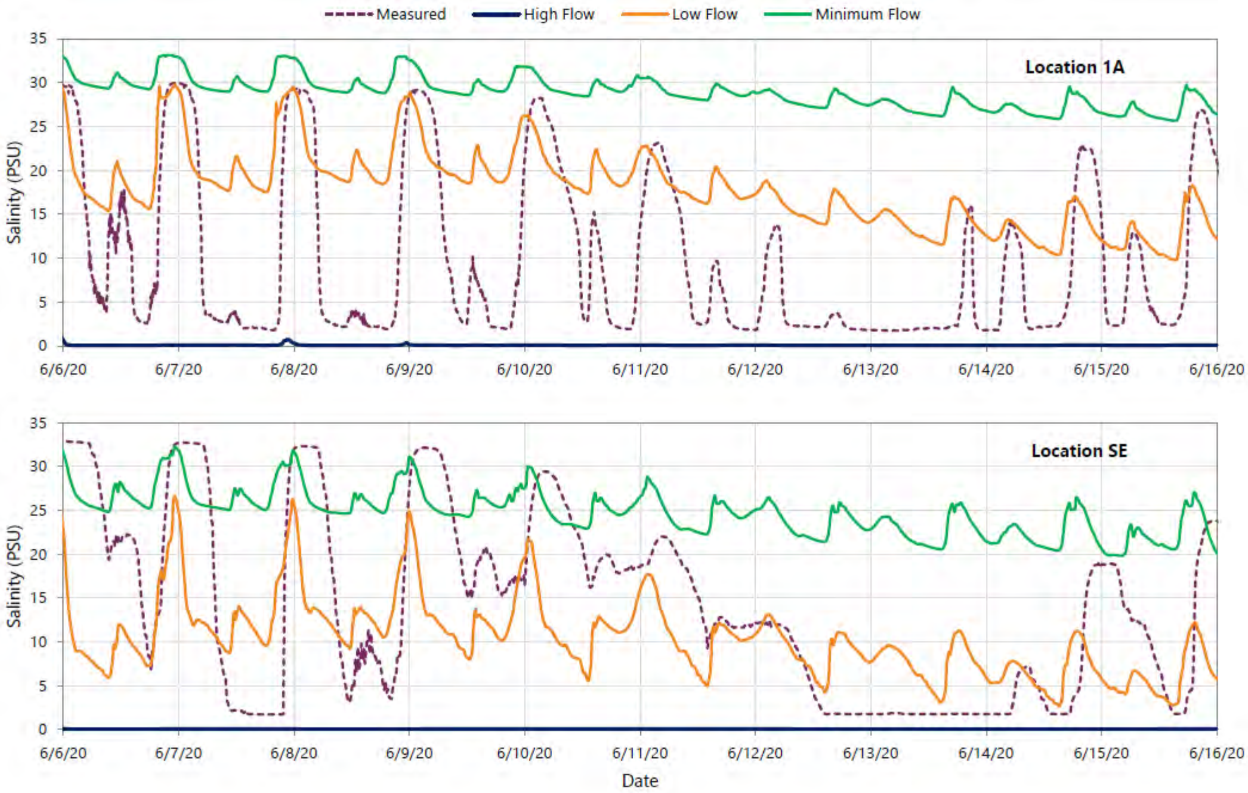


Figure A.8. 2020 Verification Round 1 Salinity

Higher salinity levels occur with lower dry weather flows. The 2020 EFDC Model is a depth-averaged model that assumes complete mixing of the salinity in the water column and would not account for flow stratification of saltwater and freshwater. If flow stratification occurs, measured salinities at the bottom of the tidal channel could be higher compared to surface salinity. At high tide elevation of 3 feet NGVD29, the water depth at the tide gauge location would be about 5 feet, and the salinity probe is more likely to measure the tidal influence at the bottom and not the freshwater at the surface.

Water levels and salinity for the Round 2 verification period are shown in Figures A.9 and A.10. Comparisons were made at the two monitoring locations at the downstream (Location 2B) and upstream (Location 2A) ends of the tidal channel. The modeled water levels showed reasonable comparison with the measured water levels given the uncertainty in the dry weather flows. The Round 2 measured salinity was not available at Location 2B due to biofouling on the instrument probe that affected the salinity measurements. At Location 2A, the measured salinity pattern differed substantially from Round 1 and showed a relatively constant high salinity, while water levels were consistent between Rounds 1 and 2. This difference in salinity may be attributed to changes in dry weather flows, potential stratification of flows, inlet condition, and/or groundwater flow inputs. There is little data to quantify freshwater sources from dry weather runoff and groundwater inputs and uncertainty in the daily or seasonal variability in the amount of freshwater. For both Rounds 1 and 2, the salinity results are consistent with stratification showing higher measured salinity compared to modeled salinity. The modeled salinity illustrates that salinity concentrations can significantly vary based on the amount of dry weather flows and that the model underpredicts salinity compared to measured field data. Since salinity is sensitive to dry weather flows, potential stratification, inlet condition, and/or groundwater inputs and these parameters are not quantified, the model-predicted salinity should be used primarily for relative comparison among scenarios in terms of use as a design tool. The model underprediction of salinity is not problematic because it provides a conservative estimate of salinity; having the actual salinity greater than the predicted salinity would be beneficial for the salt marsh restoration.

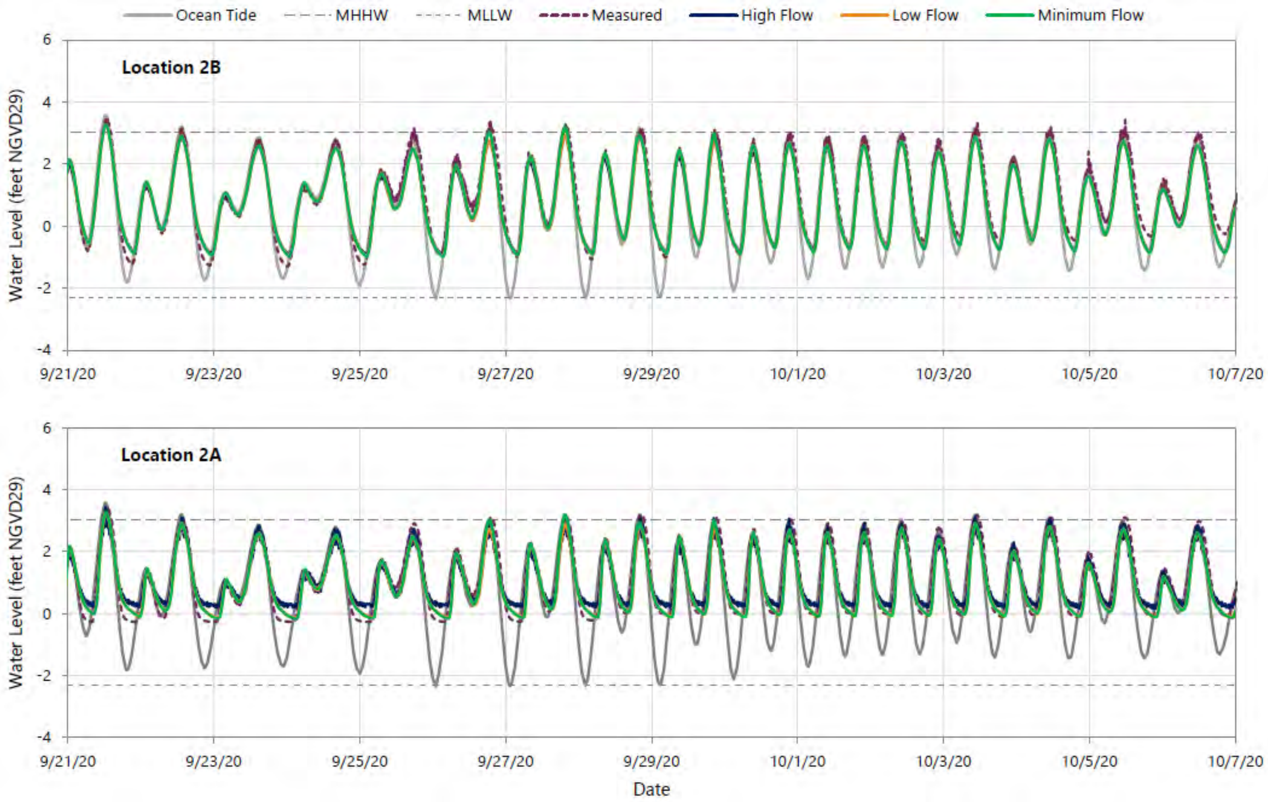


Figure A.9. 2020 Verification Round 2 Water Levels

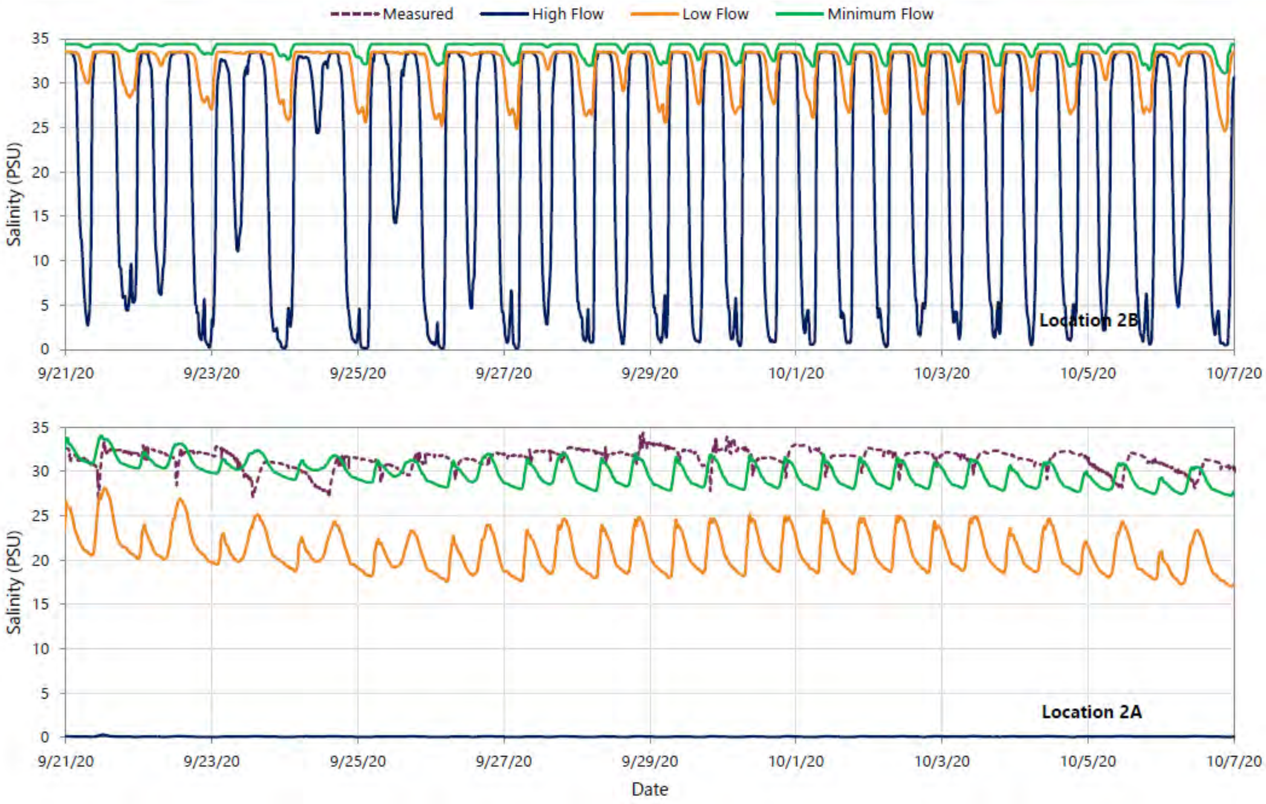


Figure A.10. 2020 Verification Round 2 Salinity

B. EFDC Modeling Results

This appendix includes the hydrodynamic modeling results for scenarios described in Section 2.

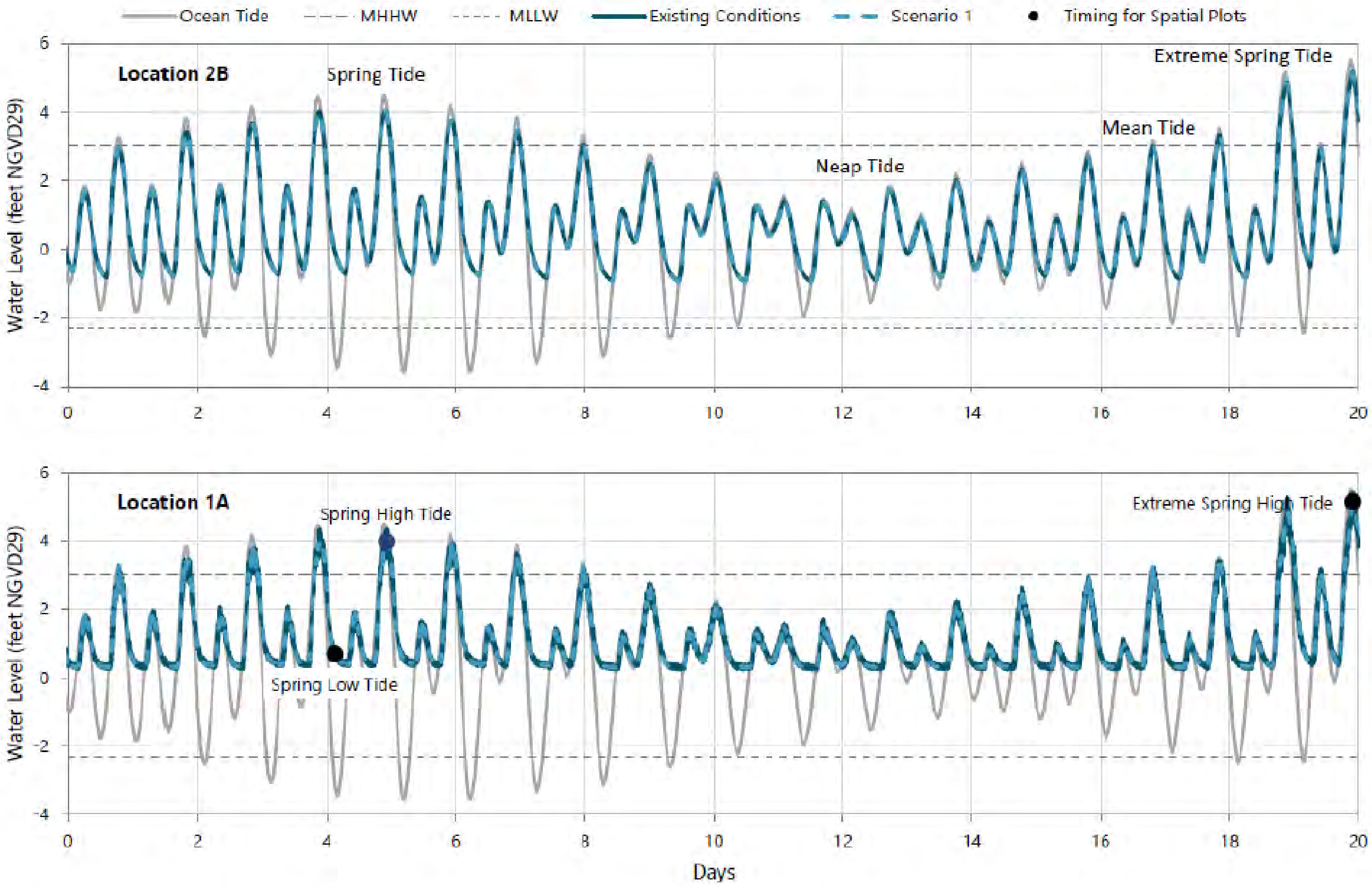


Figure B.1. Existing Conditions and Scenario 1 Water Levels at Locations 2B and 1A

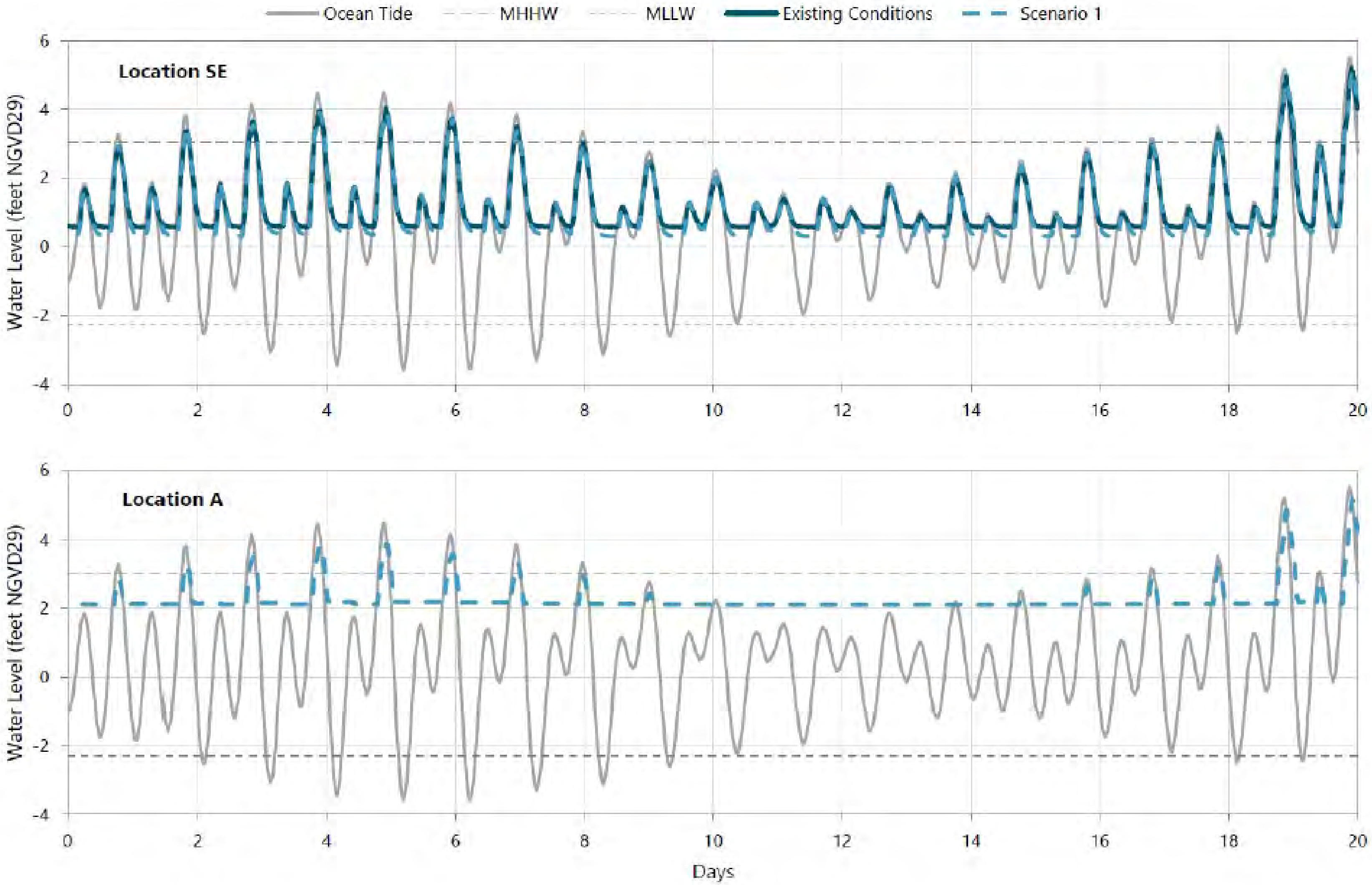


Figure B.2. Existing Conditions and Scenario 1 Water Levels at Locations SE and A

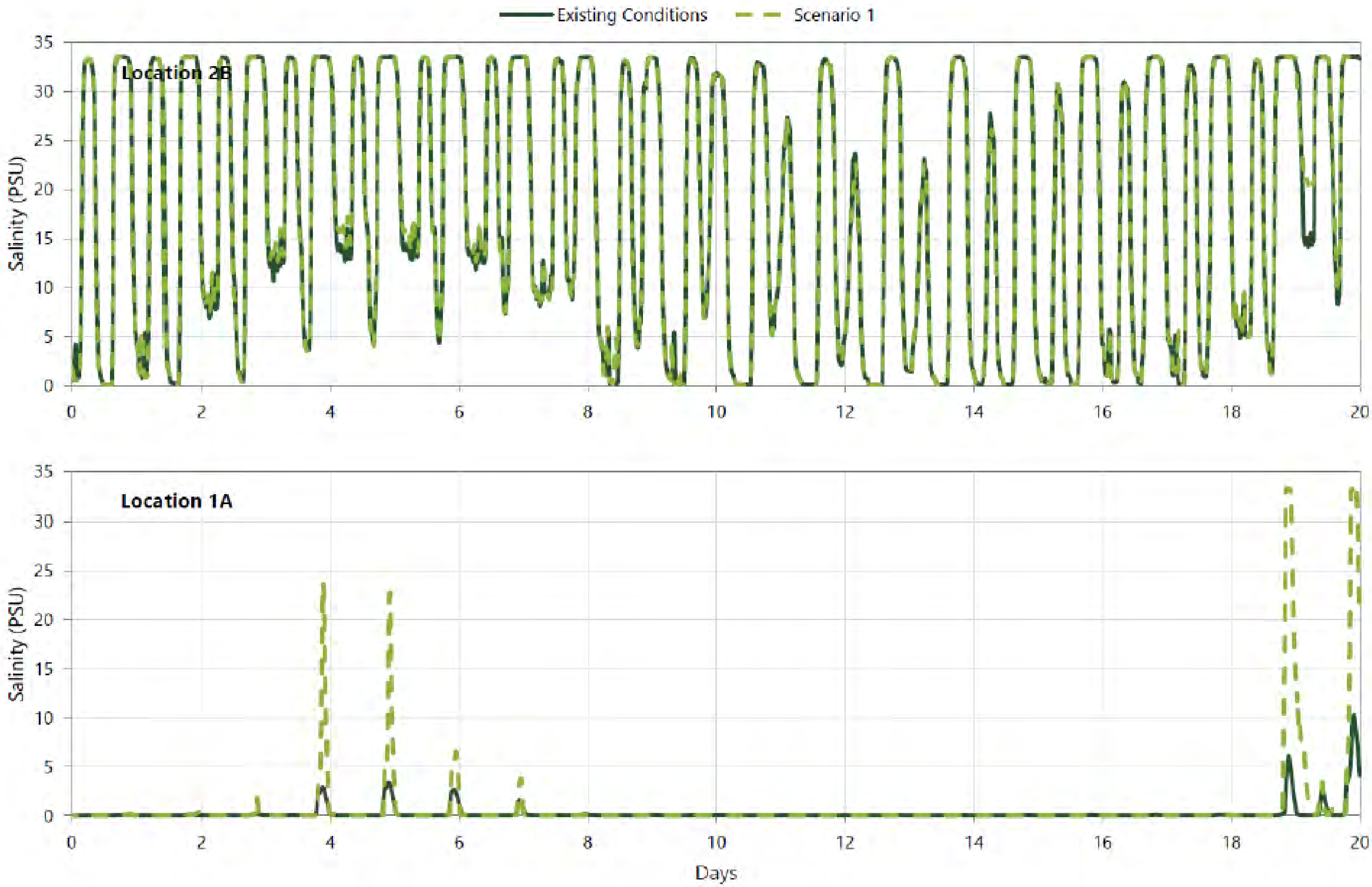


Figure B.3. Existing Conditions and Scenario 1 Salinity at Locations 2B and 1A

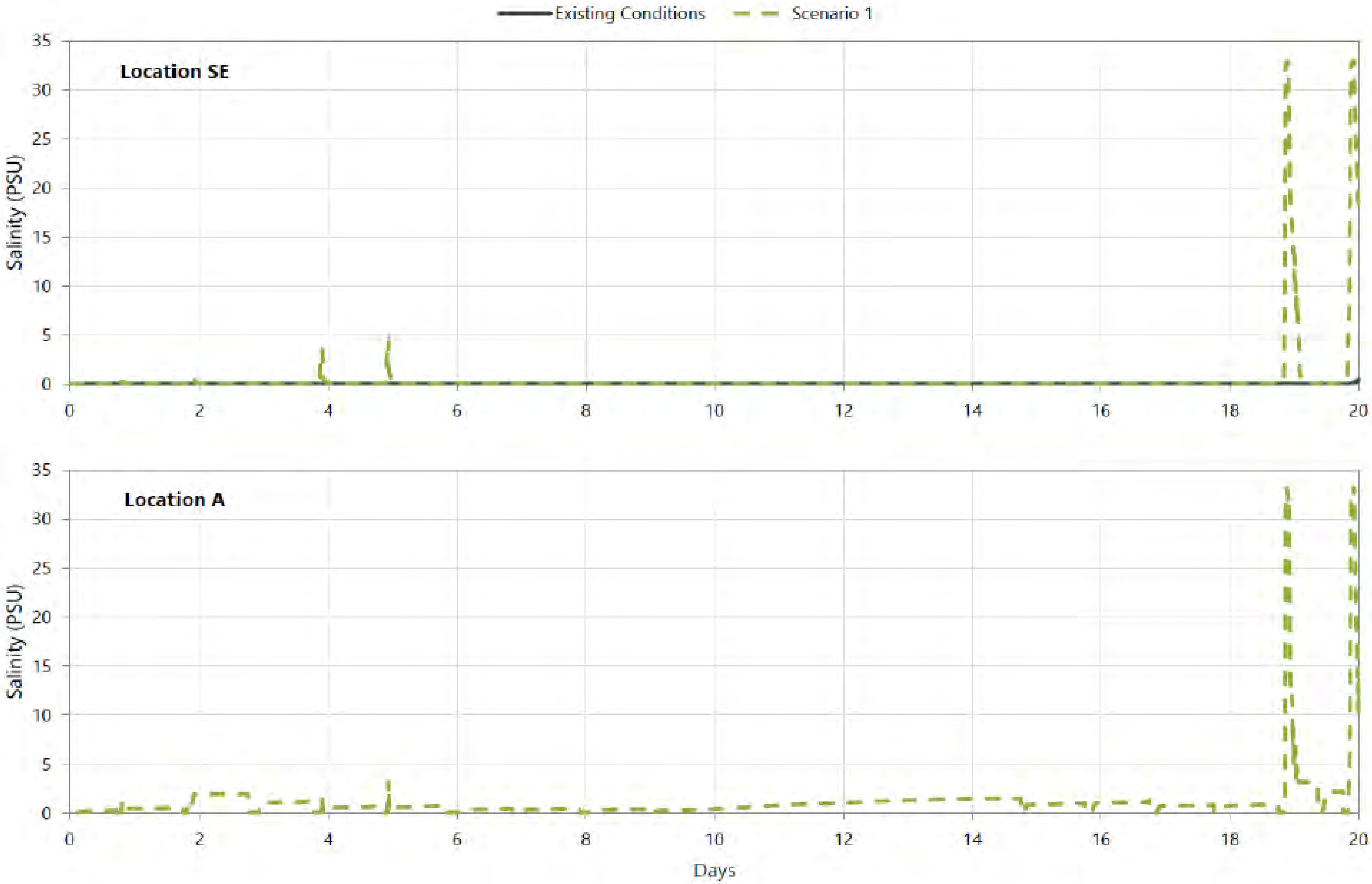


Figure B.4. Existing Conditions and Scenario 1 Salinity at Locations SE and A

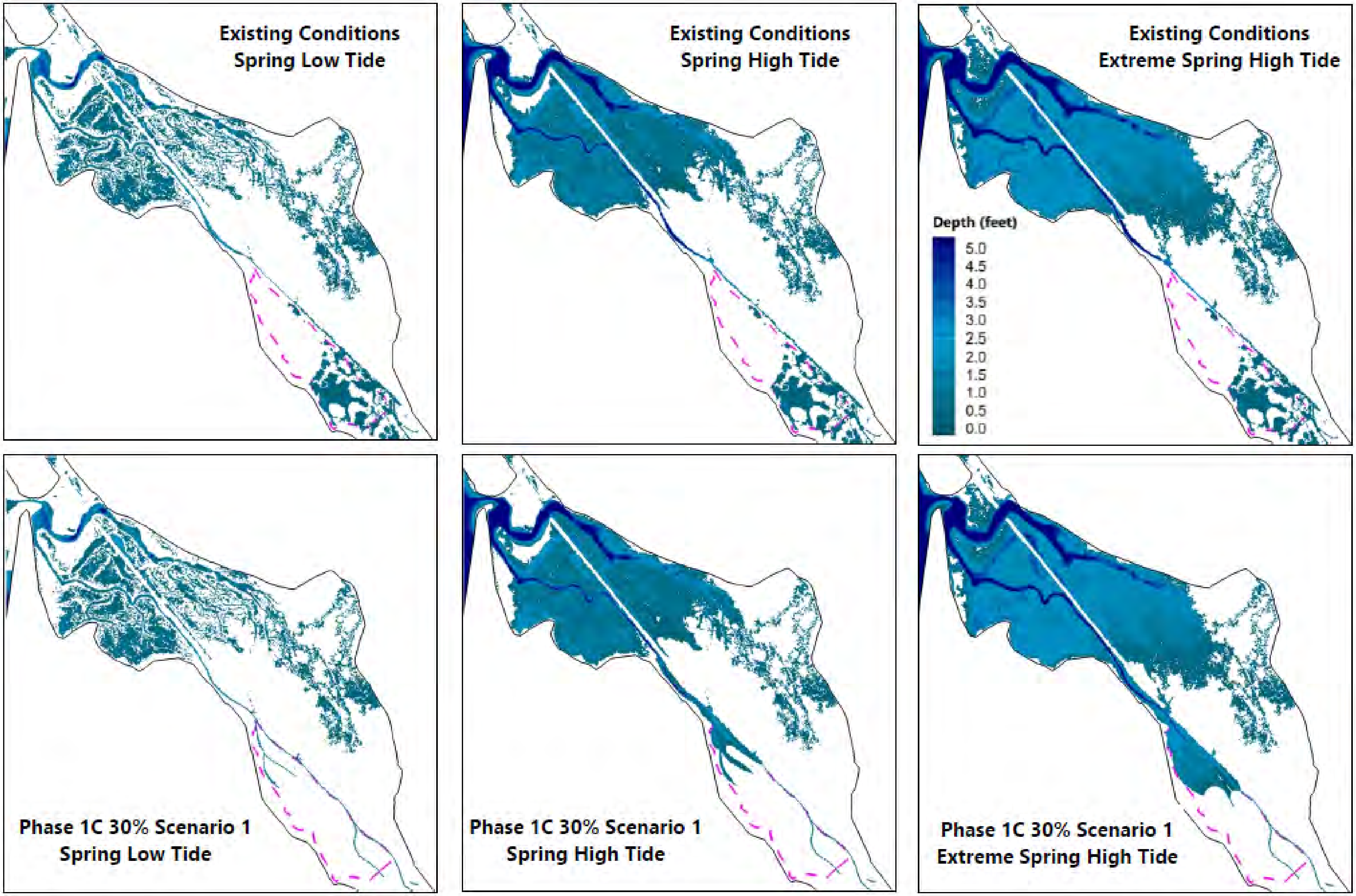


Figure B.5. Tidal Inundation Spatial Plots for Existing Conditions and Scenario 1

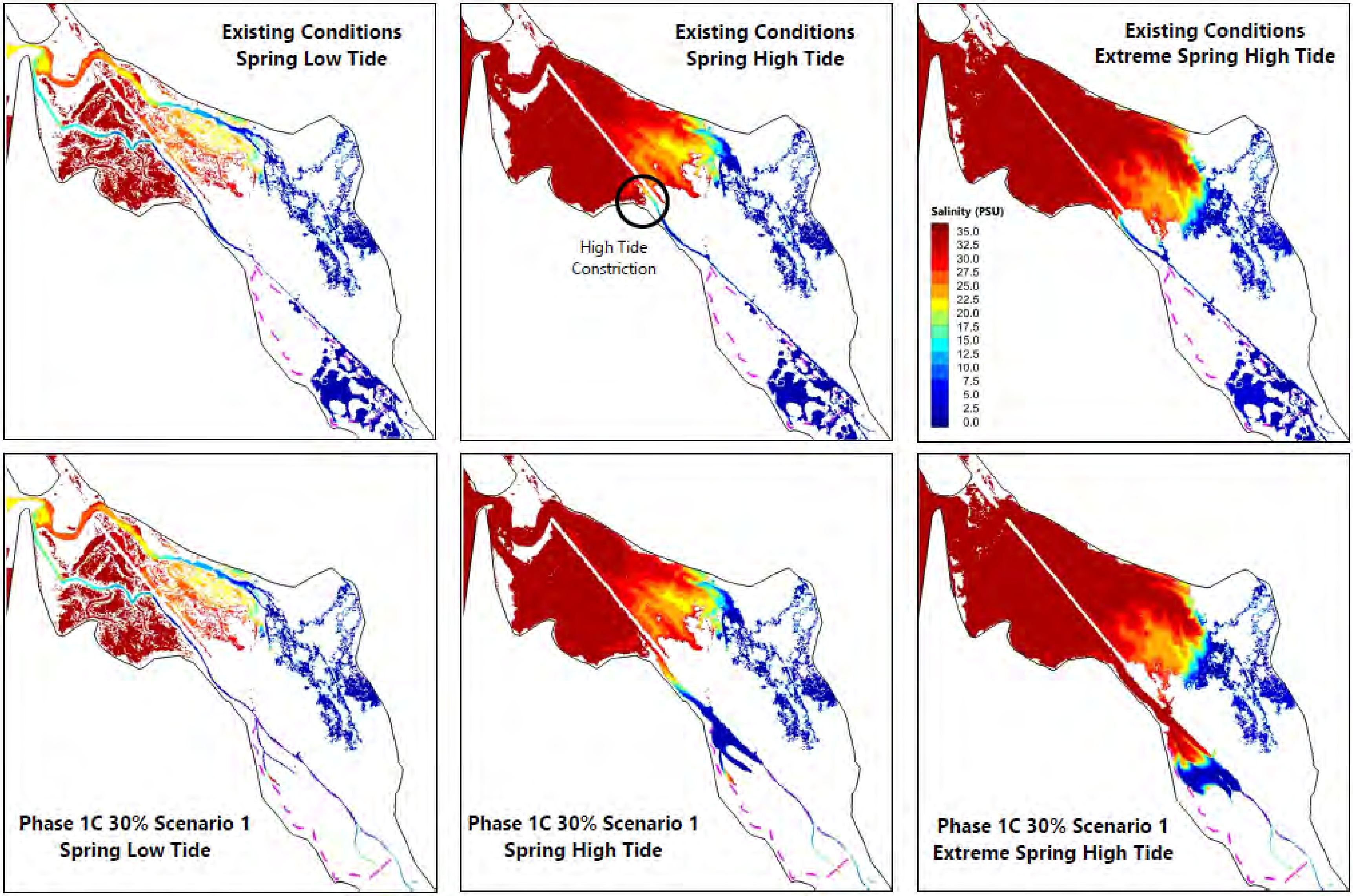


Figure B.6. Tidal Inundation Spatial Plots for Existing Conditions and Scenario 1

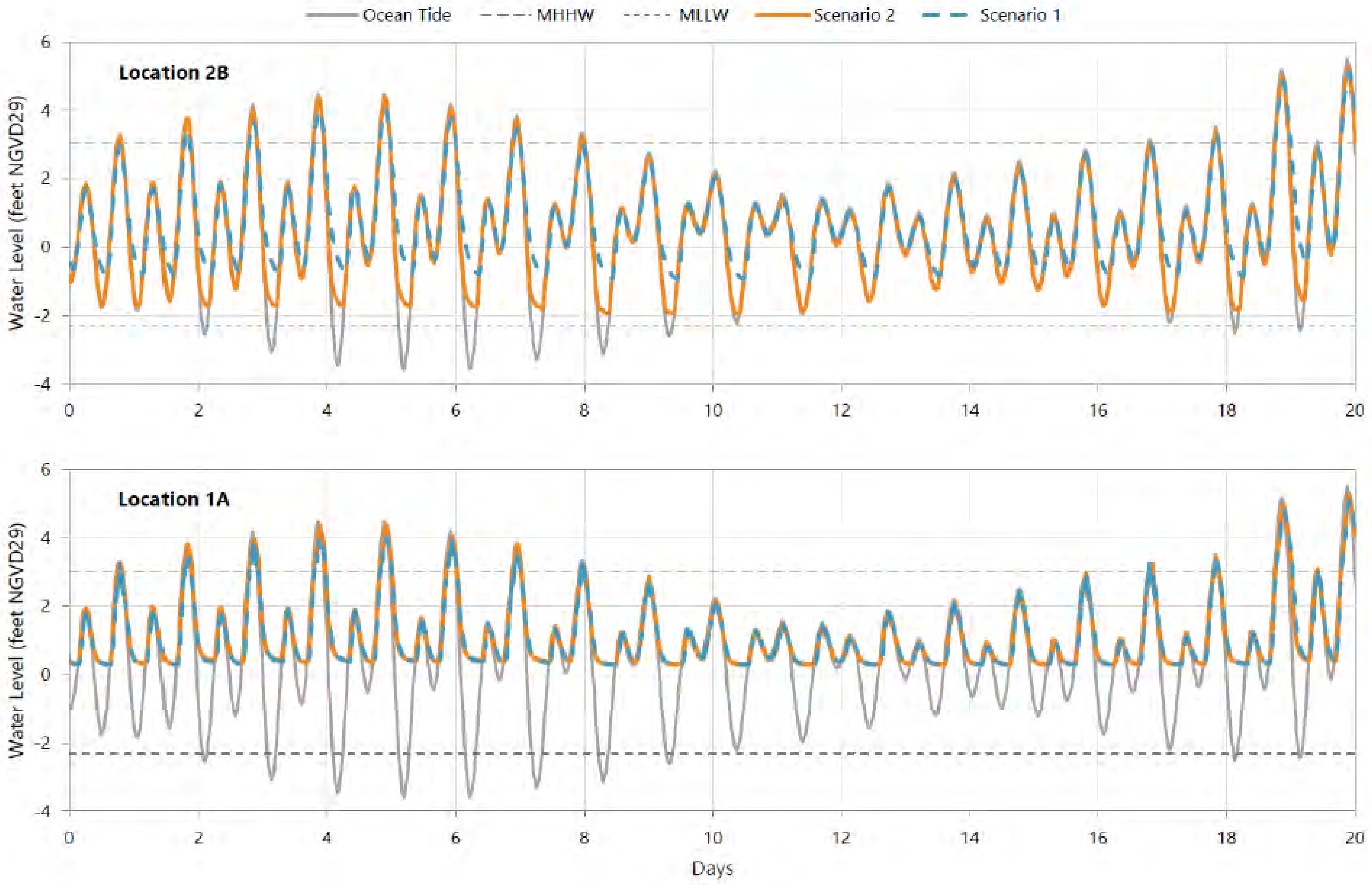


Figure B.7. Scenarios 1 and 2 Water Levels at Locations 2B and 1A

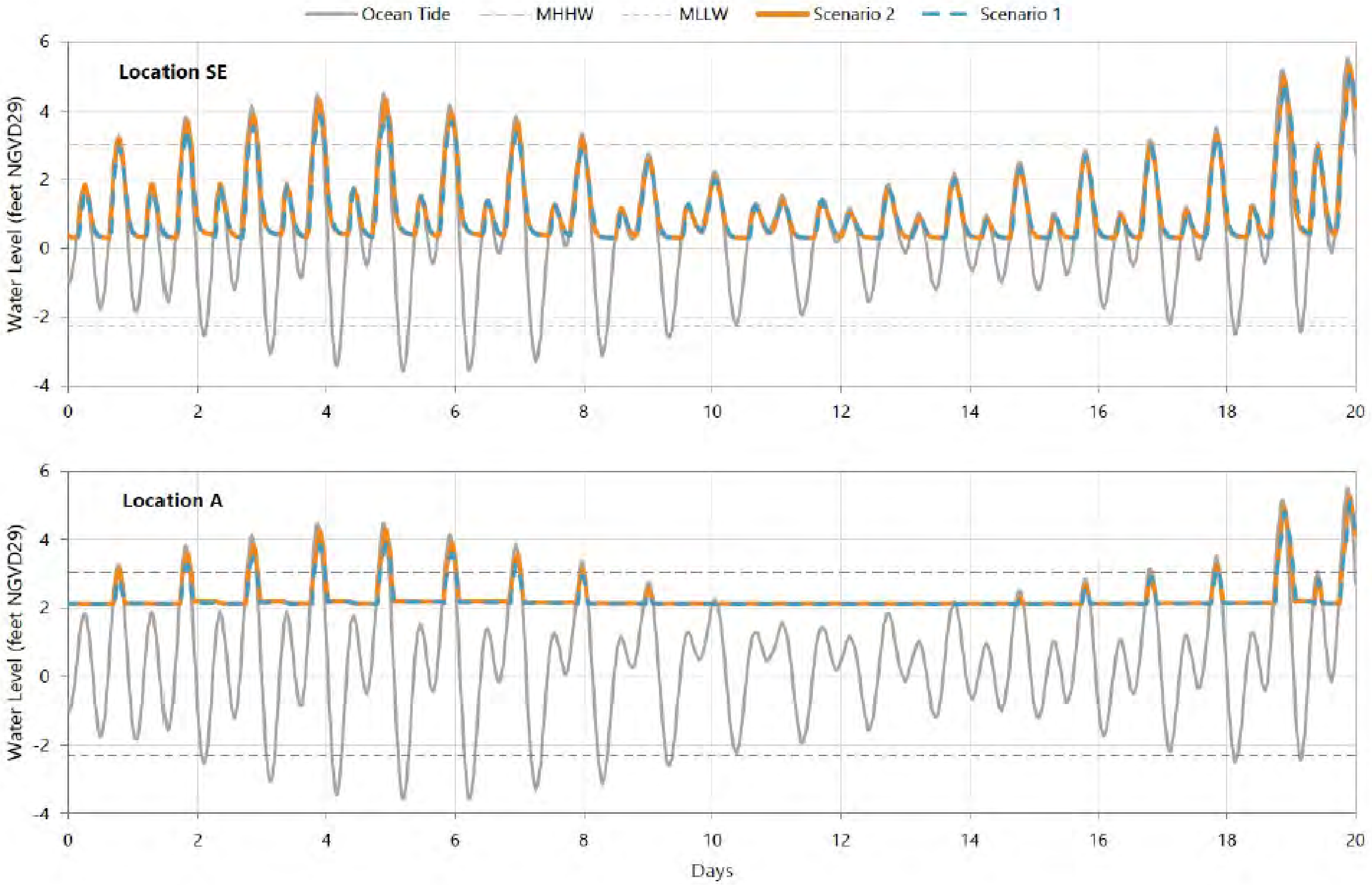


Figure B.8. Scenarios 1 and 2 Water Levels at Locations SE and A

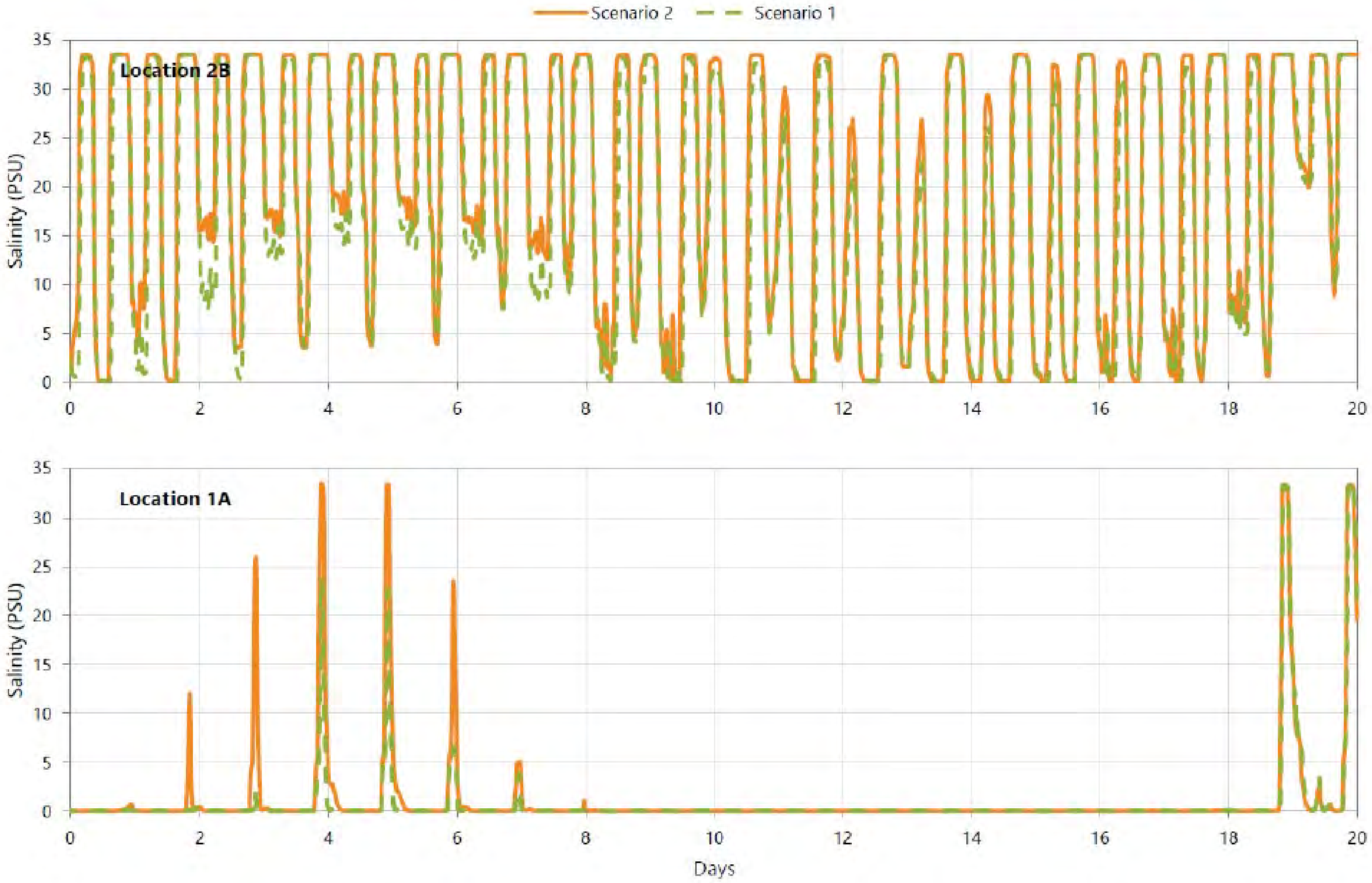


Figure B.9. Scenarios 1 and 2 Salinity at Locations 2B and 1A

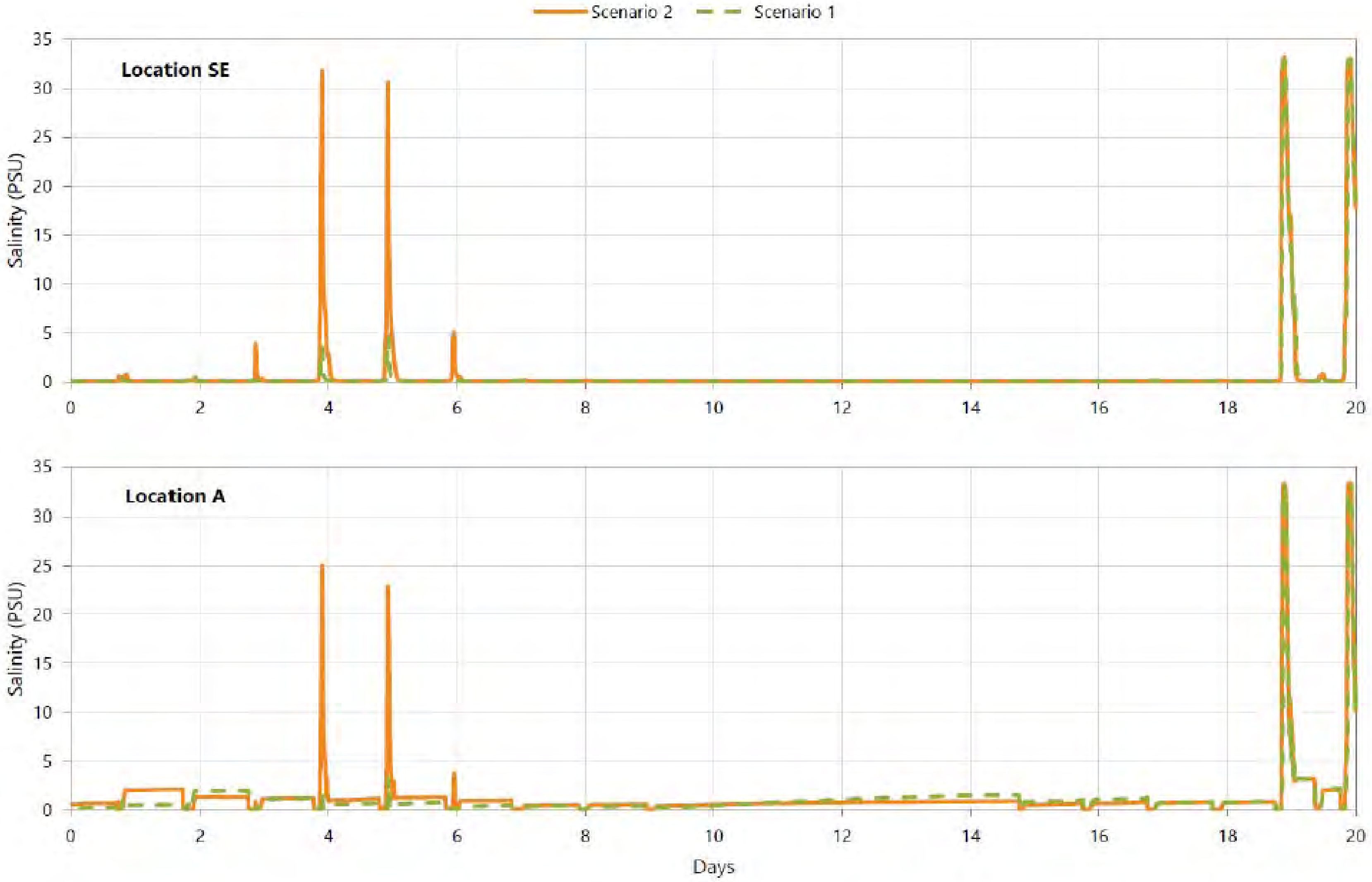


Figure B.10. Scenarios 1 and 2 Salinity at Locations SE and A

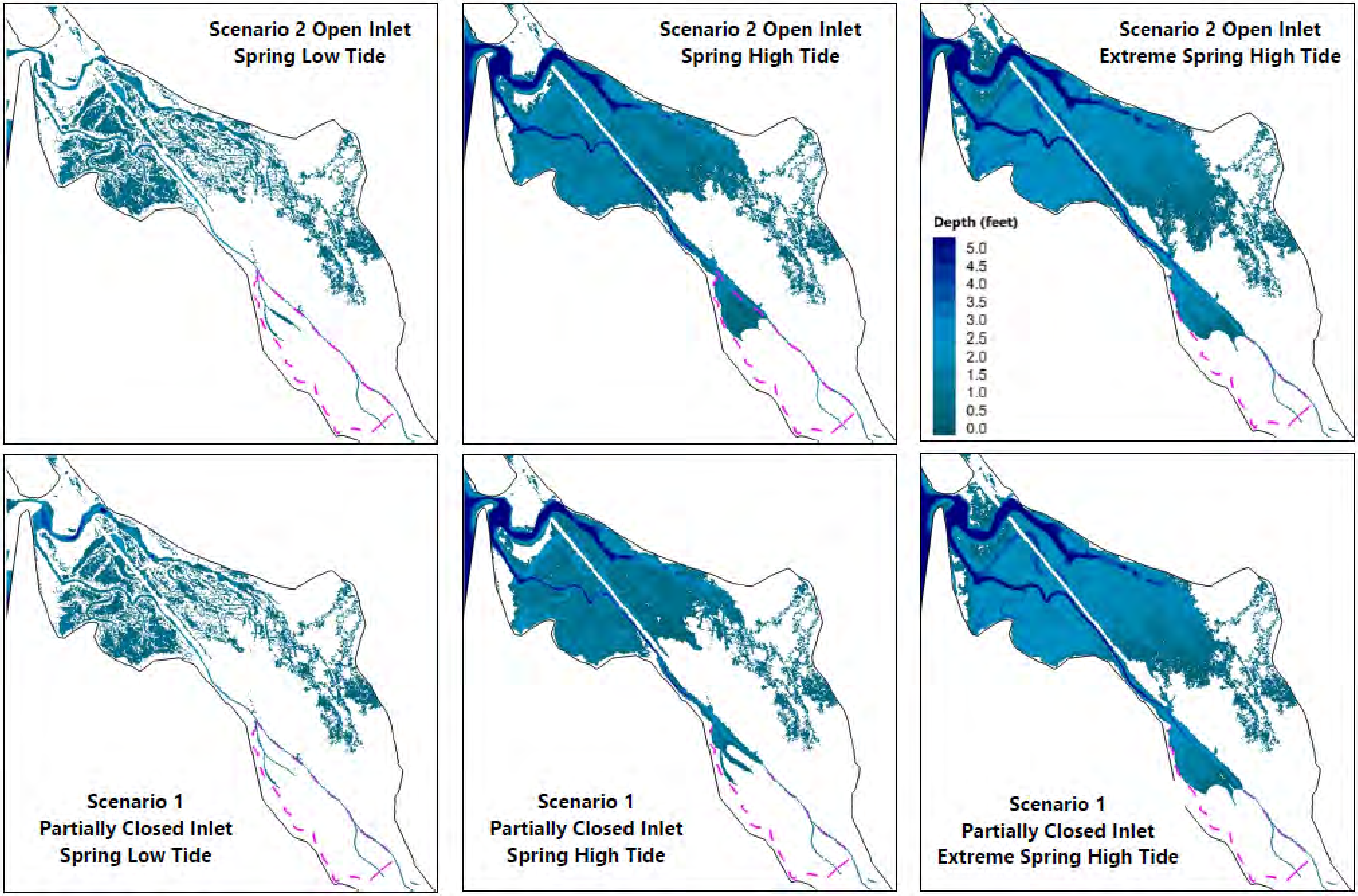


Figure B.11. Tidal Inundation Spatial Plots for Scenarios 1 and 2

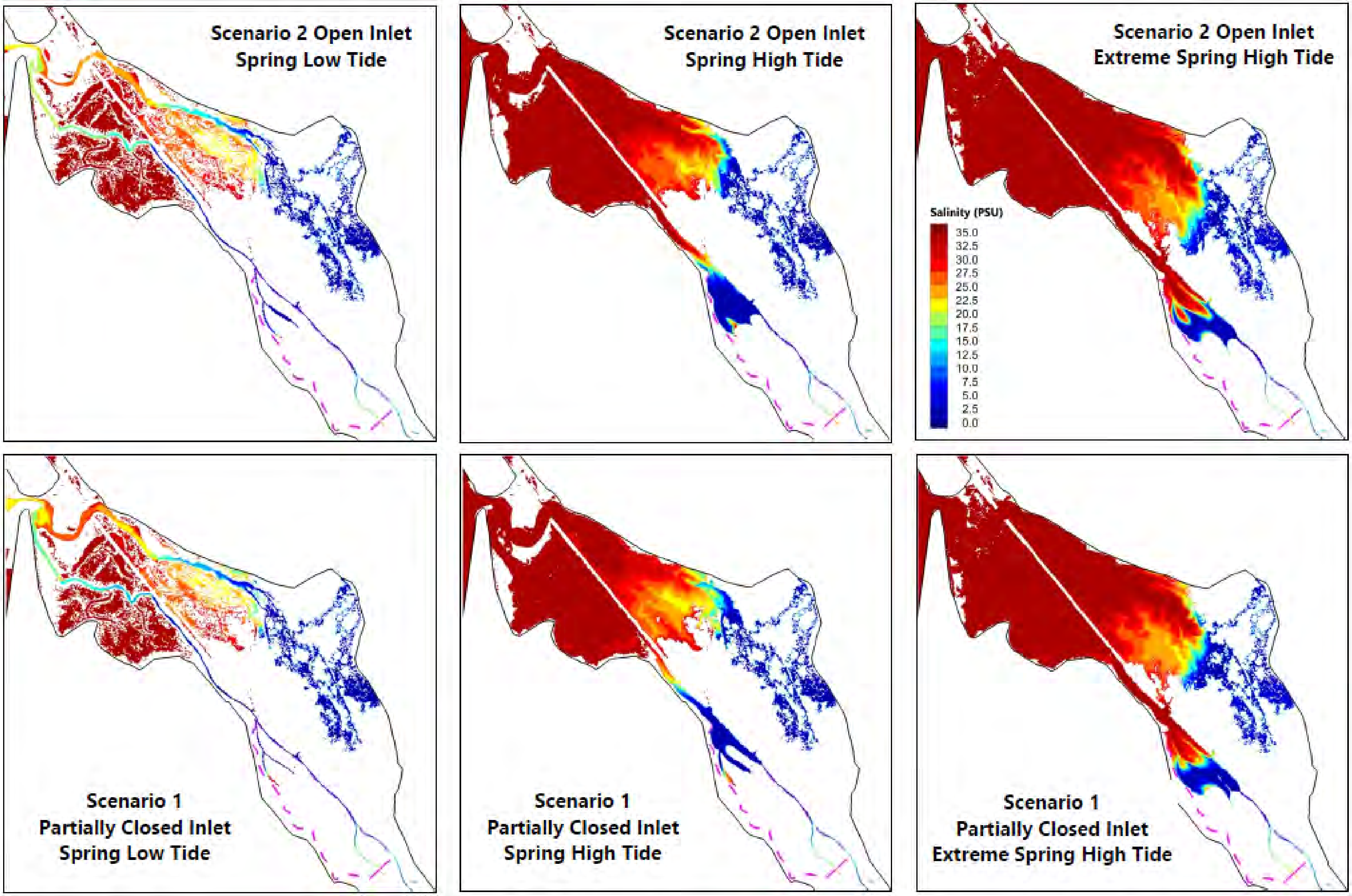


Figure B.12. Salinity Spatial Plots for Scenarios 1 and 2

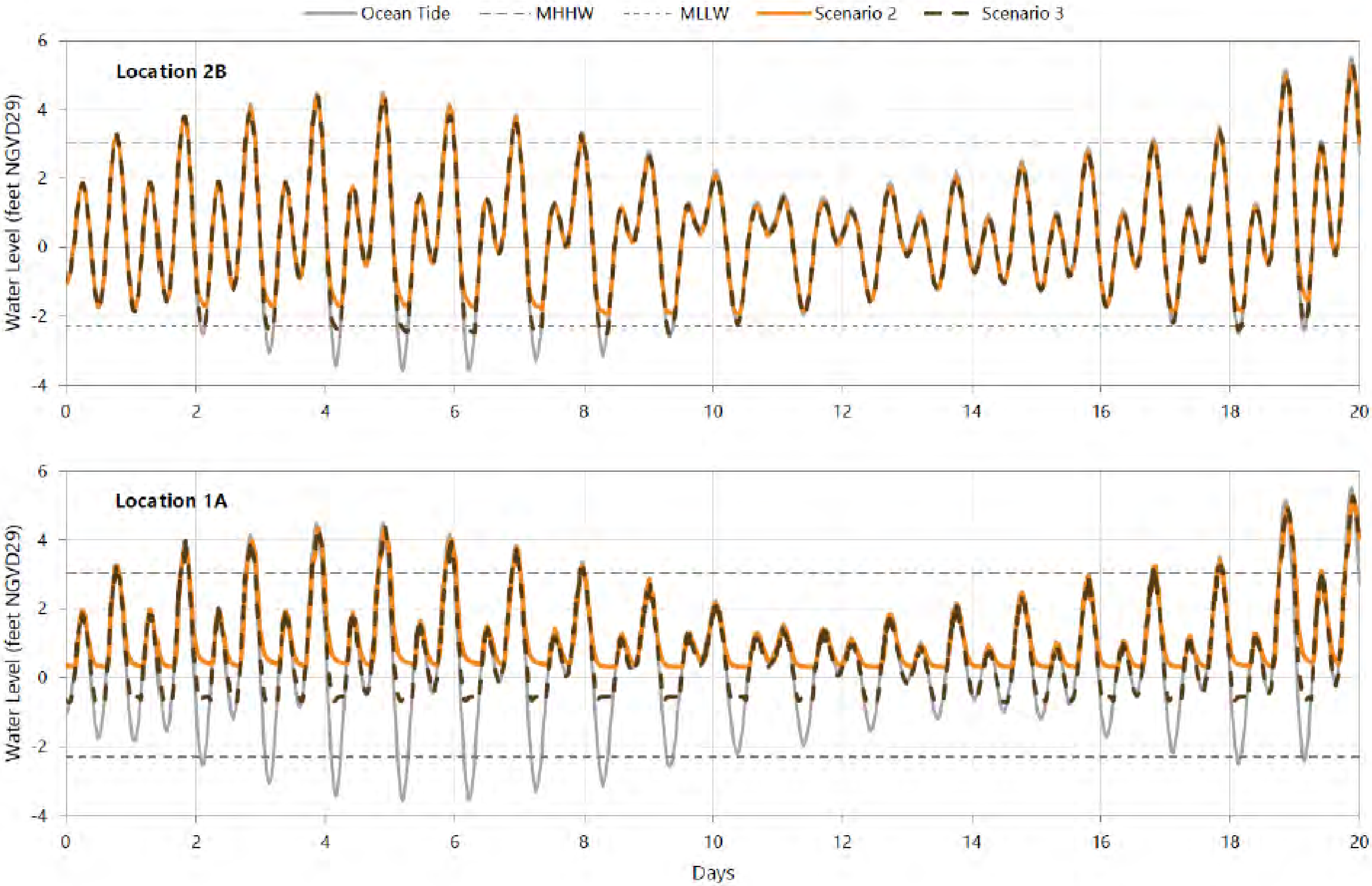


Figure B.13. Scenarios 2 and 3 Water Levels at Locations 2B and 1A

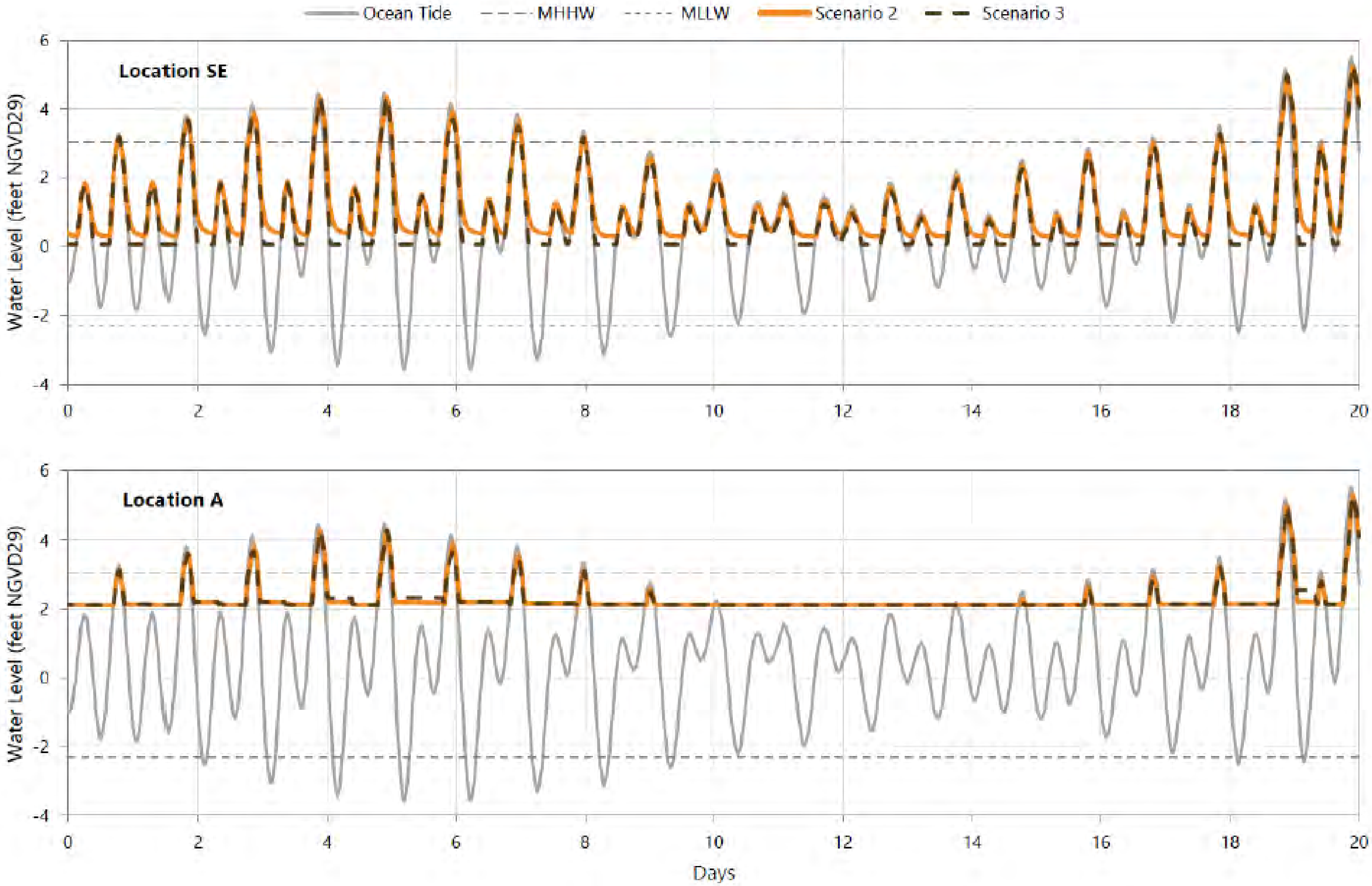


Figure B.14. Scenarios 2 and 3 Water Levels at Locations SE and A

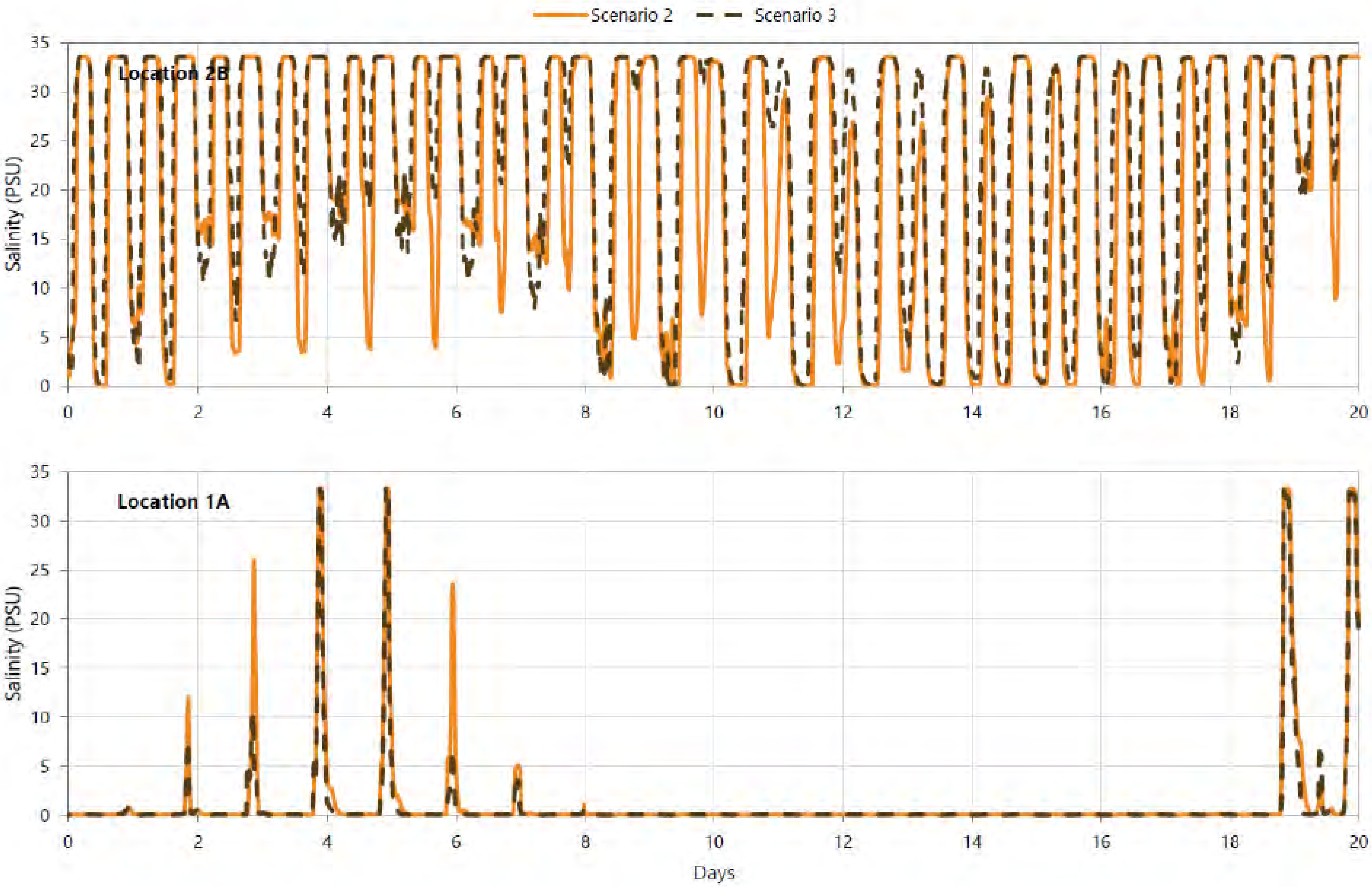


Figure B.15. Scenarios 2 and 3 Salinity at Locations 2B and 1A

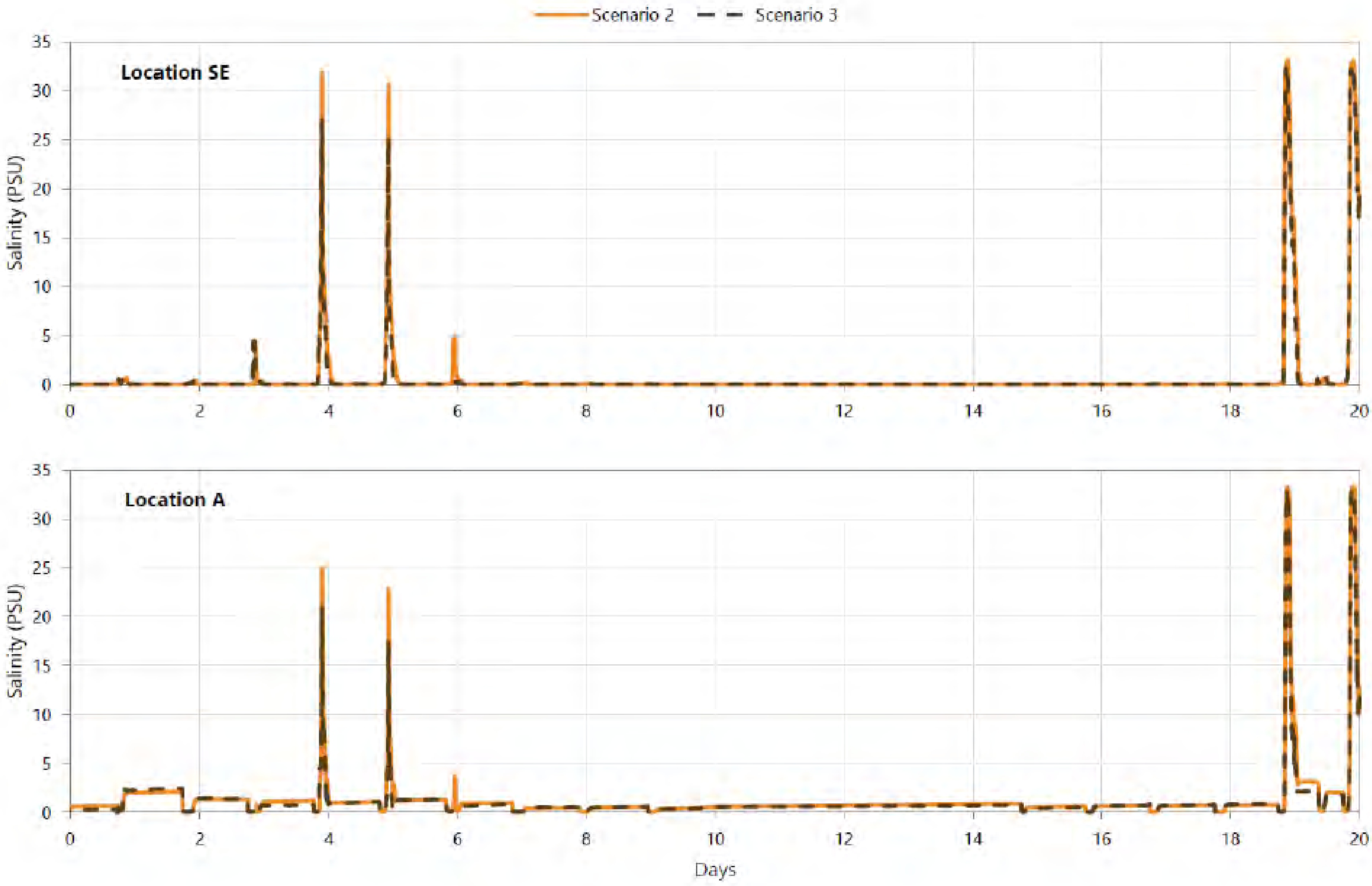


Figure B.16. Scenarios 2 and 3 Salinity at Locations SE and A

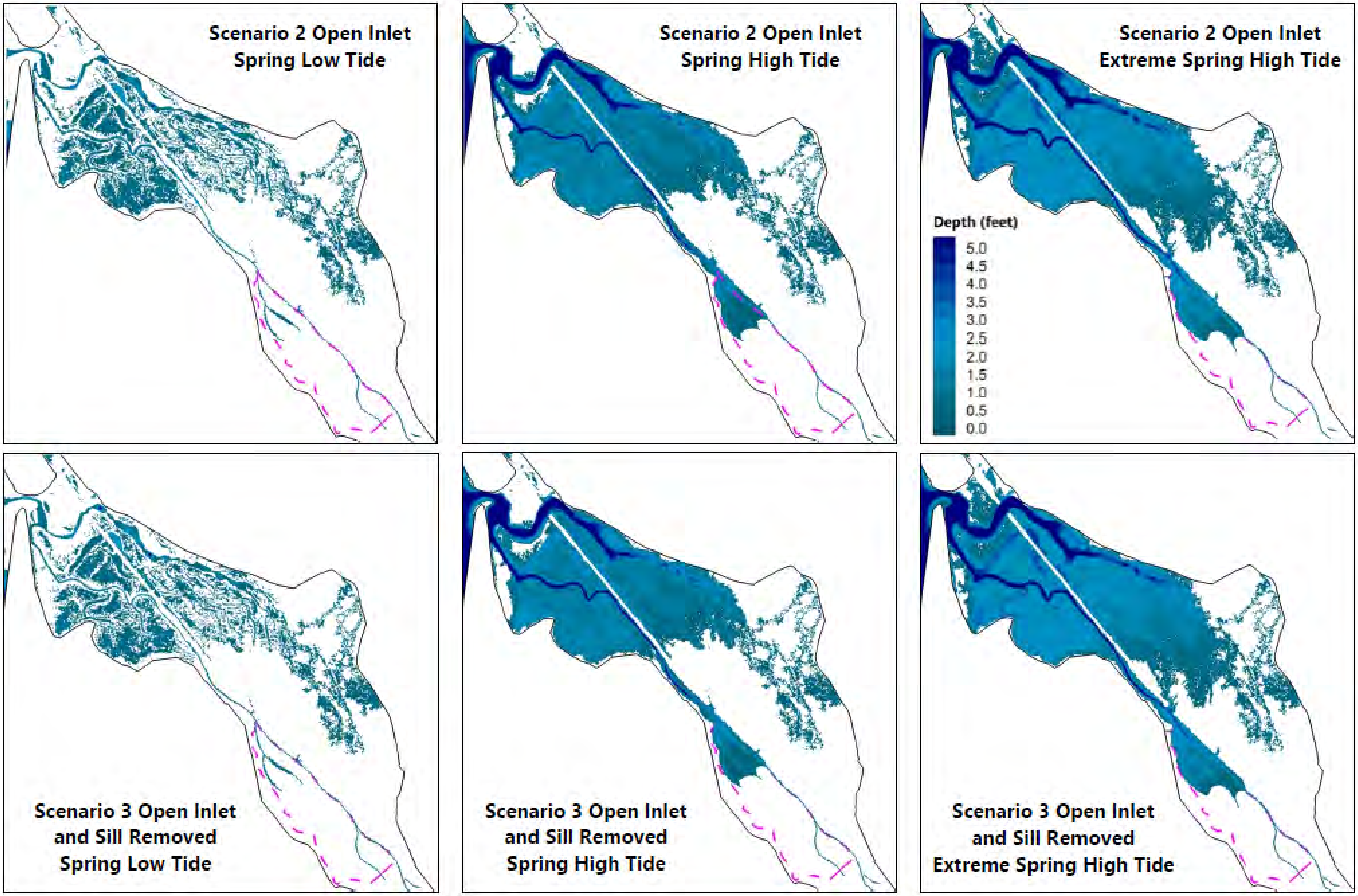


Figure B.17. Tidal Inundation Spatial Plots for Scenarios 2 and 3

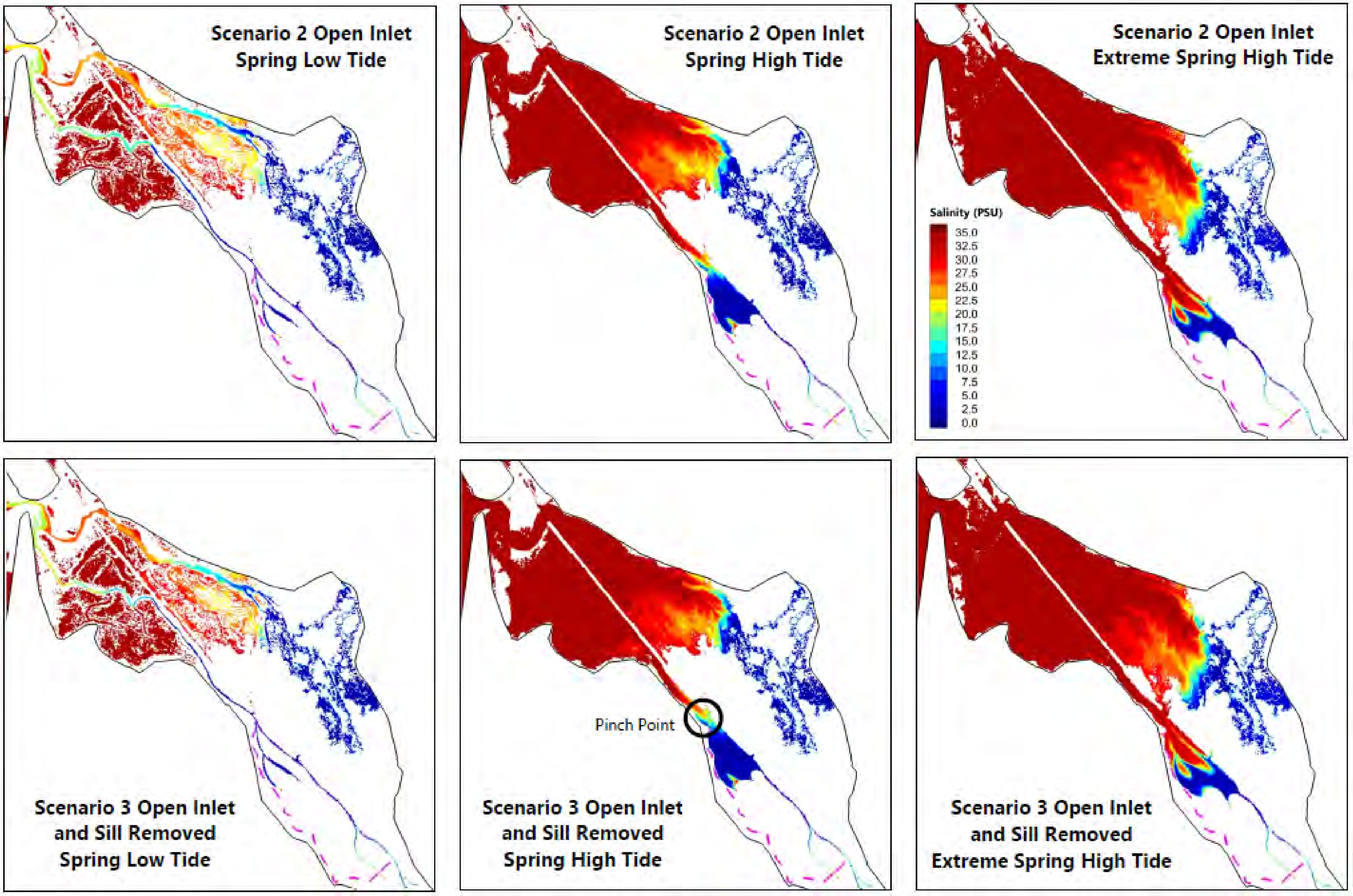


Figure B.18. Salinity Spatial Plots for Scenarios 2 and 3

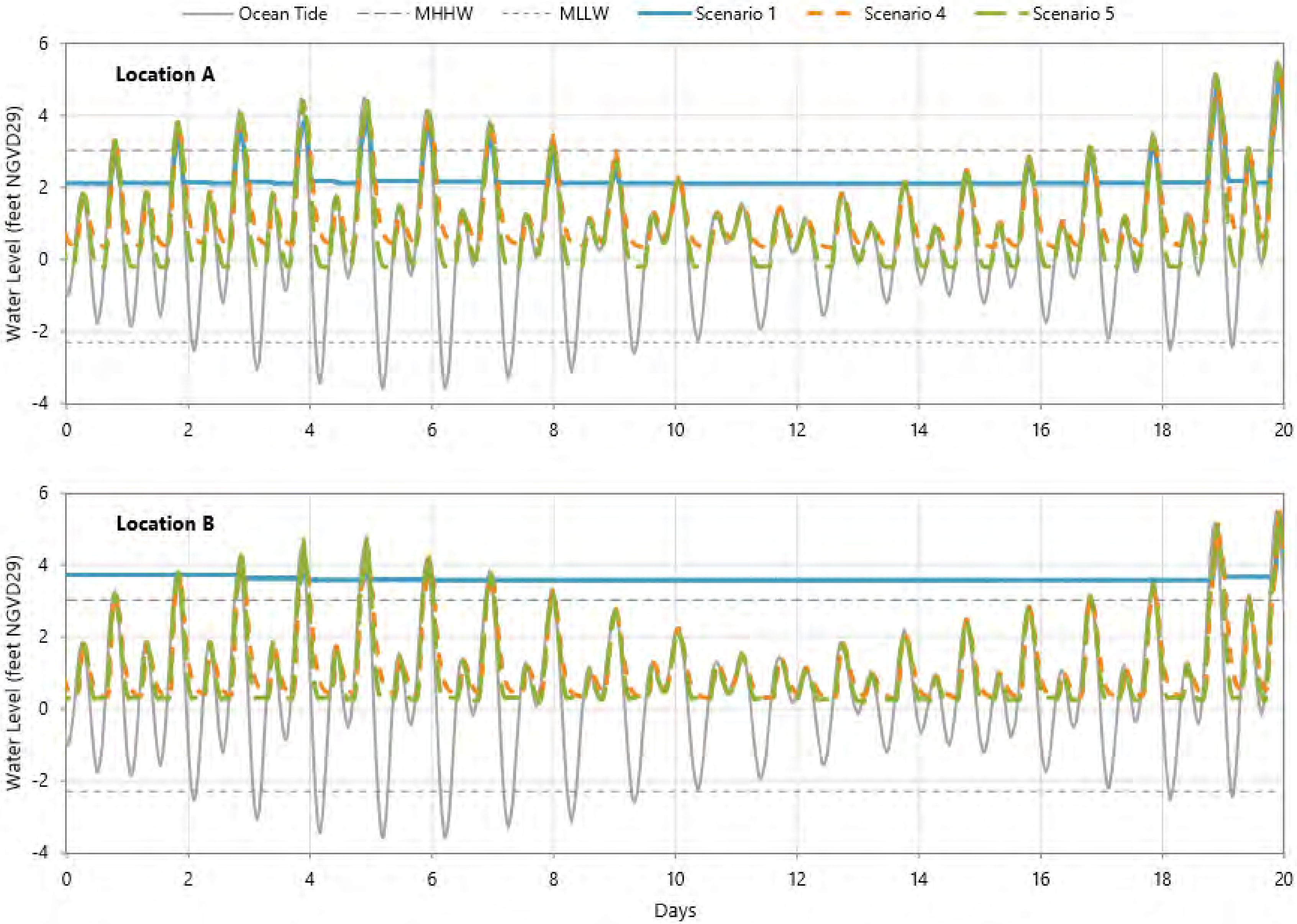


Figure B.19. Scenarios 1, 4, and 5 Water Levels at Locations A and B

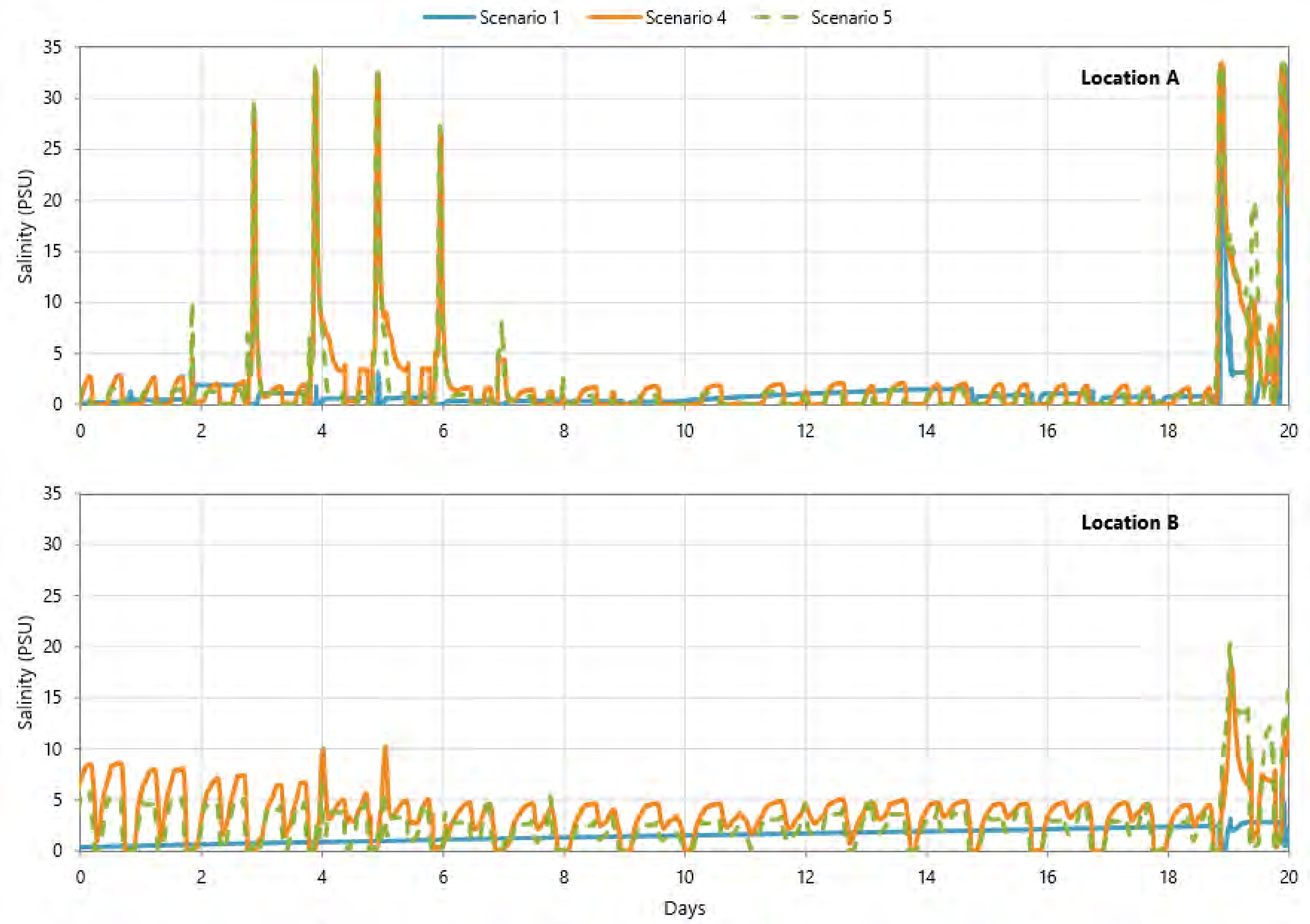


Figure B.20. Scenarios 1, 4, and 5 Salinity at Locations A and B

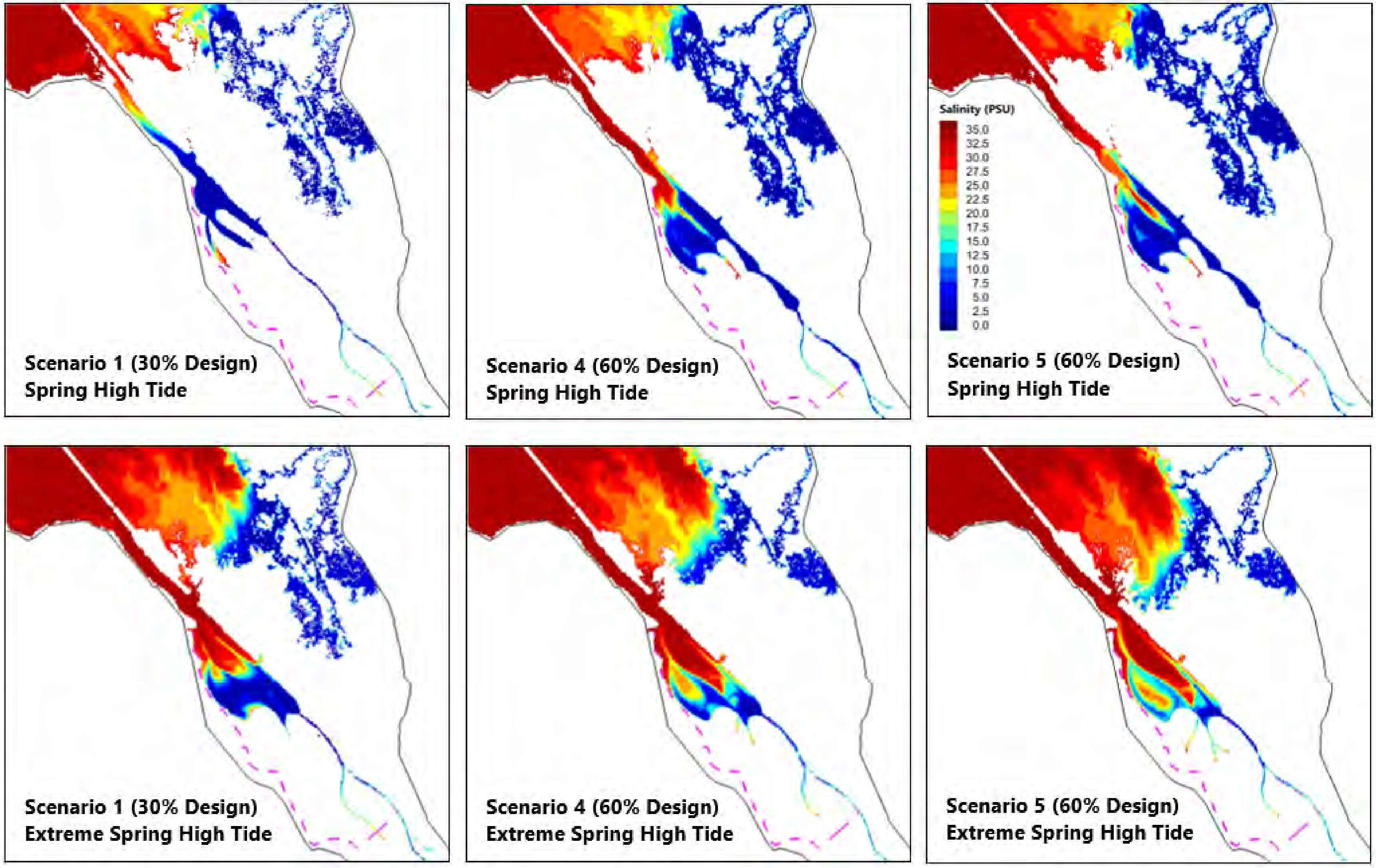


Figure B.21. Salinity Spatial Plots at Spring High Tide for Scenarios 1, 4, and 5

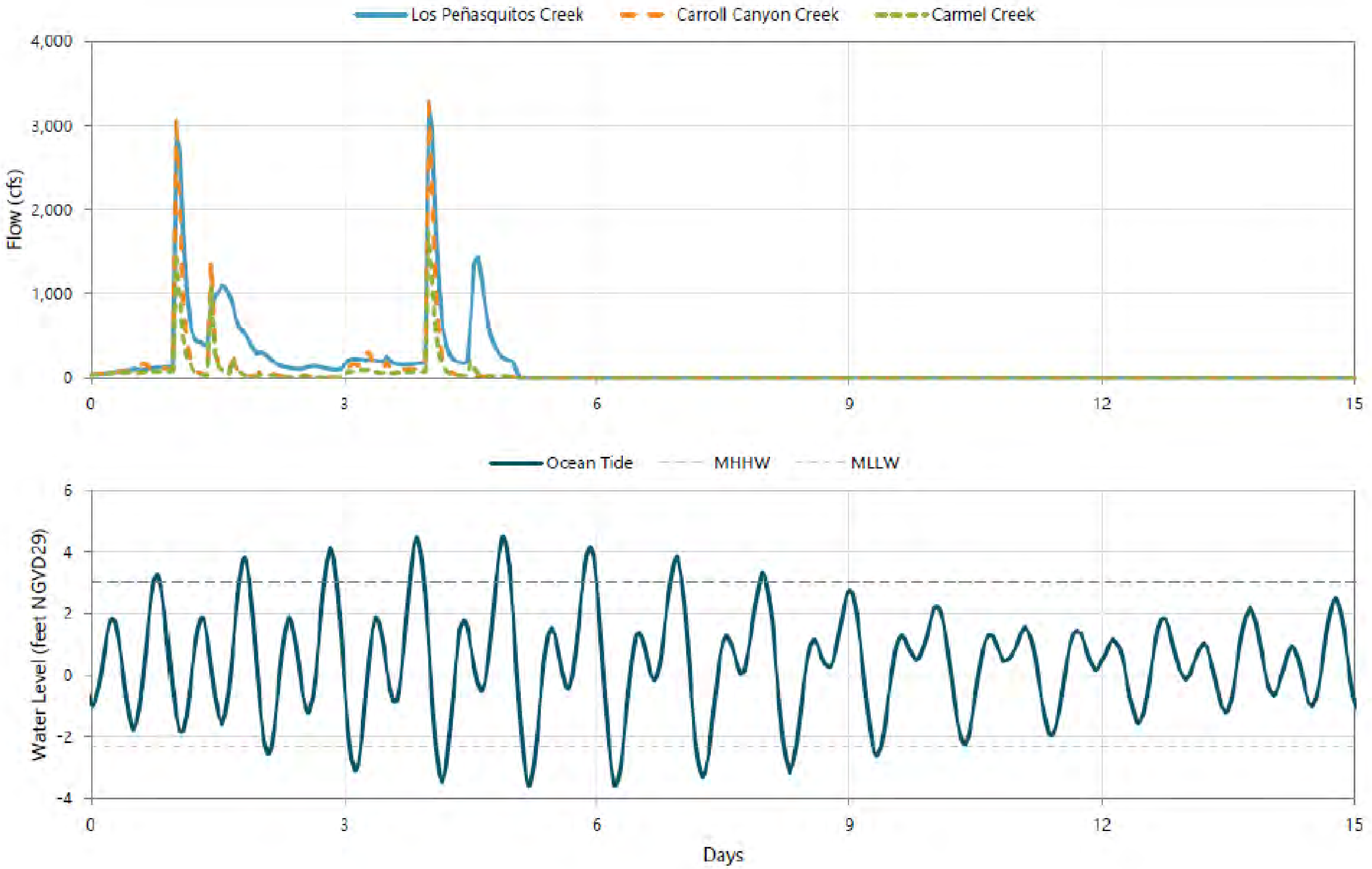


Figure B.22. 2-Year Flood Event and Tide Conditions for Scenario 6

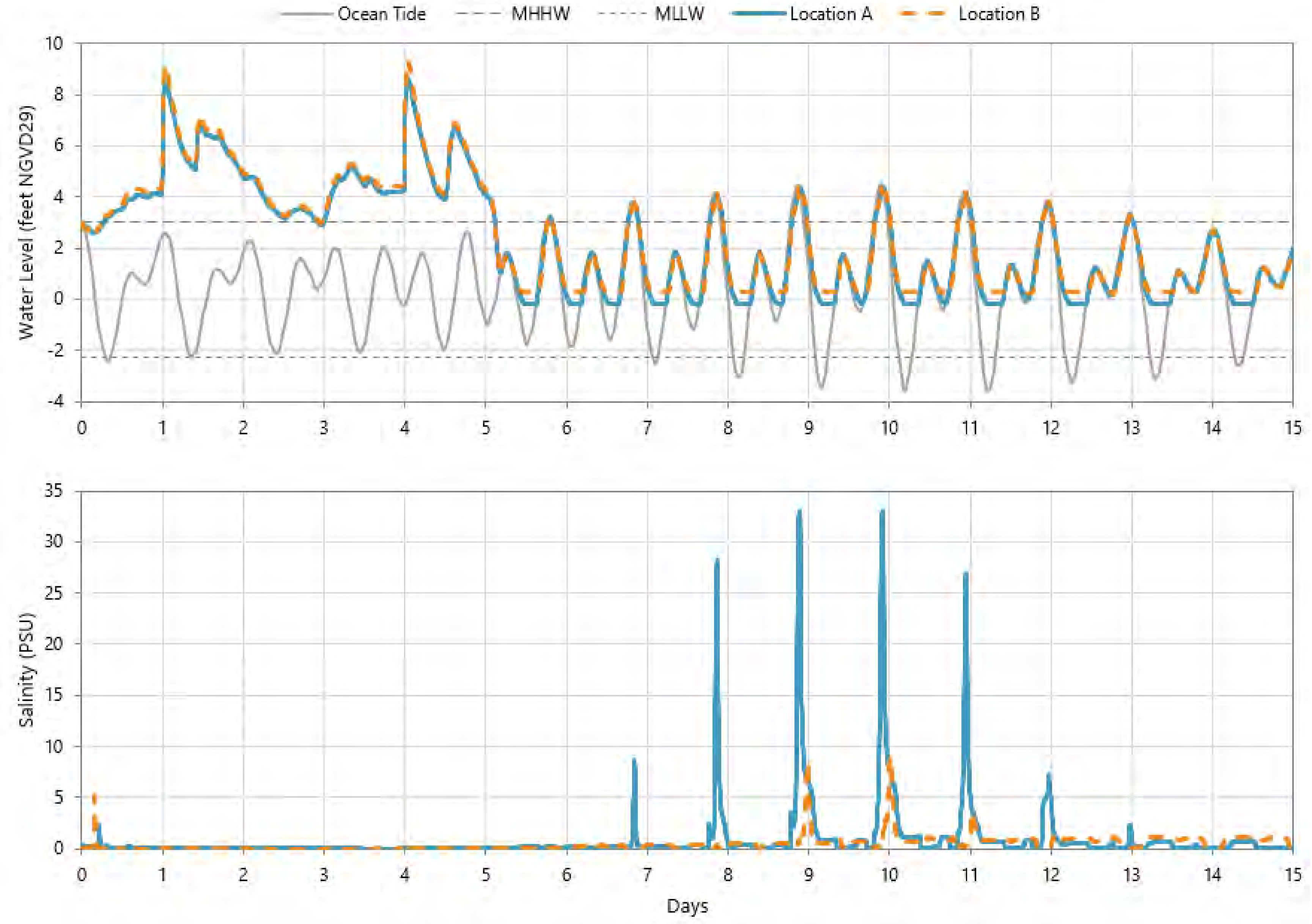


Figure B.23. Scenario 6 Water Levels and Salinity at Locations A and B

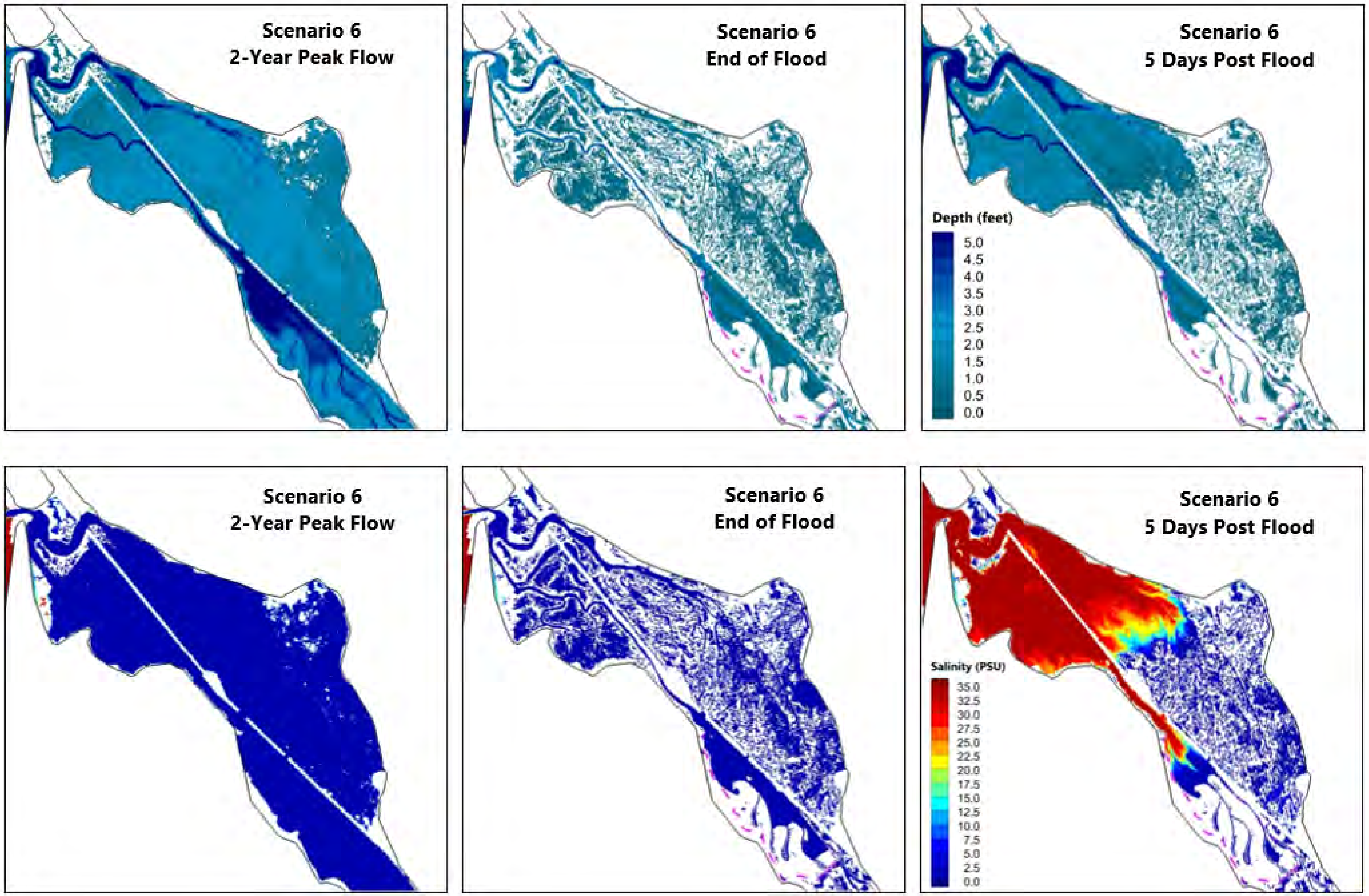


Figure B.24. Scenario 6 Water Levels and Salinity Spatial Plots

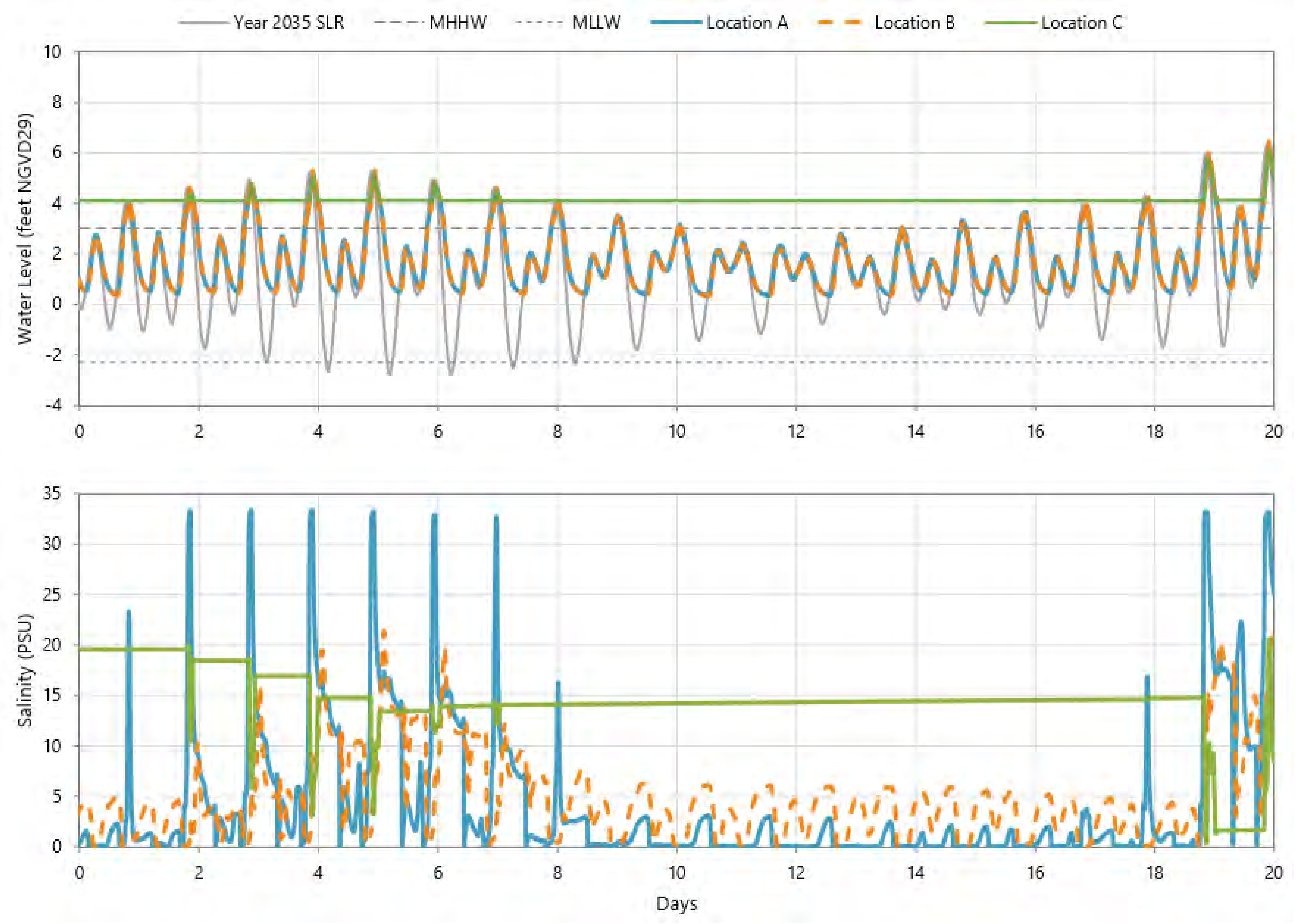


Figure B.25. Scenario 7 Water Levels and Salinity at Locations A, B, and C

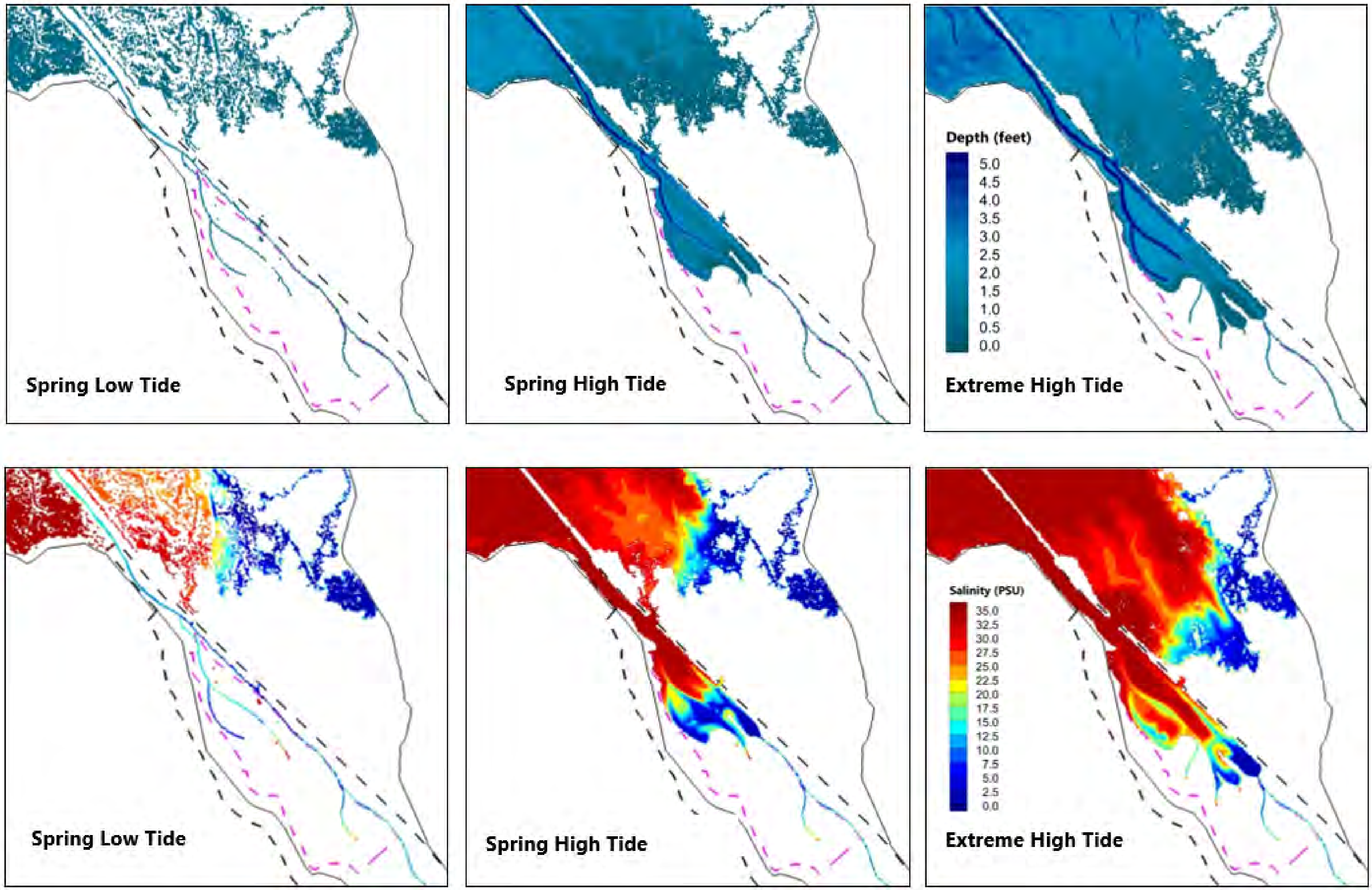


Figure B.26. Scenario 7 Tidal Inundation and Salinity Plots

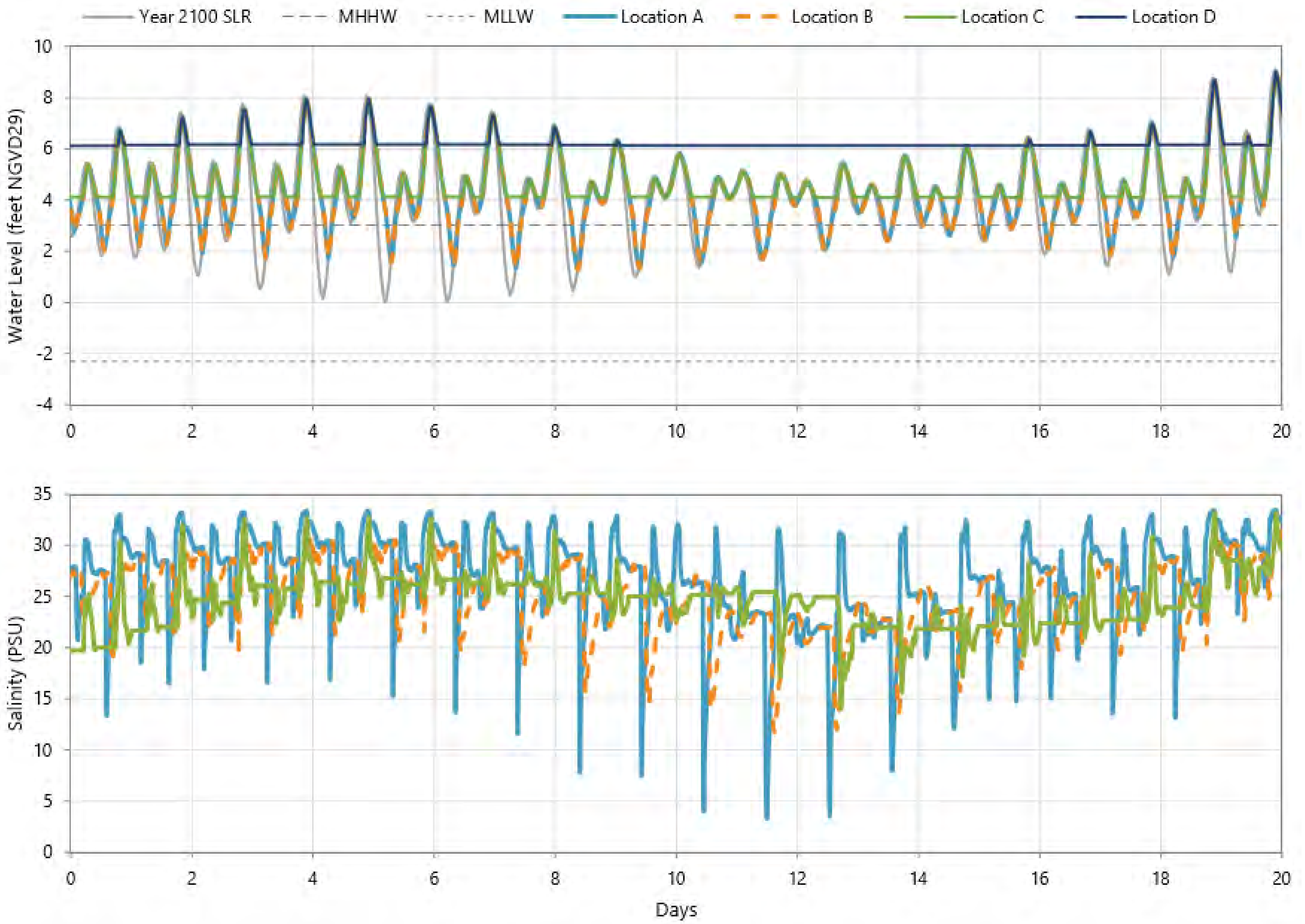


Figure B.27. Scenario 8 Water Levels and Salinity at Locations, A, B, C, and D

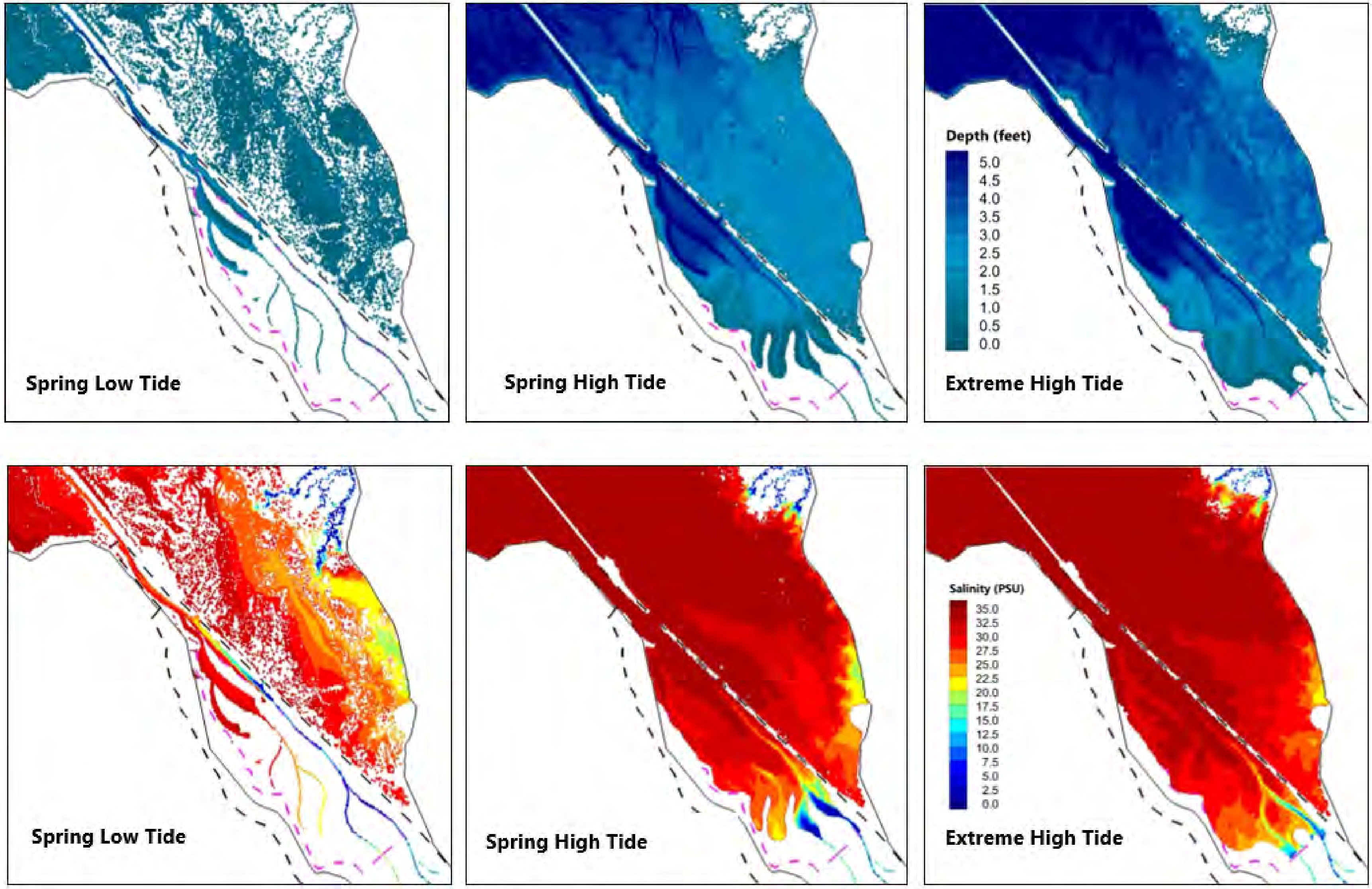


Figure B.28. Scenario 8 Tidal Inundation and Salinity Plots

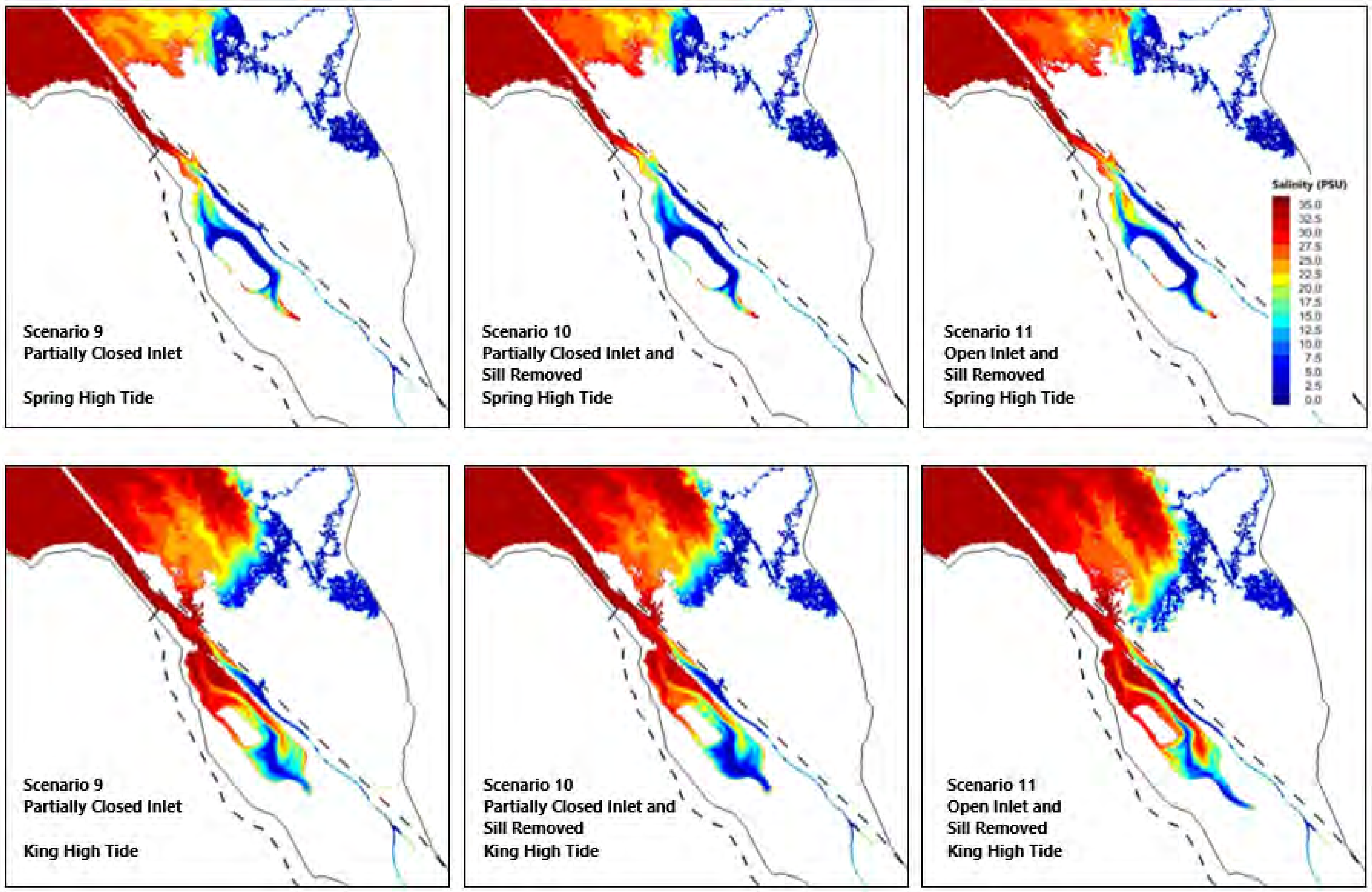


Figure B.29. Salinity Spatial Plots of Spring High Tides for Scenarios 9, 10, and 11

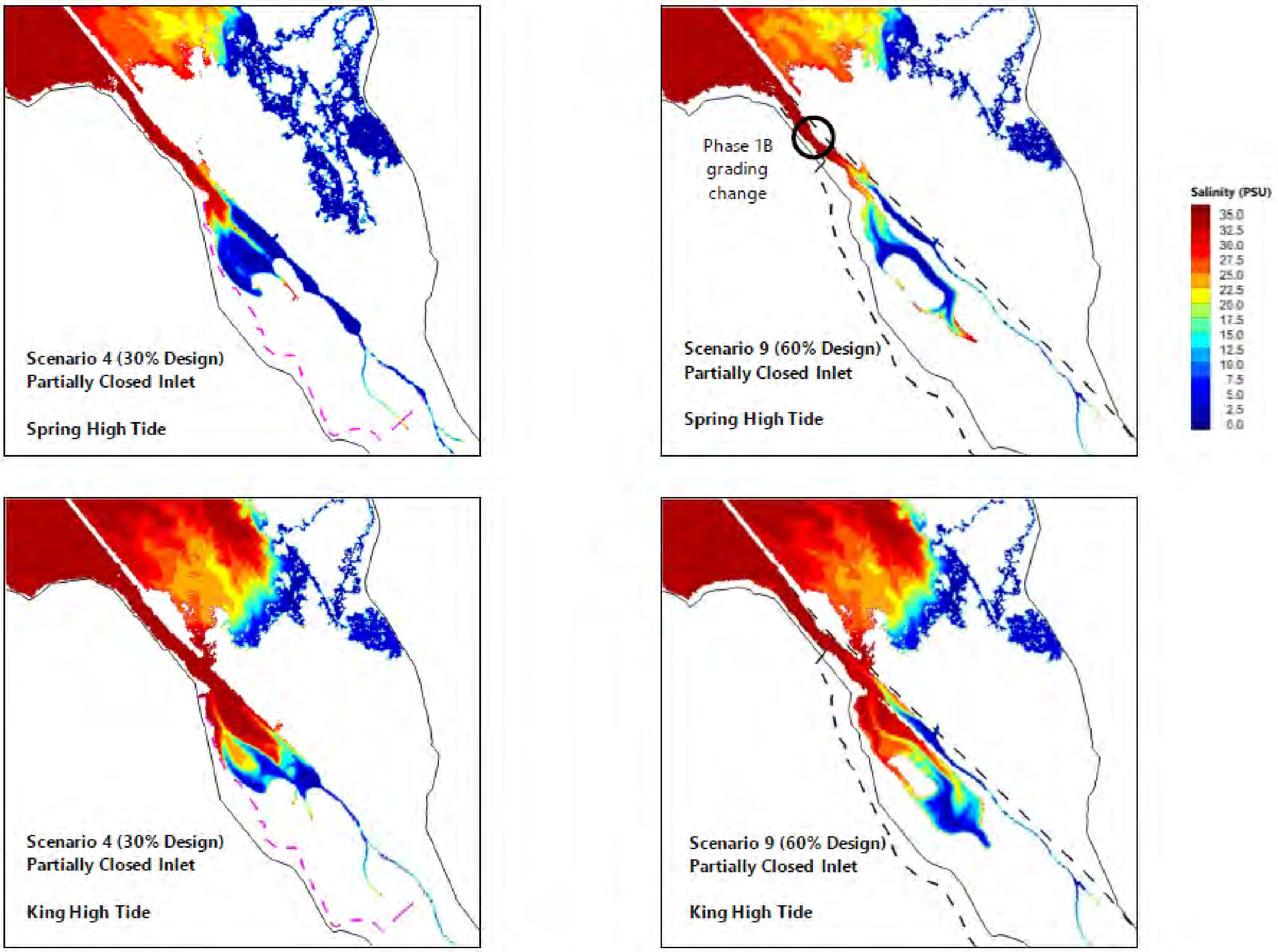


Figure B.30. Salinity Spatial Plots of Spring High Tides for Scenarios 4 and 9

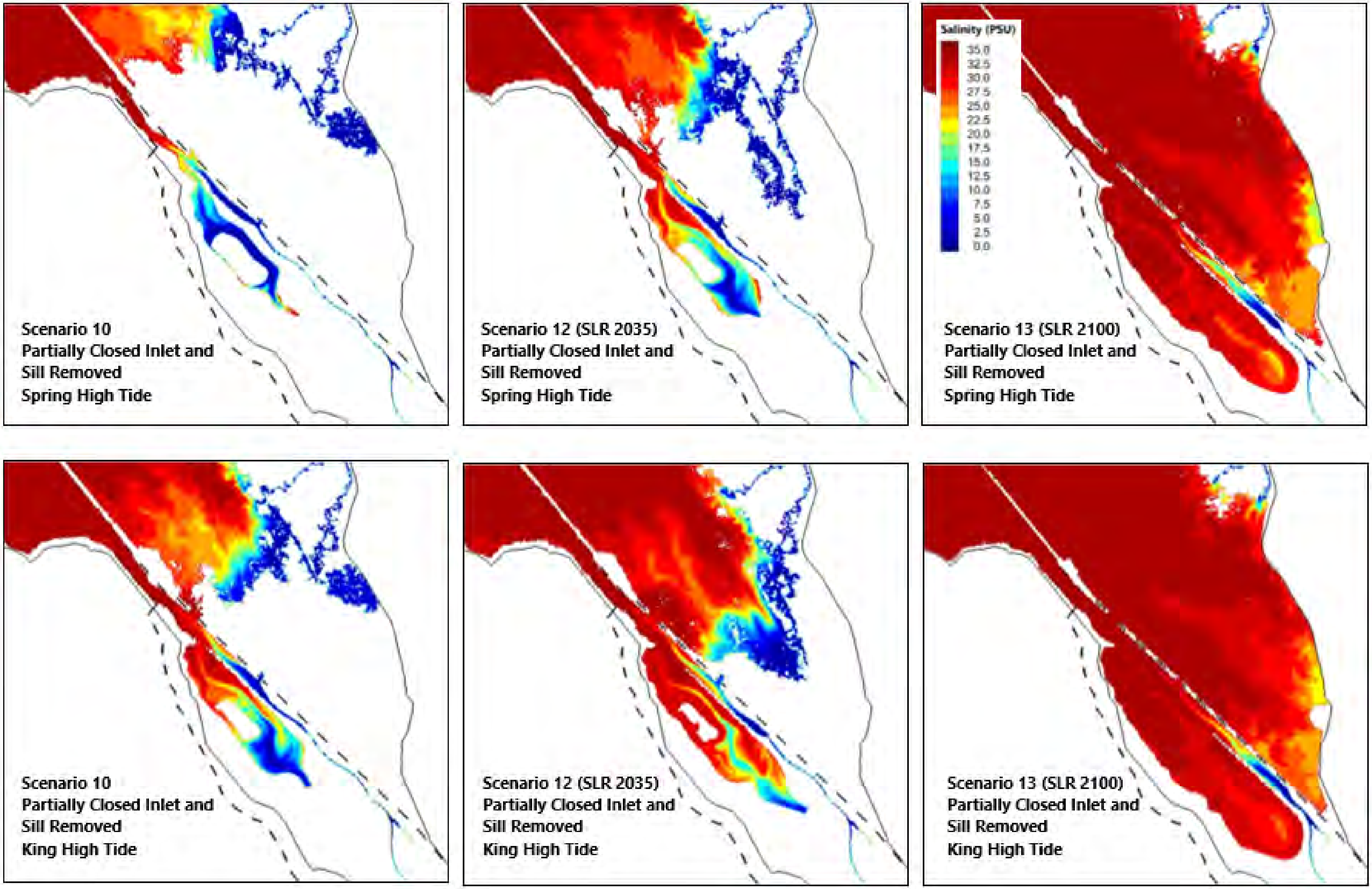


Figure B.31. Salinity Spatial Plots of Spring High Tides for Scenarios 10, 12, and 13

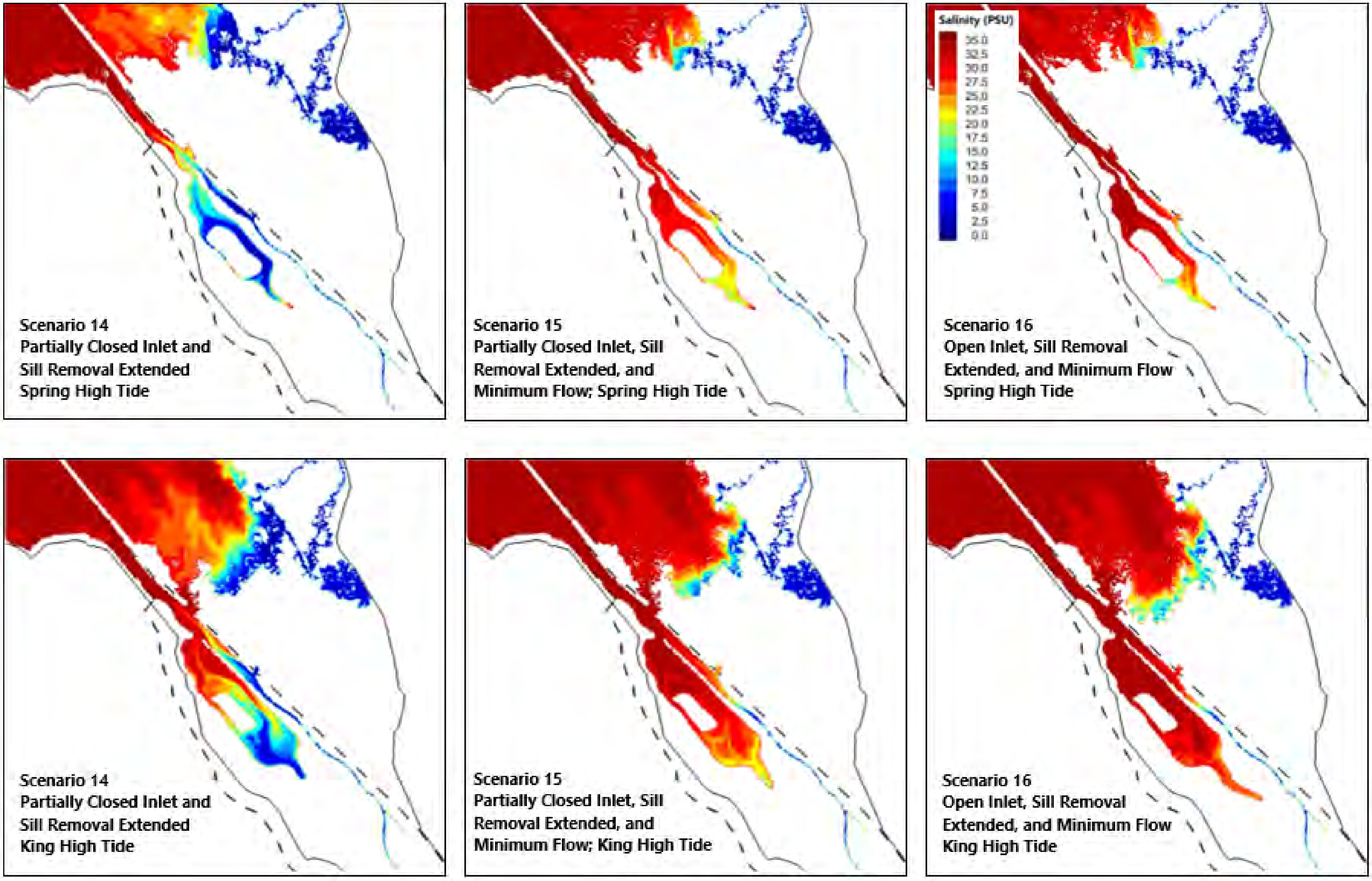


Figure B.32. Salinity Spatial Plots of Spring High Tides for Scenarios 14, 15, and 16

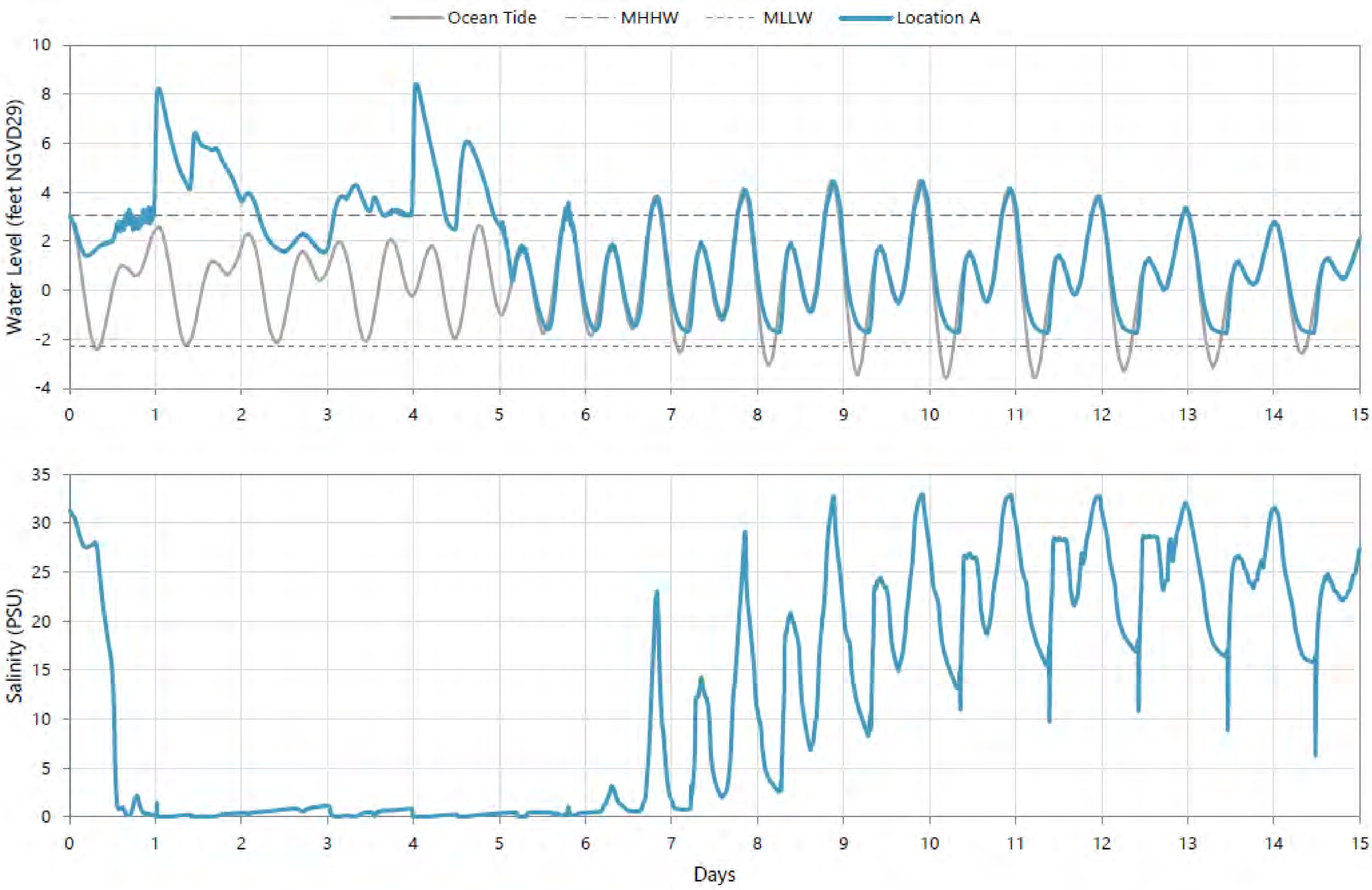


Figure B.33. Water Levels and Salinity at Location A for Scenario 17

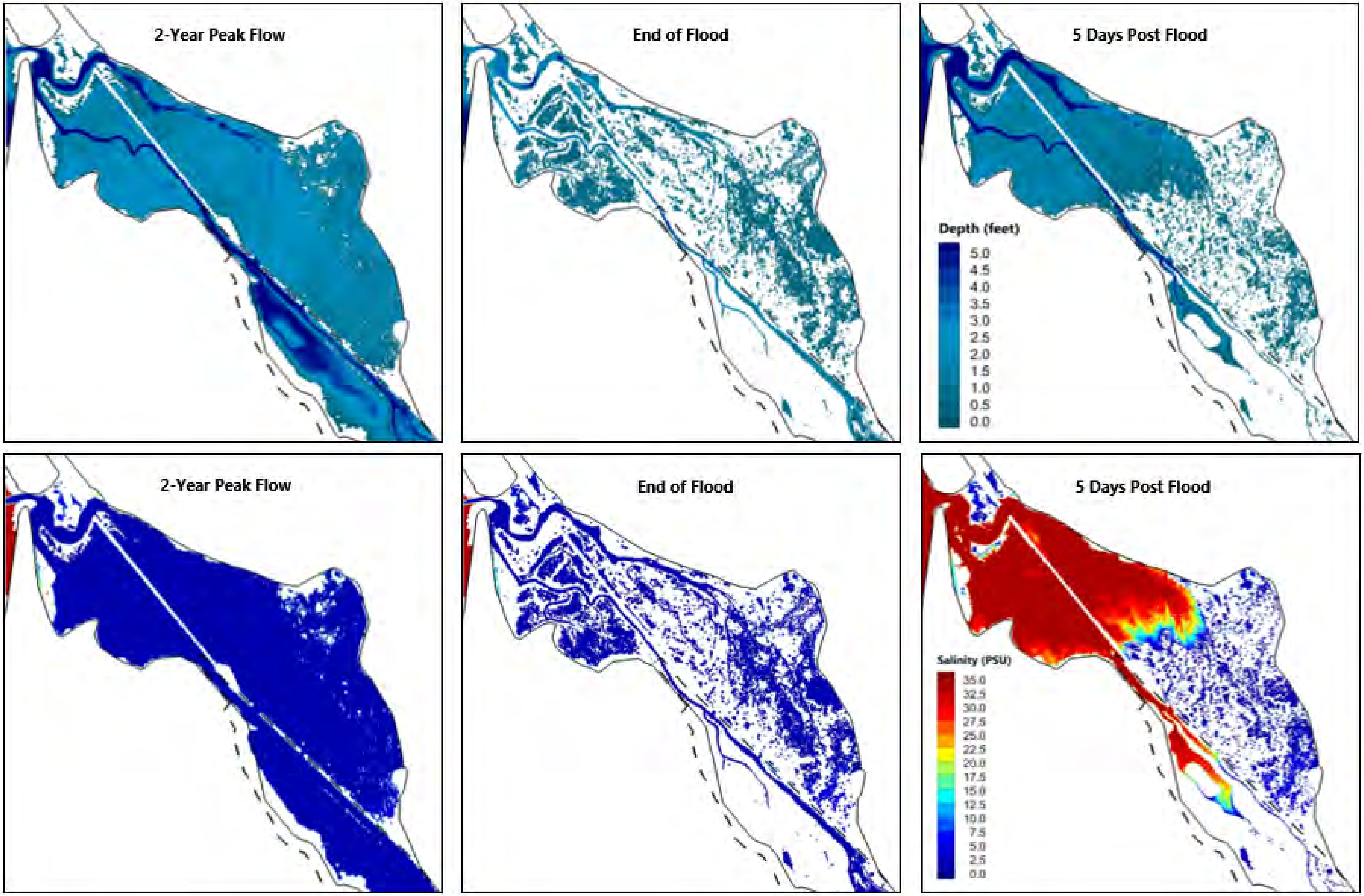


Figure B.34. Water Level and Salinity Spatial Plots for Scenario 17

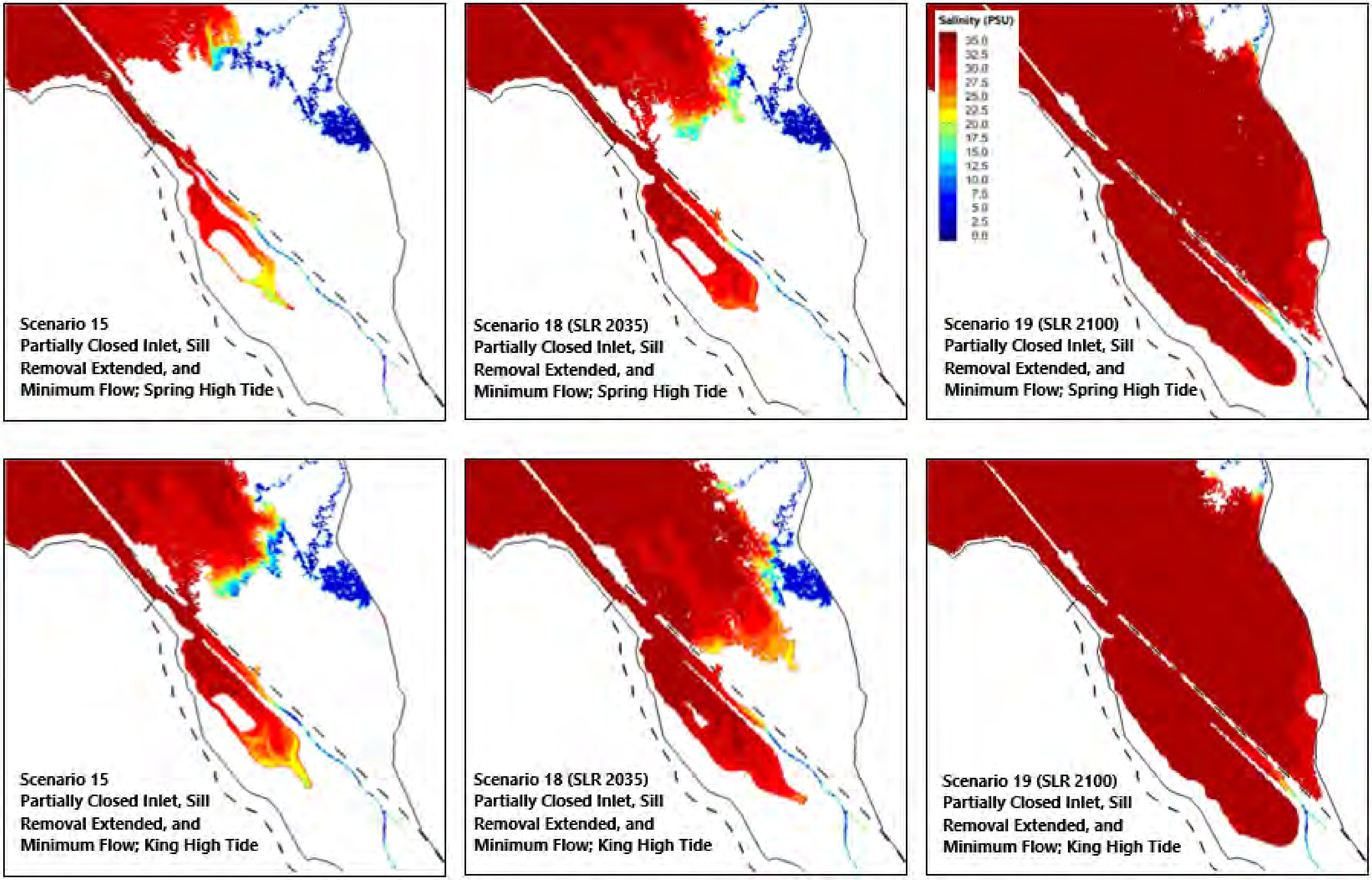


Figure B.35. Salinity Spatial Plots of Spring High Tides for Scenarios 15, 18, and 19