Appendix A

Phase 3 Study Assumptions

In developing the overall approaches and methods used for the Phase 3 Study, many implicit and explicit assumptions were required to quantify the linkages between Ventura Water Reclamation Facility (VWRF) flows and conditions affecting beneficial uses supported by the Santa Clara River Estuary (SCRE). We have attempted to document as many of the assumptions used in the Phase 3 analysis as possible in the Phase 3 Study report, including supporting information when available. In the interest of transparency and to provide context for the interpretation of study results and conclusions, this appendix summarizes assumptions used in the Phase 3 study along with references to relevant report sections. When available and not provided in the main report, we provide additional information supporting the study assumptions in the sections below.

1 GENERAL ASSUMPTIONS

As noted in the main report, in order to integrate the effects of VWRF and other discharges to the SCRE, the Phase 3 study approach relies upon several broad assumptions to link discharge, groundwater, and surface water quality data more directly into the analysis of all beneficial uses of the SCRE.

Because SCRE morphology varies in response to Santa Clara River (SCR) flood occurrence frequency, duration, and intensity due to natural variations in meteorology and climate change (Sections 3.1 and 3.2), we assume that these other factors affect all beneficial uses at either low or high VWRF discharge levels.

Because of the large number of potential species are represented in consideration of the beneficial uses of the SCRE, we use a combination of approaches that consider habitat amounts and quality for affected species. For the RARE beneficial use, we rely on a focal species approach (Section 1.3.1, 3.6 and 3.7). This assumes that evaluation of habitat amounts and suitability for focal species reflect conditions for other species.

2 HABITAT SUITABILITY AND AVAILABILITY

1. Recognizing that conditions occurring at a spatial scale beyond the SCRE watershed (e.g., conditions in the upper watershed, ocean, surrounding land uses) as well as at temporal scales beyond the scope of this analysis (e.g., decadal scale changes in El Niño Southern Oscillation, precipitation, as well as changes in mean sea levels due to global climate change) may affect population levels and viability of species that use the SCRE, we assume production and population benefits to fish and wildlife species are limited by the combination of physical habitat and water quality conditions.

2. In examining habitat suitability for selected focal RARE species as well as other native and non-native species considered by the Phase 3 study, we rely upon long established ecosystem "niche theory" that assumes individual species are adapted to a range of environmental conditions (Grinnell 1917) within each habitat type (Section 1.5.2). Wildlife associations with key habitat types is presented in Section 3.7 and cross walk tables showing how habitat use by focal species relates to the more common estuarine species present in the SCRE is included in the report (Table 3-30 and Table 3-34).
3. For existing conditions, we assume that available information regarding habitat use, direct toxicity testing results, and literature-based assessments of potential water quality impacts upon native species are representative of the effects of current discharge conditions.
4. For assessment of future conditions, we assume that habitat suitability varies in response to changes in physical habitat and water quality (Section 1.5).

5. In the absence of more specific information relating physical habitat suitability to VWRF discharges, we use areal coverage of various habitats types known to support native species (e.g., open water, mudflats, wetlands, riparian, etc.) as a measure of conditions for those species. For example, conditions for riparian-associated birds are represented by the relative areal coverage of riparian habitat, as more specific evaluation could not be done with available data and would not be representative of the full suite of species.

3 WATER BALANCE EVALUATION

The Phase 3 Study water balance evaluation models the inflows and outflows of the SCRE to estimate the volume and corresponding stage in the SCRE. The water balance utilized measured data when available (including river discharge, effluent discharge from the VWRF, SCRE stage, and local tidal elevation), but numerous assumptions were necessary to estimate components not directly measured and to model the dynamic spatially and temporally distributed estuary processes. In the absence of specific data, the model assumed homogeneous spatial conditions and uniform temporal distributions especially for groundwater and berm flows.

3.1 General assumptions

1. All surface water and groundwater inputs and outputs are assumed to be represented in the water balance.
2. Hydrologic characteristics of the SCRE subwatershed are assumed to be homogeneous (i.e., rainfall, runoff, evaporation have uniform areal inputs and losses to the water balance).
3. Historical data used in the water balance (i.e., bathymetry, berm dimensions, hydrology, etc.) were assumed to be representative of future and equilibrium SCRE conditions.
4. Data measured at a specific timescale (i.e., 1 hour) was assumed to be uniformly distributed across that timescale if it was downscaled to a smaller timescale (i.e., 30 minutes).
5. Surface water flows from McGrath Lake were assumed to not influence conditions in the SCRE since there was no evidence of a surface water connection between McGrath Lake and the SCRE during 2015-2016.
6. The rate of precipitation was assumed to be constant over the course of a storm and equal to total rainfall as measured at downtown Ventura (Station 66E) divided by the duration of the storm.
7. Subwatershed runoff downstream of Victoria Ave. was assumed to be represented by the Rational Method so runoff is assumed to be a function of storm intensity, drainage area, and land use within the drainage.
8. Symmetrical storm-event hydrographs were assumed for calculations of subwatershed runoff since the distribution of storm-event hydrographs is unknown for the subwatershed and used the assumptions: 1) storms delivering less than 1 inch of water were negligible; 2) there was no runoff from contributing areas prior to and following storm; 3) the time from peak discharge to zero discharge was twice storm duration and was essentially the total hydrograph duration; and 4) the rising and falling limbs of the storm hydrographs were linear from zero discharge to peak discharge.
9. Subwatershed runoff flow from the north and south banks of the SCRE contribute flows uniformly across the SCRE water surface.

10. Transpiration losses by wetland and riparian vegetation were assumed to be negligible in comparison to evaporation, but it is recognized that the evapotranspiration losses may be between 0.8 and 2 times the evaporation losses depending on the vegetation types.
11. Water balance development scoping and feedback from the scoping assumed wave overtopping processes during closed- or open-mouth conditions were transient conditions that did not significantly influence conditions in the SCRE. It was assumed wave overtopping and overwash processes did not need to be explicitly included in the water balance to characterize typical conditions in the SCRE so beach berm parameters (e.g., height and slope) needed to explicitly model wave overtopping and overwash were not collected during the Phase 3 study.

3.1.1 Groundwater Flows

1. Groundwater flow velocities were assumed to be approximated by Darcy flow through porous media, with flow velocities determined by relative differences in water levels between the SCRE and monitoring wells and proportional to the distance between the water level measurements (i.e., hydraulic gradient) as well as hydraulic conductivity estimates based on soil types and grain size.
2. Groundwater flows were assumed to be approximated by the apparent (i.e., Darcy) velocity above, multiplied by a cross sectional seepage face approximated by a length (i.e., along the river bank or beach berm) and depth, assumed to be equal to the depth to the confining aquitard of the shallow aquifer surrounding the SCRE.
3. Groundwater flows were assumed to be contributed to the SCRE in proportion to the contributing bank lengths between monitoring wells.
4. Seepage from the VWRF Wildlife Ponds up to Harbor Blvd. was assumed to be proportional to the measured water levels in wells in GW-13, GW-14, and GW-15. Because the data in the well nearest the ocean (GW-12) did not fluctuate with changing SCRE stage, the portion of seepage flows from the western-most pond were assumed to flow to the ocean and were not included in the SCRE water balance.
5. Groundwater flows from the north bank upstream of Harbor Blvd. were assumed to be weakly dependent upon to the measured water levels in wells in GW-8, GW-9, GW-10, and GW-11.
6. Upstream areas of the north bank were assumed to contribute flows under all stage conditions in the SCRE because measured water levels in GW-5 on the north bank were consistently higher than those in GW-4.
7. Areas of the south bank upstream of Harbor Blvd. were assumed to contribute no flows under all stage conditions in the SCRE because measured water levels in GW-7 on the north bank were consistently higher than those in GW-6.
8. Groundwater flows along the south bank downstream of Harbor Blvd. were assumed to be proportional to the measured water levels in wells in GW-1, GW-2, and GW-3.

3.1.2 Berm Flows

1. Berm seepage flows are assumed to follow the same Darcy flow relations governing groundwater flows above (See items 1 and 2 under Groundwater Flow).
2. Berm seepage flows during closed-mouth conditions were assumed to be proportional to the hydraulic gradient between the SCRE water surface elevation and the measured tidal elevation at NOAA Station 9411340 near Santa Barbara.

3. SCRE mouth berm breaching conditions were assumed based on historical observations of conditions in the SCRE when the mouth berm breached in 2015 and 2016, SCRE water surface elevation threshold triggers, and tide ranges as measured at the NOS Santa Barbara tide station.
4. The SCRE mouth is assumed to naturally open based upon thresholds of SCRE stage and whether storm or non-storm conditions are present. During storm conditions (represented by subwatershed runoff > 0.5 cfs), the mouth is assumed to naturally open when SCRE stage > 14 ft NAVD88. During non-storm conditions (represented by subwatershed runoff ≤ 0.5 cfs), the mouth is assumed to naturally open when SCRE stage > 11.2 ft NAVD88 between Jan 2015 – Jan 2016 or when SCRE stage > 10.6 ft NAVD88 between Feb 2016 – Dec 2016.
5. The SCRE mouth is assumed to close based upon thresholds based upon observations of combined surface flows and tidal ranges within either winter/spring (tidal range is <5.0 ft NAVD88 and net inflow is <65 cfs) or summer/fall (tidal range is <4.0 ft NAVD88 and net inflow is <30 cfs).
6. Surface water flow in and out of the SCRE during open-mouth periods was assumed to be a function of the estimated stage and tide levels.

3.1.3 Unmeasured Flows

1. Unmeasured flows used to close the water balance calibration during SCRE filling periods were assumed to be a combination of base flow, wave overwash, and drainage of bank storage groundwater.
2. Unmeasured flow from base flow entering the Santa Clara River channel downstream of Victoria Ave. bridge was assumed to be a constant 0.36 cfs during all times based on measurements of surface flow downstream of Victoria Ave. bridge.
3. Based on a consideration of the non-linear processes involved in both wave overwash and drainage of bank storage groundwater, it was assumed these two components of unmeasured flow can be represented together in an exponential decay function of the maximum unmeasured flow from wave overwash and drainage of bank storage groundwater, the rate of decrease for unmeasured flow from wave overwash and drainage of bank storage groundwater, and the time after a berm breach sealed.
4. It was assumed an exponential decay function modeled at the 30-minute time-scale of the water balance sufficiently represents the time integrated volume of episodic wave overwash at a smaller time-scale on filling in the SCRE.
5. Maximum unmeasured flow from wave overwash and bank storage groundwater was assumed to be a constant across a season.
6. Maximum unmeasured flow from wave overwash and drainage of bank storage groundwater was assumed to be a constant average of the seasonally determined maximum unmeasured flow from wave overwash and drainage of bank storage groundwater when no berm breaches occurred during a season.
7. Detailed discussions of the unmeasured flow assumptions are presented in Section 4.1.9 and Section 4.2.2.

3.2 Analysis of equilibrium stage and relative breaching frequencies

1. The equilibrium water balance assumes similar lagoon morphology and baseline flows as those encountered during the relatively dry 2015–2016 monitoring period. For example,

future lagoon morphology is assumed to be represented by bathymetry/topography conditions during recent (2012-2016) surveys.

2. Water balance modeling of the equilibrium SCRE stage assumes 2015 conditions for all other water balance components (e.g., river, precipitation, evaporation, tides, etc.) except VWRF flow which is assumed to be a constant flow for each of the eleven scenarios modeled
3. The SCRE relationships to solve for groundwater inflow/outflows developed from 2015 - 2016 data in the SCRE were assumed to be applicable for water balance modeling of the equilibrium SCRE stage.
4. As determined for the 2015-2016 water balance from analysis of 2015-2016 monitoring well and SCRE stage data, the groundwater gradients for the North Bank Floodplain and South Bank Floodplain were assumed to be a linear function of the SCRE stage, except the eastern portion of the North Bank Floodplain which was assumed to be a constant.
5. As determined from 2015-2016 data, the groundwater gradient for groundwater flows through the beach berm were assumed to be proportional to the hydraulic gradient between the SCRE water surface elevation and the measured tidal elevation at NOAA Station 9411340 near Santa Barbara.
6. Groundwater flow from the VWRF Wildlife Ponds under equilibrium conditions was assumed to be zero when the VWRF discharge was equal to zero since the VWRF Wildlife Ponds would not continue to contribute to groundwater gradients in that region, but there was no data available to determine the relationship between groundwater flow and stage.
7. The mouth breaching frequency was analyzed for a representative dry, normal, and wet water year assuming a series of constant VWRF flow scenarios and using data measured during the water year being modeled for Santa Clara River discharge, precipitation, tide data, and evaporation rates. All data that could not be determined from historical records was assumed to be represented by 2015 conditions (e.g., berm length).
8. The SCRE relationships to solve for groundwater flows developed from 2015-2016 data were assumed to be applicable to estimating groundwater flow for mouth breaching frequency for a representative dry, normal, and wet water year.
9. During the relative breaching frequency model runs, the maximum unmeasured flow from wave overwash and drainage of bank storage groundwater was assumed to be equal to the average of the seasonally determined maximum unmeasured flow from wave overwash and bank storage groundwater that was calculated in the water balance.

4 MODELED CHANGES IN VEGETATION COMMUNITY AND HABITAT TYPES

1. Existing and future vegetation community types are assumed to be controlled by average water levels, salinity tolerances, as well as disturbance due to channel scour and SCRE mouth breaching.
2. Modeling of vegetation communities was based upon changes from recent (2016) vegetation mapping and assumes future vegetation distribution is based upon long-term average SCRE elevations. Using literature based and observations of water depth associations with species (Section 5.3.1), the following successional rules were assumed:
    a. **Riverine reaches.** Modeling of future vegetation conditions above equilibrium water surface elevation (WSE) in riverine habitats subject to greater scour and disturbance are assumed to remain or shift to riparian vegetation, whereas areas

below the equilibrium WSE are assumed to remain or shift to open water habitats.

b. **Lagoon perimeter**. Modeling of future vegetation conditions above equilibrium water surface elevation (WSE) in lagoon areas subject to lower scour are assumed to remain or shift to riparian habitats, whereas areas 0–3 ft below the equilibrium WSE are assumed to remain or shift to freshwater wetland habitats. Areas deeper than 3 ft below the equilibrium WSE are assumed to remain or shift to open water habitats. For existing salt marsh habitats, areas lying below the modeled WSE are assumed to shift to either freshwater wetland habitats or open water depending upon depth (i.e., water depth > 3ft shifts to open water).

c. **Beach and Foredune habitats.** Modeling of future vegetation conditions above equilibrium water surface elevation (WSE) in areas near the beach subject to breaching and beach building process are assumed to remain or shift to open beach and foredune habitats, whereas areas below the equilibrium WSE are assumed to remain or shift to open water habitats.

d. **Campground Area**. Modeling of future vegetation conditions above equilibrium water surface elevation (WSE) in areas near the McGrath State Beach campground are assumed to remain or shift to either riparian habitats or to revert to disturbed/developed habitats near the campground itself. Areas 0–3 ft below the equilibrium WSE are assumed to remain or shift to wetland habitats.

5 WATER QUALITY CONDITIONS

Physical and chemical water quality conditions within the SCRE are highly variable on a daily (diel), seasonal, and annual basis due to the combination of surface and groundwater inflows, seasonal variability in the SCRE mouth conditions, ocean exchanges, as well as local and regional meteorological variability. Assessment of existing and potential future water quality conditions is based upon the following assumptions.

1. Under existing conditions, spatial variations in water quality are assumed to be represented by synoptic surface water quality measurements collected during fish and aquatic habitat surveys, longer term seasonal variations by locations used for grab sampling for NPDES compliance, as well as observed differences between water quality Sonde locations.
2. Temporal patterns in water quality are assumed to be represented by seasonal synoptic survey results as well as diel variations in *in situ* water quality at the three locations Sondes were deployed in the SCRE.
3. Recognizing that VWRF facility upgrades completed in 2011 may have altered nutrient loading to the SCRE, we assume that conditions assessed since 2012 are representative of existing water quality conditions in the SCRE.
4. Assessment of future water quality conditions are assumed to be solely attributed to variations in VWRF flows and treatment and do not consider other variability or changes in nutrient levels or potential contaminants arriving from areas contributing to the SCRE subwatershed and lower Santa Clara River.
5. Because water quality conditions in the outfall channel location is strongly influenced by discharges from the VWRF Ponds, we have assumed that future conditions in the open water portions of the SCRE are primary determinants of habitat suitability for native species.

5.1 Estuary Mixing Model Assumptions

1. Mixing model approaches used to assess future salinity as well as nutrient loads assume complete estuary mixing and that the total of all material inflows and outflows balance over the course of a day (i.e., mass in equals mass out). Although these assumptions are not always valid due to non-steady periods of estuary filling and wave overwash inputs of salinity, among other factors, this assumption is generally valid based upon the predominance of uniform water quality conditions with depth (i.e, profile data) as well as in spatially explicit water quality mapping conducted using data collected during seasonal species surveys (See Appendix D).
2. The conductivities of SCRE inflows and outflows used in the mixing model are detailed in Section 4.3 for 2015 – 2016 and Section 5.3 for alternative VWRF discharge scenarios. The component of unmeasured flow attributed to wave overwash and drainage of bank storage groundwater was assumed to be primarily wave overwash and assigned a conductivity consistent with seawater. The initial SCRE conductivity was assumed to be 2624 uS/cm based on averages of the measured estuary conductivity after several months without berm breaches.
3. The estuary conductivity was assumed to be constant when the outflow from the estuary through a berm breach was greater than 5,000,000 cubic feet.
4. The analysis of conductivity under alternative VWRF discharge scenarios assumed the estuary conductivity had reached equilibrium before berm breaching and the time the SCRE mouth was open was sufficiently brief that the initial SCRE conductivity when the berm breach closed was equal to 2624 uS/cm. Under frequent berm breaching conditions or after a long period when the SCRE mouth was open, this assumption is not valid and the initial SCRE conductivity would be higher.
5. In assessing the potential for episodic algal blooms and associated impacts to DO and pH, flows from the Santa Clara River, the subwatershed runoff, the VWRF, the various groundwater regions (VWRF Wildlife Ponds up to Harbor Blvd, north bank upstream of Harbor Blvd., upstream areas of the north bank, and south bank downstream of Harbor Blvd.) and unmeasured flow are assumed to contribute to the nutrient loading to the SCRE, while the flow from the ocean is assumed to not contribute to the N or P loading in the SCRE.
6. The nutrient loading assumed for each flow is based on data collected during the 2015 and 2016 monitoring period.
7. The nutrient uptake and removal processes are assumed to be represented on an areal basis (i.e., areal or “zero order” reaction kinetics not strongly dependent upon ambient concentrations) using a single zero-order removal rate for all times since data availability limits the development of more detailed reaction kinetics.

5.2 Estuary Heat Balance Model Assumptions

1. The estuary heat balance was assumed to be the sum of advective heat transport from the water balance inflows and outflows and surface heat exchange transport from insolation (solar radiation), long wave radiation (in and out), and evaporation.
2. Heat exchange from heat transport processes not specifically listed in Section 4.4. (i.e., conduction between air and water, conduction between water and estuary sediments, etc.) was assumed to be zero.
3. The estuary heat balance was assumed to be in equilibrium with its surrounding so the sum of the advective and surface exchange heat transport processes is equal to zero.

4. All surface heat exchange processes were assumed to uniformly transport heat across surfaces.
5. Assumptions of the equations and the various parameters needed to represent advective and surface heat exchange in the SCRE are detailed in Section 4.4.

6 COMPARISON OF VWRF DISCHARGE SCENARIOS

Beneficial use assessments for the Phase 3 study have relied upon conceptual modeling in combination with available data and quantitative models to distill ecosystem functioning of the SCRE into a manageable set of key processes with defined relationships. Because a number of physical, chemical, and biological factors that maybe quantitatively or qualitatively linked to alternative VWRF discharge levels affect multiple beneficial uses, we have made several assumptions in order to arrive at recommendations regarding “enhancement” as well as the maximum ecologically protective diversion volume (MEPDV). The section below details high-level assumptions related the design of the analysis and interpretation of results.

6.1 Assessment by Beneficial Use Assumptions

1. The beneficial use assessment assumes present day support of beneficial uses may be assessed by present day monitoring of discharge and estuary stage, groundwater monitoring data, mapping of habitat types, aquatic and terrestrial species monitoring data, as well as historical and present-day compilations of water quality data.
2. The assessment assumes future support of beneficial uses may be assessed using water balance and GIS model approaches to examine changes in equilibrium estuary stage, changes in open water, wetlands, and other vegetation community types, water quality conditions, relative breaching frequencies, as well as other factors.
3. The analysis of discharge scenarios by beneficial use relies on the information and tools developed in prior sections, and is thus subject to the assumptions made in the development of those tools or compilation of information.
4. Selection of factors affecting beneficial uses as well as metrics and threshold criteria for comparison of VWRF discharge scenarios (Section 5.5) were based on the scientific literature and professional judgment, with the intent to capture the primary determinants of habitat suitability that are relatable to VWRF discharges. Although several other variables may potentially affect population levels and abundance, their exclusion from analysis was considered valid on the basis that (a) they were not deemed to have large enough effects to be considered, (b) there are not sufficient data to accurately characterize their effects, and/or (c) their effects are unaffected by varying VWRF operations. Specific examples of variables that may affect realization of that beneficial use, but were not included in the comparison of discharge scenarios, are detailed in the main text of the report (Sections 5.5.1 through 5.5.11), including rationale for their exclusion.

6.2 Weighting of Beneficial Uses

1. Weighting of beneficial uses was based on the assumption that not all beneficial uses are of equal value, and that protection of rare and endangered species, as well as protection of native species and ecological functions of the SCRE should be prioritized.
2. The process for weighting was based on the assumption that the pairwise comparisons made by the Stillwater team, in consultation with technical experts and resource agency personnel, was effective in accurately reflecting the true relative values of the beneficial

uses of the estuary and the factors supporting those beneficial uses. This assumption was tested by evaluating the pairwise comparisons of four other technical experts or agency personnel[1] and resulting weighting (see Figure 5-29 and Table 5-25). This sensitivity testing showed that the Stillwater weighting approximated the composite weighting of alternative perspectives, supporting the validity of this assumption.

6.3 Determination of Enhancement

1. The determination of enhancement was based on the assumption that increased realization of beneficial uses, represented by the scoring of discharge scenarios by beneficial use and the relative weights of each beneficial use, by a discharge scenario relative to the absence of discharge (Scenario 11) constitutes enhancement of the estuary.
2. We assumed that not all beneficial uses must be enhanced under current VWRF discharges vs. an assumption of zero discharge, but that the weighted balance of beneficial use realization must be greater.

6.4 MEPDV and Continued Discharge Recommendations

1. MEPDV and Continued Discharge recommendations assumed that the AHP weighting process appropriately weighted ecological beneficial uses, such that prioritization scores can be used as a measure of the realization of ecological functions of the SCRE.
2. We assumed that reductions in beneficial use realization (as measured by the prioritization score resulting from the AHP) of less than 5% from the maximum are ecologically protective.

[1] Agency input should be interpreted as input from informed persons but not representing official agency positions/perspectives

Appendix B

Phase 3 Study Data Compilation
(see accompanying data CD)

Data Folder Archive Contents

Compiled VWRF NPDES Reporting

Folder: Annual NPDES Reports 2012-2015
Files:
- VWRF Annual Reports of Analysis in PDF format for 2012 to 2015
- Annual macroinvertebrate bioassessment reports in PDF format for 2012 to 2015

Compiled Phase 3 Habitat Suitability Data

Folder: Habitat_Data_Collection
Subfolder: BMI_ABCLabs
Files:
- Phase 3 quarterly benthic macroinvertebrate sampling data in .xlsx format for 2015

Subfolder: Fish Species data
Files:
- Preliminary results memoranda for 2015 (March, June, and September) and 2016 (September) fish sampling in PDF format
- Compiled fish monitoring data in .xlsx format (2015 and 2016)

Compiled Phase 3 Physical Data

Folder: Physical_Data_Collection
Subfolder: Logger_Data
Files:
- Compiled barometric data in .xlsx format (2009 to 2016)
- Compiled logger data in .xlsx format for:
  - Evaporation site PE-1 (2015 to 2016)
  - Groundwater sites GW-1 through GW-3 (2009 to 2016)
  - GW-4 through GW-7 (2012 to 2016)
  - GW-8 through GW-15 (2015 to 2016)
  - McGrath Lake sites E-3a and E-3b (2015 to 2016)
  - Sites SR-1 and SR-2 (2009 to 2016)
  - SCRE water surface elevation (2009 to 2016)

Subfolder: MouthStatus&Flow
Files:
- SCRE mouth status in .xlsx format (1984 to 2016)
- SCRE-McGrath Lake surface connection observations in .xlsx format (2015 to 2016)

Subfolder: Precipitation_Data
Files:
- Precipitation data from site VCWPD-66E in .xlsx format (2008 to 2016)

Subfolder: River_Discharge
Files:
- Compiled Santa Clara River discharge in .xlsx format (1928 to 2016)

Subfolder: Survey_Data
Files:
- Santa Clara River Estuary survey data in .xlsx format from 2016

Subfolder: Tidal_Data
Files:
- Compiled tide data from NOAA site 9411340 in .xlsx format (2008 to 2016)

Subfolder: VWRF_Discharge

Files:

- Compiled discharge data for VWRF sites ETS and D-1 in .xlsx format (1984 to 2016)

Compiled Phase 3 Water Quality Data

Folder: WQ_Data_Collection

Subfolder: Annual CEC

Files:

- Compiled CEC Laboratory Results in PDF format (2015 and 2016)
- Folder: 2015 Lab EDD
    - Electronic data deliverable (.xls) CEC testing results 2015
- Folder: 2016 Lab EDD
    - Electronic data deliverable (.xls) CEC testing results 2016

Subfolder: Continuous Sonde WQ

Files

- Compiled continuous sonde data in .xlsx format (2015 to 2016)
- Compiled *in situ* spot check data in .xlsx format (2015 to 2016)
- Ventura sonde deployment QA document detailing QA procedures and data exclusions in PDF format
- Folder: Sonde calibrations
    - Calibration log for water quality sondes in PDF format (2015 to 2016)
    - Zip files containing documents with details of monthly sonde calibrations in .docx and PDF format

Subfolder: Metals

Files

- Folder: Spreadsheets
    - Analytical water quality metals laboratory results in .xls format (2015 and 2016)
- Compiled analytical water quality metals laboratory results in .xlsx format (2015 to 2016)
- Compiled analytical water quality metals laboratory reports in PDF format (2015 to 2016)

Subfolder: Nutrients

Files

- Zip folder containing monthly analytical chlorophyll-a results in .xlsx and laboratory reports in PDF formats and compiled chlorophyll-a results in .xlsx (2015 to 2016)
- Compiled analytical water quality nutrient laboratory results in .xlsx format (2015 to 2016)
- Compiled analytical water quality nutrient laboratory reports in PDF format (2015 to 2016)
- PDF file detailing QA for nutrient analysis

File: Compiled water quality data for site R1 in .xlsx format (2016)

Subfolder: Toxicity (.zip)

Files

- Folders for each quarterly toxicity event (2015 to 2016), each containing:
    - A folder containing laboratory reports in PDF format
    - A results summary file in .xlsx format

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Appendix C

SCRE Historical Change Analysis (1855–2014)

This appendix provides a narrative and pictorial summary of long-term changes to the SCRE as depicted in historical survey maps and aerial photographs. This summary builds directly upon an assessment previously conducted by Stillwater Sciences for the Phase 1 Estuary Study (see Stillwater Sciences 2011a).

The entire lower river corridor and SCRE have undergone considerable geomorphic change over the past 150 years since European-American settlement due to a combination of land-use practices and climatic conditions. Historically, the SCRE was an expansive ecosystem that included an open-water lagoon and a series of channels that supported intertidal vegetation (Beller et al. 2011). Land development since the mid-19th century has resulted in a 75% (Swanson et al. 1990, ESA 2003) to 90% (Nautilus Environmental 2005) decrease in overall SCRE area and available habitat, and the confinement of flood flows by levees. Following the period of intensive development, a shift in precipitation patterns associated with the El Niño Southern Oscillation (ENSO) has resulted in a wet-period ENSO cycle in southern California between the mid-1960s and mid-2000s, resulting in a higher frequency and duration of large storms.

Changes to the lower river corridor and SCRE extent since the mid-19th century were assessed to highlight the drivers for morphologic change. Data sources used included pre-existing descriptions of morphologic change in and around the SCRE (e.g., Swanson et al. 1990, Schwartzberg and Moore 1995, ESA 2003, Nautilus Environmental 2005, Barnard et al. 2009, Beller et al. 2011, Stillwater Sciences 2011), and orthorectified topographic maps and aerial photographs from 1855 through 2014. These data were compiled and then used to assess morphologic changes approximately every few decades since 1855. Based on previous assessments, five distinct morphologic periods were identified (Table C-1). Historical maps and aerial photographs of the SCRE produced between 1855 and 2014 are presented below in Figures D-1 through D-7. Narrative summaries of the SCRE morphology as depicted in the historical maps and photographs are provided below.

A secondary analysis was performed to demarcate the SCRE beach berm position during recent years: 2000, 2005, 2009, 2012, and 2016 (Figure C-8). As discussed below, the berm has been steadily migrating landward since the last major river flood in 2005, equating to a maximum migration length of 1,000 feet between the 2005 and 2016 berm positions.

Table C-1. SCRE morphologic periods since the early 19th century through 2016.

Time period	Description	Major storms in a water year (≥Q 5-yr, or 50,000 cfs) A, B, C
Pre-settlement Early 1800s–1850s	Relatively pristine estuary ecosystem that supported extensive tidal and upland habitat.	1815 (78,406) 1825 (120,526) 1833 (52,796) 1840 (102,237)
Initial settlement 1850s–Early 1900s	Portions of the estuary were converted to agricultural land and channel infilling begins. Impact to estuary increased but estuary continued to maintained tidal and upland habitat.	1862 (111,132) 1884 (108,412) 1890 (82,690)
Agriculture Early 1900s–Late 1940s	Wide-spread land reclamation, channel infilling, and the start of levee building. Beginning of estuary confinement.	1907 (51,853) 1914 (55,522) 1928 (175,000) D 1938 (120,000) 1941 (131,552) 1943 (58,459)
Levees and Infrastructure Late 1940s–Early 1970s	Major development and infrastructure within and adjacent to estuary. Estuary becomes very confined by flood control levees.	**1958** (52,200) **1966** (51,900) **Jan 1969** (165,000) **Feb 1969** (152,000)
Full Build-out and ENSO wet-period Early 1970s–2005	Development in the estuary subwatershed peaks to contemporary levels. Estuary very confined; levees contain large 2005 floods.	**1973** (58,200) **Feb 1978** (98,600) **Mar 1978** (102,200) **1980** (81,400) **1983** (100,000) **1992** (104,000) **1995** (110,000) **1998** (84,000) **Jan 2005** (136,000) **Feb 2005** (82,200)
Present day (Post-2005)	Estuary in quasi-stable state following 2005 floods.	No flows >50,000 cfs; Highest flows in: 2008 (33,000) 2011 (44,000)

Table footnotes:

A Known ENSO years since 1950 are shown in bold, based on NOAA's Climate Prediction Center (2016).
B The 5-year flood is used as the threshold flow because of that flow's ability to cause vegetation scour and rework depositional bars (Swanson et al. 1990, as cited in Nautilus Environmental 2005).
C Estimated peak flood values from the correlation with Santa Paula precipitation are underlined (Stillwater Sciences and URS Corporation 2007). Peak flows in water years 2005–2015 from station #723 maintained by VCWPD (2016).
D The St. Francis Dam failure; peak flood estimate from Begnudelli and Sanders (2007).

1855 The map of the SCR mouth from 1855 shows a meandering river channel with a broad floodplain and an extensive estuary/lagoon complex with a distributary channel network at the southern extent of the mouth complex (Figure C-1). The shoreline and the river mouth (and associated estuary) were inland and the mouth/estuary complex was farther north compared with the post-2005 location. The extent of the SCRE was approximately 870 acres (Swanson et al. 1990; Beller et al. 2011).

1927 The shoreline and river mouth shown in the 1927 photograph—the earliest known aerial image of the SCRE and taken two years prior to the St. Francis Dam failure—advanced in comparison with the 1855 position (Figure C-1). The river meandered through an active channel that extended an additional 2,500 feet to the north and 1,000 feet to the south in comparison with current conditions. A significant portion of the historical estuary to the north appears to have been filled in and the mouth/estuary complex appears to have moved to the south (to approximate present location). Agriculture encroachment at the southern extent appears to have caused infilling of the distributary's channel network. Vegetation establishment within the active channel was not prevalent.

1938 The lower river and SCRE experienced significant geomorphic activity in 1928 during the St. Francis Dam failure catastrophe and in March 1938 during a natural storm-induced flood event. The estimated river flow in the lower river during the dam failure was 175,000 cfs (Begnudelli and Sanders 2007), while the flood waters in 1938 were gaged at 120,000 cfs. Comparison of aerial photographs from the years before and after the dam failure suggests that the flood, which originated approximately 50 miles upstream on San Francisquito Canyon Creek near present day Santa Clarita, did not have that great a geomorphic impact on the SCRE, which may be due to the flood being able to spread out onto the Oxnard Plain and dissipate energy before reaching the estuary and ocean. Photographic evidence suggests that the smaller 1938 flood, however, did cause noticeable geomorphic change, including substantial bed scour, channel widening on the north side of the channel, and infilling of the wetland/backwater area to the north (Figure C-2). This flood also deposited a considerable amount of sediment on the offshore delta that contributed to down-coast beach accretion between 1947 and 1955 (Inman 1950; Oceanographic Services Inc. 1977, as cited in O'Hirok 1985). An increase in upstream flow constraints by levees and other floodplain infrastructure between the 1928 dam failure and the 1938 flood event may have contributed to the differing geomorphic impacts. A greater amount of land development associated with agriculture is apparent on the floodplain area north and south of the active river.

1945 The shoreline and river mouth shown in the October 1945 photograph remained relatively stable in comparison with the 1938 position, with some landward migration of the beach berm (Figure C-2). The sediment deposited from the St. Francis Dam failure (1928) and following 1938 floods is evident in the 1945 photograph. Vegetation within the main channel was still absent, presumably from scour associated with the 1938 flood event. The distributary channel network at the southern extent appears in-filled due to agricultural encroachment.

1958 The shoreline and river mouth shown in the April 1958 photograph eroded landward at both the north and south ends in comparison with the 1945 photograph (Figure C-3). A decade without a major discharge event in the watershed (i.e., instantaneous discharge was less than 50,000 cfs between 1945 and 1958) led to considerable vegetation development within the active channel. Riparian forest development at the southern portion of the active channel extent within the mouth/estuary complex led to a quasi-stable channel exiting to the north. By 1953, an extensive agricultural levee was built to reclaim land within the southern portion of the mainstem channel upstream of the main lagoon, essentially decreasing the channel area and effective flow width by one-third to one-half. Between 1953 and 1957, the continued encroachment of agricultural land and the establishment of levees for flood protection resulted in an approximate 75% decrease in historical channel and adjacent delta areas (Swanson et al. 1990). Also apparent in this air photo is the presence of Harbor Blvd bridge and the City of Ventura's wastewater treatment plant.

1969 The shoreline and river mouth shown in the February 1969 photograph appear relatively unchanged when compared with the 1958 photograph (Figure C-3). Levees on both banks established upstream of the Harbor Blvd bridge had been established by 1969. By 1968, the McGrath State Beach campground was established in the southern portion of the SCRE, Ventura Harbor was established in the historical northern backwater portion of the SCRE, and an extensive flood protection levee was established along the north bank upstream of the main lagoon. Combined, these features decreased the overall area of the SCRE, decreased the effective flow width during flood events, and essentially "locked" the SCRE into its present-day location and extent. The effects of the January and February 1969 floods—the highest flow on record in the lower watershed—within and around the SCRE mouth are apparent in the photograph: a scoured channel network is evident on the north side of the channel (upstream of Harbor Blvd bridge) where the flow overtopped the levee; the impact of levee overtopping on the destruction of Ventura Marina is evident; and considerable deposition of sediment on the south side of channel upstream of Harbor Blvd is apparent. The location of the channel within the mouth/estuary complex was still to the north, but bank erosion induced by the 1969 flood is evident on riparian forest terrace to the south. The late 1960s and early 1970s large storm events mark the start of a multi-decadal wet period marked by the occurrence of eight water years having at least one flood greater than 50,000 cfs (see Table B-1).

1978 The shoreline and river mouth shown in the May 1978 photograph had migrated landward compared to the 1969 photograph (Figure C-4). The March 1978 storm event caused the main channel through the SCRE to move south towards its current location and resulted in the establishment of depositional bars with side channels along the main SCRE channel downstream of Harbor Blvd and in the mainstem channel upstream of Harbor Blvd. There is very little in-channel and tidal vegetation shown in the photograph, which is presumably caused by scour during the 1978 flood event. The completion of the VWRF's wildlife/polishing ponds and flood protection levees by 1974 marks the most recent major infrastructure establishment in the SCRE. Also apparent in the photograph is the City of Ventura's Olivas Links golf course on the northern floodplain, east of Harbor Blvd.

1983 The July 1983 photograph was taken a few months after the large 100,000 cfs flood in March 1983 (Figure C-4). The image depicts a shoreline that has migrated more towards the ocean compared with the 1978 photograph, particularly along the beach area on the north side of the SCRE and west of the VWRF's ponds. The appearance of the approaching river channel is quite similar to that shown in the 1978 photograph. The long-term effect of the levee and bridge confinement on overall geomorphic character of the SCRE is, thus, a generally static morphology, varying only within the boundaries of the levees. The active floodplain within the levees also appears to have been densely established with riparian vegetation, including the non-native, invasive giant reed (*Arundo donax*) (Stillwater Sciences 2007, Beller et al. 2011).

1995 / 1998 The January 1995 photograph depicts the lower river and SCRE after two more >100,000 cfs floods since the 1983 photograph (Figure C-5), yet the scour path that extends through the SCRE is considerably narrower than observed in previous historical photographs. The mouth positions visible in the 1995 and 1998 photographs are similar to the 1983 photograph but the areal extent of established riparian vegetation is greater on the north and south sides.

2005 The shoreline and river mouth shown in the September 2005 photograph extended seaward and southward compared to the 1995 photograph due to sediment deposition associated with the January and February 2005 flood events (two of the largest floods of record) (Figure C-6). Topographic surveys show that the shoreline adjacent to the SCRE extended seaward approximately 400 feet due to the large amount of sediment delivered from the 2005 flood events (Barnard et al. 2009). In addition to causing the formation of a nearshore delta, these floods scoured all bar vegetation in the channel upstream of the Harbor Blvd bridge, and scoured and widened the main SCRE channel downstream of the bridge. Unlike the 1969 floods, the levees in the LSCR were capable of containing the 2005 flood flows. Although the 2005 floods did cause considerable vegetation scour, vegetation established in the northern portion of the SCRE since 1978 remained.

2009 The shoreline and river mouth shown in the 2009 photograph eroded landward compared to the 2005 photograph (Figure C-6). By 2009, vegetation re-established on depositional bars within the lower river channel and SCRE, a southern backwater area had developed, and the mouth berm position stabilized. The southern backwater area currently extends approximately 2,000 feet south of the pre-2005 southwest corner of the main lagoon that appears to connect with the outfall channel from McGrath Lake. The areal extent of the lagoon, in addition to its volume, is the greatest since well before the 2005 flood year. Overall, this morphology appears generally sTable Dnd will likely remain until the next large storm event.

2012 / 2016 The 2012 and 2016 aerial photographs, the most current provided by the National Agriculture Imagery Program, depict a river and SCRE morphology similar to the 2009 photograph (Figures D-6 and D-7). The obvious differences included a beach berm that has migrated landward about 250 feet, a filling of the southwestern backwater that had previously connected with the McGrath Lake outfall channel, and sediment deposition and vegetation growth within the SCRE. The McGrath Beach campground also began experiencing significant flooding that has since caused the campground to remain closed indefinitely. Review of the 2016 aerial photograph indicates that the SCRE footprint has continued to reduce in size, primarily due to the continued landward migration of the beach berm, the position of which is similar to the pre-2005 flood photograph. Overall, since 2005, the berm has migrated landward by up to 1,000 feet (see Figure C-7f).

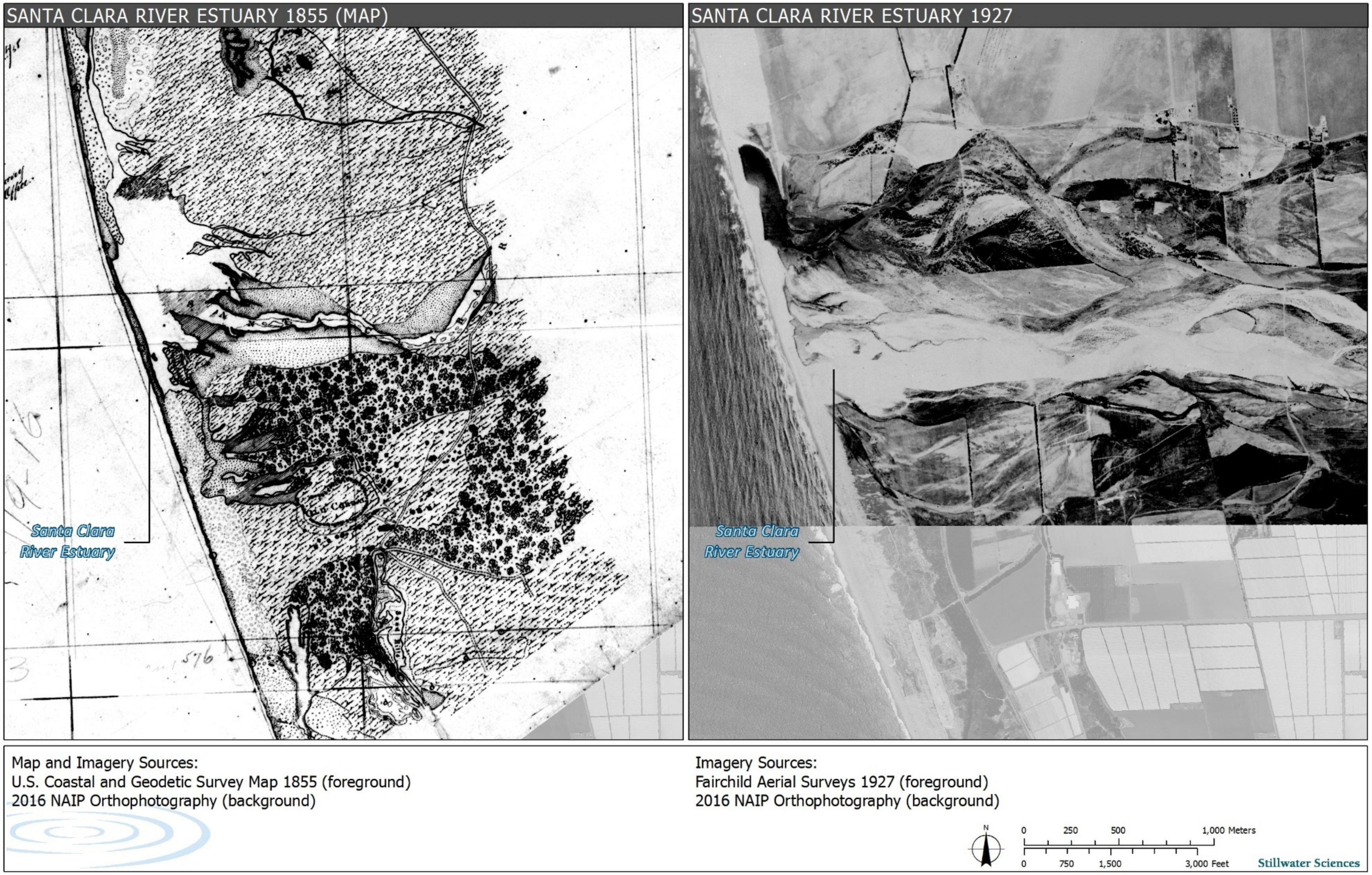


Figure C-1. SCRE and surrounding floodplain (1855 and 1927).

Figure C-2. SCRE and surrounding floodplain (1938 and 1945).

Figure C-3. SCRE and surrounding floodplain (1958 and 1969).

Figure C-4. SCRE and surrounding floodplain (1978 and 1983).

Figure C-5. SCRE and surrounding floodplain (1995 and 1998).

Figure C-6. SCRE and surrounding floodplain (2005 and 2009).

Figure C-7. SCRE and surrounding floodplain (2012 and 2016).

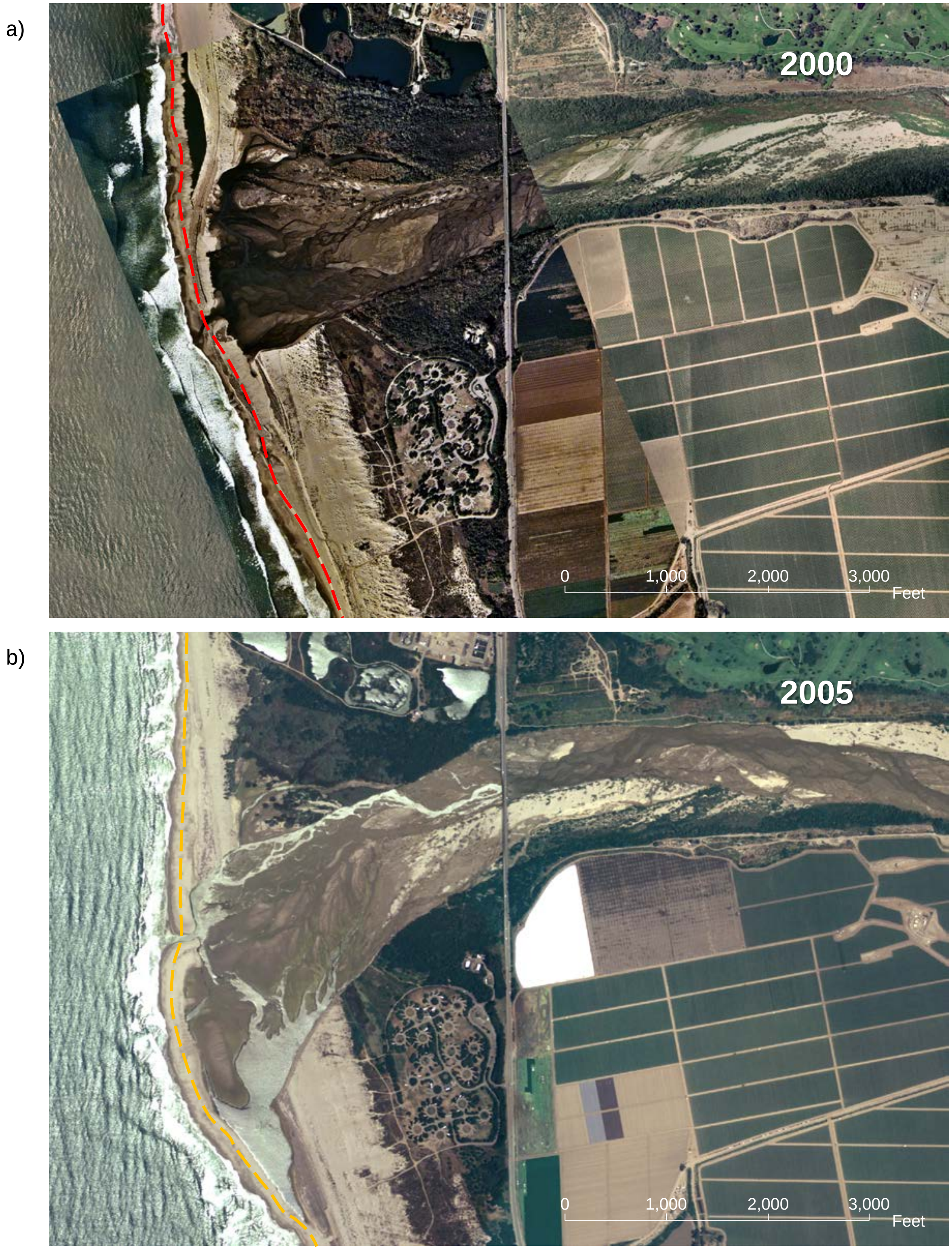
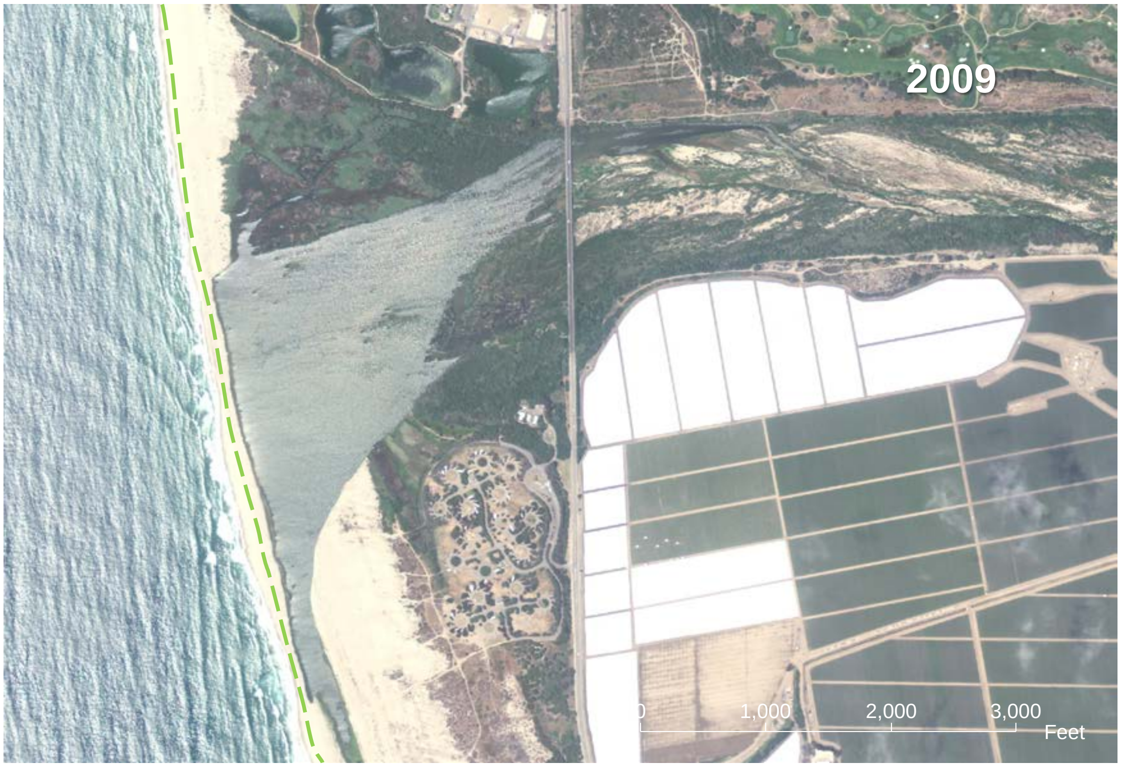


Figure C-8 continued on next page

c)



d)

Figure C-8 continued on next page

e)

f)

Figure C-8. Repeat aerial photographic views of the SCRE during 2000 (a), 2005 (b), 2009 (c), 2012 (d), and 2016 (e), with combined overlay of beach berm positions (f). Imagery sources from State Parks and NAIP.

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Appendix D

Supplemental Water Quality Plots for the Phase 3 Study (2015-2016)

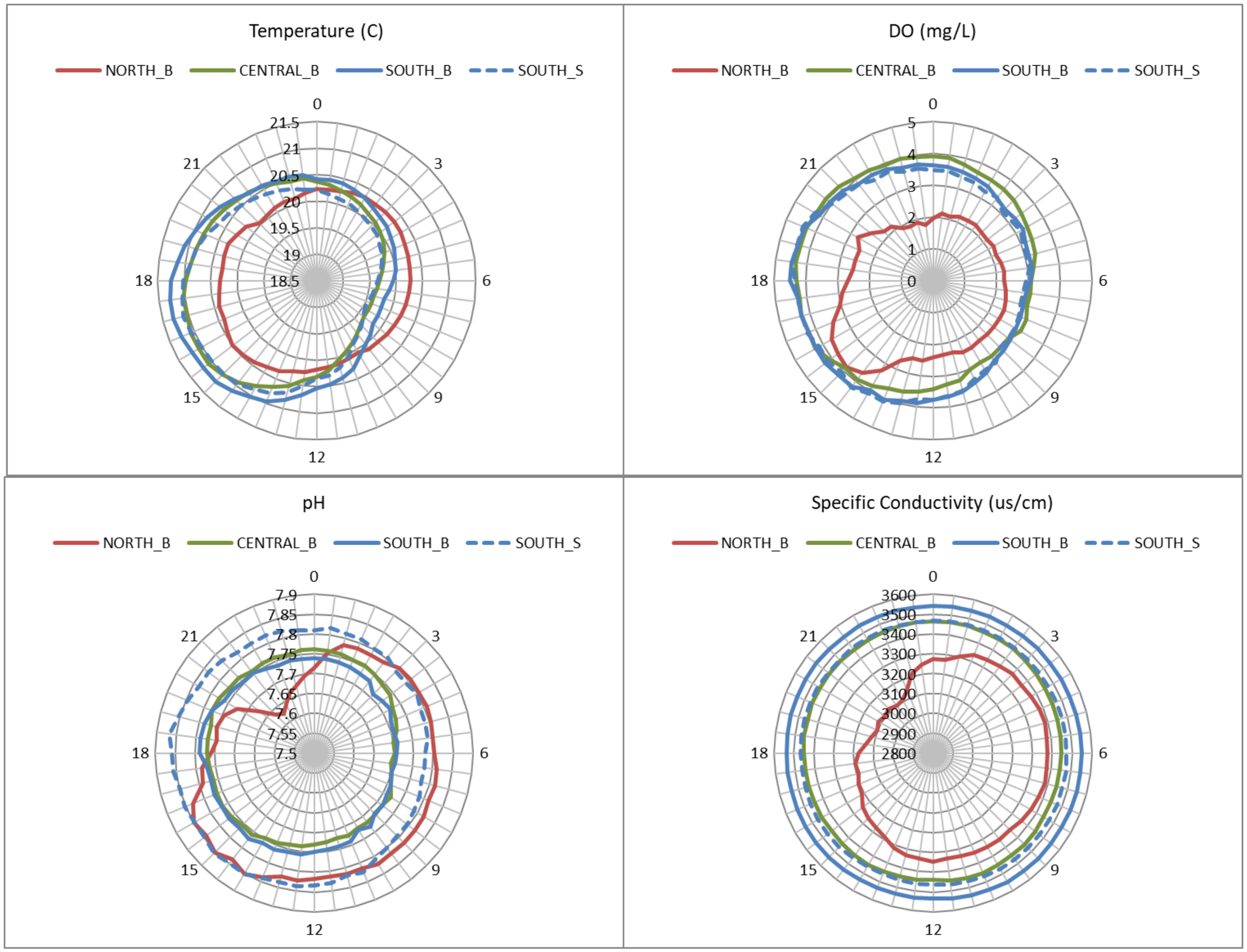


Figure D-1. Hourly variation of *in-situ* water quality at continuous monitoring sites in the Santa Clara River Estuary (January 1st–March 31st, 2015).

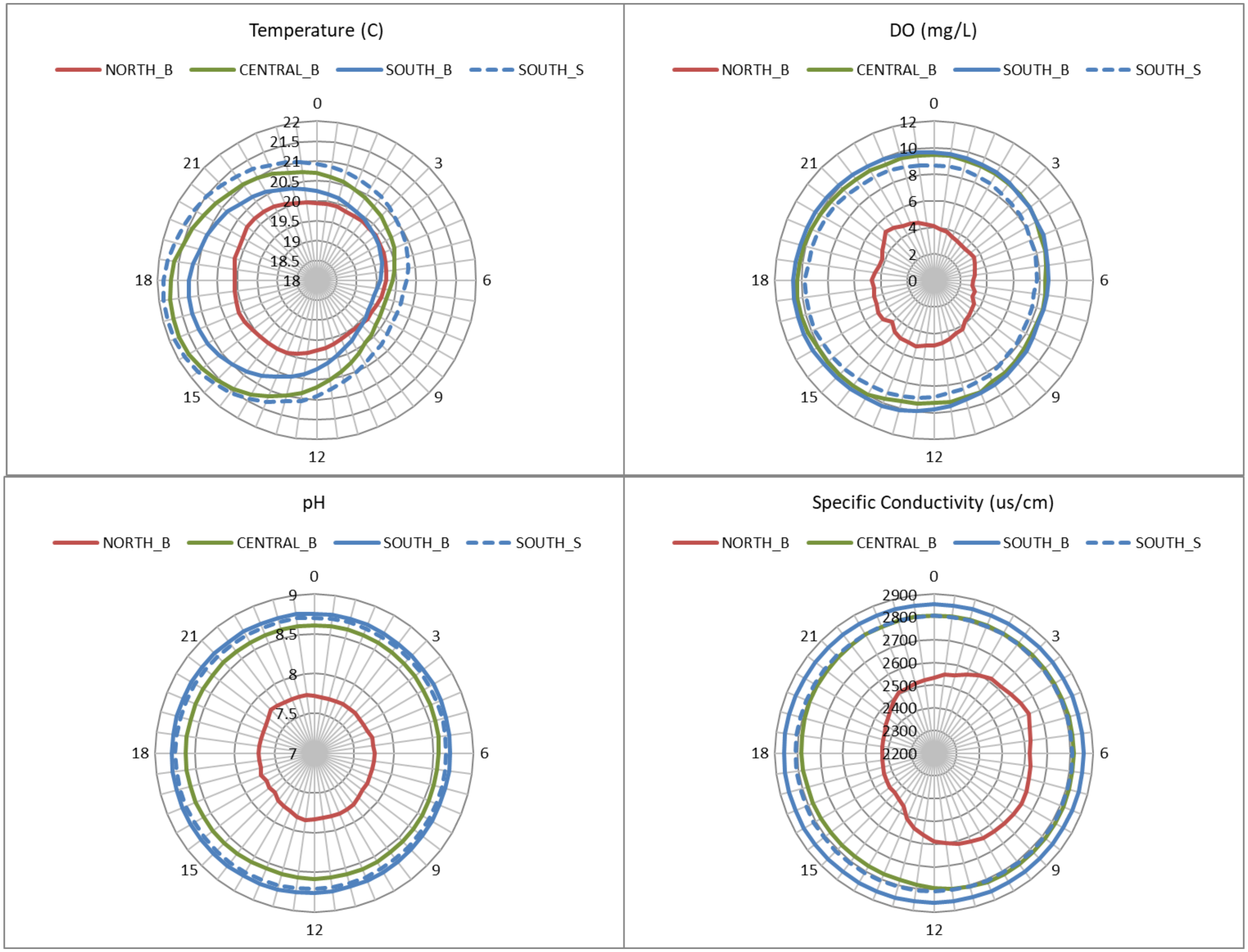


Figure D-2. Hourly variation of in-situ water quality at continuous monitoring sites in the Santa Clara River Estuary (April 1st–June 30th, 2015).

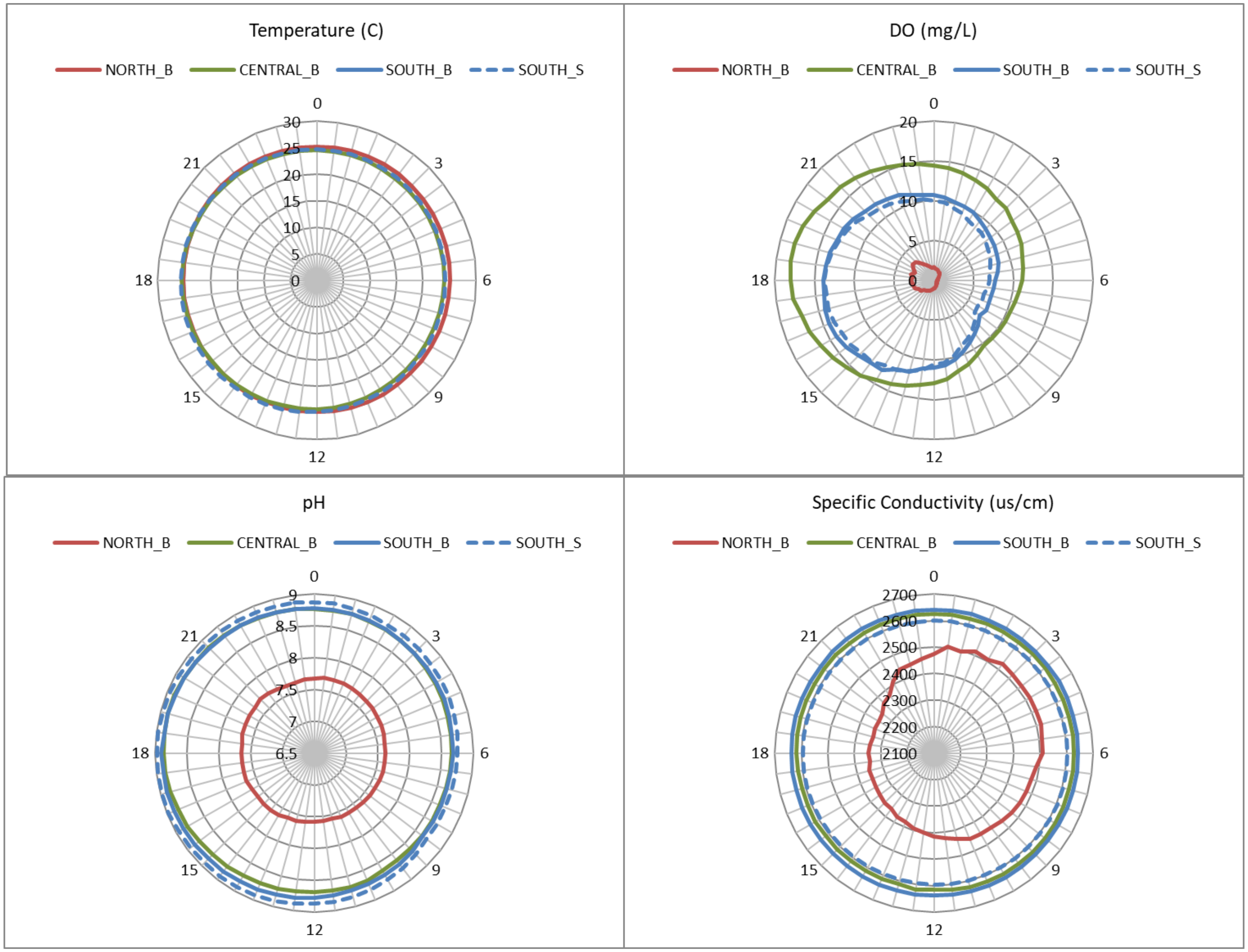


Figure D-3. Hourly variation of in-situ water quality at continuous monitoring sites in the Santa Clara River Estuary (July 1st–September 30th, 2015).

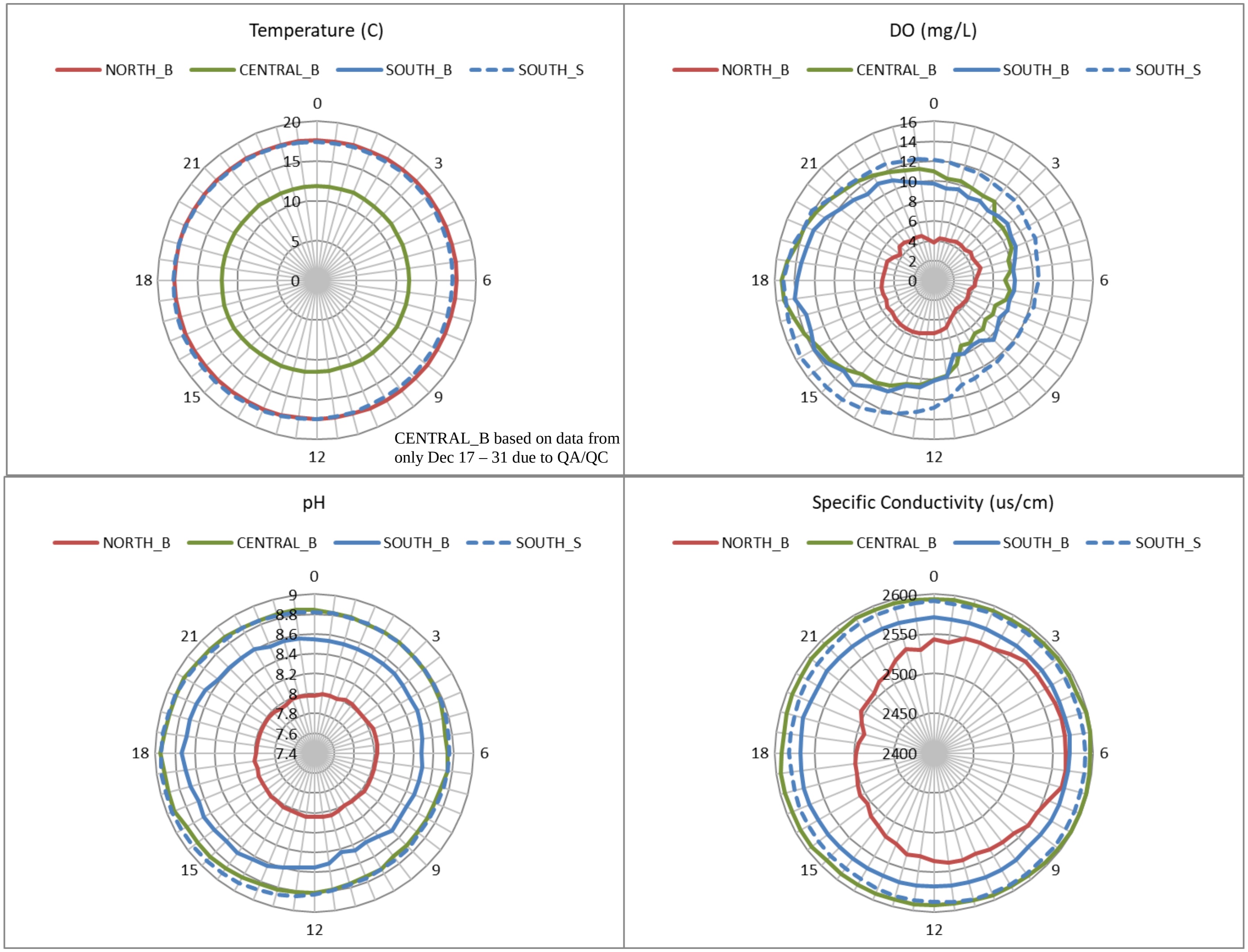


Figure D-4. Hourly variation of in-situ water quality at continuous monitoring sites in the Santa Clara River Estuary (October 1st–December 31st, 2015).

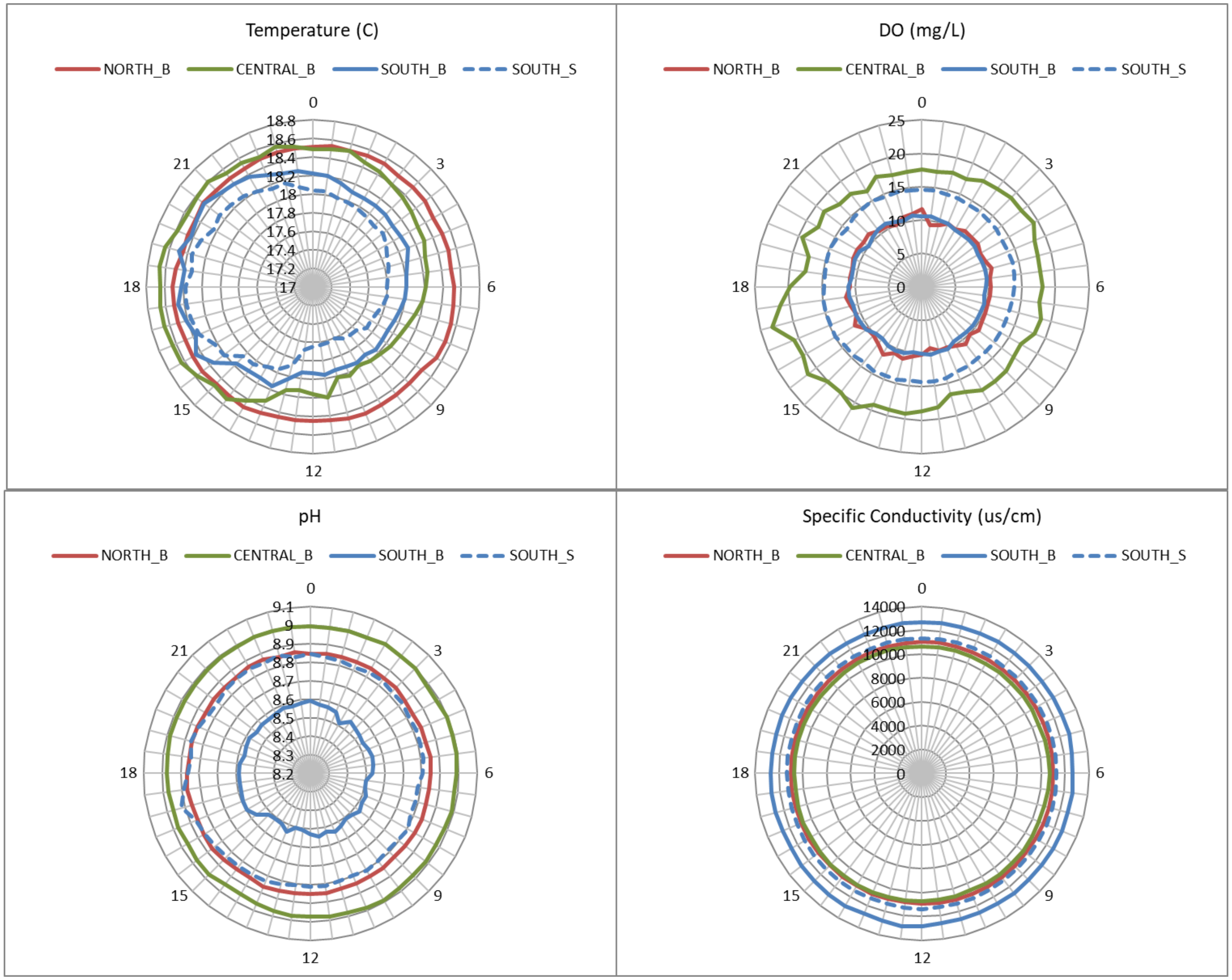


Figure D-5. Hourly variation of in-situ water quality at continuous monitoring sites in the Santa Clara River Estuary (January 1st–March 31st, 2016).

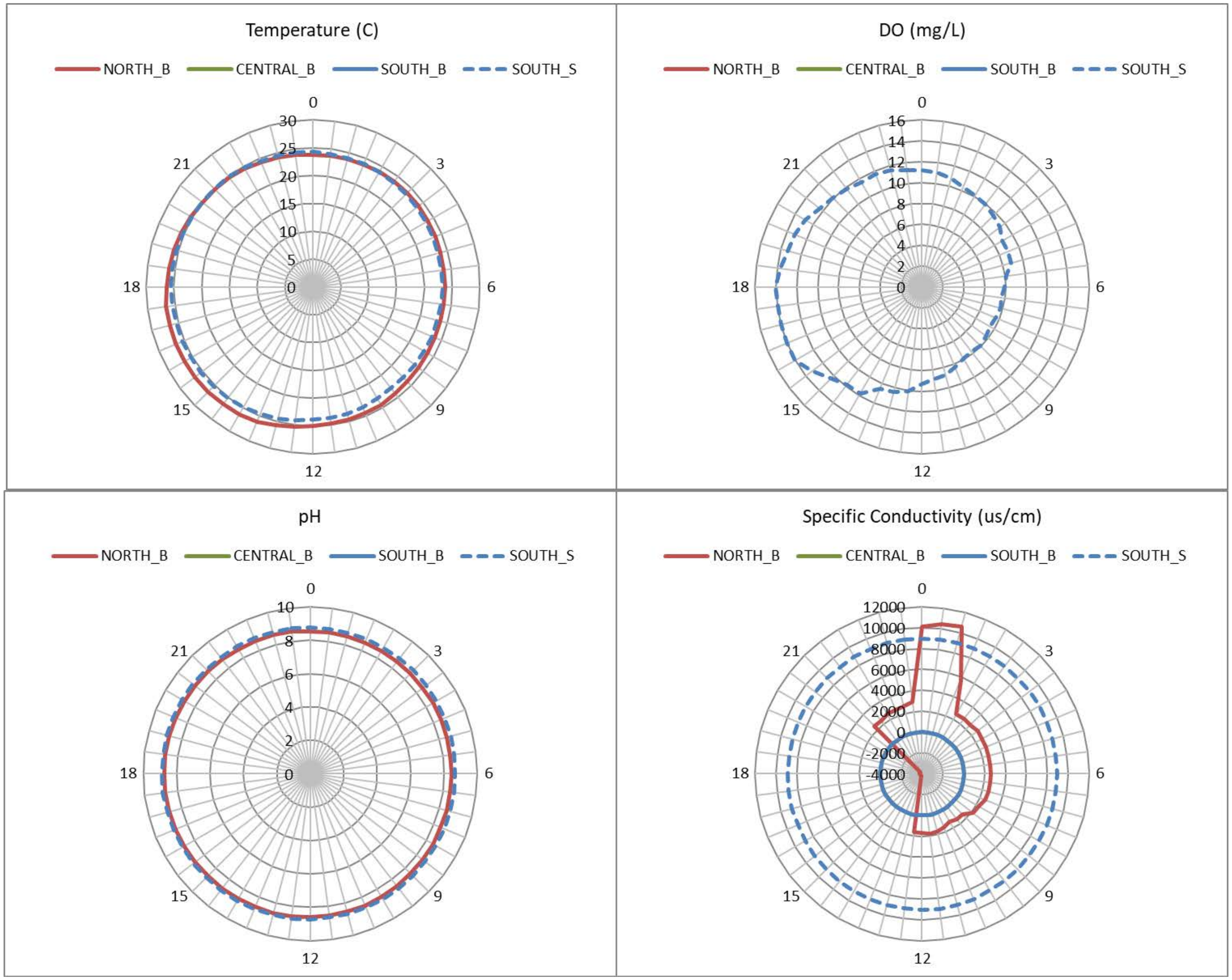


Figure D-6. Hourly variation of in-situ water quality at continuous monitoring sites in the Santa Clara River Estuary (April 1st–June 30th, 2016).

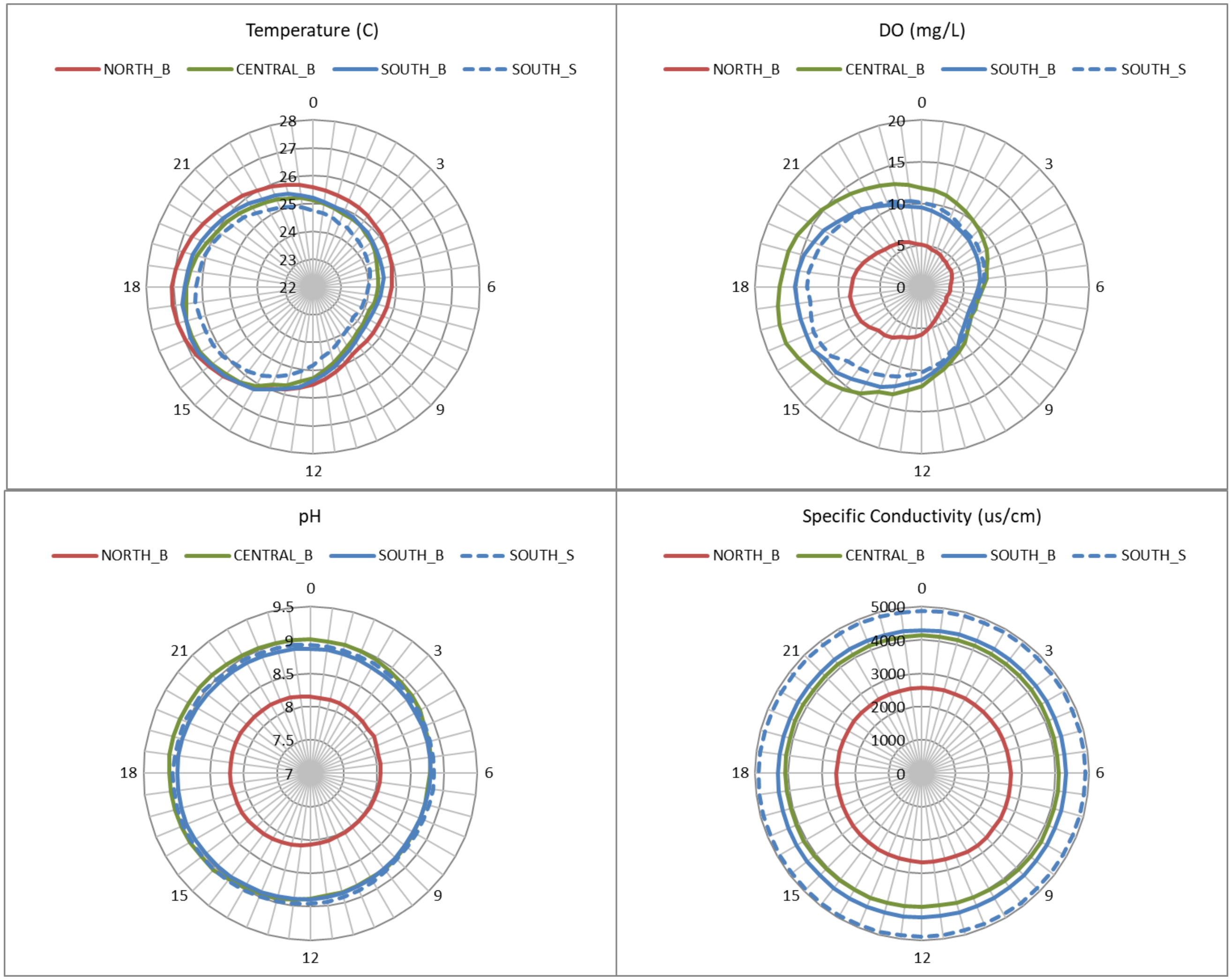


Figure D-7. Hourly variation of in-situ water quality at continuous monitoring sites in the Santa Clara River Estuary (July 1st– September 30th, 2016).

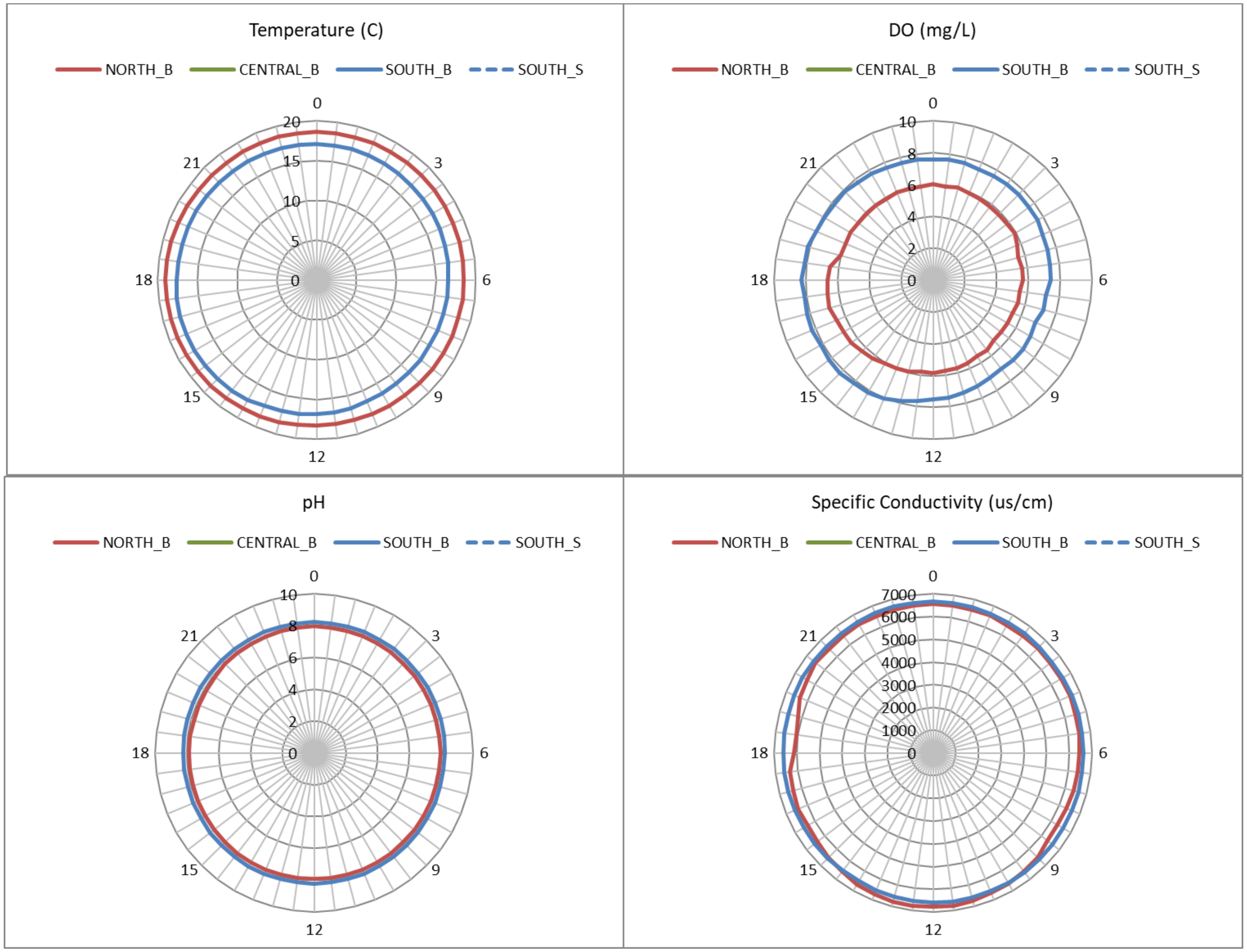


Figure D-8. Hourly variation of in-situ water quality at continuous monitoring sites in the Santa Clara River Estuary (October 1st–December 31st, 2016).

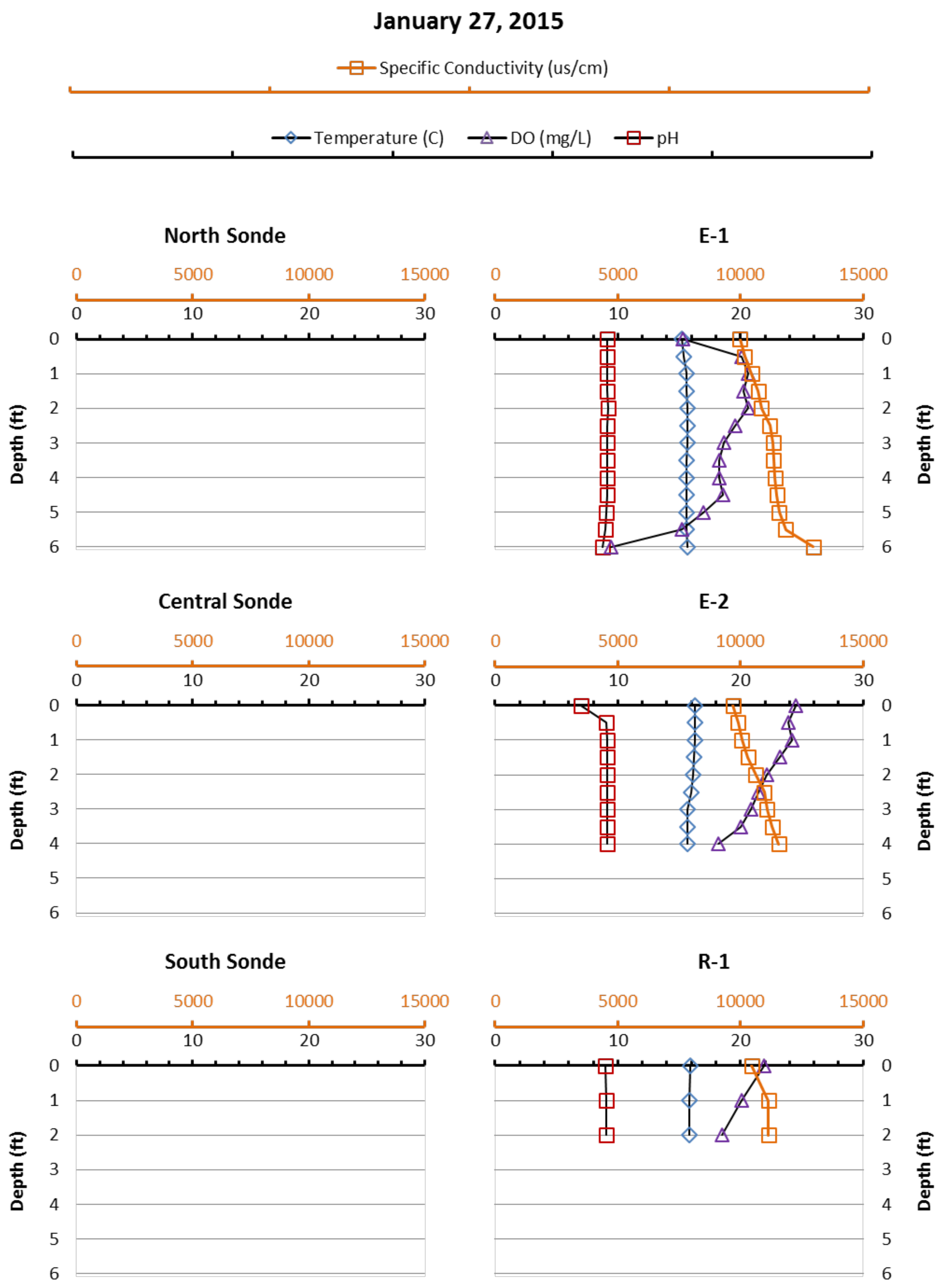


Figure D-9. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, January 2015.

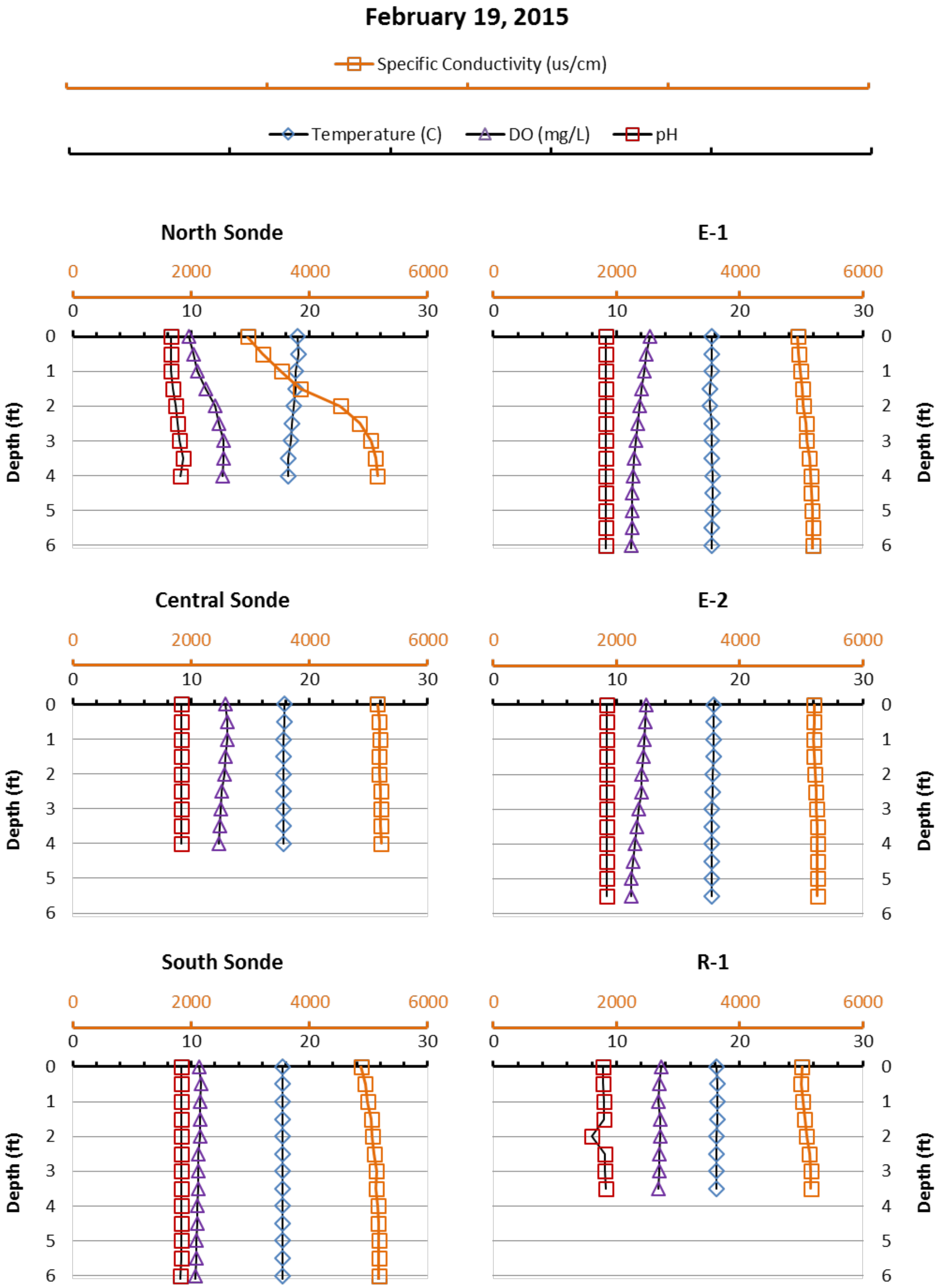


Figure D-10. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, February 2015.

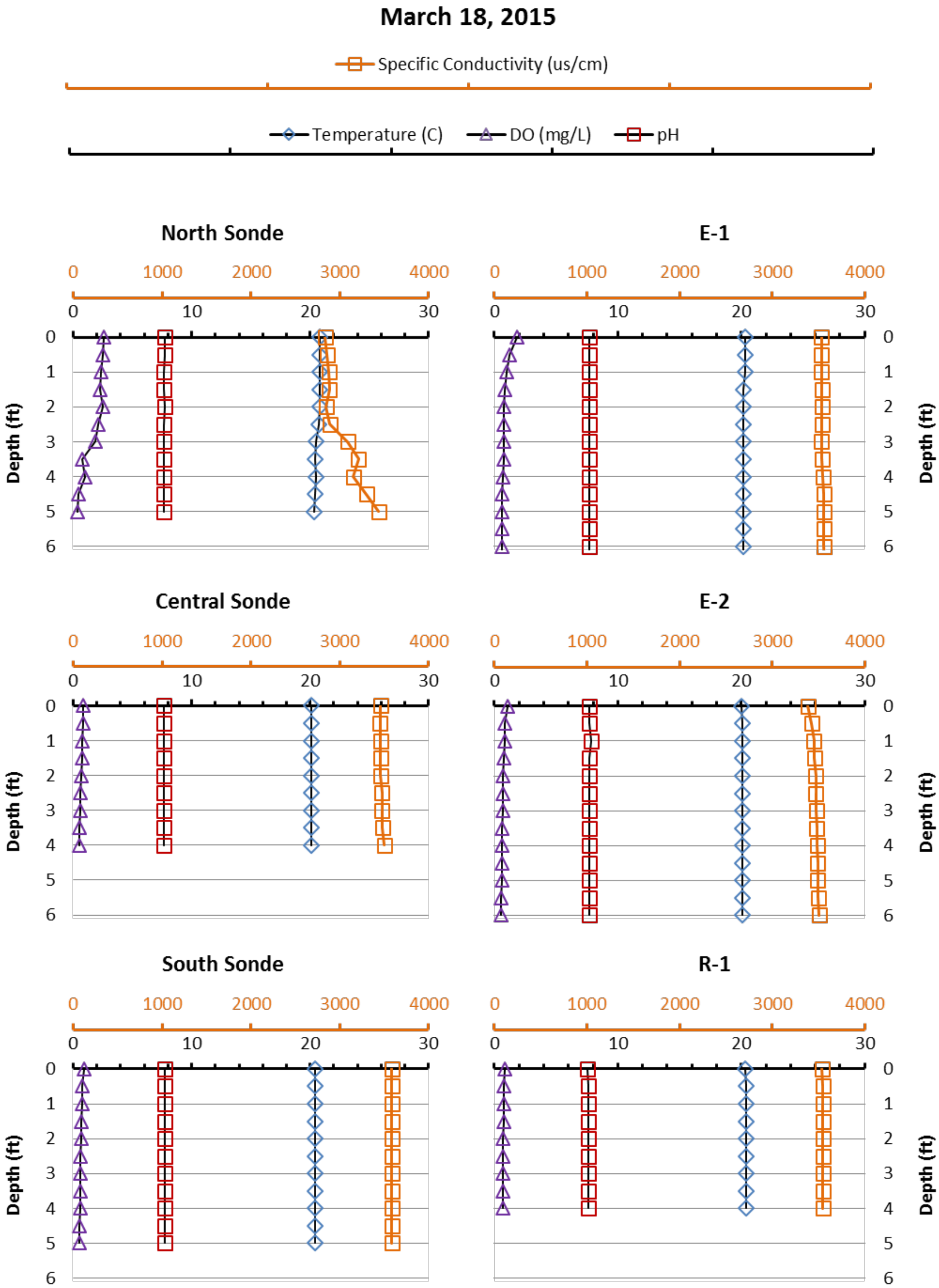


Figure D-11. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, March 2015.

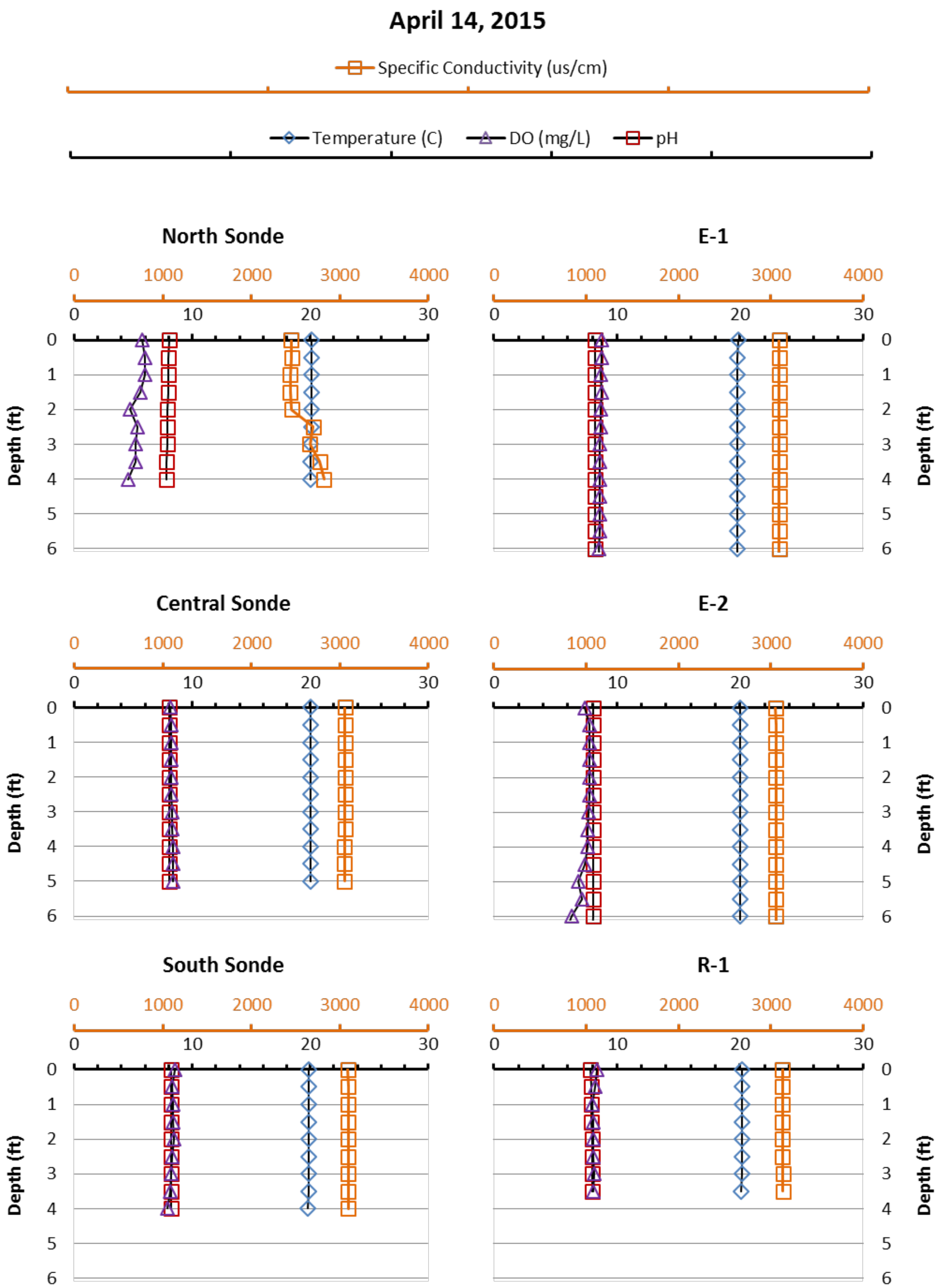


Figure D-12. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, April 2015.

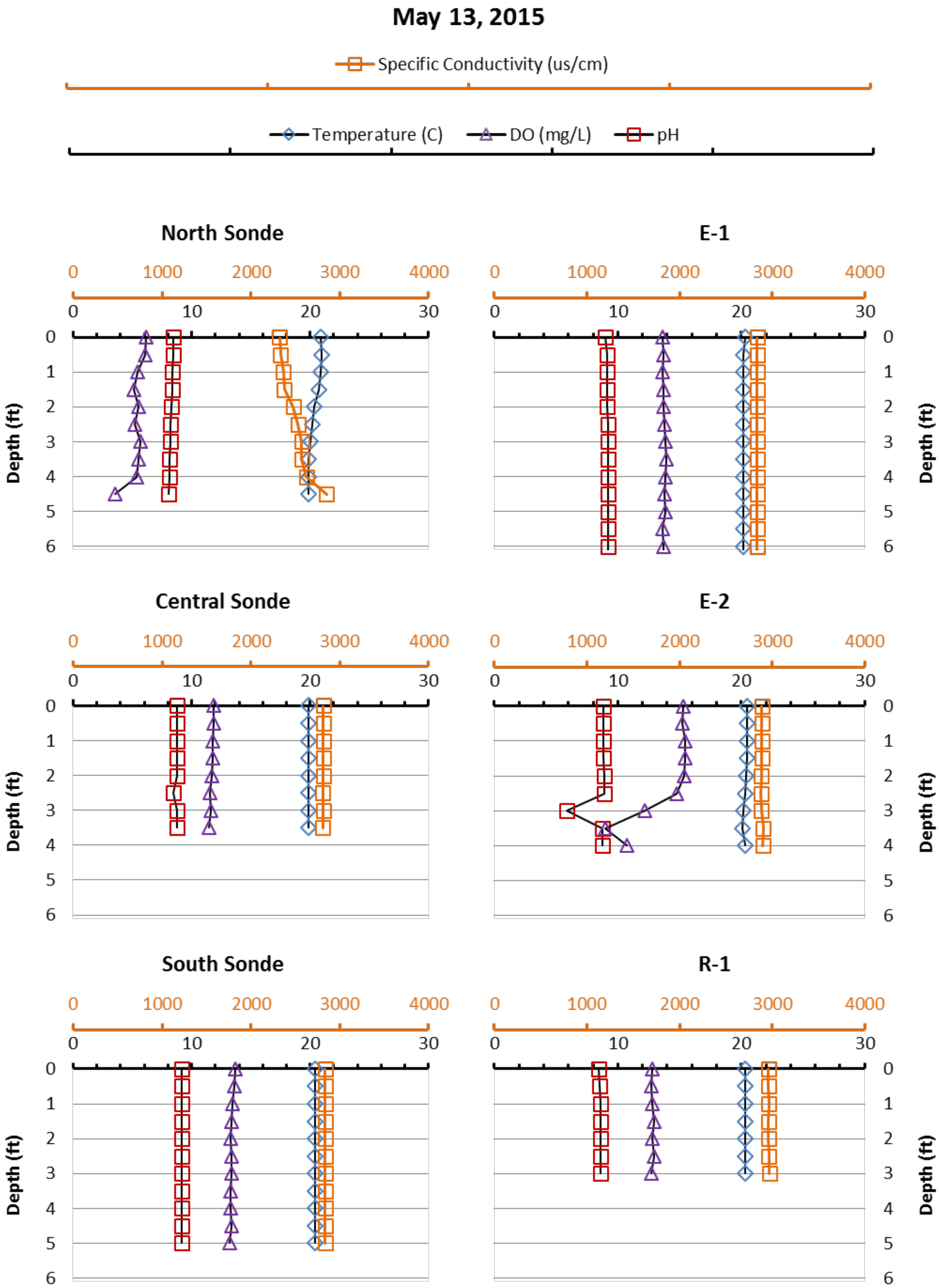


Figure D-13. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, May 2015.

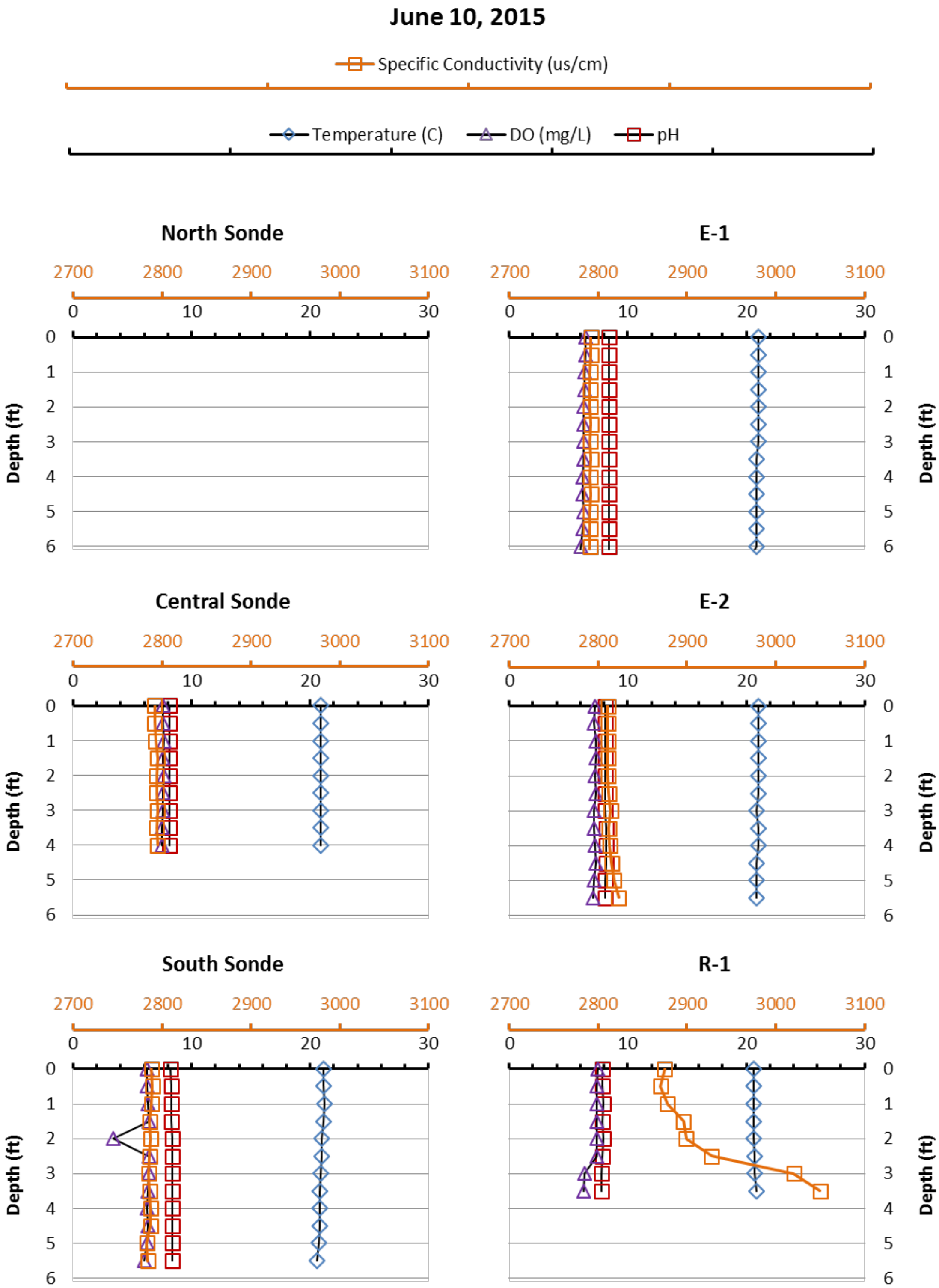
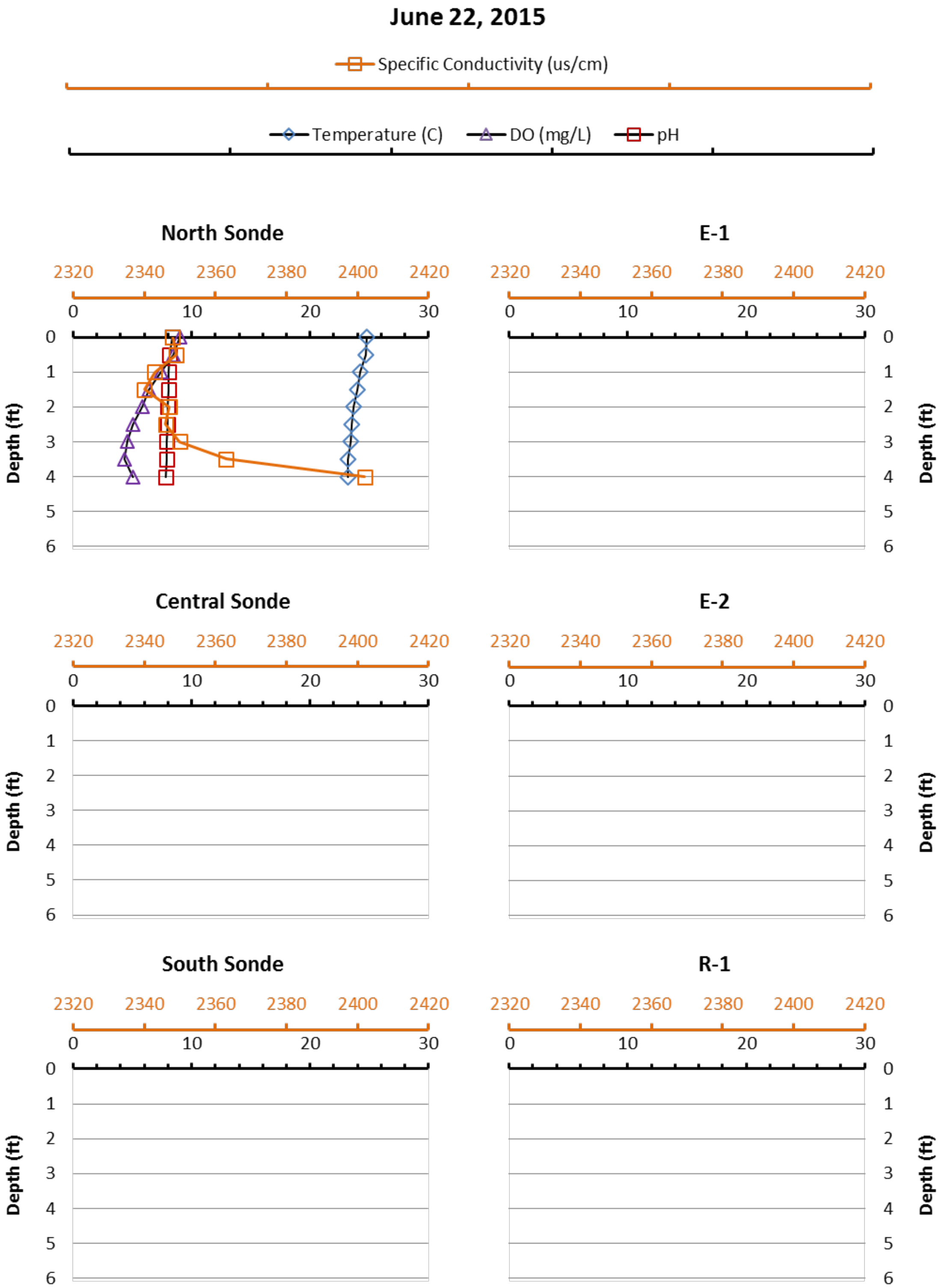


Figure D-14. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, June 2015.



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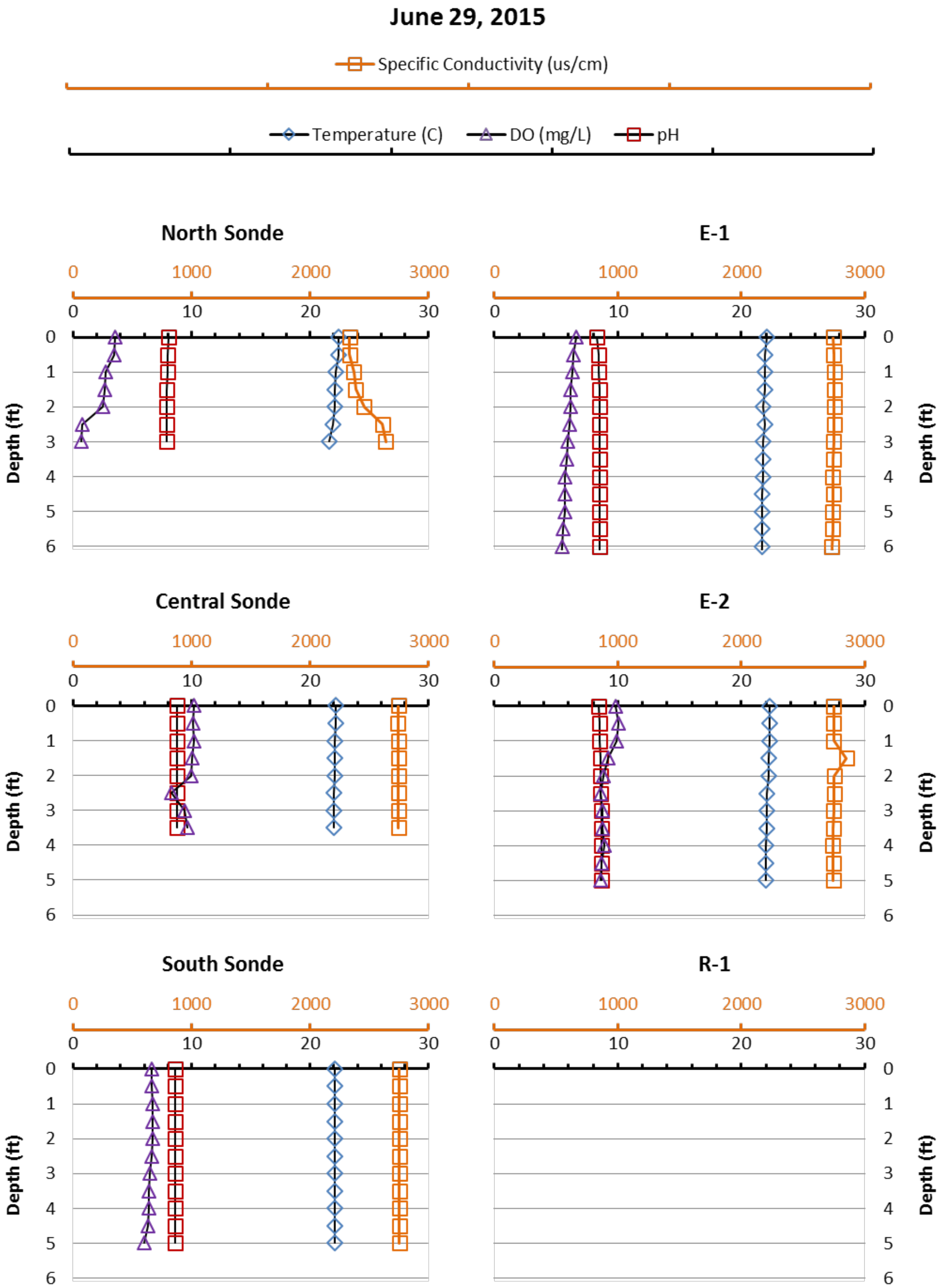


Figure D-16. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, June 2015.

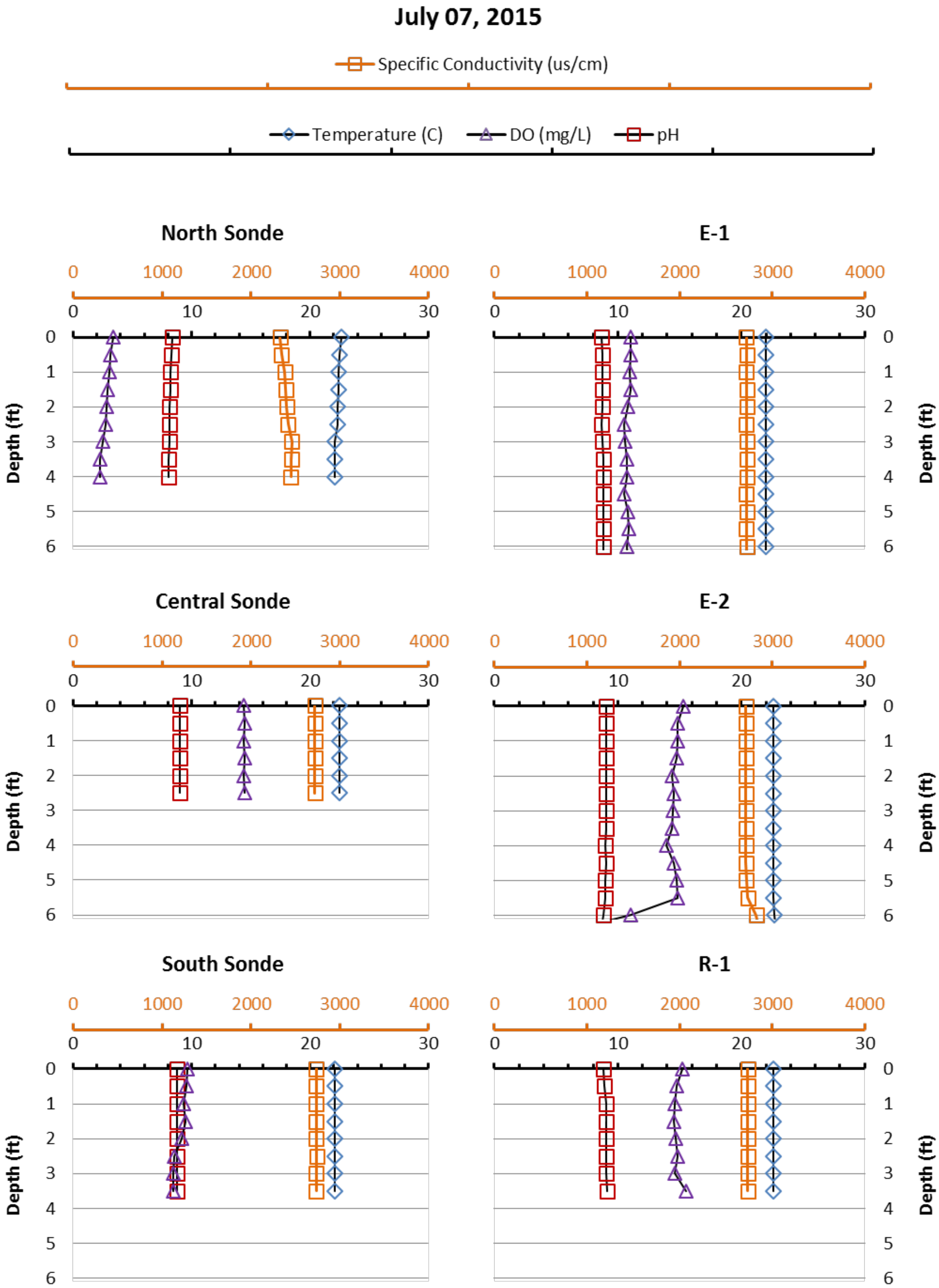
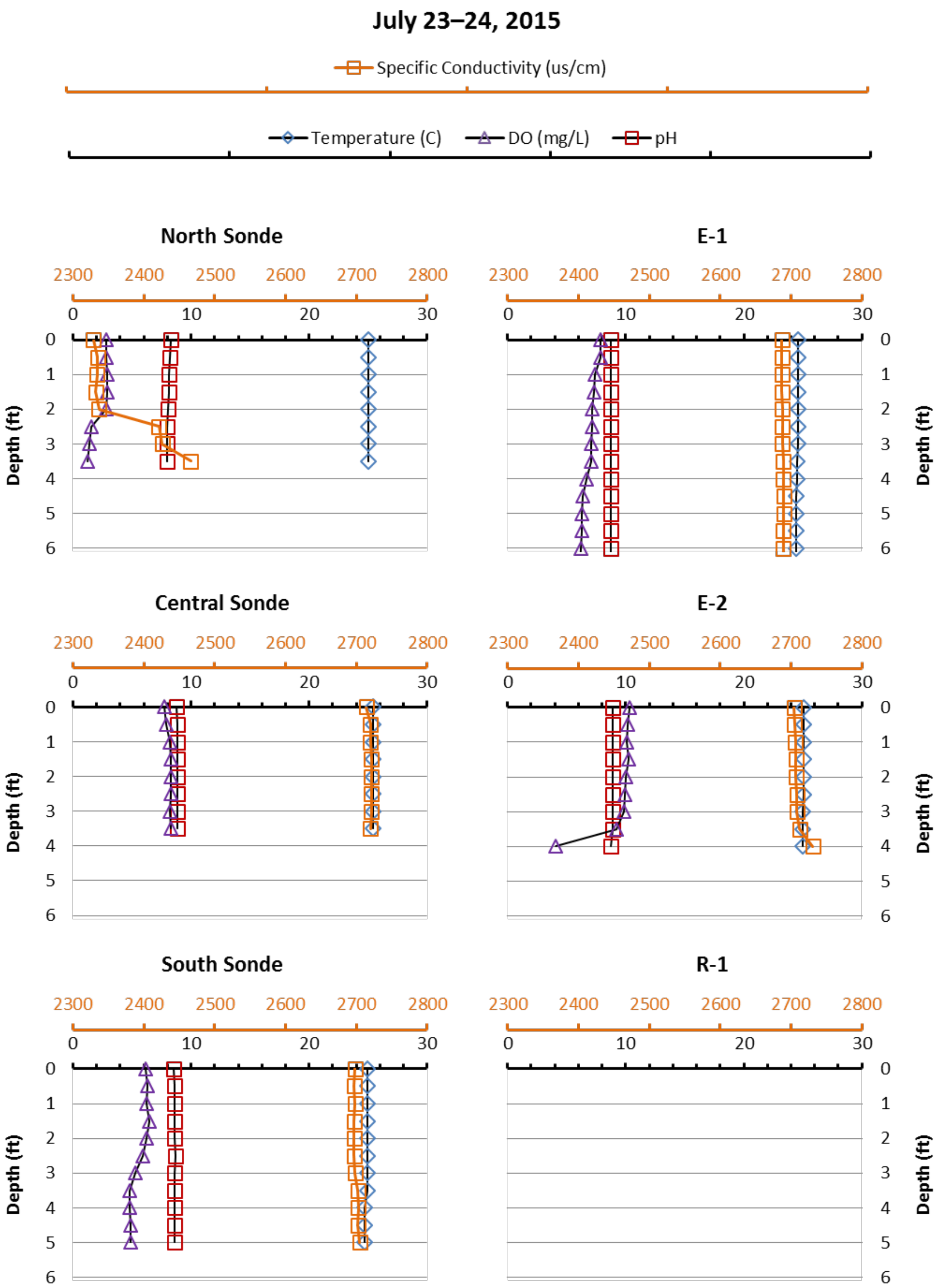


Figure D-17. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, July 2015.



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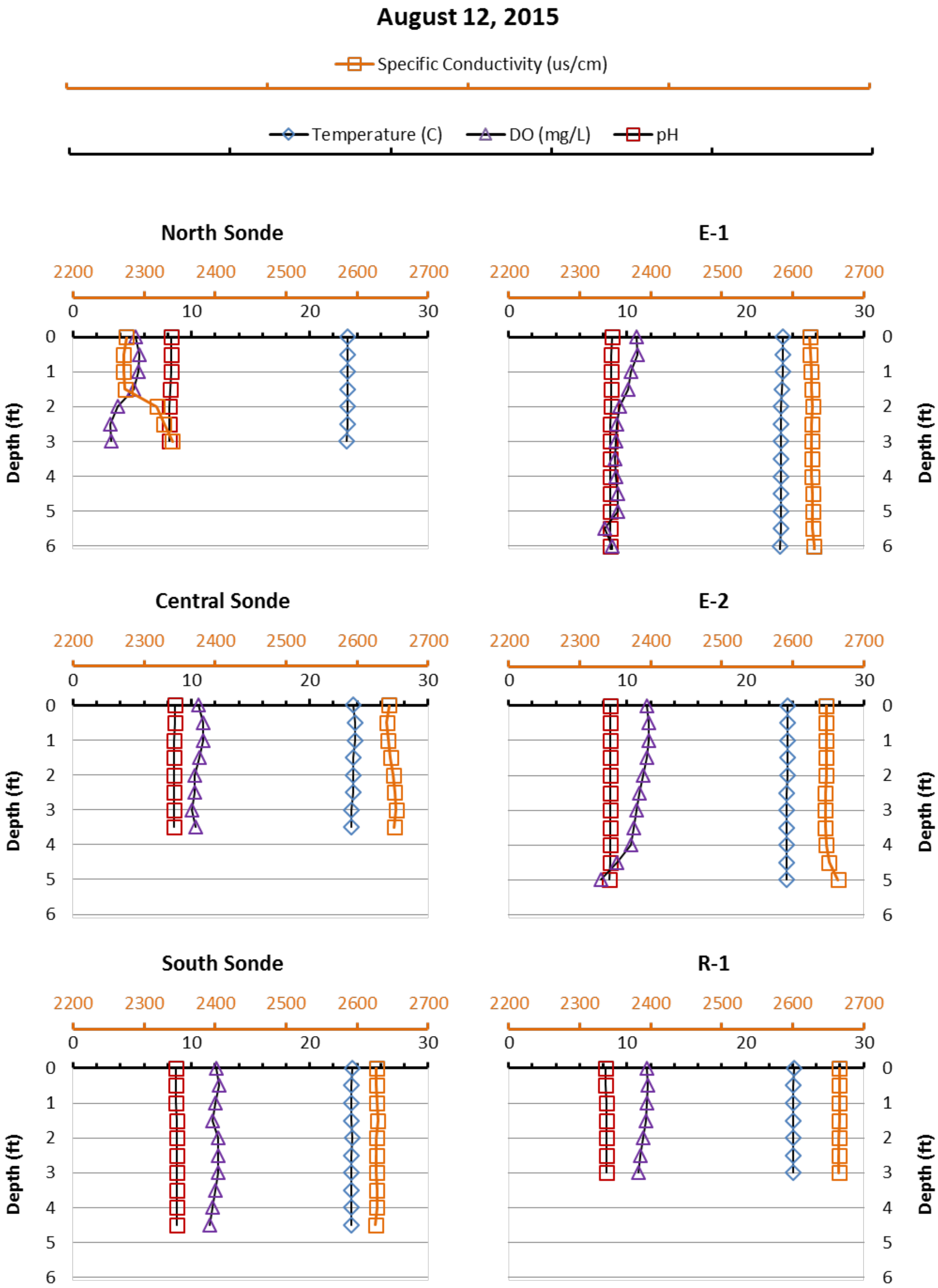
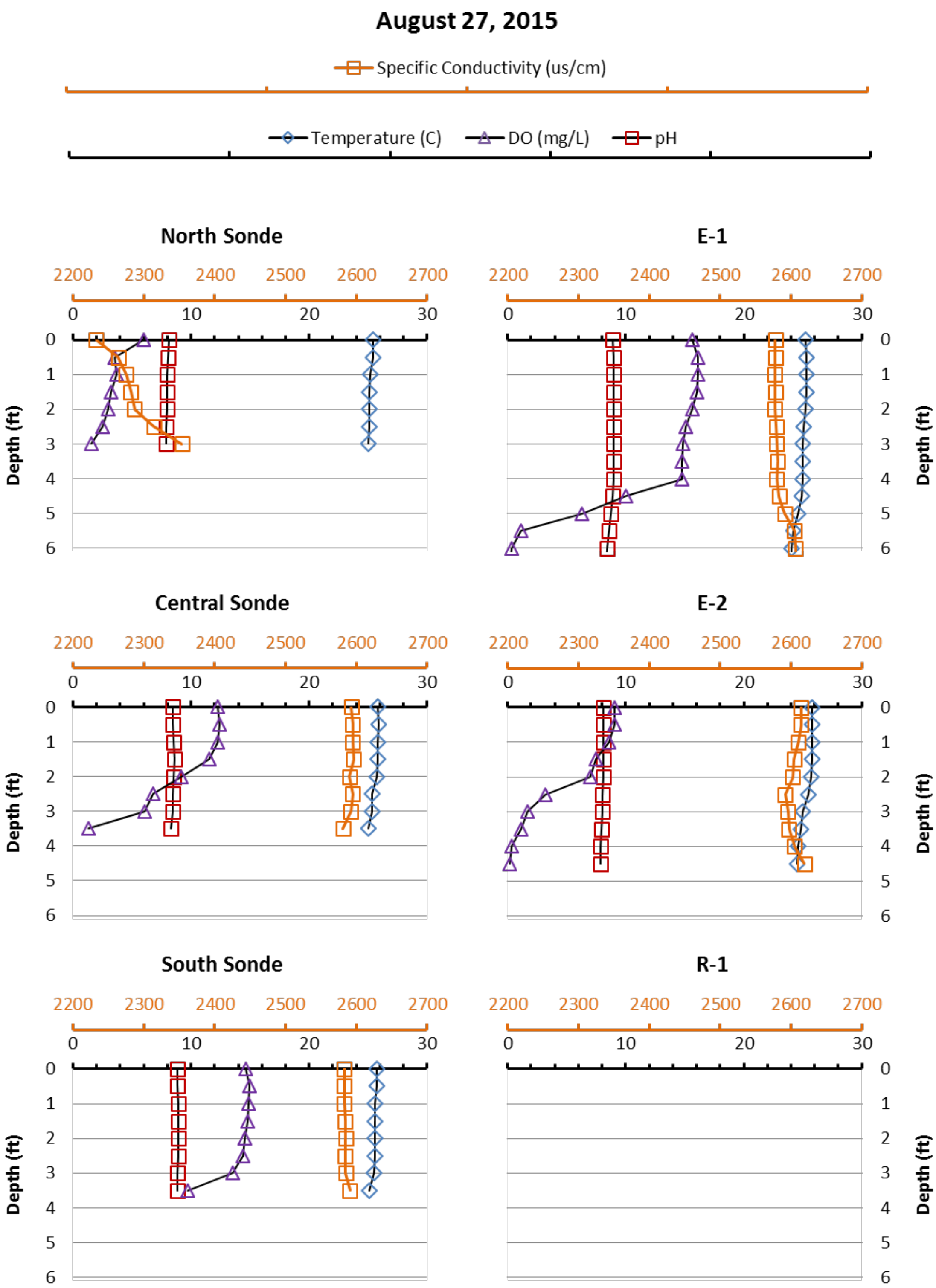


Figure D-19. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, August 2015.



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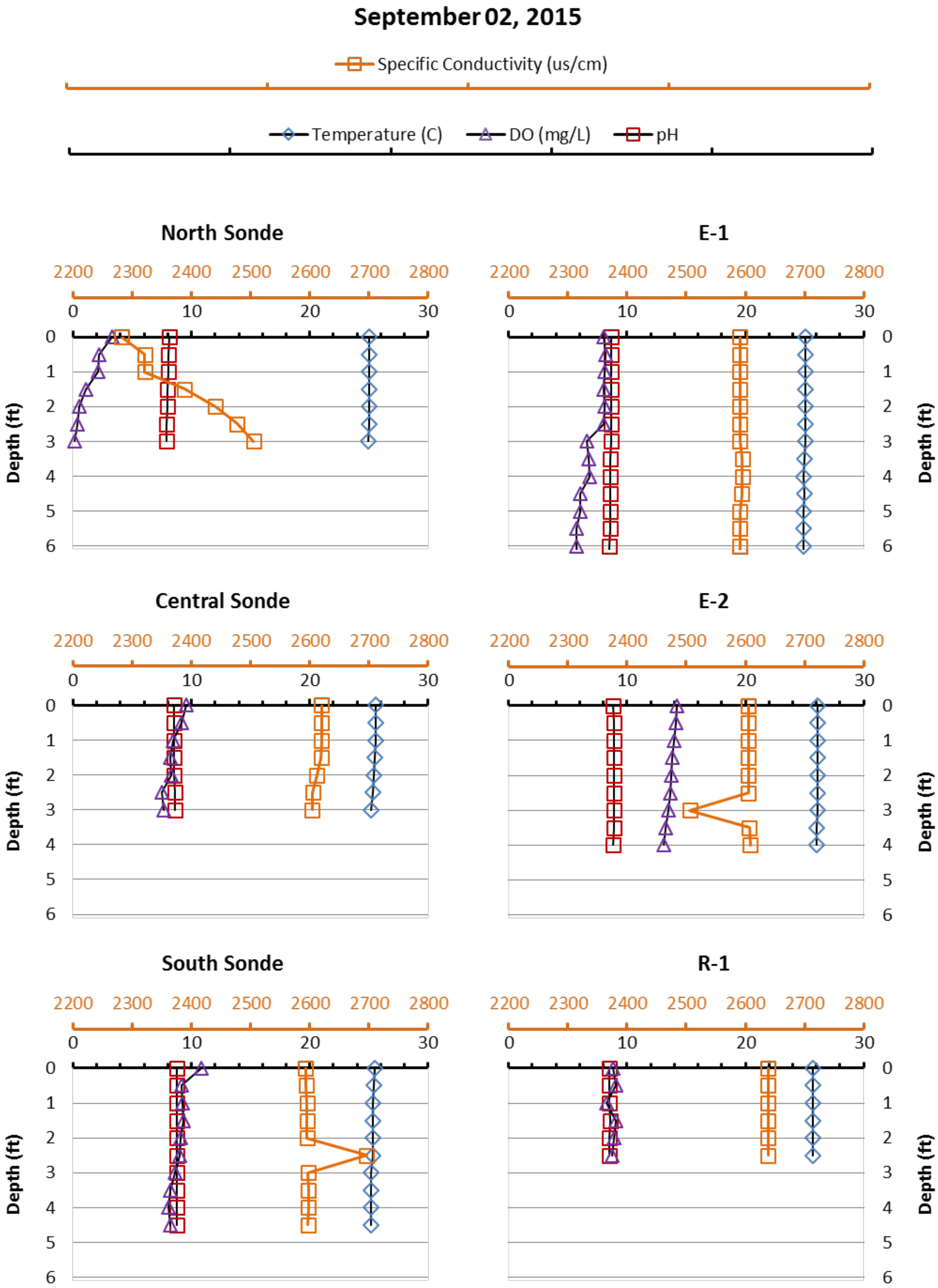
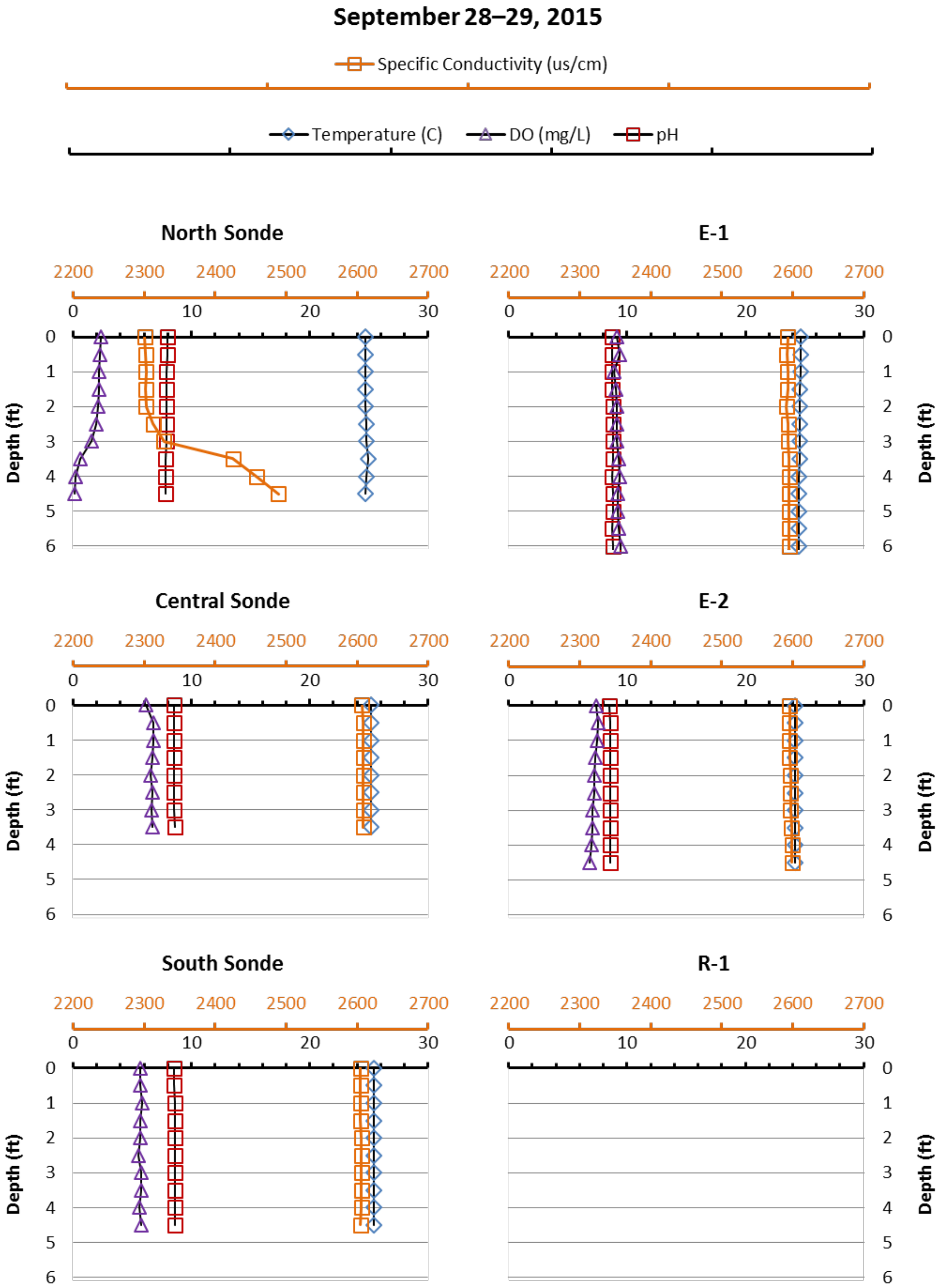


Figure D-21. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, September 2015.



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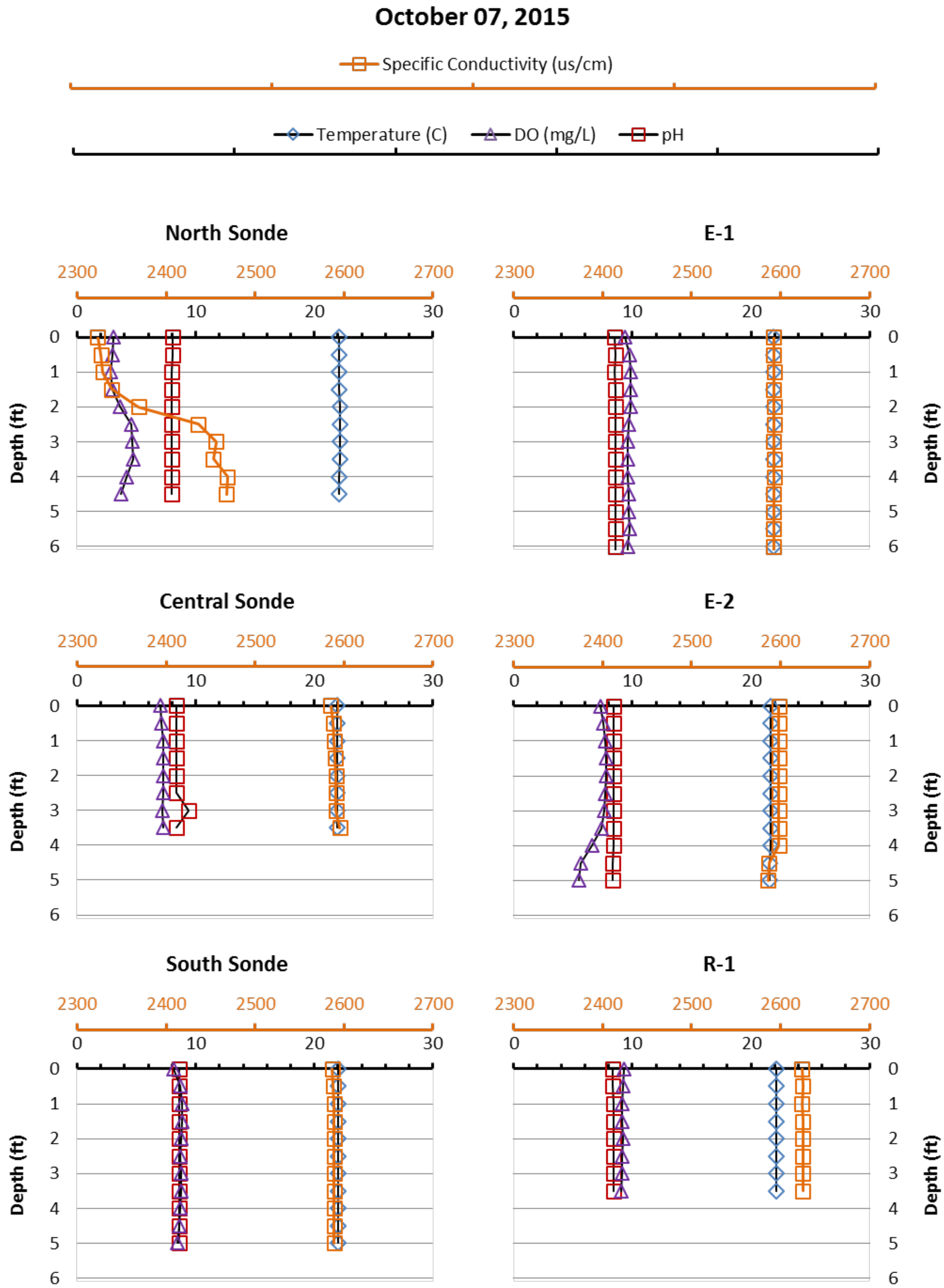

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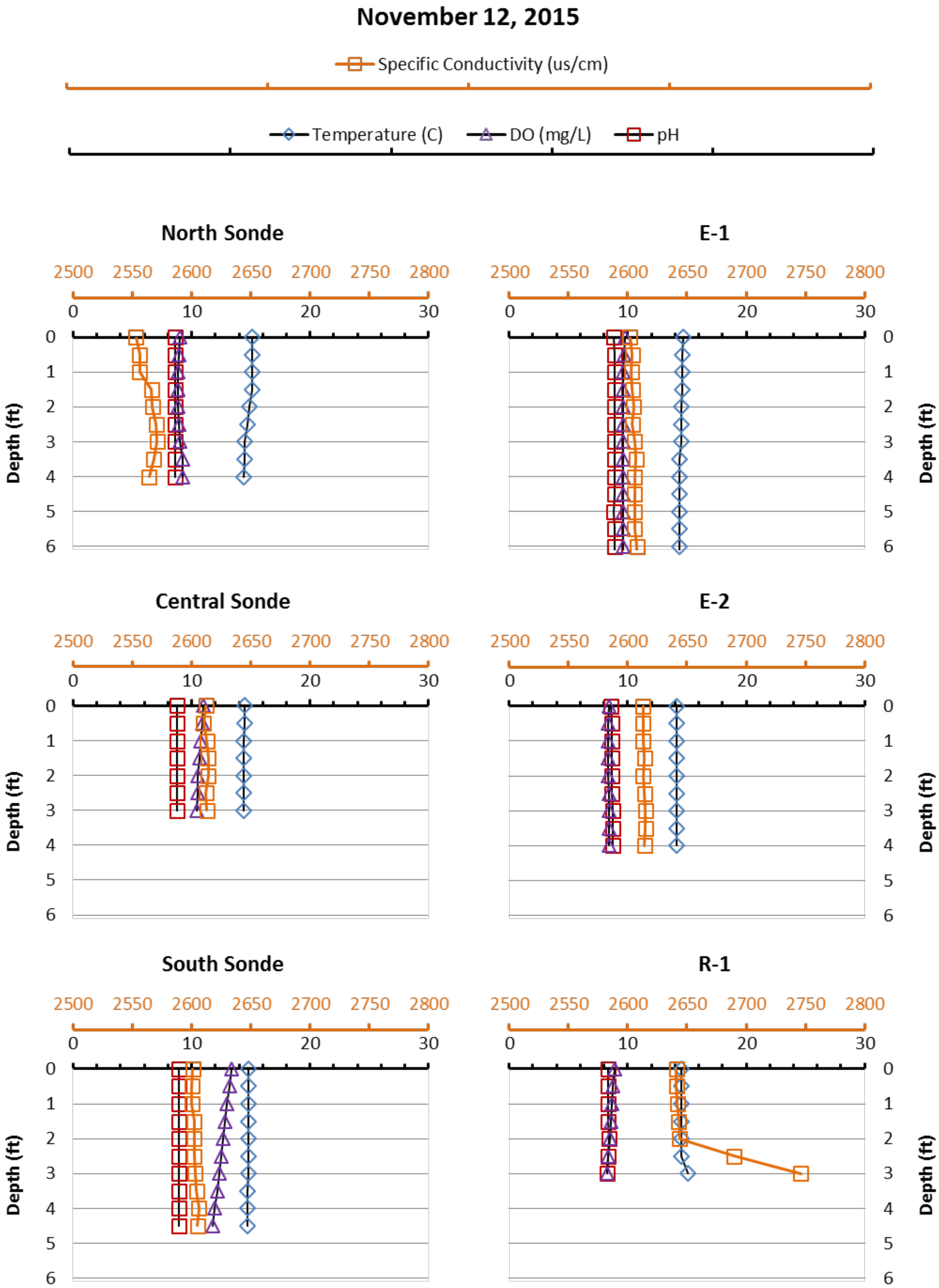

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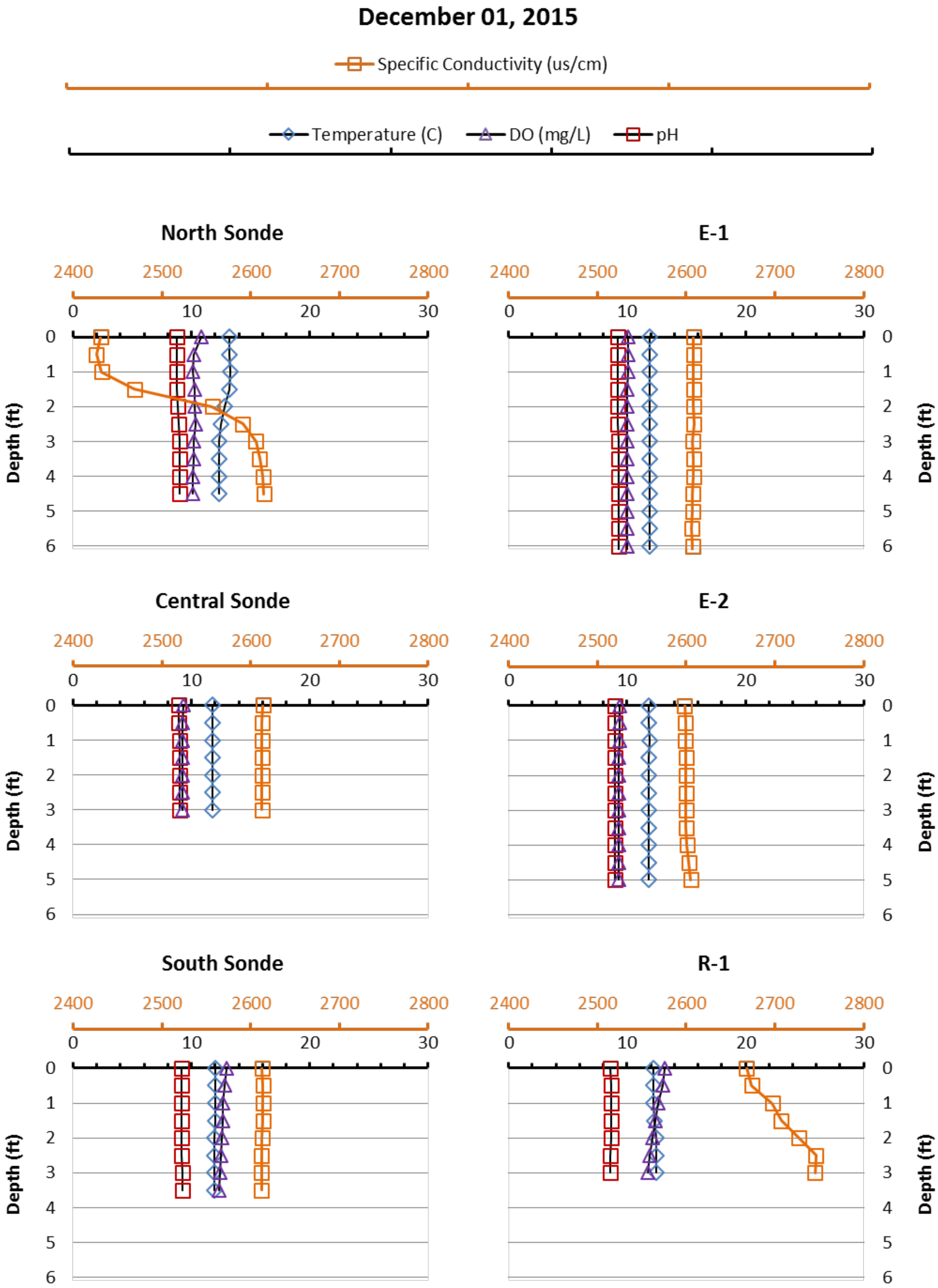

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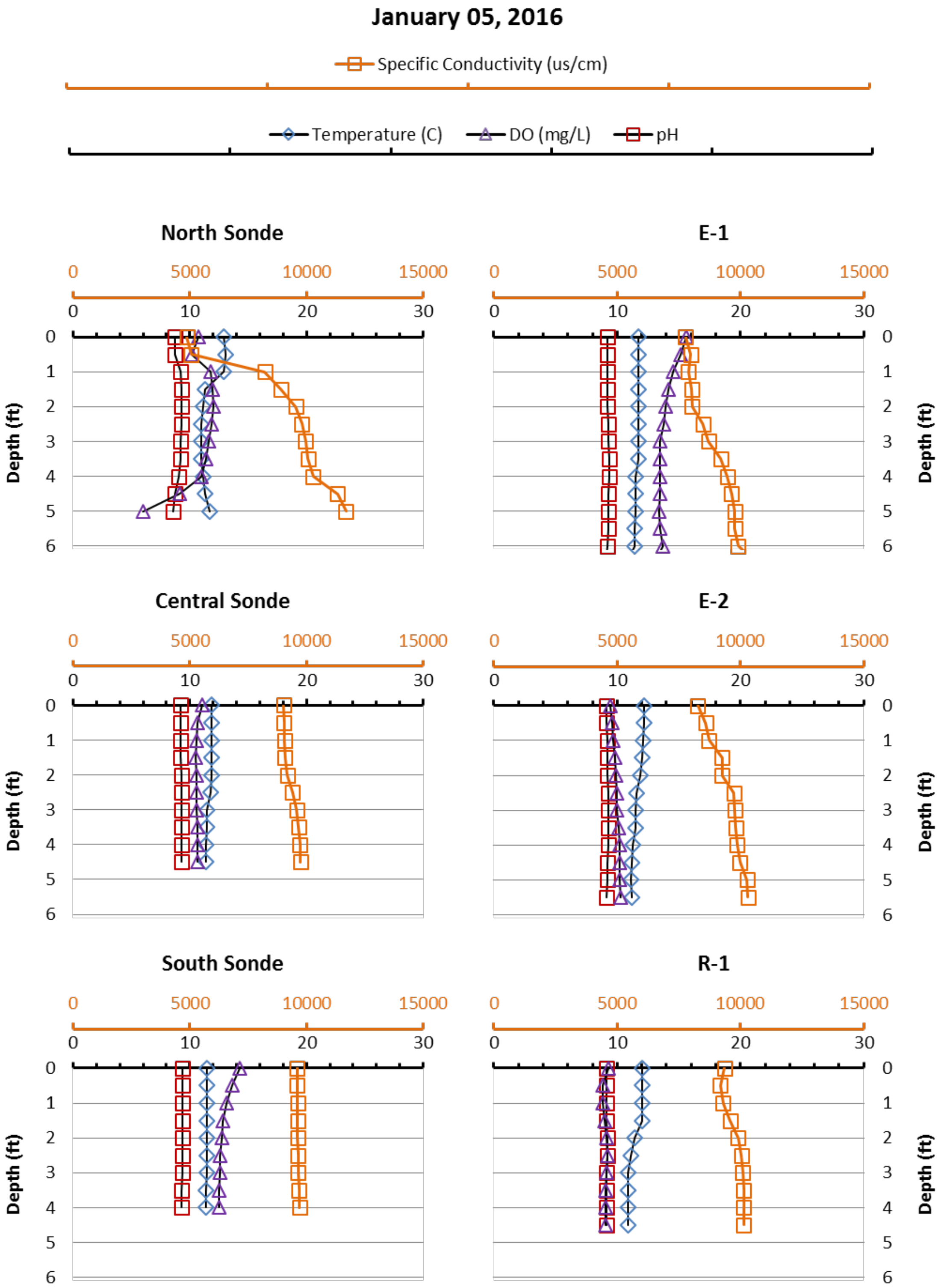


Figure D-26. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, January 2016.

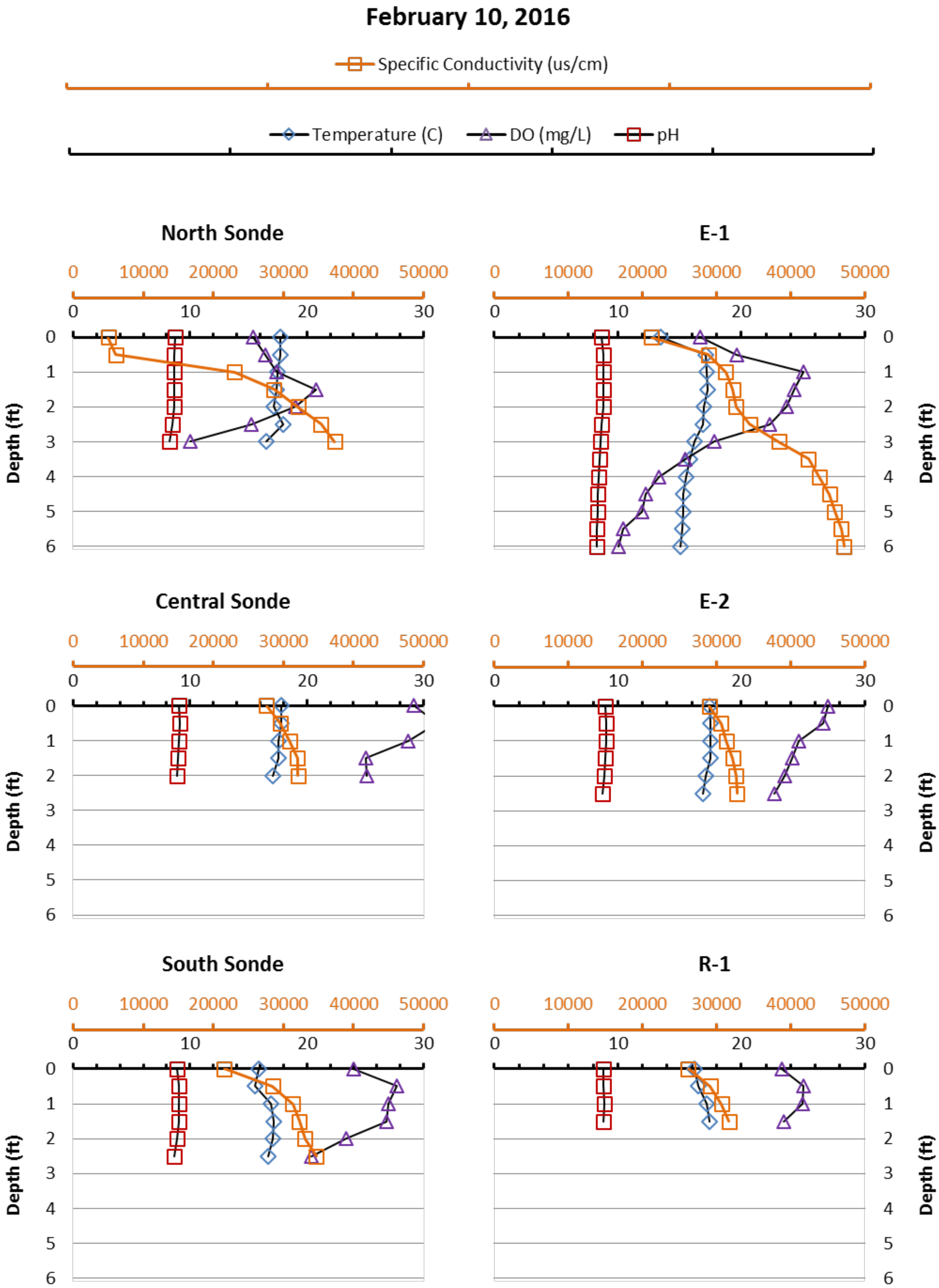
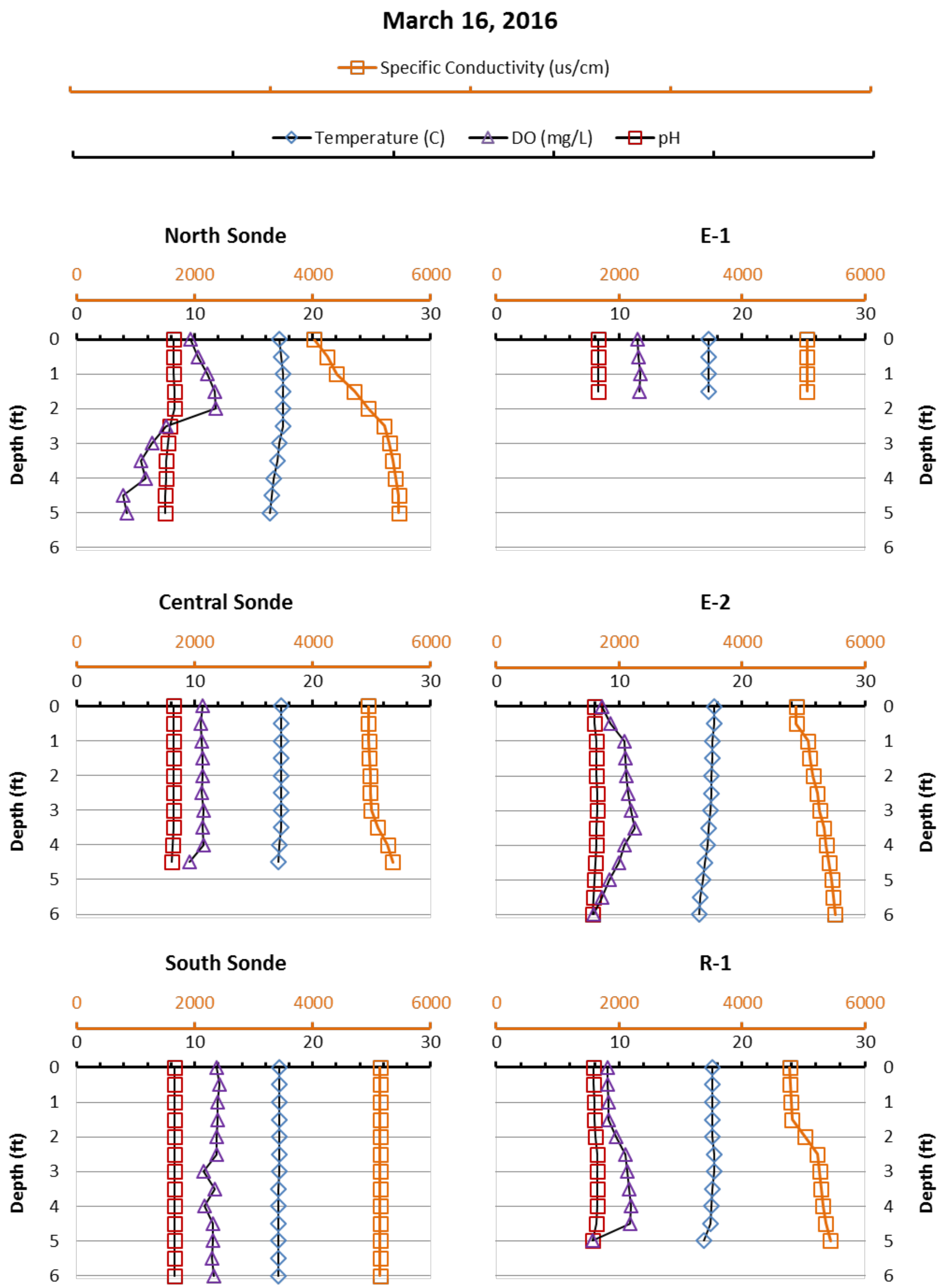


Figure D-27. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, February 2016.



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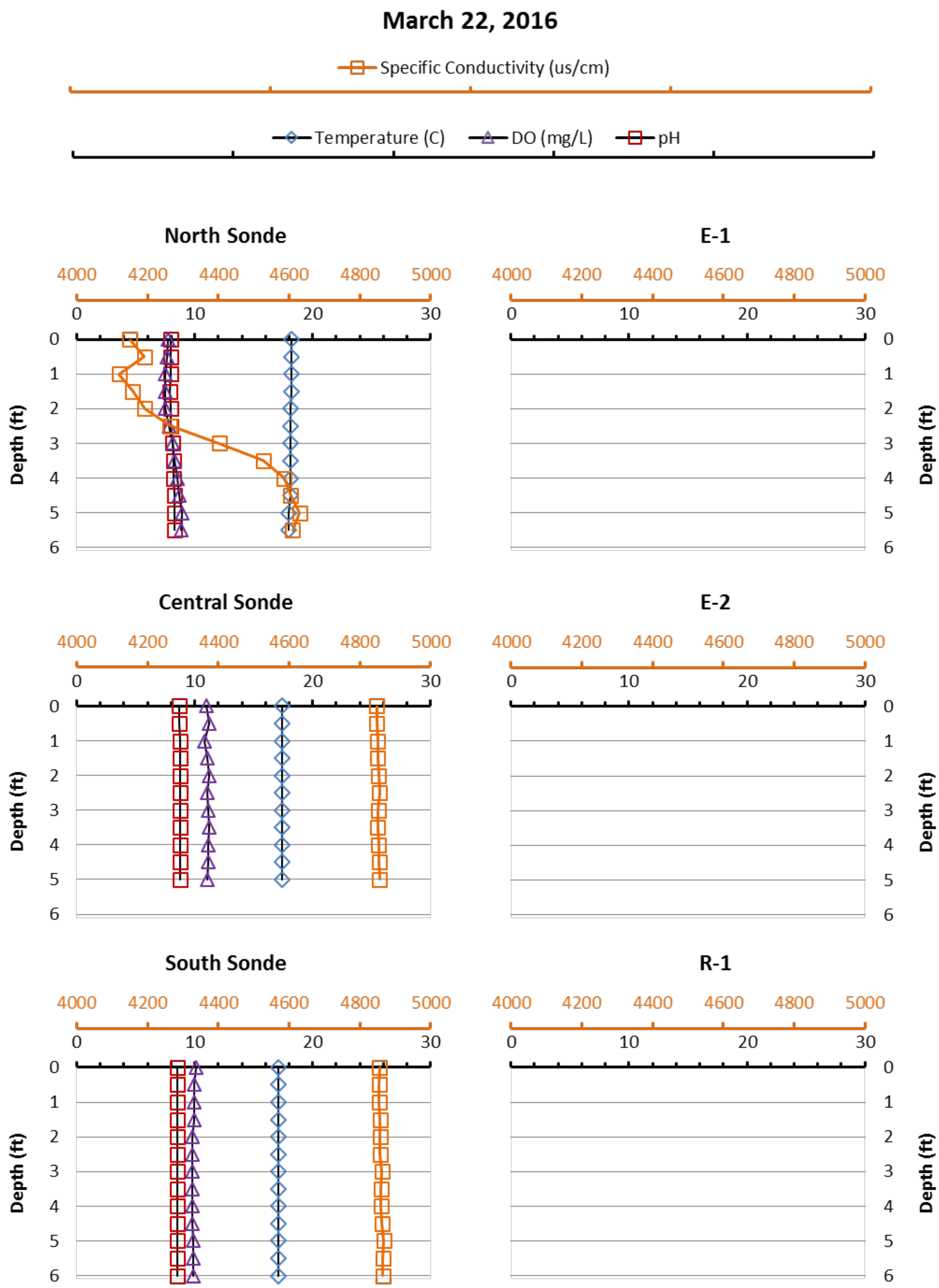

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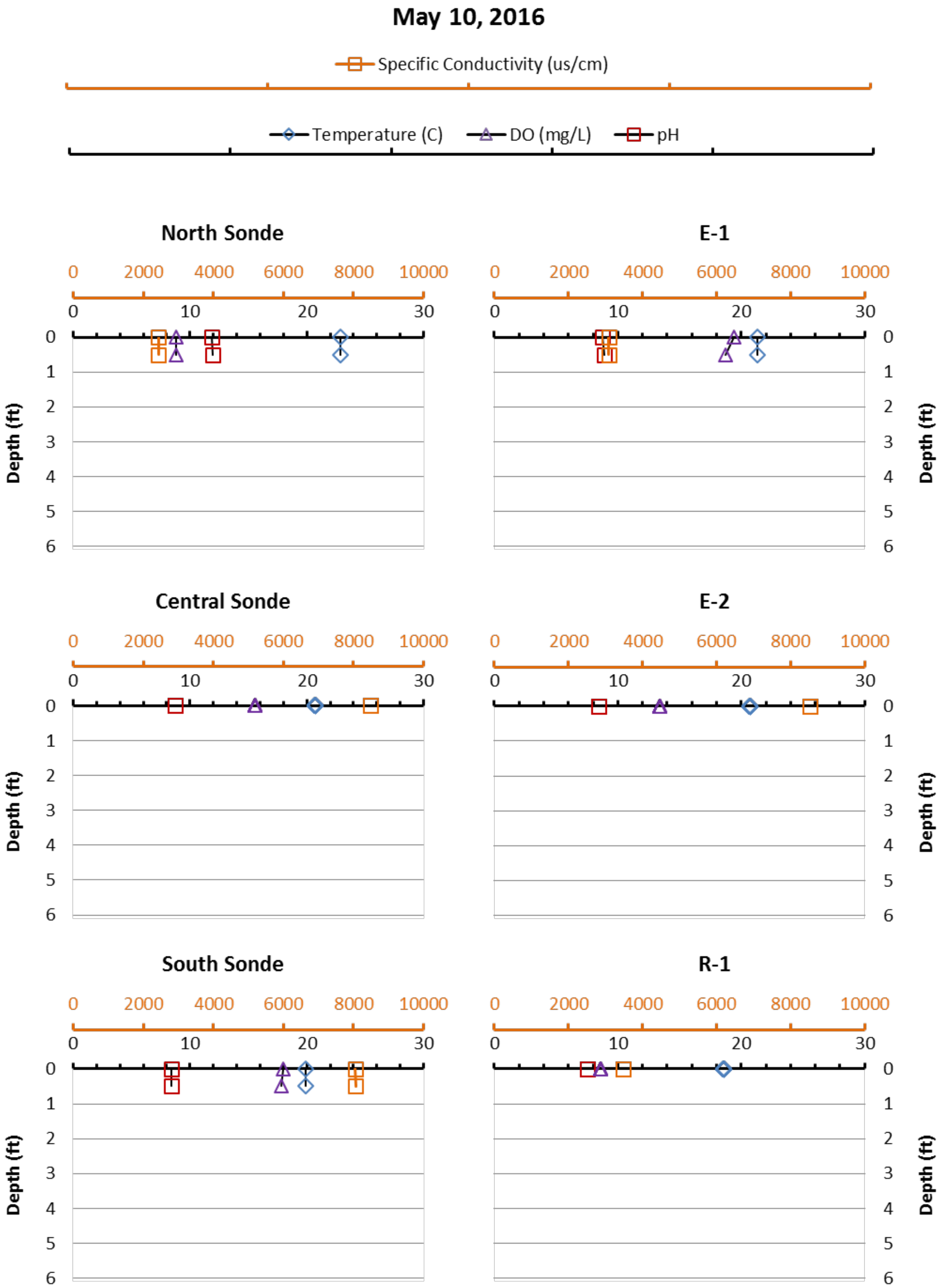

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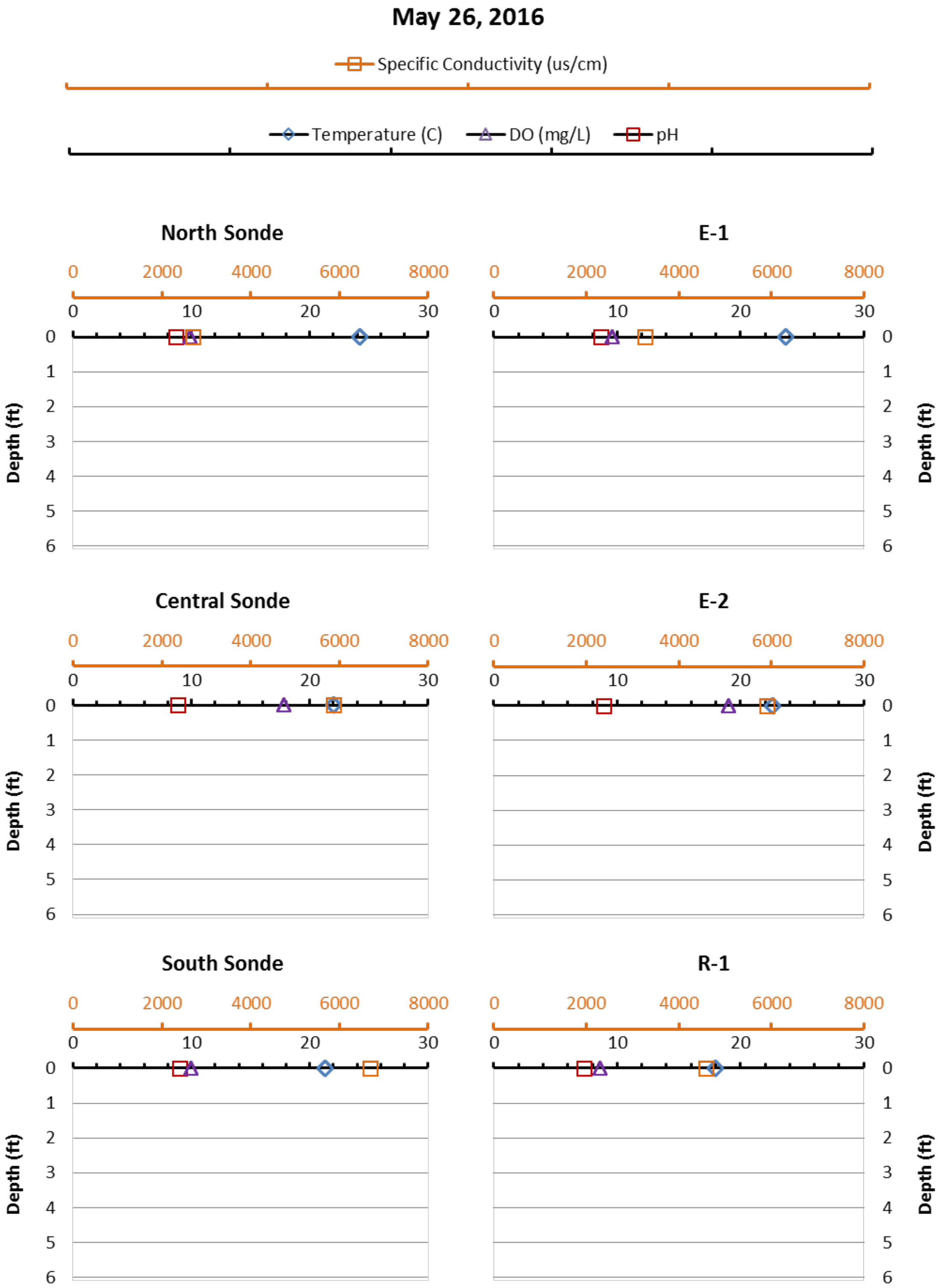

Figure D-31. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, May 2016.

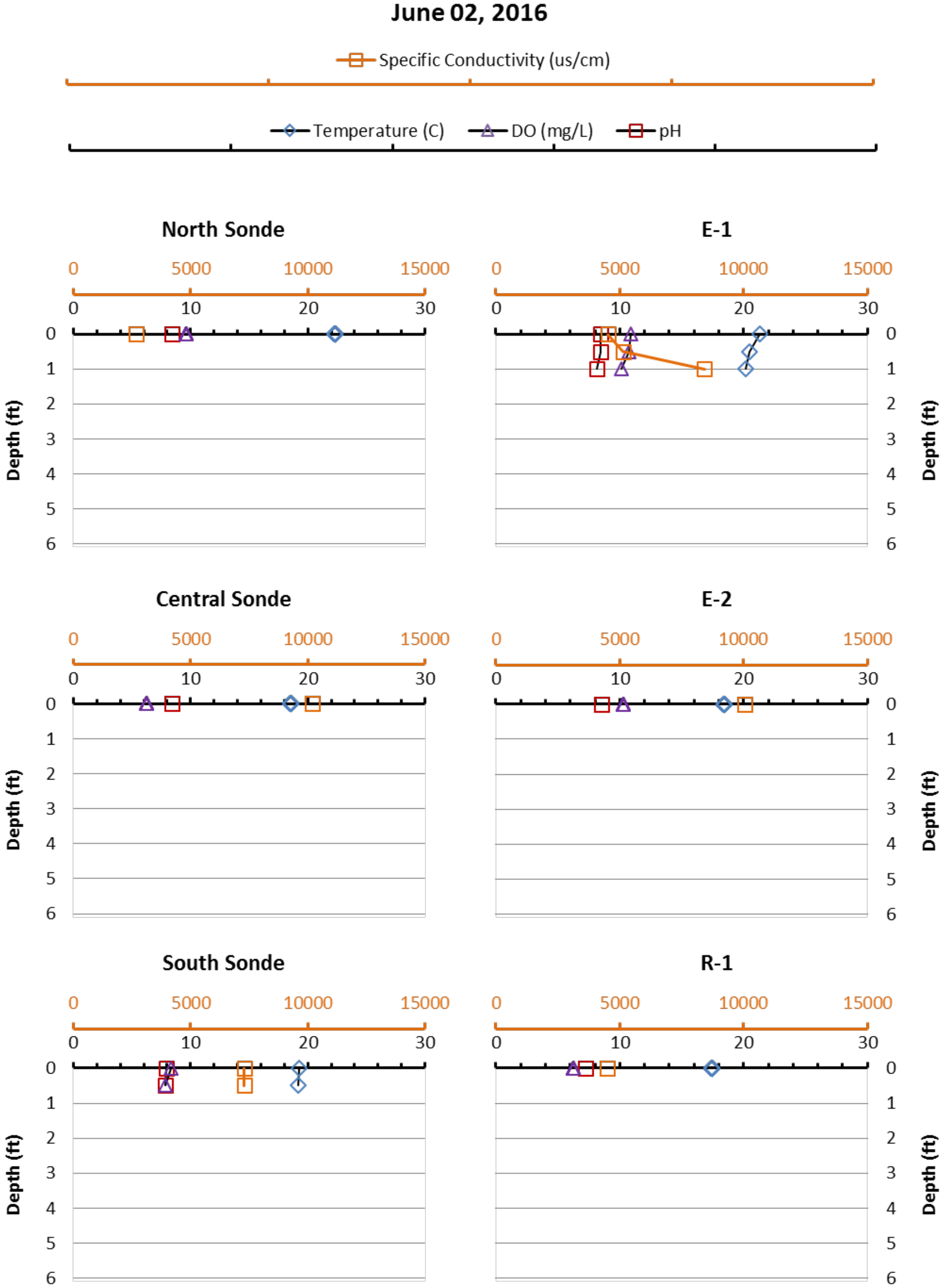

Figure D-32. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, June 2016.

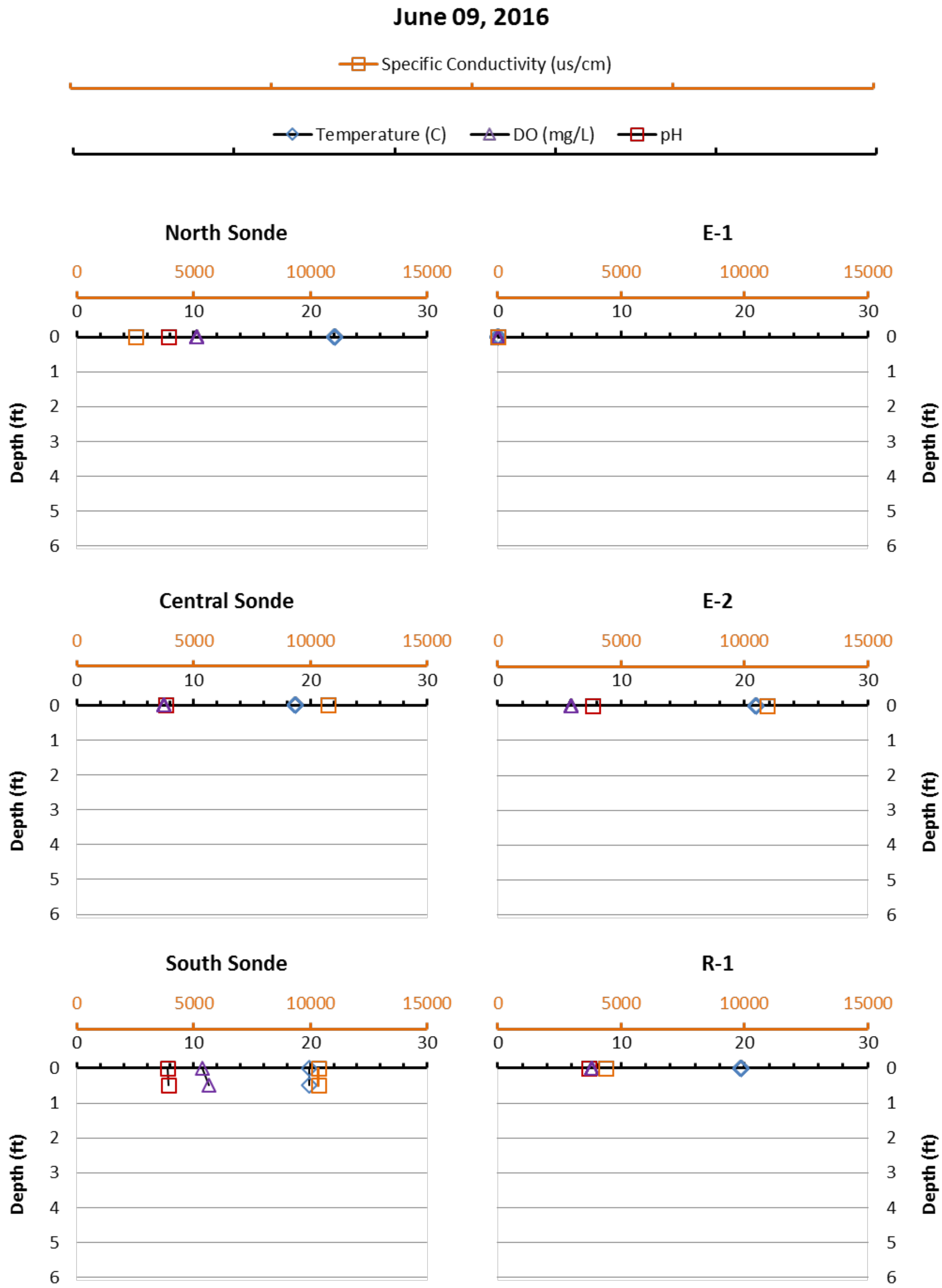

Figure D-33. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, June 2016.

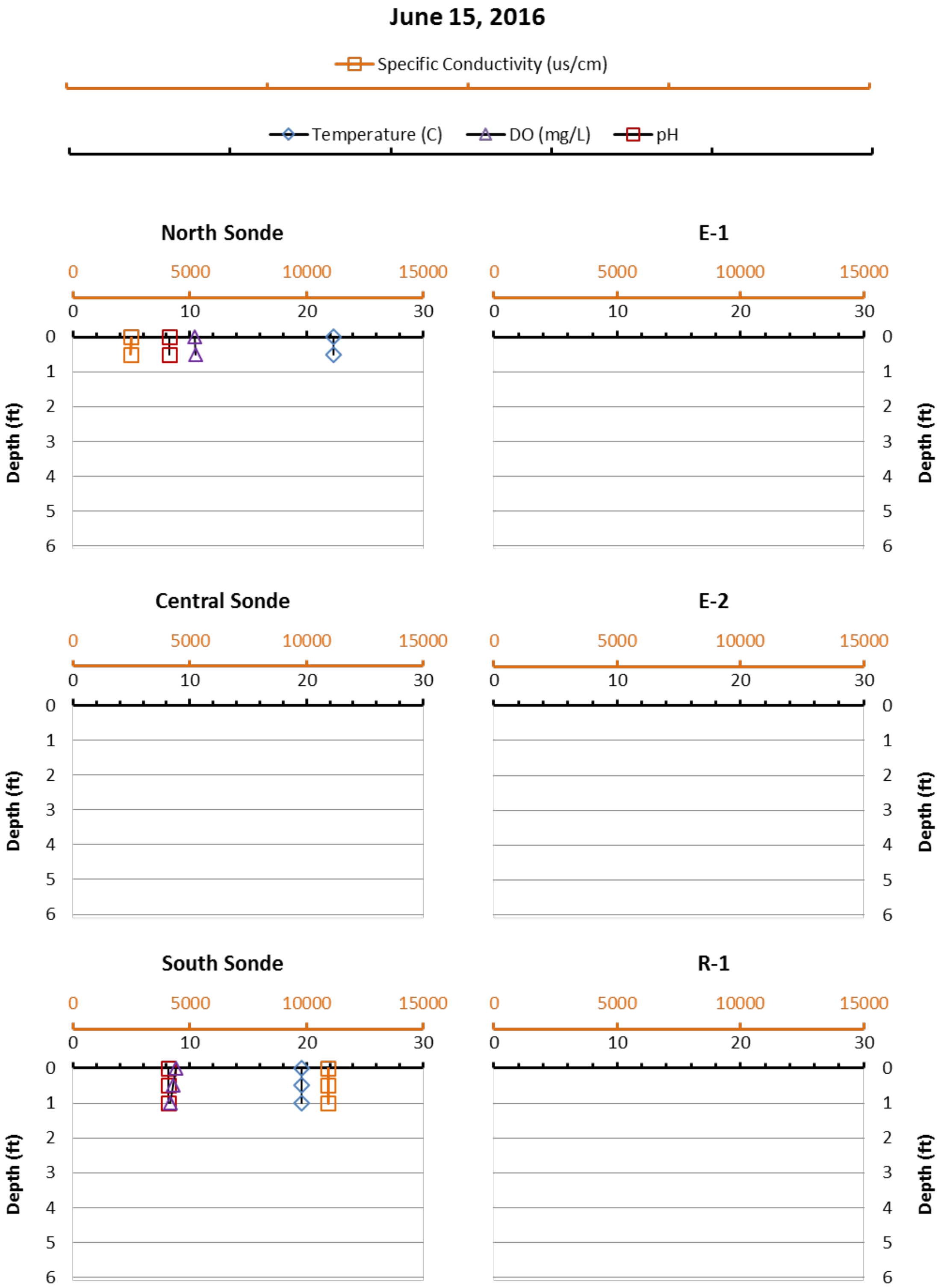

Figure D-34. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, June 2016.

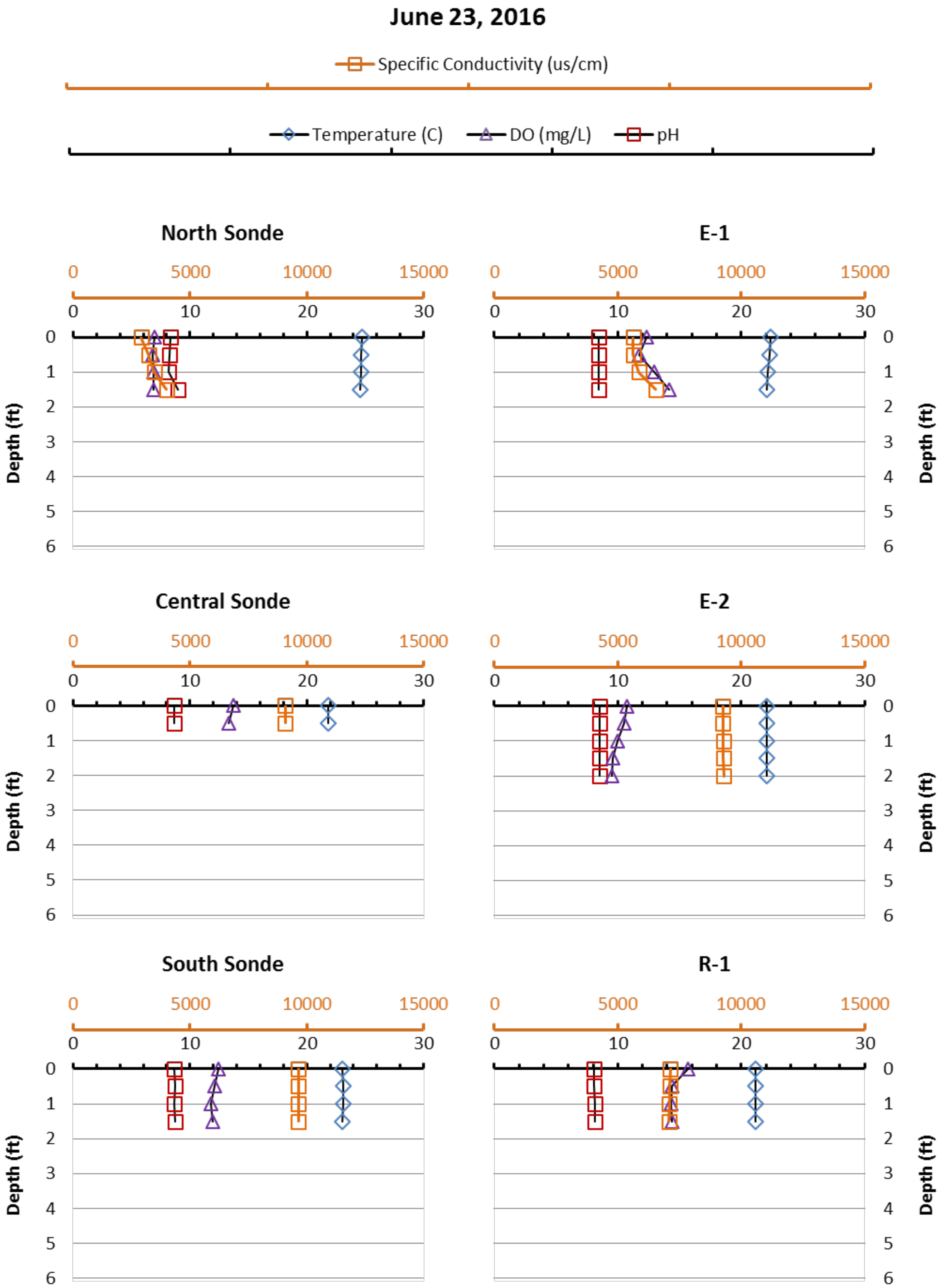

Figure D-35. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, June 2016.

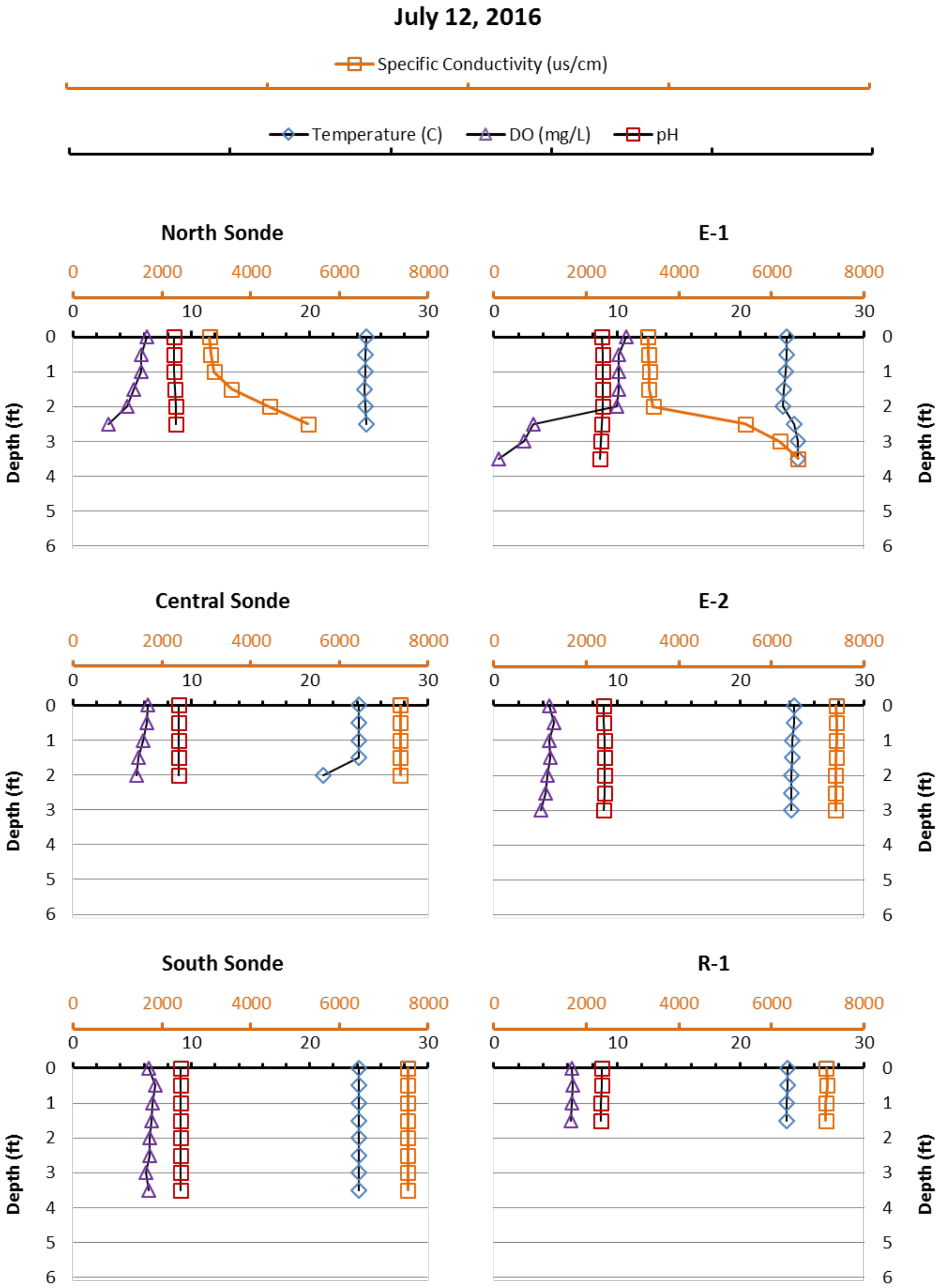

Figure D-36. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, July 2016.

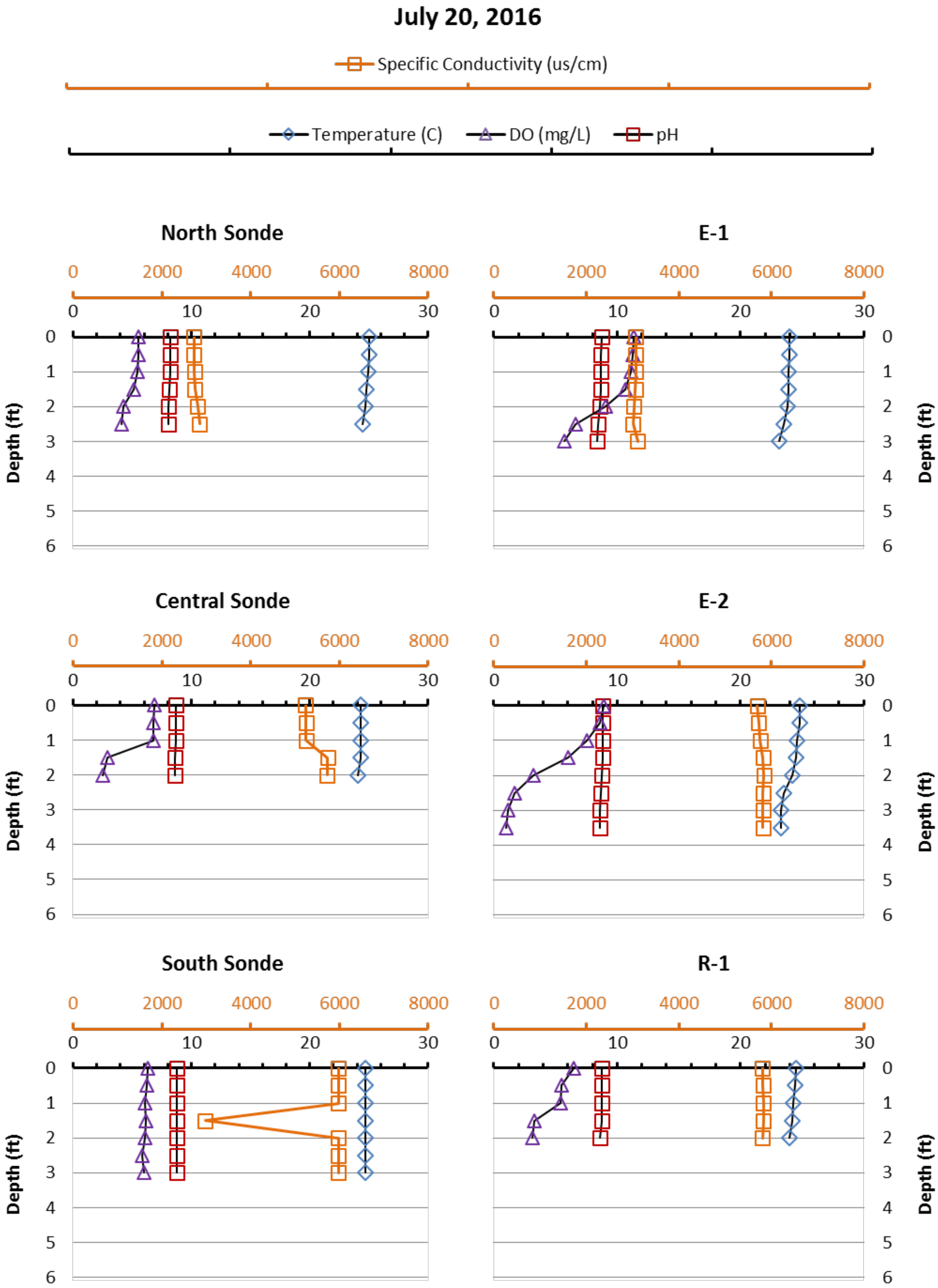

Figure D-37. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, July 2016.

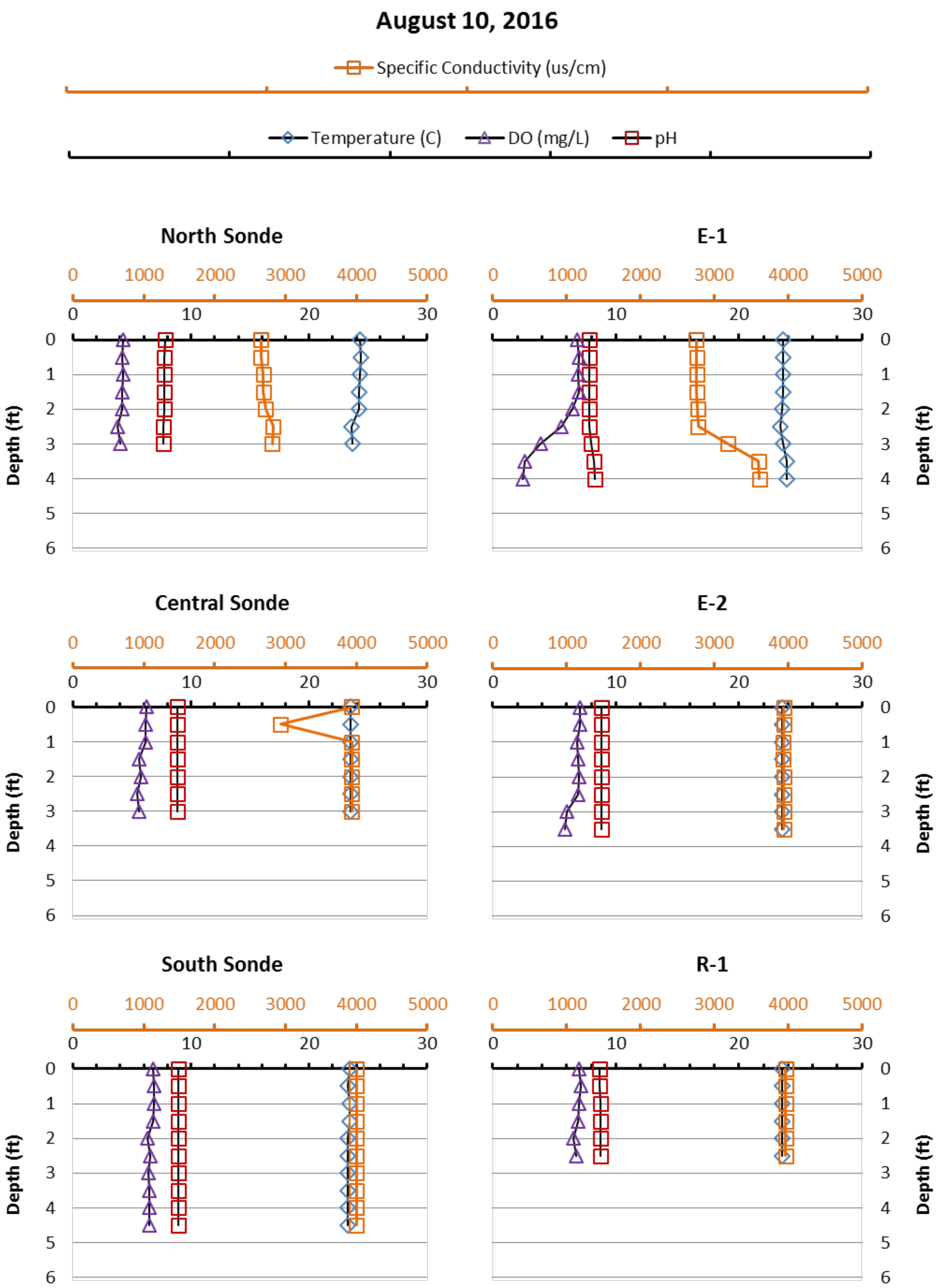

Figure D-38. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, August 2016.

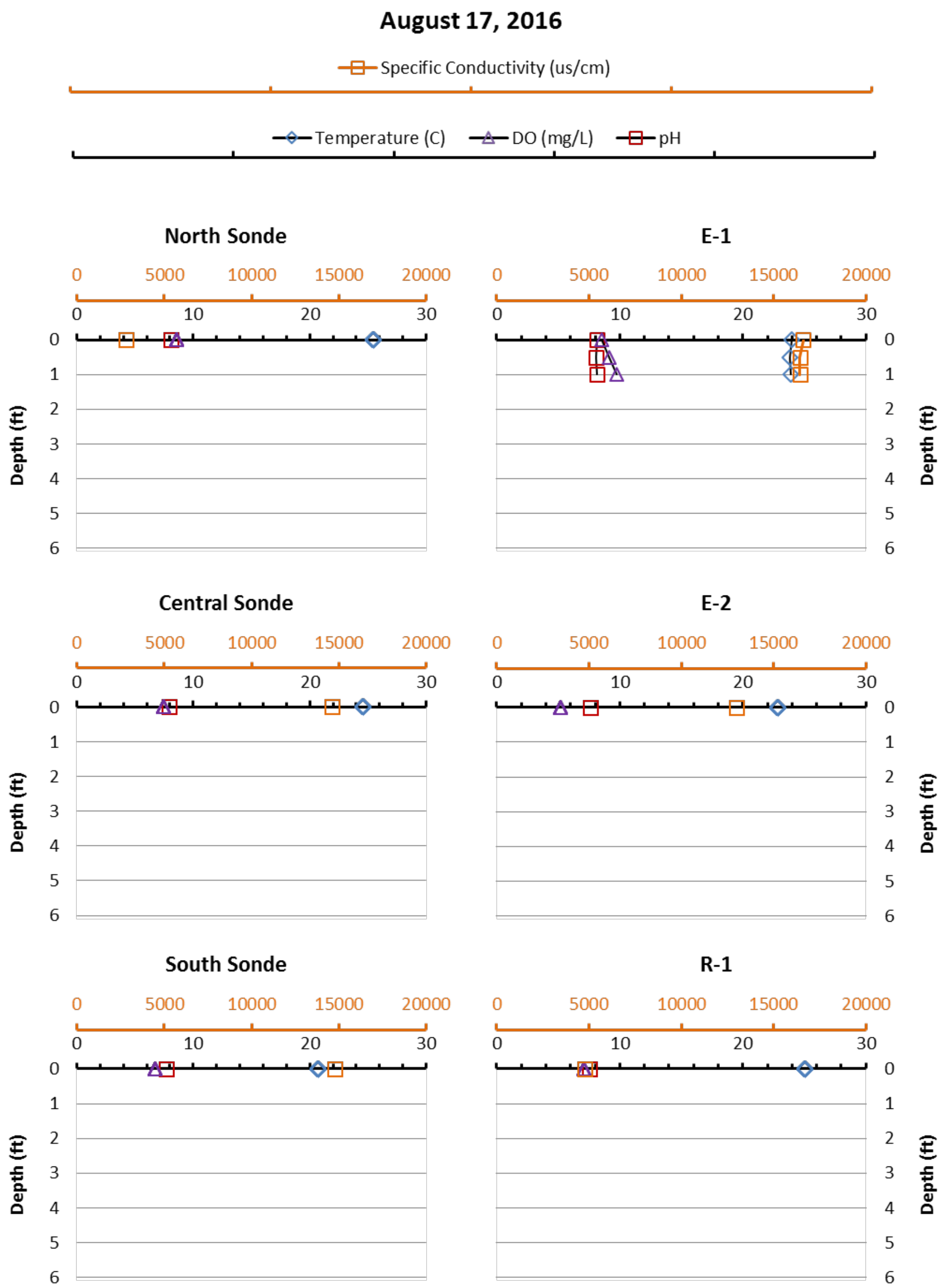

Figure D-39. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, August 2016.

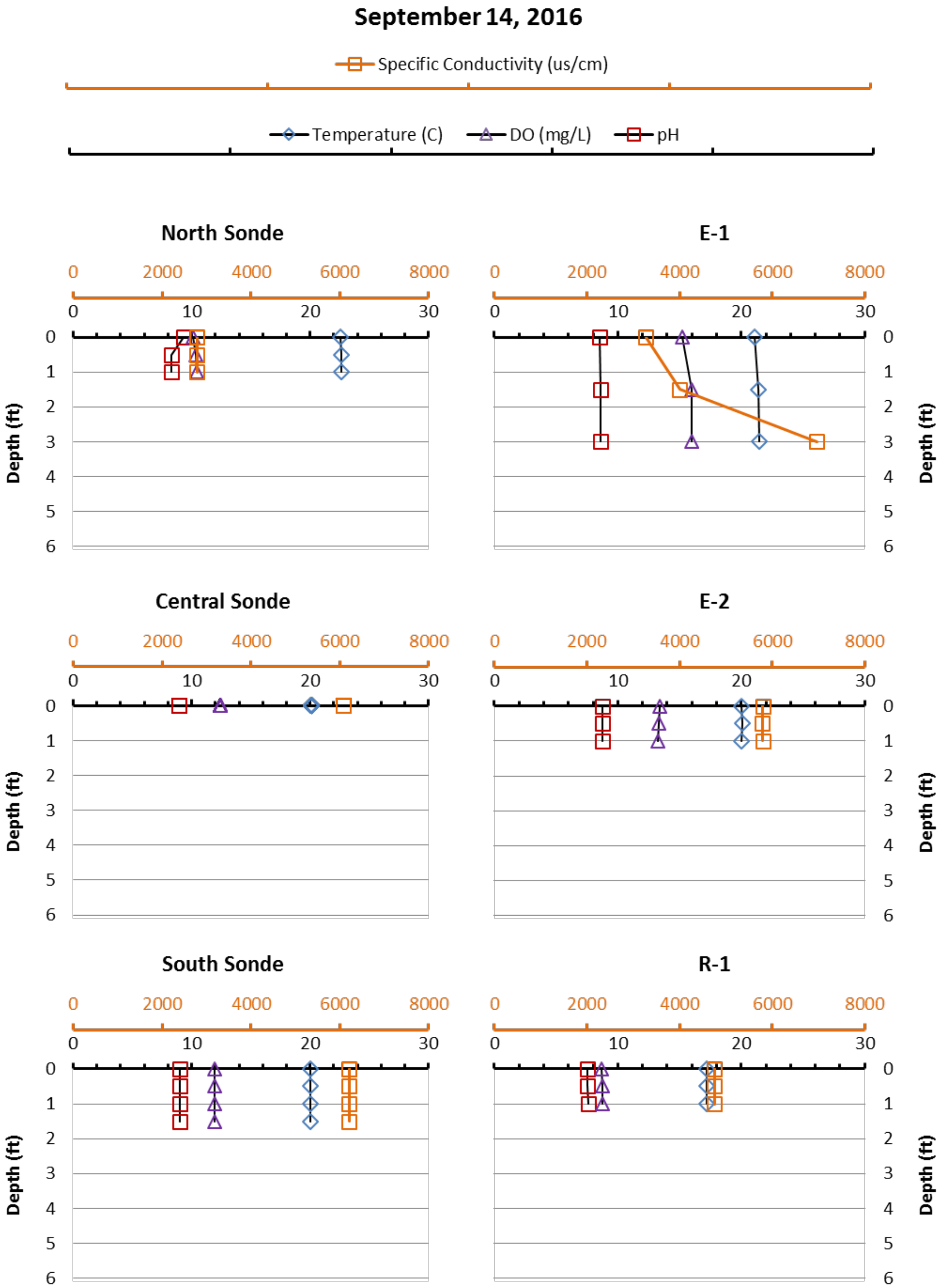

Figure D-40. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, August 2016.

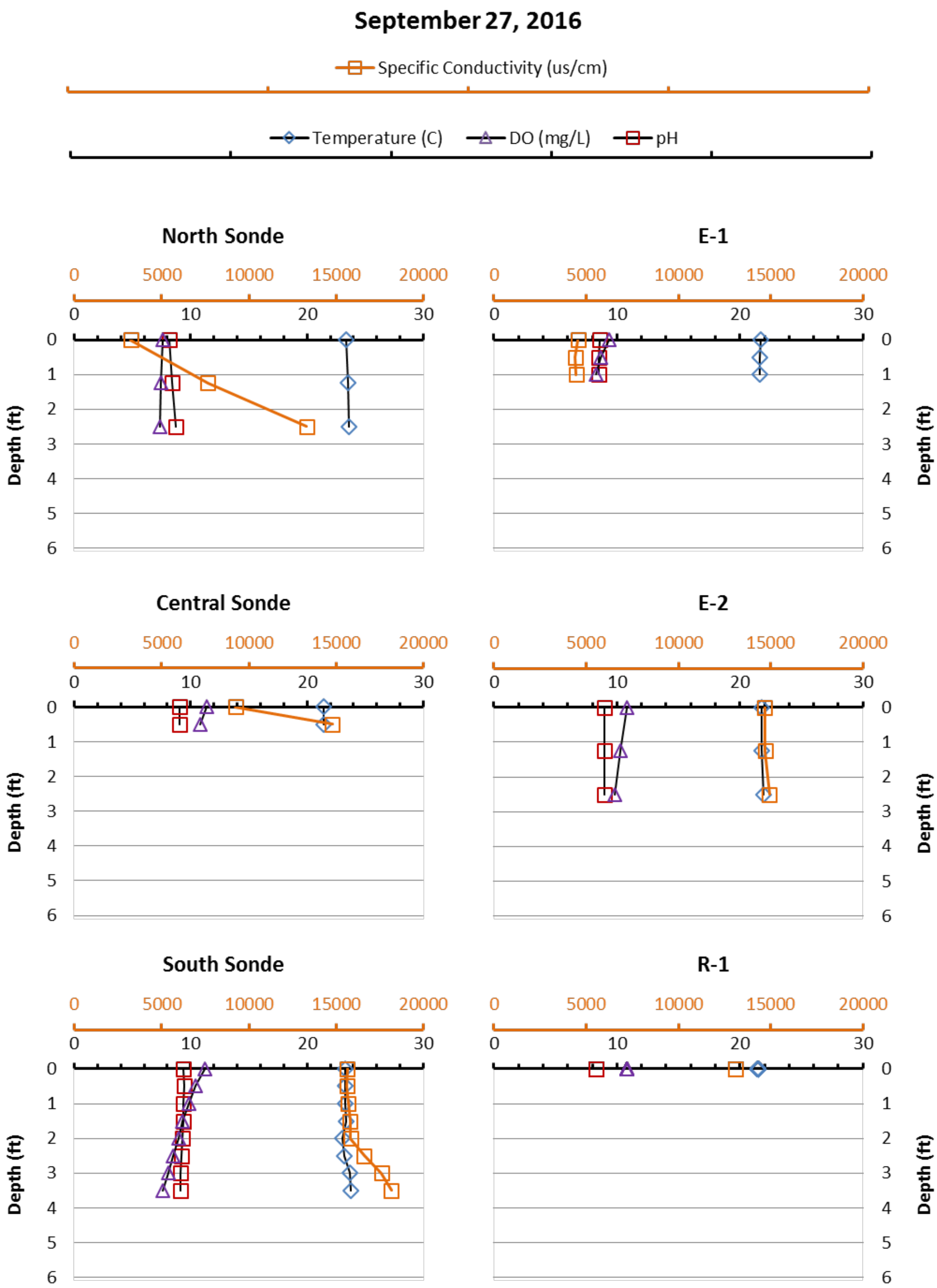

Figure D-41. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, September 2016.

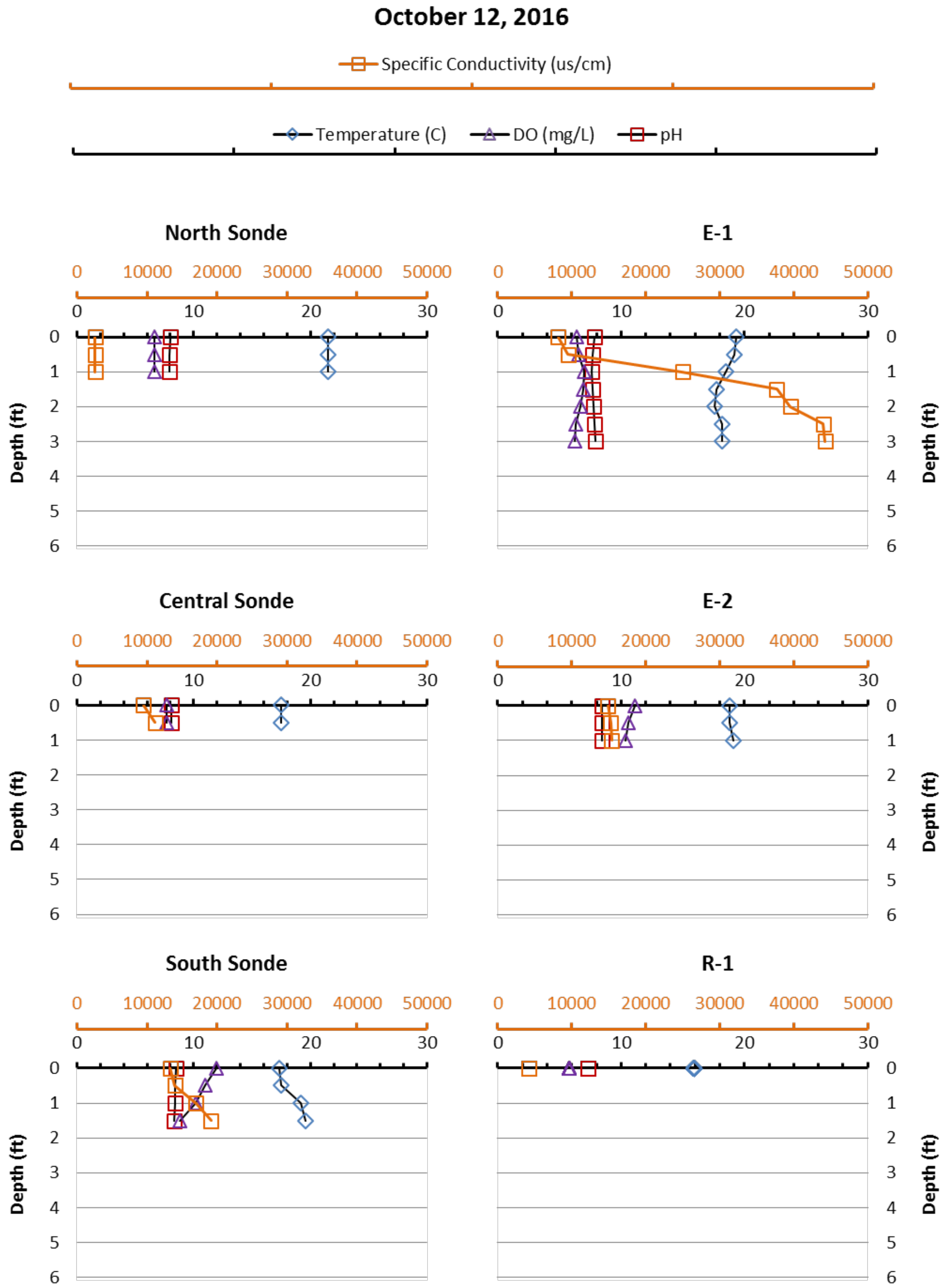

Figure D-42. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, October 2016.

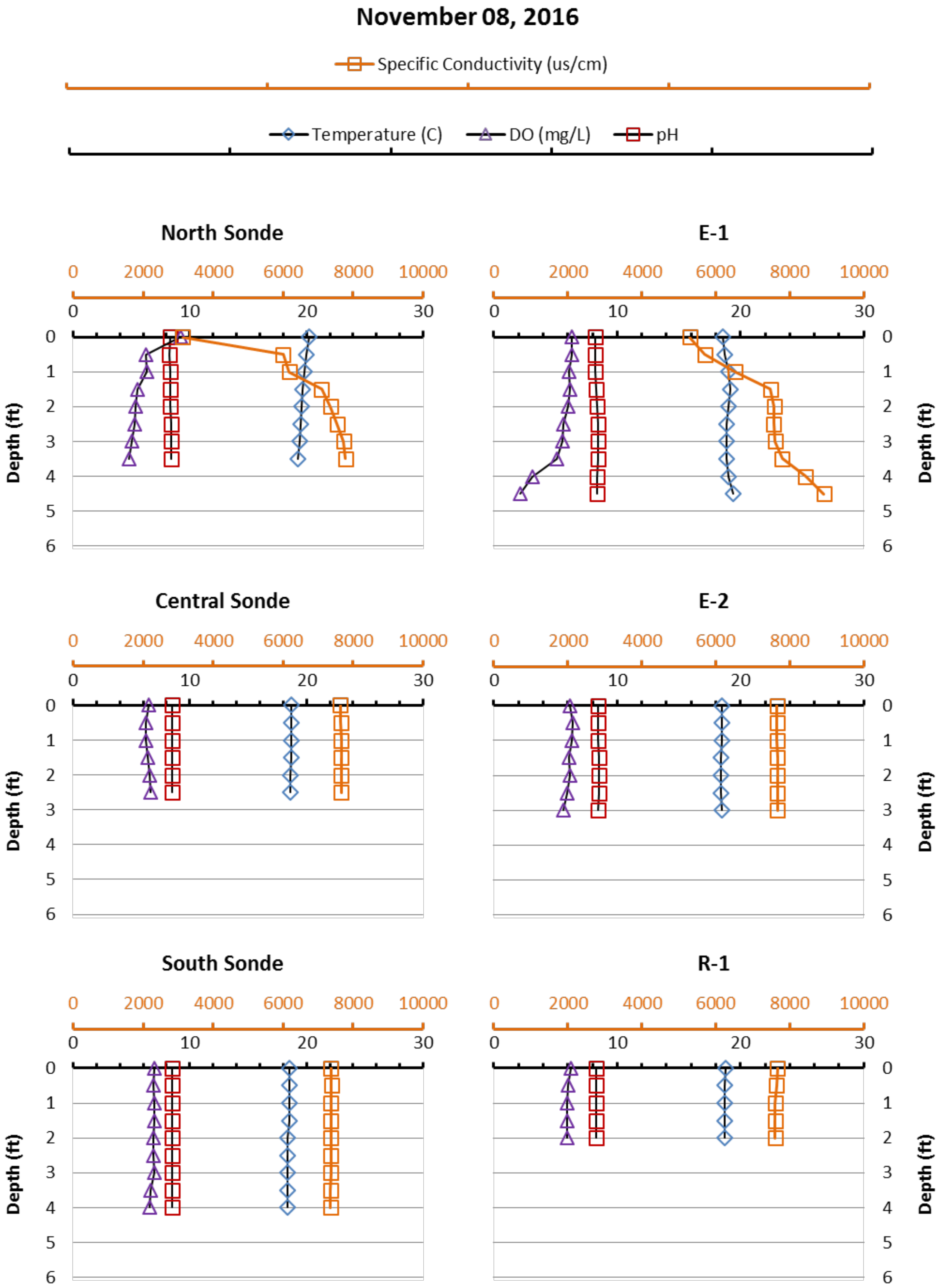

Figure D-43. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, November 2016.

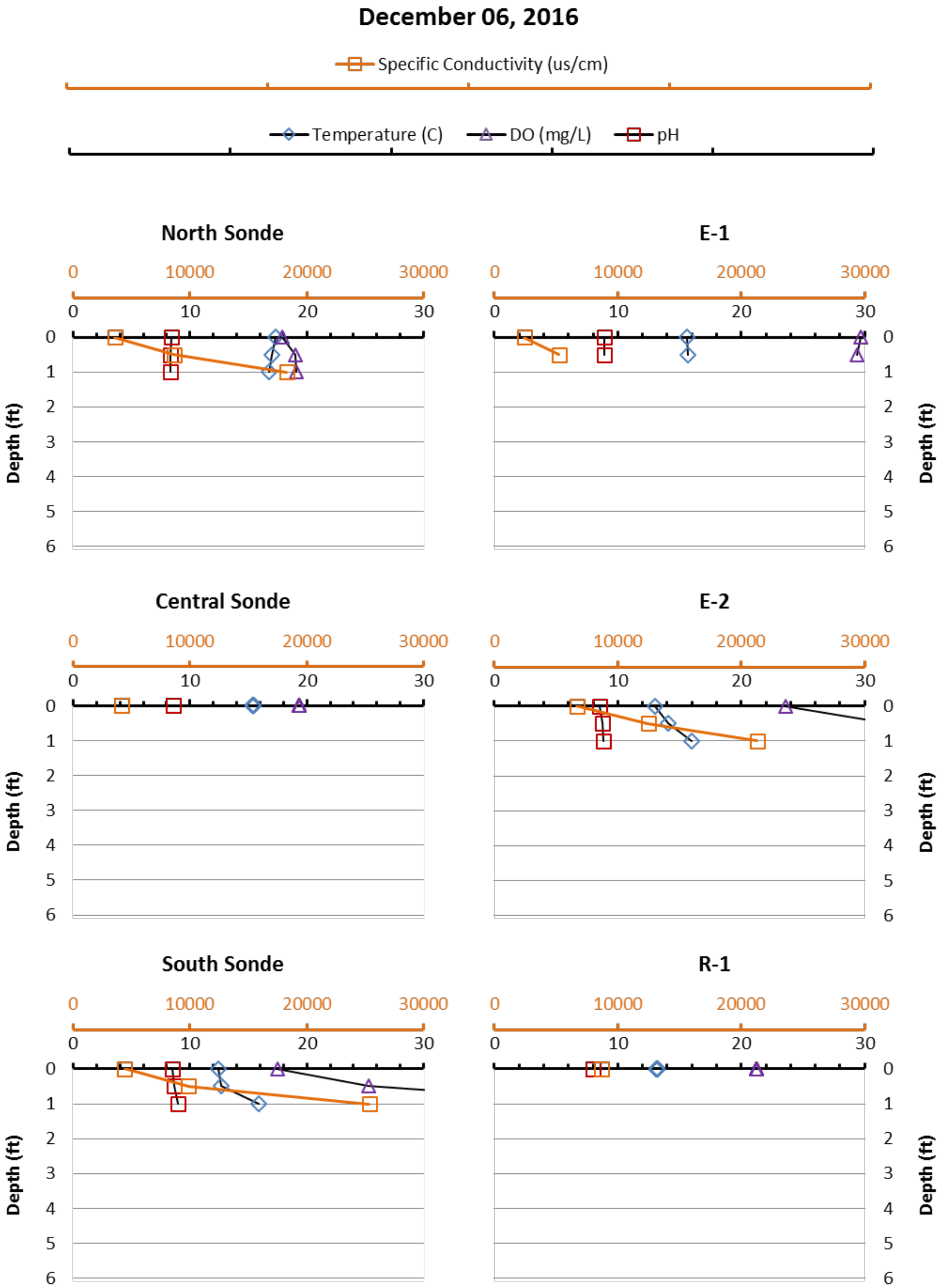

Figure D-44. In situ water quality profiles for the Phase 3 Santa Clara Estuary water quality study, December 2016.

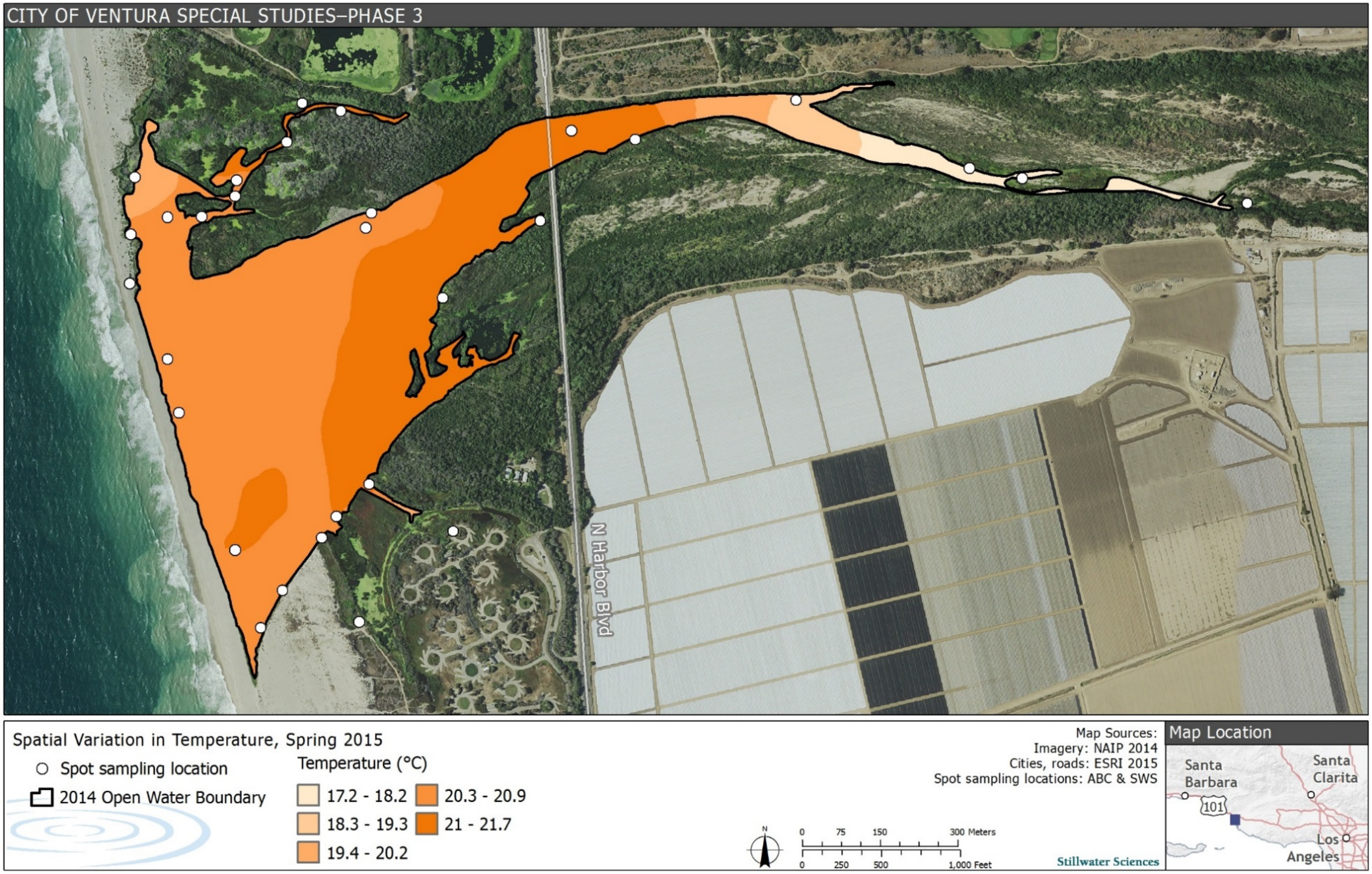

Figure D-45. Spatial Characterization of Temperature within the Santa Clara River Estuary, Spring 2015.

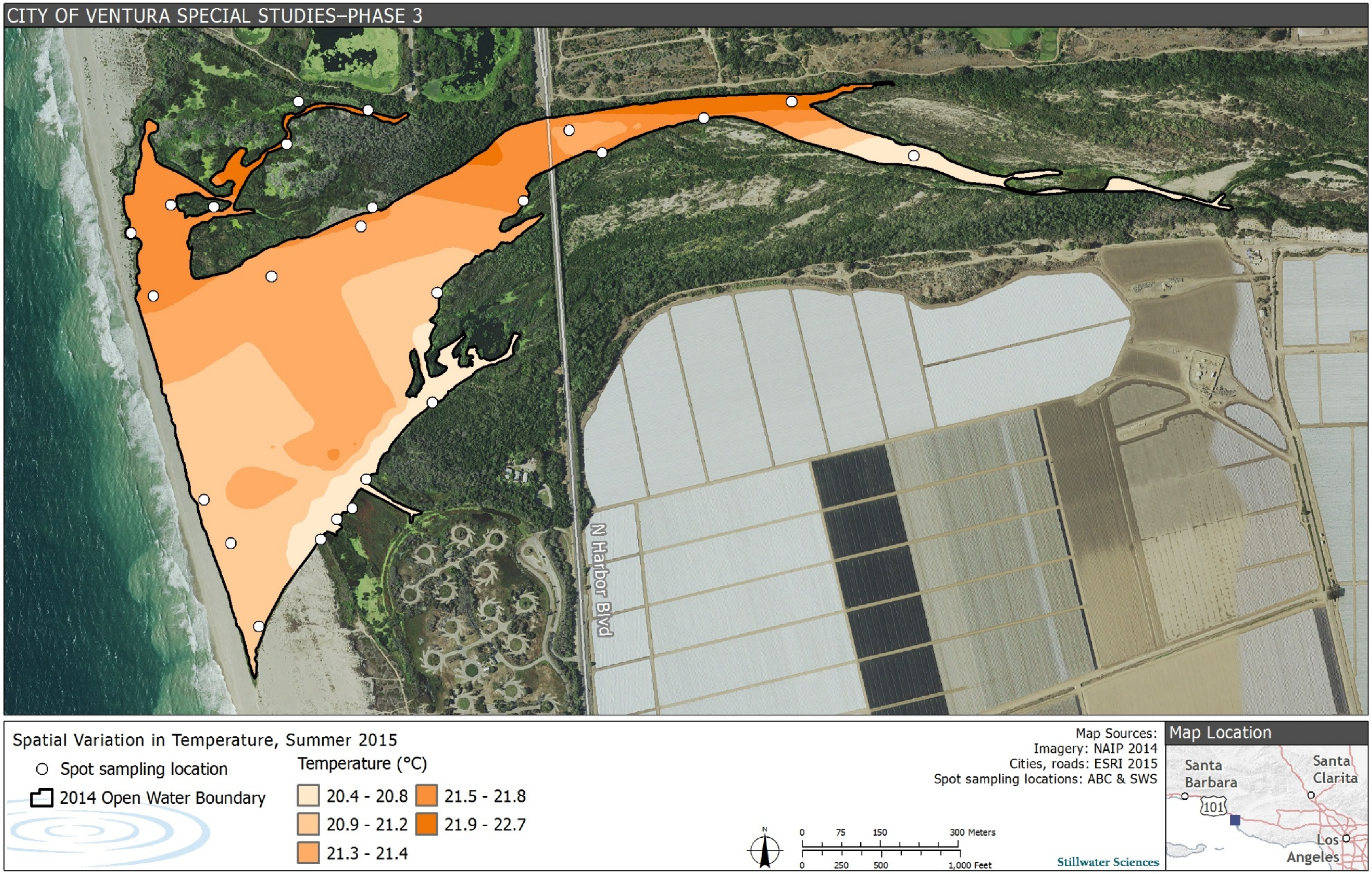

Figure D-46. Spatial Characterization of Temperature within the Santa Clara River Estuary, Summer 2015.

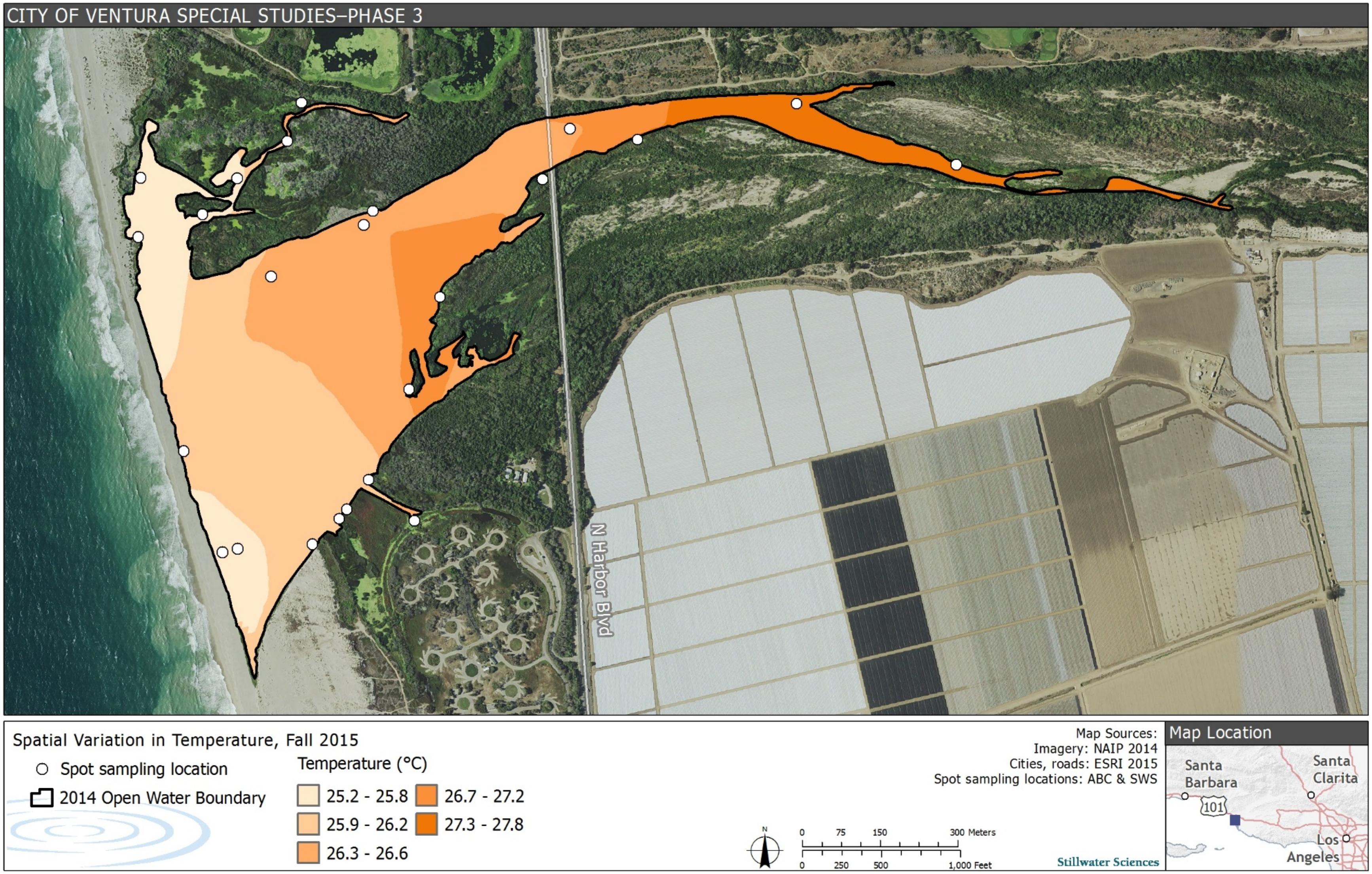

Figure D-47. Spatial Characterization of Temperature within the Santa Clara River Estuary, Fall 2015.

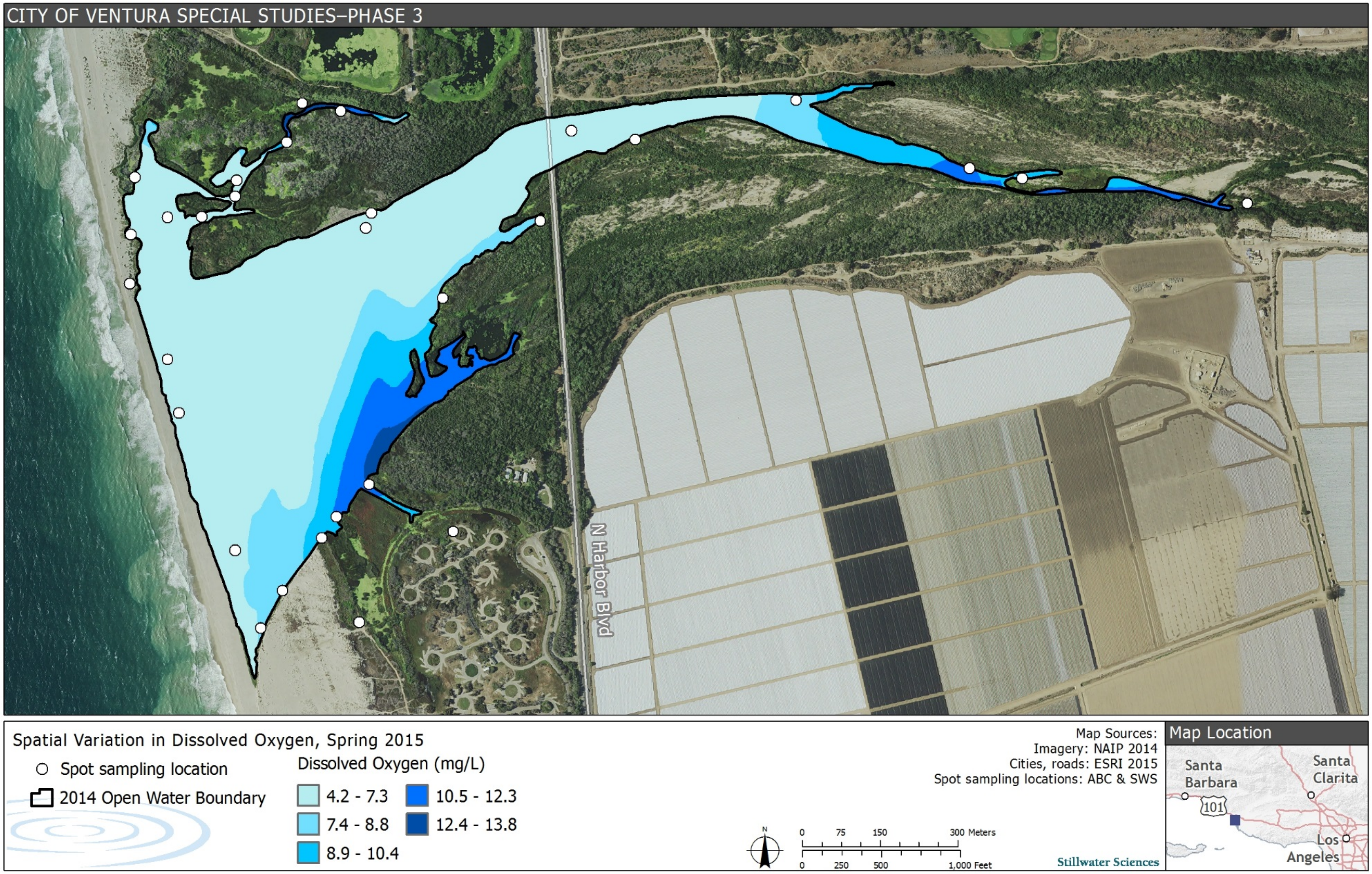

Figure D-48. Spatial Characterization of Dissolved Oxygen within the Santa Clara River Estuary, Spring 2015.

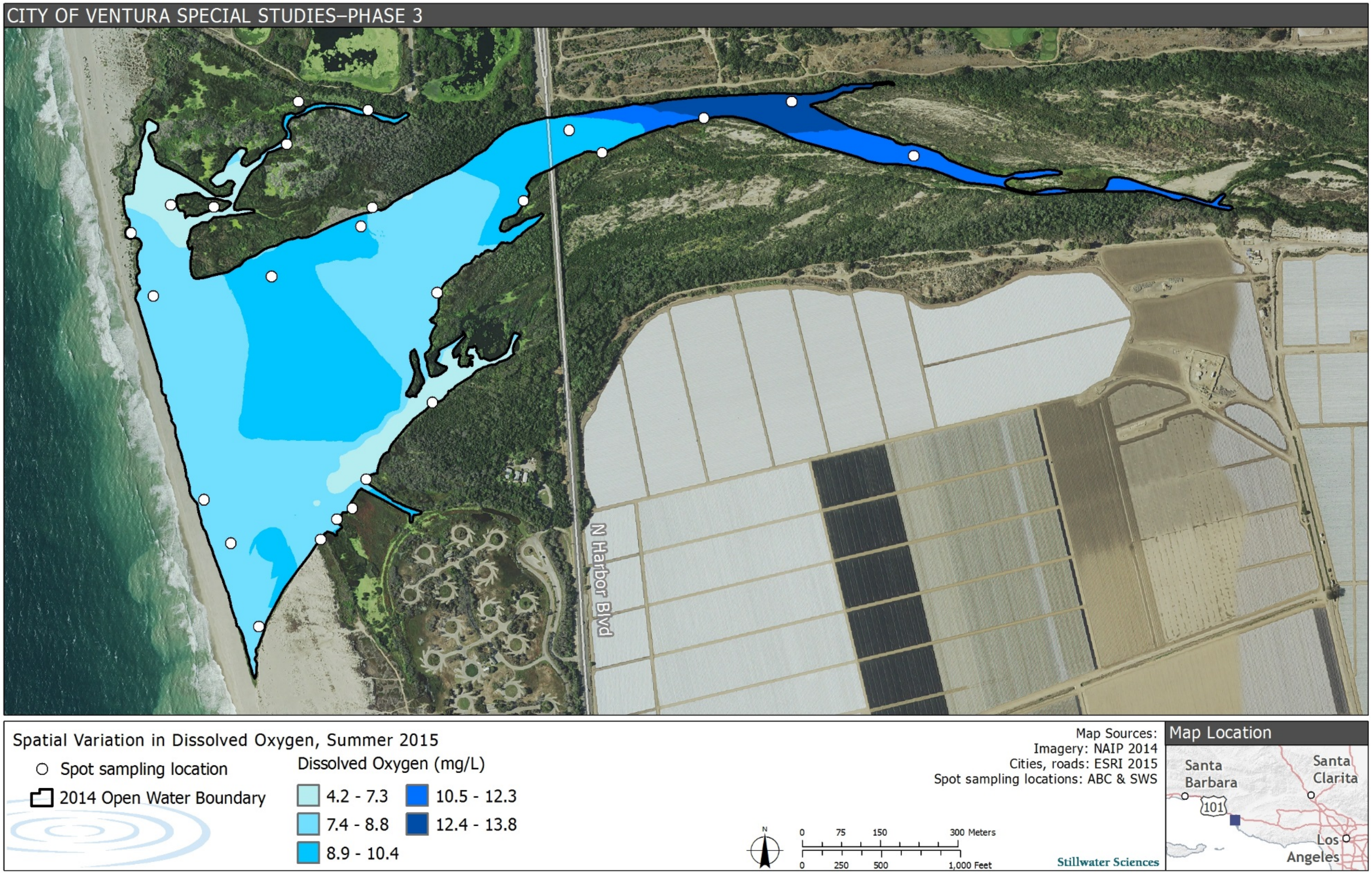

Figure D-49. Spatial Characterization of Dissolved Oxygen within the Santa Clara River Estuary, Summer 2015.

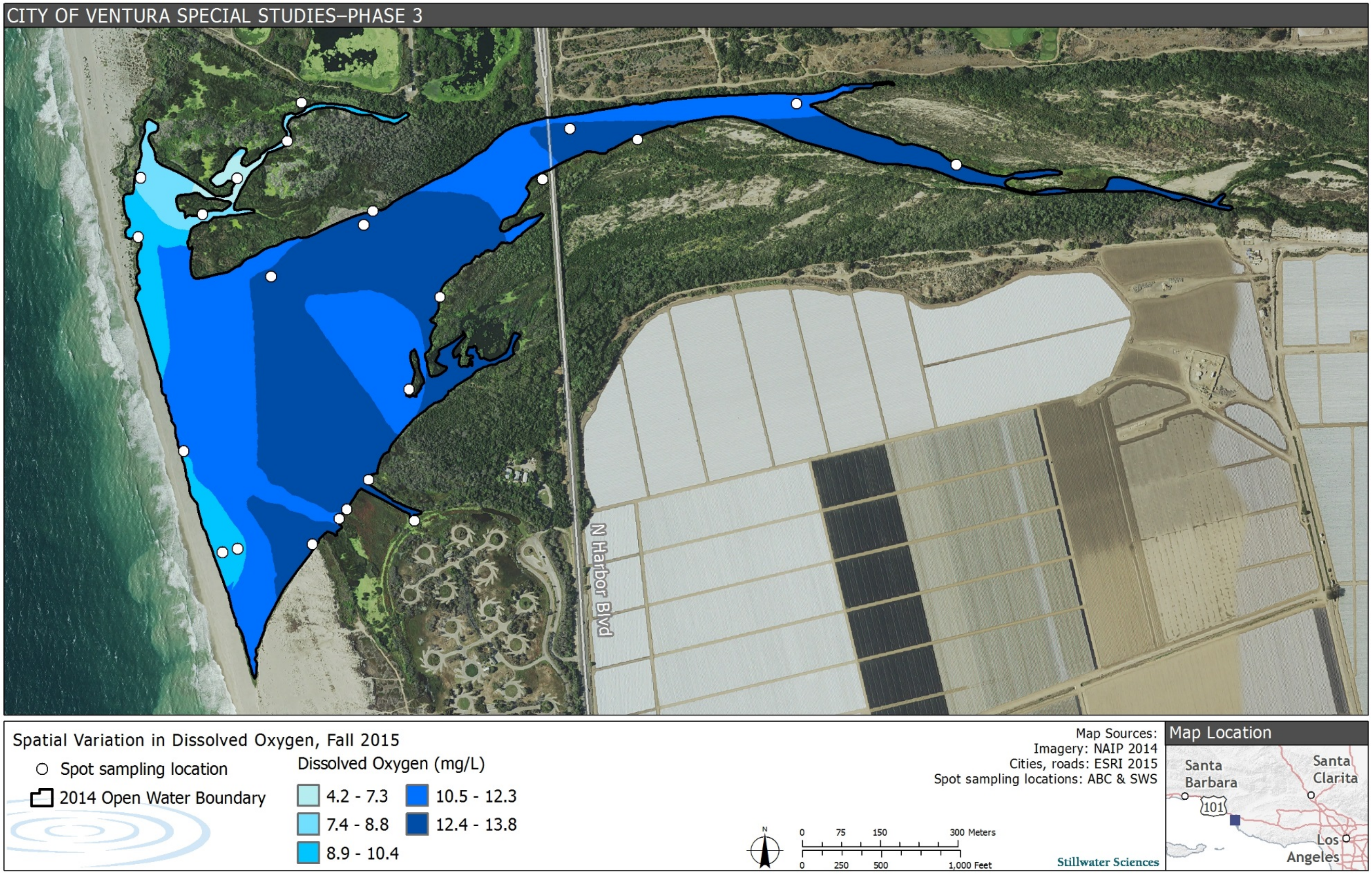

Figure D-50. Spatial Characterization of Dissolved Oxygen within the Santa Clara River Estuary, Fall 2015.

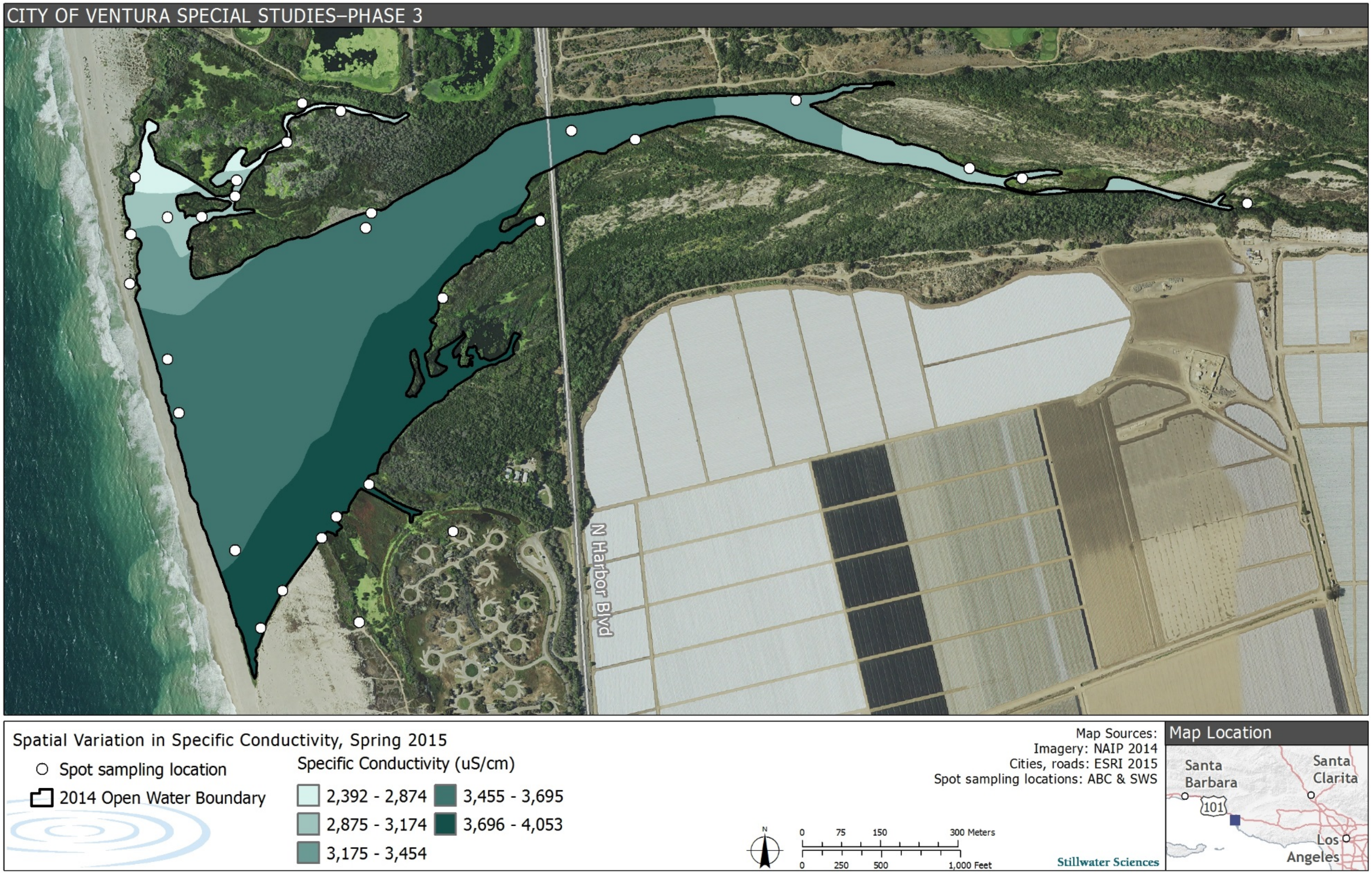

Figure D-51. Spatial Characterization of Specific Conductivity within the Santa Clara River Estuary, Spring 2015.

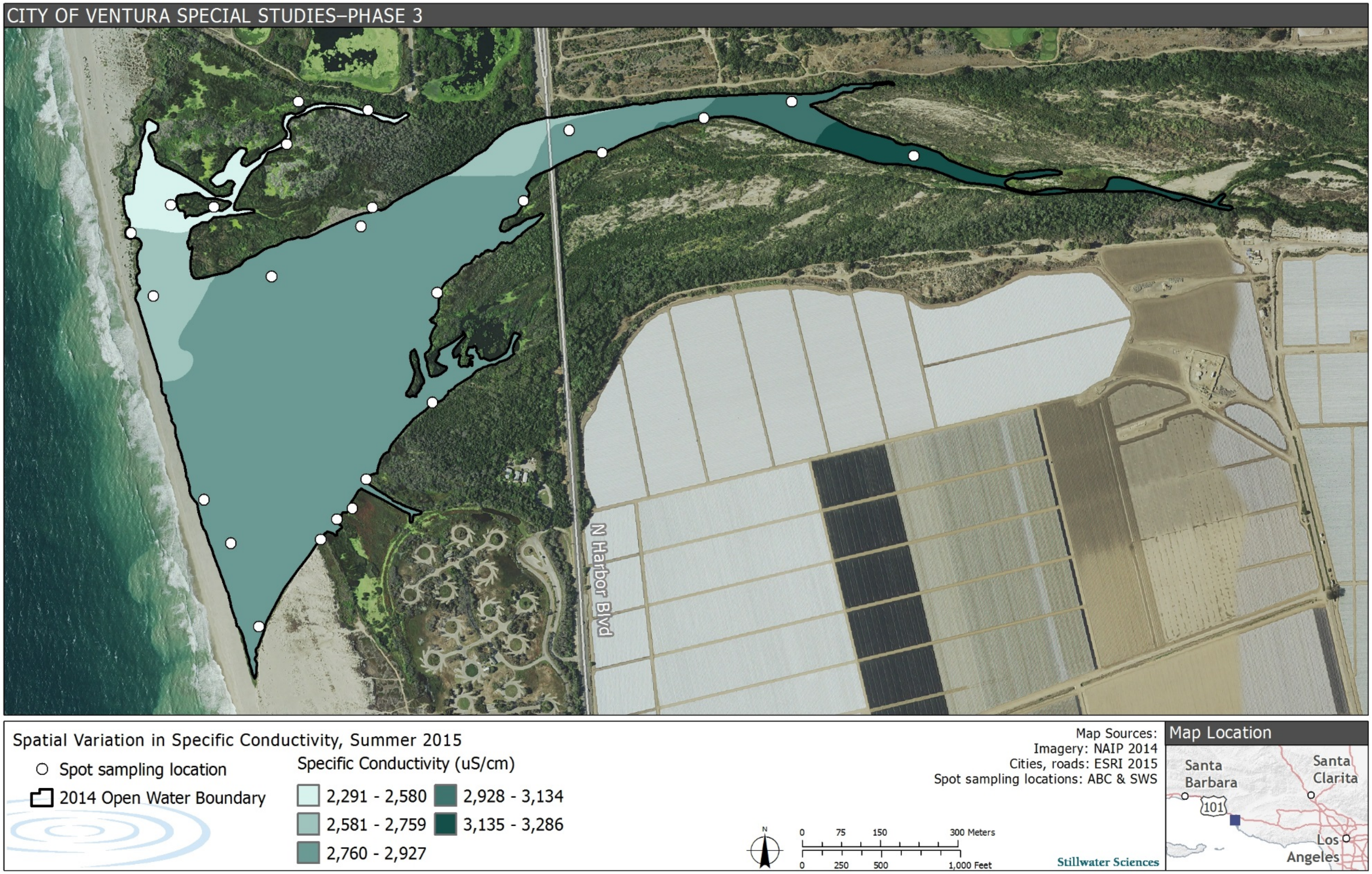

Figure D-52. Spatial Characterization of Specific Conductivity within the Santa Clara River Estuary, Summer 2015.

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Appendix E

Phase 3 Toxicity Testing Results (2015-2016)

SCRE Phase III Special Study
Quarterly Toxicity Results
Sample Date: February 19, 2015

aquatic bioassay & consulting laboratories, inc

SCRE Phase III Special Study

Test Organism	Endpoint	Effect	Station			
			ETS	E-1	E-2	R-1
Urchin	Fertilization (%)	NOEC (%)	100	100	100	100
		TUc	1	1	1	1
		EC25 (%)	>100	>100	>100	>100
		EC50 (%)	>100	>100	>100	>100
Selenastrum	Cell Density (Count)	NOEC (%)	100	NA	NA	NA
		TUc	1			
		EC25 (%)	>100			
		EC50 (%)	>100			

NA= Not applicable, no Selenastrum toxicity required at these sites.

NPDES Permitted

Test Organism	Endpoint	Effect	NPDES Station ID (Phase III Station ID)[1]			
			R-4 (North Sonde)	R-5 (R-1)	M001a (D-1)	R-003 (E-1)
Selenastrum	Cell Density (Count)	NOEC (%)	100	100	100	100
		TUc	1	1	1	1
		EC25 (%)	>100	>100	>100	>100
		EC50 (%)	>100	>100	>100	>100

1. Stations R-4 and R-5 were collected on February 25, 2015

SCRE Phase III Special Study
Quarterly Toxicity Results
Sample Date: February 19, 2015

aquatic bioassay & consulting laboratories, inc

Phase III Special Study

Test Organism	Test	Station	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[1.]
Chronic Urchin	Fertilization (%)	ETS	0	100.0	NA	NA	NA
			50	100.0	100	0.00	NSG
			100	100.0	100	0.00	NSG
		E-1	0	100.0	NA	NA	NA
			50	100.0	100	0.00	NSG
			100	100.0	100	0.00	NSG
		E-2	0	100.0	NA	NA	NA
			50	100.0	100	0.00	NSG
			100	100.0	100	0.00	NSG
		R-1	0	100.0	NA	NA	NA
			50	100.0	100	0.00	NSG
			100	100.0	100	0.00	NSG
Selenastrum	Cell Density (Count)	ETS	0	1291000	NA	NA	NA
			50	2050000	159	0.00	NSG
			100	1966000	152	0.00	NSG

1. NSG- Not statistically significant and greater than the evaluation threshold (>80 % of the control).

NPDES Permitted

Test Organism	Test	Station[1]	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[2.]
Selenastrum	Cell Density (Count)	R-4[2] (North Sonde)	0	1310000	NA	NA	NA
			10	1921000	147	0.00	NSG
			18	1970000	150	0.00	NSG
			32	2098000	160	0.00	NSG
			56	1809000	138	0.00	NSG
			100	1667000	127	0.00	NSG
		R-5[2] (R-1)	0	1310000	NA	NA	NA
			10	1567000	120	0.00	NSG
			18	1644000	125	0.00	NSG
			32	1702000	130	0.00	NSG
			56	1627000	124	0.00	NSG
			100	1373000	105	0.00	NSG

SCRE Phase III Special Study
Quarterly Toxicity Results
Sample Date: February 19, 2015

NPDES Permitted (Continued)

Test Organism	Test	Station[1]	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[2.]
		M001a	0	1291000	NA	NA	NA
		(D-1)	10	1694000	131	0.00	NSG
			18	1882000	146	0.00	NSG
			32	2216000	172	0.00	NSG
			56	2015000	156	0.00	NSG
			100	1840000	143	0.00	NSG
		R-003	0	1291000	NA	NA	NA
		(E-1)	10	1651000	128	0.00	NSG
			18	2020000	156	0.00	NSG
			32	1922000	149	0.00	NSG
			56	1816000	141	0.00	NSG
			100	1544000	120	0.00	NSG

1. (NPDES permitted station ID)
2. Stations R-4 and R-5 were collected on February 25, 2015
3. NSG- Not statistically significant and greater than the evaluation threshold (>80 % of the control).

SCRE Phase III Special Study
Quarterly Toxicity Results
Sample Date: May 13, 2015

aquatic bioassay & consulting laboratories, inc

Test Organism	Endpoint	Effect	Station			
			ETS	E-1	E-2	R-1
Hyalella	Survival	NOEC (%)	100	100	100	100
		TUc	1	1	1	1
		EC25 (%)	>100	>100	>100	>100
		EC50 (%)	>100	>100	>100	>100
Hyalella	Growth	NOEC (%)	100	100	100	100
		TUc	1	1	1	1
		EC25 (%)	>100	>100	>100	>100
		EC50 (%)	>100	>100	>100	>100
Trout	Survival	NOEC (%)	100	100	100	100
		TUa	0	0	0	0
Selenastrum	Cell Density (Count)	NOEC (%)	100	100	100	100
		TUc	1	1	1	1
		EC50 (%)	>100	>100	>100	>100

NPDES Permitted

Test Organism	Endpoint	Effect	NPDES Station ID (Phase III Station ID)[1]		
			R-4 (North Sonde)	R-5 (R-1)	M001a (D-1)
Selenastrum	Cell Density (Count)	NOEC (%)	100	100	100
		TUc	1	1	1
		EC25 (%)	>100	>100	92.63
		EC50 (%)	>100	>100	>100

1. NPDES permitted station ID

SCRE Phase III Special Study
Quarterly Toxicity Results
Sample Date: May 13, 2015

aquatic bioassay & consulting laboratories, inc

Test Organism	Test	Station	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[1.]
Hyalella	Survival (%)	ETS	0	70.0	NA	NA	NA
			50	70.0	100	0.00	NSG
			100	86.0	123	0.00	NSG
		E-1	0	70.0	NA	NA	NA
			50	96.0	137	0.00	NSG
			100	92.0	131	0.00	NSG
		E-2	0	70.0	NA	NA	NA
			50	78.0	111	0.00	NSG
			100	98.0	140	0.00	NSG
		R-1	0	70.0	NA	NA	NA
			50	86.0	123	0.00	NSG
			100	72.0	103	0.00	NSG
Hyalella	Growth (mg)	ETS	0	0.0304	NA	NA	NA
			50	0.0218	72	28.29	NSL
			100	0.0422	139	0.00	NSG
		E-1	0	0.0304	NA	NA	NA
			50	0.0426	140	0.00	NSG
			100	0.0538	177	0.00	NSG
		E-2	0	0.0304	NA	NA	NA
			50	0.0340	112	0.00	NSG
			100	0.1242	409	0.00	NSG
		R-1	0	0.0304	NA	NA	NA
			50	0.0326	107	0.00	NSG
			100	0.0816	268	0.00	NSG
Trout	Survival (%)	ETS	0	100.0	NA	NA	NA
			100	100.0	100	0.00	NSG
		E-1	0	100.0	NA	NA	NA
			100	100.0	100	0.00	NSG
		E-2	0	100.0	NA	NA	NA
			100	100.0	100	0.00	NSG
		R-1	0	100.0	NA	NA	NA
			100	100.0	100	0.00	NSG

SCRE Phase III Special Study
Quarterly Toxicity Results
Sample Date: May 13, 2015

Test Organism	Test	Station	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[1.]
Selenastrum	Cell Density (Count)	ETS	0	1130000	NA	NA	NA
			10	1486000	132	0.00	NSG
			18	1617000	143	0.00	NSG
			32	1642000	145	0.00	NSG
			56	1587000	140	0.00	NSG
			100	1013000	90	10.29	NSG
		E-1 (R-003)[2.]	0	1130000	NA	NA	NA
			10	1575000	139	0.00	NSG
			18	1533000	136	0.00	NSG
			32	1498000	133	0.00	NSG
			56	1561000	138	0.00	NSG
			100	1342000	119	0.00	NSG
		E-2	0	1130000	NA	NA	NA
			50	1524000	135	0.00	NSG
			100	1465000	130	0.00	NSG
		R-1 (R-5)[2.]	0	1130000	NA	NA	NA
			50	1646000	146	0.00	NSG
			100	1651000	146	0.00	NSG
		R-4[2.] (North Sonde)	0	1130000	NA	NA	NA
			10	1706000	151	0.00	NSG
			18	1759000	156	0.00	NSG
			32	1865000	165	0.00	NSG
			56	1797000	159	0.00	NSG
			100	1318000	117	0.00	NSG
		R-5[2.] (R-1)	0	1130000	NA	NA	NA
			10	1741000	NA	0.00	NSG
			18	1592000	NA	0.00	NSG
			32	1622000	NA	0.00	NSG
			56	1438000	NA	0.00	NSG
			100	1346000	NA	0.00	NSG
		M001a[2.] (D-1)	0	1130000	NA	NA	NA
			10	1552000	137	0.00	NSG
			18	1717000	152	0.00	NSG
			32	1791000	158	0.00	NSG
			56	1828000	162	0.00	NSG
			100	1122000	99	0.66	NSG

1. NSG- Not statistically significant and greater than the evaluation threshold (>80 % of the control). NSL - Not statistically significant and lower than the evaluation threshold (>80% of the control).

2. NPDES permitted station ID

SCRE Phase III Special Study
Quarterly Toxicity Results
Sample Date: August 12, 2015

aquatic bioassay & consulting laboratories, inc

SCRE Phase III Special Study

Test Organism	Endpoint	Effect	Station			
			ETS	E-1	E-2	R-1
Hyalella	Survival	NOEC (%)	100	100	100	100
		TUc	1	1	1	1
		EC25 (%)	>100	>100	>100	>100
		EC50 (%)	>100	>100	>100	>100
Hyalella	Growth	NOEC (%)	100	100	100	100
		TUc	1	1	1	1
		IC25 (%)	91.54	>100	>100	>100
		IC50 (%)	>100	>100	>100	>100
Trout	Survival	NOEC (%)	100	100	100	100
		TUa	0	0	0	0
Selenastrum	Cell Density (Count)	NOEC (%)	100	100	100	100
		TUc	1	1	1	1
		IC25 (%)	>100	>100	>100	>100
		IC50 (%)	>100	>100	>100	>100

NPDES Permitted

Test Organism	Endpoint	Effect	NPDES Station ID (Phase III Station ID)[1]		
			R-4 (North Sonde)	R-5 (R-1)	M001a (D-1)
Selenastrum	Cell Density (Count)	NOEC (%)	100	100	100
		TUc	1	1	1
		IC25 (%)	>100	>100	>100
		IC50 (%)	>100	>100	>100

SCRE Phase III Special Study
Quarterly Toxicity Results
Sample Date: August 12, 2015

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Test Organism	Test	Station	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[1.]
Hyalella	Survival (%)	ETS	0	74.0	NA	NA	NA
			50	80.0	108	0.00	NSG
			100	82.0	111	0.00	NSG
		E-1	0	74.0	NA	NA	NA
			50	86.0	116	0.00	NSG
			100	98.0	132	0.00	NSG
		E-2	0	74.0	NA	NA	NA
			50	92.0	124	0.00	NSG
			100	96.0	130	0.00	NSG
		R-1	0	74.0	NA	NA	NA
			50	92.0	124	0.00	NSG
			100	90.0	122	0.00	NSG
Hyalella	Growth (mg)	ETS	0	0.0250	NA	NA	NA
			50	0.0408	163	28.29	NSL
			100	0.0230	92	0.00	NSG
		E-1	0	0.0250	NA	NA	NA
			50	0.0398	159	0.00	NSG
			100	0.0934	374	0.00	NSG
		E-2	0	0.0250	NA	NA	NA
			50	0.0340	136	0.00	NSG
			100	0.0404	162	0.00	NSG
		R-1	0	0.0250	NA	NA	NA
			50	0.0320	128	0.00	NSG
			100	0.0298	119	0.00	NSG
Trout	Survival (%)	ETS	0	100.0	NA	NA	NA
			100	100.0	100	0.00	NSG
		E-1	0	100.0	NA	NA	NA
			100	100.0	100	0.00	NSG
		E-2	0	100.0	NA	NA	NA
			100	100.0	100	0.00	NSG
		R-1	0	100.0	NA	NA	NA
			100	100.0	100	0.00	NSG

SCRE Phase III Special Study
Quarterly Toxicity Results
Sample Date: August 12, 2015

Test Organism	Test	Station	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[1]
Selenastrum	Cell Density (Count)	ETS	0	1094000	NA	NA	NA
			10	1454000	133	0.00	NSG
			18	1999000	183	0.00	NSG
			32	1993000	182	0.00	NSG
			56	1870000	171	0.00	NSG
			100	1472000	135	0.00	NSG
		E-1 (R-003)[2]	0	1094000	NA	NA	NA
			10	1051000	96	3.95	NSG
			18	1194000	109	0.00	NSG
			32	1192000	109	0.00	NSG
			56	1144000	105	0.00	NSG
			100	1194000	109	0.00	NSG
		E-2	0	1094000	NA	NA	NA
			50	1195000	109	0.00	NSG
			100	1033000	94	0.00	NSG
		R-1 (R-5)[2]	0	1094000	NA	NA	NA
			50	1131000	103	0.00	NSG
			100	1269000	116	0.00	NSG
		R-4[2] (North Sonde)	0	1094000	NA	NA	NA
			10	1228000	112	0.00	NSG
			18	1374000	126	0.00	NSG
			32	1458000	133	0.00	NSG
			56	1546000	141	0.00	NSG
			100	1402000	128	0.00	NSG
		R-5[2] (R-1)	0	1094000	NA	NA	NA
			10	981800	90	10.24	NSG
			18	957800	88	12.43	SG
			32	1088000	99	0.50	NSG
			56	1057000	97	3.34	NSG
			100	1213000	111	0.00	NSG
		M001a[2] (D-1)	0	1094000	NA	NA	NA
			10	1557000	142	0.00	NSG
			18	1781000	163	0.00	NSG
			32	1711000	156	0.00	NSG
			56	1675000	153	0.00	NSG
			100	1239000	113	0.00	NSG

1. NSG- Not statistically significant and greater than the evaluation threshold (>80 % of the control). NSL - Not statistically significant and lower than the evaluation threshold (>80% of the control). SG - Statistically significant and greater than the evaluation threshold (>80% of the control).
2. NPDES permitted station ID

SCRE Phase III Special Study
Quarterly Toxicity Results
Sample Date: November 12, 2015

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SCRE Phase III Special Study

Test Organism	Endpoint	Effect	Station			
			ETS	E-1	E-2	R-1
Hyalella	Survival	NOEC (%)	100	100	100	100
		TUc	1	1	1	1
		EC25 (%)	>100	>100	>100	>100
		EC50 (%)	>100	>100	>100	>100
Hyalella	Growth	NOEC (%)	100	100	100	100
		TUc	1	1	1	1
		IC25 (%)	>100	>100	>100	>100
		IC50 (%)	>100	>100	>100	>100
Trout	Survival	NOEC (%)	100	65	35	50
		TUa	0	0.91	>1.00	1.00
Selenastrum	Cell Density (Count)	NOEC (%)	100	100	100	100
		TUc	1	1	1	1
		IC25 (%)	>100	>100	>100	>100
		IC50 (%)	>100	>100	>100	>100

NPDES Permitted

Test Organism	Endpoint	Effect	NPDES Station ID (Phase III Station ID)[1]		
			R-4 (North Sonde)	R-5 (R-1)	M001a (D-1)
Selenastrum	Cell Density (Count)	NOEC (%)	100	100	100
		TUc	1	1	1
		IC25 (%)	>100	>100	>100
		IC50 (%)	>100	>100	>100

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Test Organism	Test	Station	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[1.]
Hyalella	Survival (%)	ETS	0	82.0	NA	NA	NA
			50	94.0	115	0.00	NSG
			100	94.0	115	0.00	NSG
		E-1	0	86.0	NA	NA	NA
			50	94.0	109	0.00	NSG
			100	98.0	114	0.00	NSG
		E-2	0	86.0	NA	NA	NA
			50	96.0	112	0.00	NSG
			100	94.0	109	0.00	NSG
		R-1	0	82.0	NA	NA	NA
			50	94.0	115	0.00	NSG
			100	98.0	120	0.00	NSG
Hyalella	Growth (mg)	ETS	0	0.0828	NA	NA	NA
			50	0.0992	120	0.00	NSG
			100	0.0910	110	0.00	NSG
		E-1	0	0.0544	NA	NA	NA
			50	0.0414	76	23.90	NSL
			100	0.0424	78	22.06	NSL
		E-2	0	0.0544	NA	NA	NA
			50	0.0702	129	0.00	NSG
			100	0.0498	92	8.46	NSG
		R-1	0	0.0828	NA	NA	NA
			50	0.0570	69	31.16	NSL
			100	0.0772	93	6.76	NSG
Trout	Survival (%)	ETS	0	100.0	NA	NA	NA
			100	100.0	100.00	0.00	NSG
		E-1	0	100.0	NA	NA	NA
			100	65.0	65.00	35.00	SL
		E-2	0	100.0	NA	NA	NA
			100	35.0	35.00	65.00	SL
		R-1	0	100.0	NA	NA	NA
			100	50.0	50.00	50.00	SL

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Test Organism	Test	Station	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[1.]
Selenastrum	Cell Density (Count)	ETS	0	1203000	NA	NA	NA
			10	1671000	139	0.00	NSG
			18	1835000	153	0.00	NSG
			32	1800000	150	0.00	NSG
			56	1731000	144	0.00	NSG
			100	1899000	158	0.00	NSG
		E-1 (R-003)[2.]	0	1203000	NA	NA	NA
			10	1416000	118	0.00	NSG
			18	1544000	128	0.00	NSG
			32	1601000	133	0.00	NSG
			56	1562000	130	0.00	NSG
			100	1646000	137	0.00	NSG
		E-2	0	1208000	NA	NA	NA
			50	1407000	116	0.00	NSG
			100	1498000	124	0.00	NSG
		R-1 (R-5)[2.]	0	1203000	NA	NA	NA
			50	1461000	121	0.00	NSG
			100	1380000	115	0.00	NSG
		R-4[2.] (North Sonde)	0	1203000	NA	NA	NA
			10	1562000	130	0.00	NSG
			18	1460000	121	0.00	NSG
			32	1700000	141	0.00	NSG
			56	1724000	143	0.00	NSG
			100	1627000	135	0.00	NSG
		R-5[2.] (R-1)	0	1203000	NA	NA	NA
			10	1413000	117	0.00	NSG
			18	1547000	129	0.00	NSG
			32	1446000	120	0.00	NSG
			56	1503000	125	0.00	NSG
			100	1551000	129	0.00	NSG
		M001a[2.] (D-1)	0	1203000	NA	NA	NA
			10	1555000	129	0.00	NSG
			18	1759000	146	0.00	NSG
			32	1619000	135	0.00	NSG
			56	1517000	126	0.00	NSG
			100	1218000	101	0.00	NSG

1. NSG- Not statistically significant and greater than the evaluation threshold (>80 % of the control). NSL - Not statistically significant and lower than the evaluation threshold (>80% of the control). SG - Statistically significant and greater than the evaluation threshold (>80% of the control).
2. NPDES permitted station ID

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Test Organism	Test	Station	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[1.]
Chronic Urchin	Fertilization (%)	ETS	0	100.0	NA	NA	NA
			50	100.0	100	0.00	NSG
			100	100.0	100	0.00	NSG
		E-1	0	100.0	NA	NA	NA
			50	100.0	100	0.00	NSG
			100	100.0	100	0.00	NSG
		E-2	0	100.0	NA	NA	NA
			50	100.0	100	0.00	NSG
			100	100.0	100	0.00	NSG
		R-1	0	100.0	NA	NA	NA
			50	100.0	100	0.00	NSG
			100	100.0	100	0.00	NSG
Selenastrum	Cell Density (Count)	ETS[2.]	0				
			50				
			100				

1. NSG- Not statistically significant and greater than the evaluation threshold (>80 % of the control).
2. Selenasturm test conducted by the City of Ventura. Please contact the City to request these results.

NPDES Permitted

Test Organism	Test	Station[1]	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[2.]
Selenastrum	Cell Density (Count)	R-4[2] (North Sonde)	0	1432000	NA	NA	NA
			10	1840000	128	0.00	NSG
			18	2094000	146	0.00	NSG
			32	1920000	134	0.00	NSG
			56	1726000	121	0.00	NSG
			100	1542000	108	0.00	NSG
		R-5[2] (R-1)	0	1432000	NA	NA	NA
			10	1695000	118	0.00	NSG
			18	1595000	111	0.00	NSG
			32	1130000	79	21.10	SL
			56	568000	40	60.32	SL
			100	81000	6	94.34	SL

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NPDES Permitted (Continued)

Test Organism	Test	Station[1]	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[2.]
		M001a	0	1432000	NA	NA	NA
		(D-1)	10	2036000	142	0.00	NSG
			18	2175000	152	0.00	NSG
			32	2429000	170	0.00	NSG
			56	2011000	140	0.00	NSG
			100	1487000	104	0.00	NSG
		R-003	0	1432000	NA	NA	NA
		(E-1)	10	1588000	111	0.00	NSG
			18	1570000	110	0.00	NSG
			32	1487000	104	0.00	NSG
			56	1287000	90	10.09	NSG
			100	772800	54	46.02	SL

1. (NPDES permitted station ID)
2. Stations R-4 and R-5 were collected on February 25, 2015
3. NSG- Not statistically significant and greater than the evaluation threshold (>80 % of the control); SL - Statistically significant and less than the evluation threshold (>80% of the control).

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Test Organism	Test	Station	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[1.]
Chronic Urchin	Fertilization (%)	ETS	0	100.0	NA	NA	NA
			50	100.0	100	0.00	NSG
			100	100.0	100	0.00	NSG
		E-1	0	100.0	NA	NA	NA
			50	100.0	100	0.00	NSG
			100	100.0	100	0.00	NSG
		E-2	0	100.0	NA	NA	NA
			50	100.0	100	0.00	NSG
			100	100.0	100	0.00	NSG
		R-1	0	100.0	NA	NA	NA
			50	100.0	100	0.00	NSG
			100	100.0	100	0.00	NSG
Selenastrum	Cell Density (Count)	ETS[2.]	0				
			50				
			100				

1. NSG- Not statistically significant and greater than the evaluation threshold (>80 % of the control).
2. Selenasturm test conducted by the City of Ventura. Please contact the City to request these results.

NPDES Permitted

Test Organism	Test	Station[1]	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[2.]
Selenastrum	Cell Density (Count)	R-4[2] (North Sonde)	0	1432000	NA	NA	NA
			10	1840000	128	0.00	NSG
			18	2094000	146	0.00	NSG
			32	1920000	134	0.00	NSG
			56	1726000	121	0.00	NSG
			100	1542000	108	0.00	NSG
		R-5[2] (R-1)	0	1432000	NA	NA	NA
			10	1695000	118	0.00	NSG
			18	1595000	111	0.00	NSG
			32	1130000	79	21.10	SL
			56	568000	40	60.32	SL
			100	81000	6	94.34	SL

SCRE Phase III Special Study
Quarterly Toxicity Results
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NPDES Permitted (Continued)

Test Organism	Test	Station[1]	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[2.]
		M001a	0	1432000	NA	NA	NA
		(D-1)	10	2036000	142	0.00	NSG
			18	2175000	152	0.00	NSG
			32	2429000	170	0.00	NSG
			56	2011000	140	0.00	NSG
			100	1487000	104	0.00	NSG
		R-003	0	1432000	NA	NA	NA
		(E-1)	10	1588000	111	0.00	NSG
			18	1570000	110	0.00	NSG
			32	1487000	104	0.00	NSG
			56	1287000	90	10.09	NSG
			100	772800	54	46.02	SL

1. (NPDES permitted station ID)
2. Stations R-4 and R-5 were collected on February 25, 2015
3. NSG- Not statistically significant and greater than the evaluation threshold (>80 % of the control); SL - Statistically significant and less than the evluation threshold (>80% of the control).

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Quarterly Toxicity Results
Sample Date: May 10, 2016

SCRE Phase III Special Study

Test Organism	Endpoint	Effect	Station: ETS	E-1	E-2	R-005
Urchin	Fertilization (%)	NOEC (%)	100	NA	100	100
		TUc	1	NA	1	1
		EC25 (%)	>100	NA	>100	>100
		EC50 (%)	>100	NA	>100	>100
Selenastrum	Cell Density (Count)	NOEC (%)	*	100	NA	56
		TUc		1		1.79
		EC25 (%)		>100		96.58
		EC50 (%)		>100		>100
Hyalella	Survival	NOEC (%)	100	100	NA	NA
		TUc	1	1		
		EC25 (%)	>100	>100		
		EC50 (%)	>100	>100		
Hyalella	Growth	NOEC (%)	100	100	NA	NA
		TUc	1	1		
		IC25 (%)	>100	>100		
		IC50 (%)	>100	>100		
Trout	Survival	NOEC (%)	100	100	NA	NA
		TUa	0	0		

NA= Not applicable, no Selenastrum toxicity required at these sites.

*Selenasturm test conducted by the City of Ventura. Please contact the City to request these results.

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Quarterly Toxicity Results
Sample Date: May 10, 2016

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NPDES Permitted

Test Organism	Endpoint	Effect	NPDES Station ID (Phase III Station ID) R-4 (North Sonde)	R-5 (R-1)	M001a (D-1)	R-003 (E-1)
Selenastrum	Cell Density (Count)	NOEC (%)	100	NA	100	NA
		TUc	1		1	
		EC25 (%)	>100		>100	
		EC50 (%)	>100		>100	

SCRE Phase III Special Study
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Sample Date: February 10, 2016

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Phase III Special Study

Test Organism	Test	Station	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[1.]
Chronic Urchin	Fertilization (%)	ETS	0	94.0	NA	NA	NA
			50	93.3	99	0.08	NSG
			100	94.5	101	0.00	NSG
		E-2	0	95.5	NA	NA	NA
			50	95.3	100	0.00	NSG
			100	95.5	100	0.00	NSG
		R-005	0	94.5	NA	NA	NA
			50	96.8	102	0.00	NSG
			100	97.3	103	0.00	NSG
Selenastrum	Cell Density (Count)	E-1	0	1371000	NA	NA	NA
			10	1442000	105	0.00	NSG
			18	1675000	122	0.00	NSG
			32	1765000	129	0.00	NSG
			56	1746000	127	0.00	NSG
			100	1424000	104	0.00	NSG
		R-005	0	1371000	NA	NA	NA
			10	1593000	116	0.00	NSG
			18	1661000	121	0.00	NSG
			32	1619000	118	0.00	NSG
			56	1780000	130	0.00	NSG
			100	1170000	85	14.68	SG
Hyalella	Survival (%)	ETS	0	82.0	NA	NA	NA
			50	84.0	102	0.00	NSG
			100	84.0	102	0.00	NSG
		E-1	0	82.0	NA	NA	NA
			50	90.0	110	0.00	NSG
			100	84.0	102	0.00	NSG
Hyalella	Growth (mg)	ETS	0	0.0176	NA	NA	NA
			50	0.0622	353	0.00	NSG
			100	0.0976	555	0.00	NSG
		E-1	0	0.0176	NA	NA	NA
			50	0.0454	258	23.90	NSG
			100	0.0730	415	22.06	NSG
Trout	Survival (%)	ETS	0	100.0	NA	NA	NA
			100	100.0	100.00	0.00	NSG
		E-1	0	100.0	NA	NA	NA
			100	100.0	100.00	0.00	NSG

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NPDES Permitted

Test Organism	Test	Station	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[1.]
Selenastrum	Cell Density	R-4	0	1371000	NA	NA	NA
	(Count)	(North Sonde)	10	1675000	122	0.00	NSG
			18	1735000	127	0.00	NSG
			32	1885000	137	0.00	NSG
			56	1762000	129	0.00	NSG
			100	1540000	112	0.00	NSG
		M001a	0	1371000	NA	NA	NA
		(D-1)	10	1631000	119	0.00	NSG
			18	1756000	128	0.00	NSG
			32	1855000	135	0.00	NSG
			56	1777000	130	0.00	NSG
			100	1438000	105	0.00	NSG

1. NSG- Not statistically significant and greater than the evaluation threshold (>80 % of the control).
SG-Statistically significant and greater than the evaluation threshold (>80 % of the control).

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Sample Date: August 10, 2016

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Test Organism	Endpoint	Effect	Station			
			ETS	**E-1**	**E-2**	**R-005**
Urchin	Fertilization (%)	NOEC (%)	100	NA	100	100
		TUc	1		1	1
		EC25 (%)	>100		>100	>100
		EC50 (%)	>100		>100	>100
Selenastrum	Cell Density (Count)	NOEC (%)	*	100	NA	100
		TUc		1		1
		EC25 (%)		>100		>100
		EC50 (%)		>100		>100
Hyalella	Survival	NOEC (%)	100	100	NA	NA
		TUc	1	1		
		EC25 (%)	>100	>100		
		EC50 (%)	>100	>100		
Hyalella	Growth	NOEC (%)	100	100	NA	NA
		TUc	1	1		
		IC25 (%)	>100	86.32		
		IC50 (%)	>100	>100		
Trout	Survival	NOEC (%)	100	100	NA	NA
		TUa	0	0		

NA= Not applicable, no Selenastrum toxicity required at these sites.

*Selenasturm test conducted by the City of Ventura. Please contact the City to request these results.

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NPDES Permitted

Test Organism	Endpoint	Effect	NPDES Station ID (Phase III Station ID)			
			R-4 (North Sonde)	R-5 (R-1)	M001a (D-1)	R-003 (E-1)
Selenastrum	Cell Density (Count)	NOEC (%)	100	NA	56	NA
		TUc	1		1.786	
		EC25 (%)	>100		84.08	
		EC50 (%)	>100		>100	

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Test Organism	Test	Station	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[1.]
Chronic Urchin	Fertilization (%)	ETS	0	93.8	NA	NA	NA
			50	95.0	101	0.00	NSG
			100	94.5	101	0.00	NSG
		E-2	0	92.2	NA	NA	NA
			50	93.8	102	0.00	NSG
			100	92.8	101	0.00	NSG
		R-005	0	93.3	NA	NA	NA
			50	93.8	101	0.00	NSG
			100	96.5	103	0.00	NSG
Selenastrum	Cell Density (Count)	E-1	0	1044000	NA	NA	NA
			10	1120000	107	0.00	NSG
			18	1103000	106	0.00	NSG
			32	1280000	123	0.00	NSG
			56	1390000	133	0.00	NSG
			100	1343000	129	0.00	NSG
		R-005	0	1044000	NA	NA	NA
			10	1040000	100	0.31	NSG
			18	1106000	106	0.00	NSG
			32	1096000	105	0.00	NSG
			56	1173000	112	0.00	NSG
			100	1278000	122	0.00	NSG
Hyalella	Survival (%)	ETS	0	84.0	NA	NA	NA
			50	100.0	119	0.00	NSG
			100	96.0	114	0.00	NSG
		E-1	0	84.0	NA	NA	NA
			50	100.0	119	0.00	NSG
			100	100.0	119	0.00	NSG
Hyalella	Growth (mg)	ETS	0	0.0186	NA	NA	NA
			50	0.0824	443	0.00	NSG
			100	0.0734	395	0.00	NSG
		E-1	0	0.0186	NA	NA	NA
			50	0.0430	231	0.00	NSG
			100	0.0202	109	0.00	NSG
Trout	Survival (%)	ETS	0	100.0	NA	NA	NA
			100	100.0	100.00	0.00	NSG
		E-1	0	100.0	NA	NA	NA
			100	100.0	100.00	0.00	NSG

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NPDES Permitted

Test Organism	Test	Station	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[1.]
Selenastrum	Cell Density	R-4	0	1044000	NA	NA	NA
	(Count)	(North Sonde)	10	1262000	121	0.00	NSG
			18	1352000	130	0.00	NSG
			32	1571000	150	0.00	NSG
			56	1654000	158	0.00	NSG
			100	1465000	140	0.00	NSG
		M001a	0	1044000	NA	NA	NA
		(D-1)	10	1063000	102	0.00	NSG
			18	1139000	109	0.00	NSG
			32	1092000	105	0.00	NSG
			56	1065000	102	0.00	NSG
			100	6703000	642	0.00	SG

1. NSG- Not statistically significant and greater than the evaluation threshold (>80 % of the control).
SG-Statistically significant and greater than the evaluation threshold (>80 % of the control).

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Quarterly Toxicity Results
Sample Date: November 8, 2016

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SCRE Phase III Special Study

Test Organism	Endpoint	Effect	Station			
			ETS	**E-1**	**E-2**	**R-005**
Urchin	Fertilization (%)	NOEC (%)	100	100	100	100
		TUc	1	1	1	1
		EC25 (%)	>100	>100	>100	>100
		EC50 (%)	>100	>100	>100	>100

NA= Not applicable, no Selenastrum toxicity required at these sites.

SCRE Phase III Special Study
Quarterly Toxicity Results
Sample Date: November 8, 2016

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Phase III Special Study

Test Organism	Test	Station	Concentration	Mean	Percent Control	Percent Effect	Significant Effect[1.]
Chronic Urchin	Fertilization (%)	ETS	0	80.0	NA	NA	NA
			50	81.5	102	0.00	NSG
			100	86.0	107	0.00	NSG
		E-1	0	80.3	NA	NA	NA
			50	77.0	84	4.05	NSG
			100	66.5	73	17.13	NSL
		E-2	0	91.3	NA	NA	NA
			50	86.0	94	5.75	NSG
			100	71.0	78	22.19	NSL
		R-005	0	80.3	NA	NA	NA
			50	82.0	102	0.00	NSG
			100	67.3	84	16.20	NSG

1. NSG- Not statistically significant and greater than the evaluation threshold (>80 % of the control).
SG- Statistically significant and greater than the evaluation threshold (>80 % of the control).
NSL- Not statistically significant and less than the evaluation threshold (<80 % of the control).

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Appendix F

GIS Estimates of Future Habitat Types by VWRF Discharge Scenario

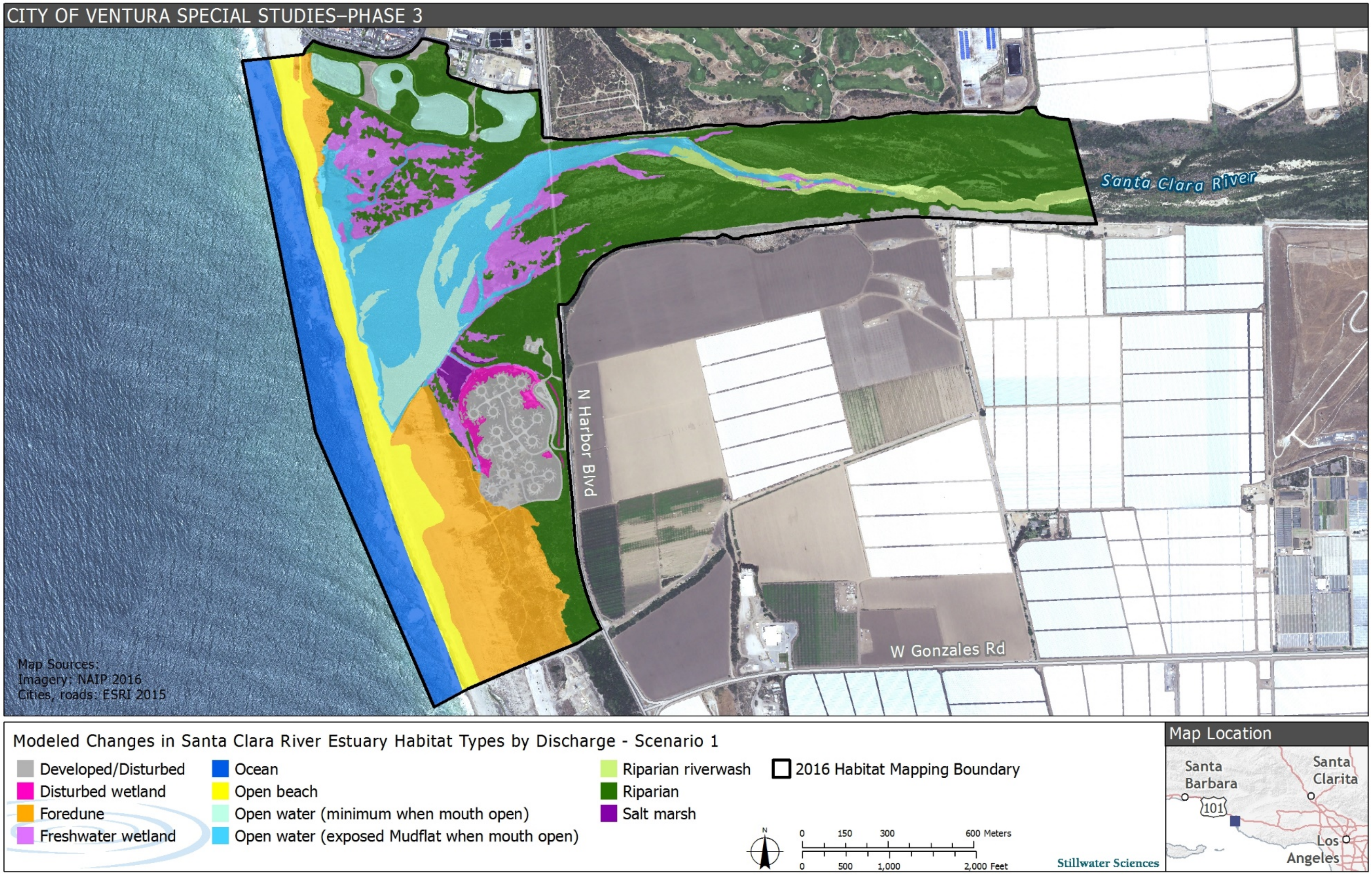

Figure F-1. GIS modeled changes in SCRE habitat types by discharge (Scenario 1).

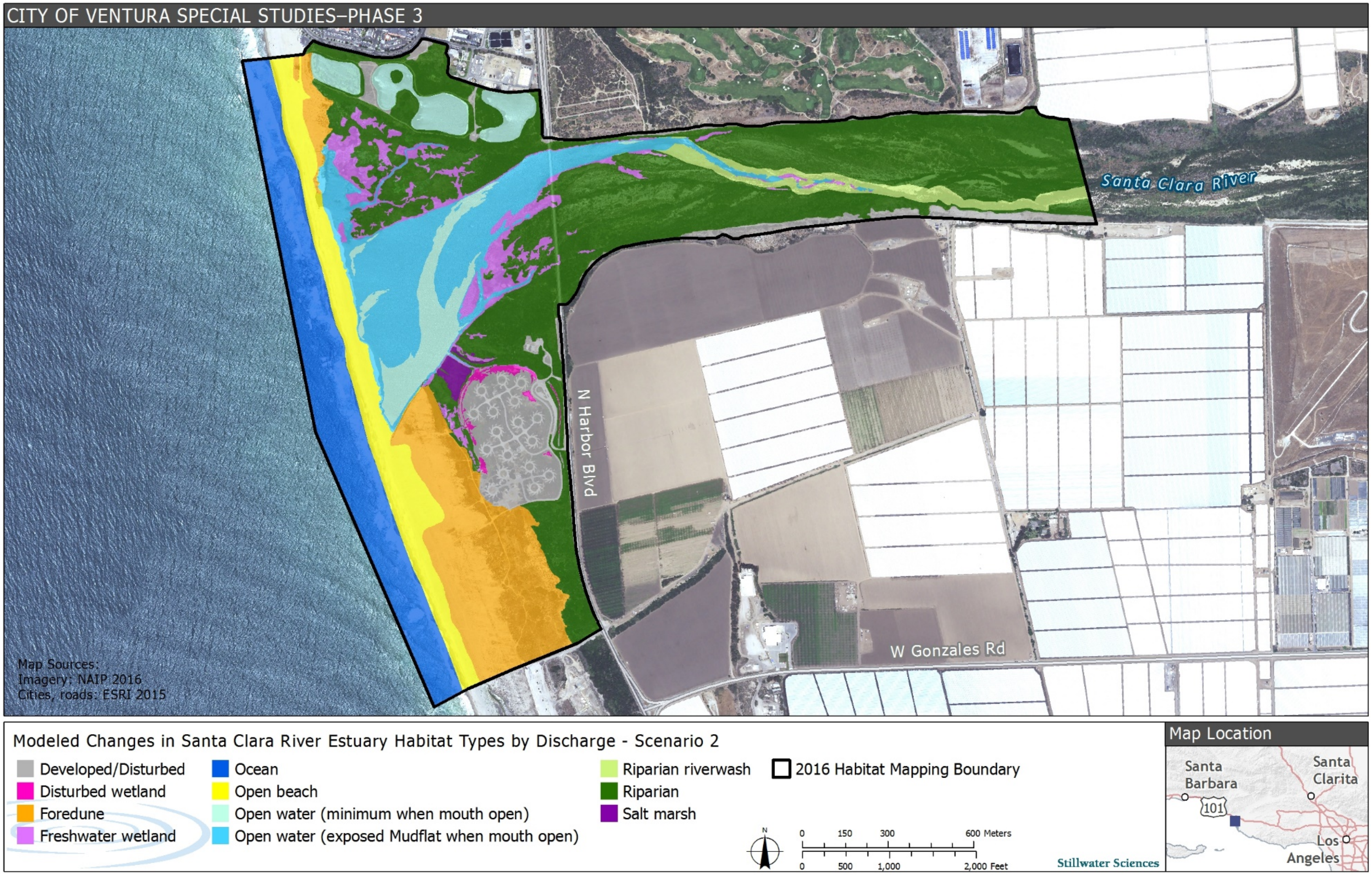

Figure F-2. GIS modeled changes in SCRE habitat types by discharge (Scenario 2).

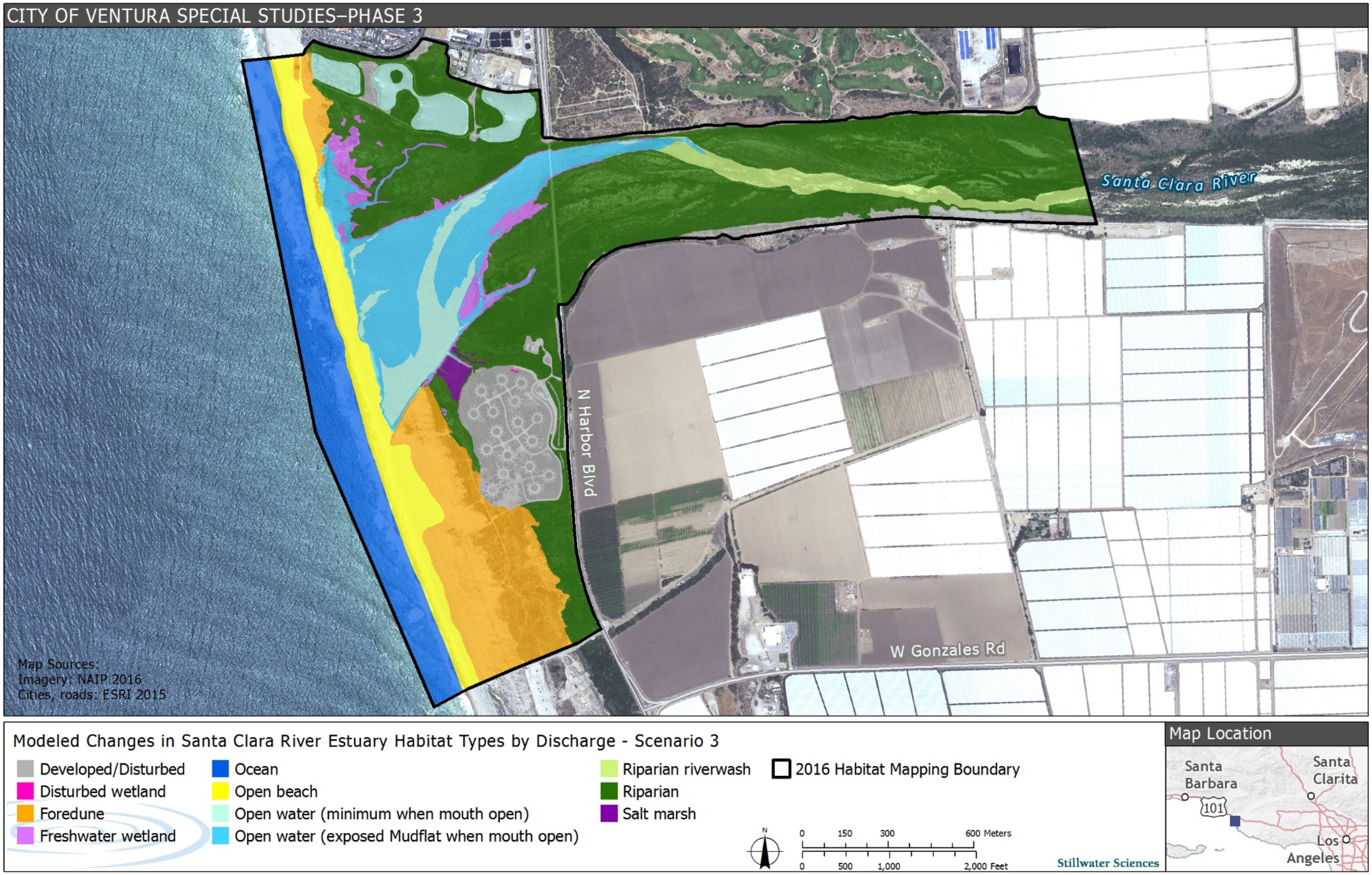

Figure F-3. GIS modeled changes in SCRE habitat types by discharge (Scenario 3).

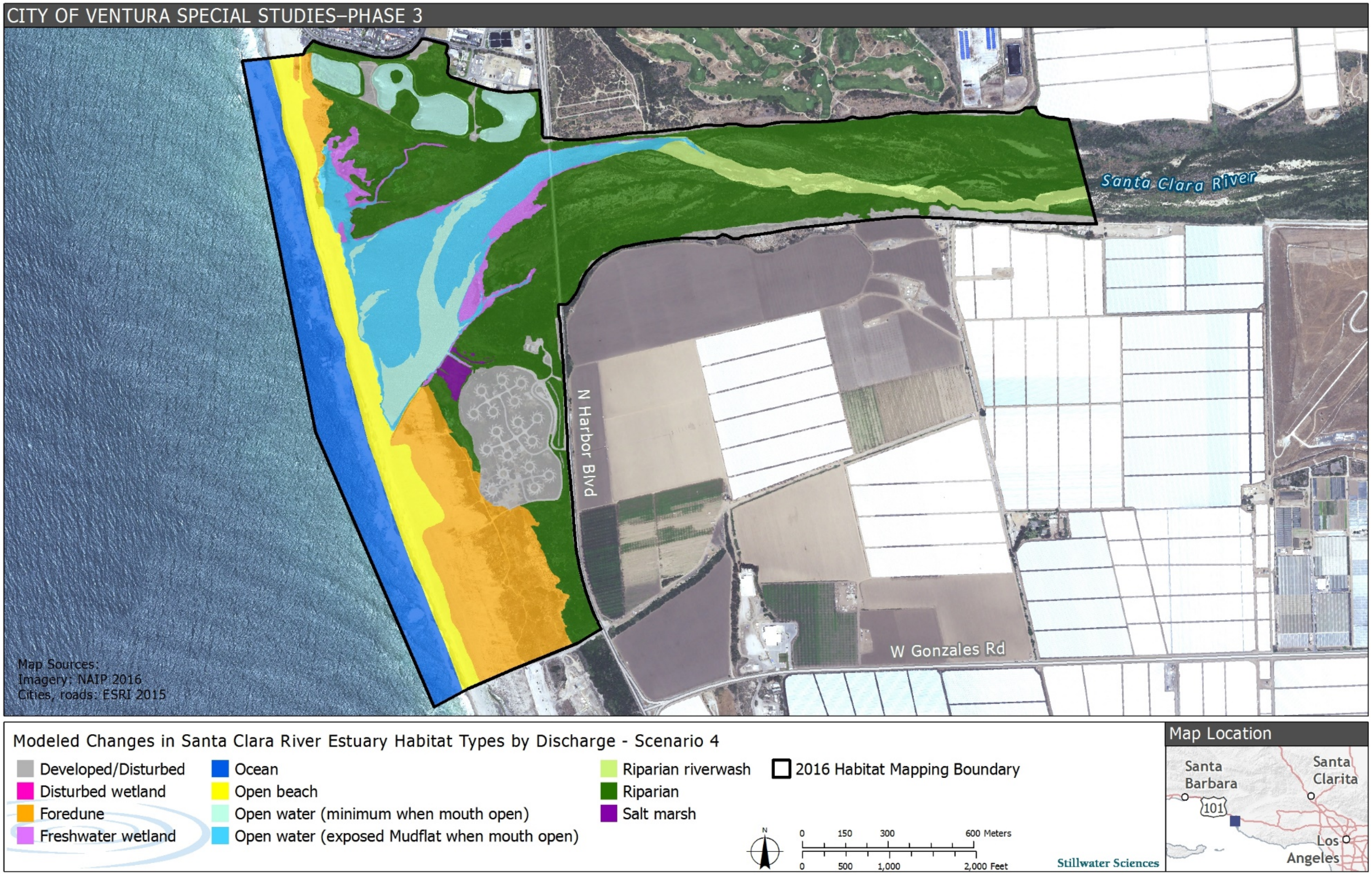

Figure F-4. GIS modeled changes in SCRE habitat types by discharge (Scenario 4).

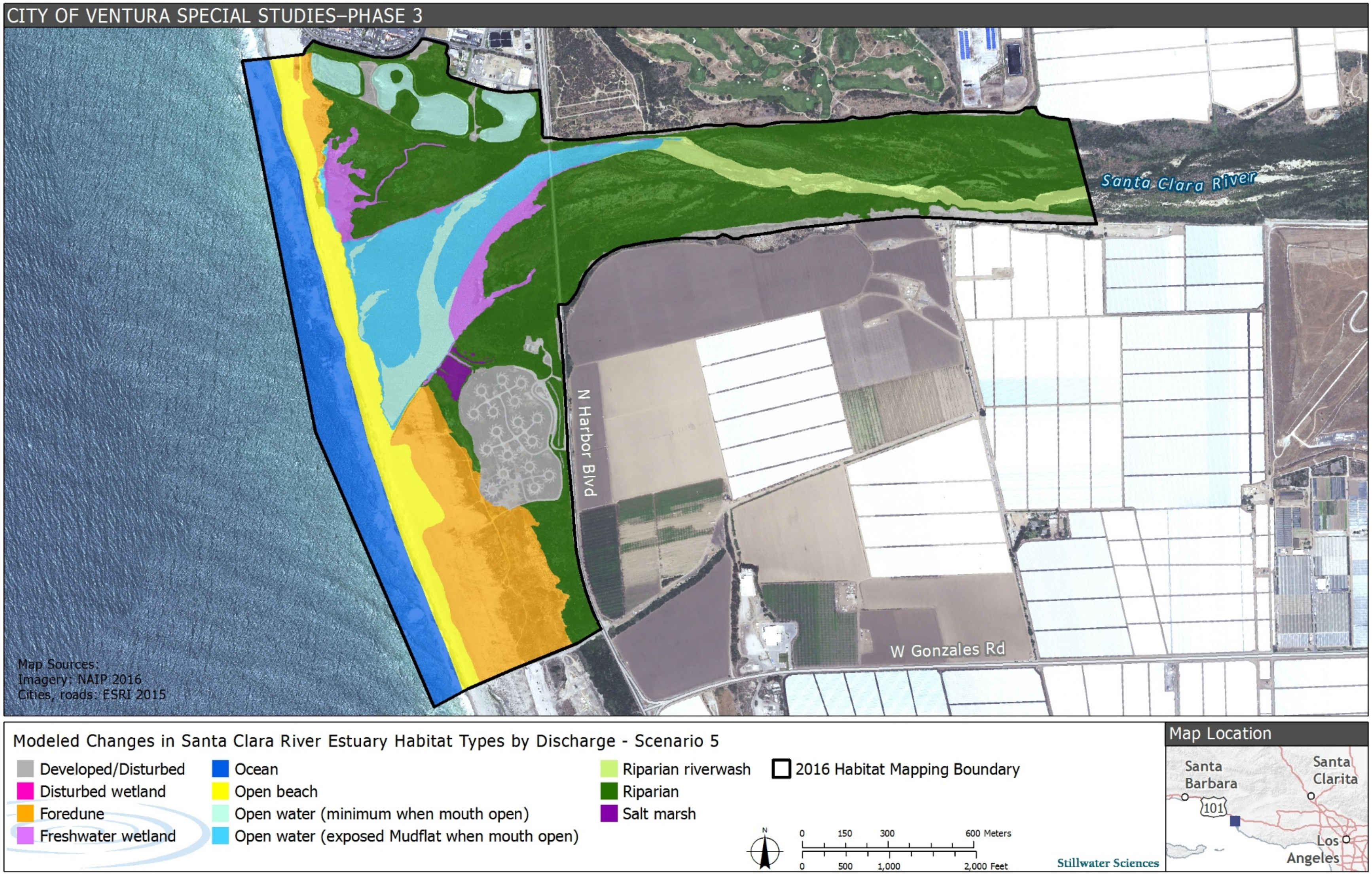

Figure F-5. GIS modeled changes in SCRE habitat types by discharge (Scenario 5).

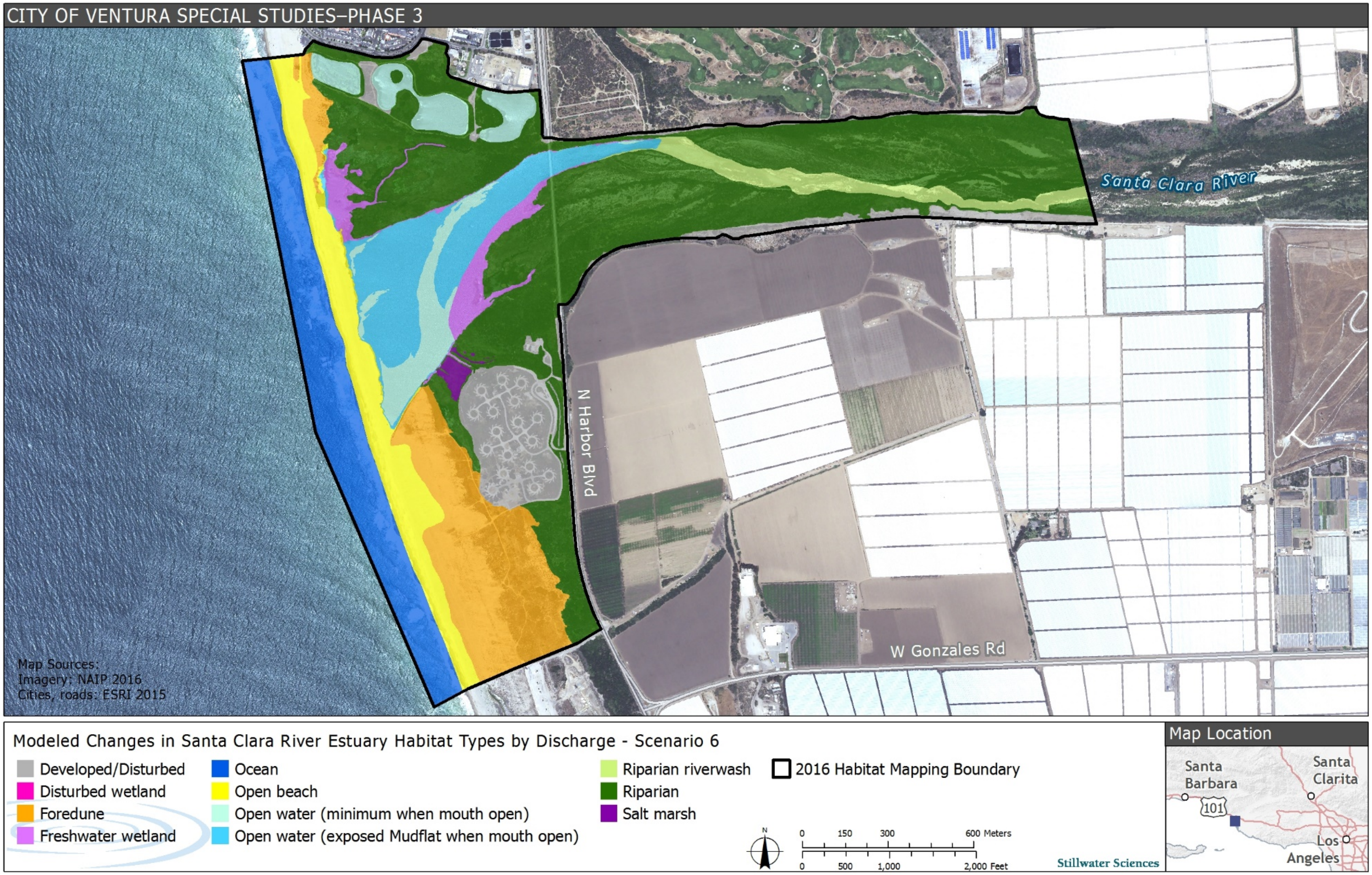

Figure F-6. GIS modeled changes in SCRE habitat types by discharge (Scenario 6).

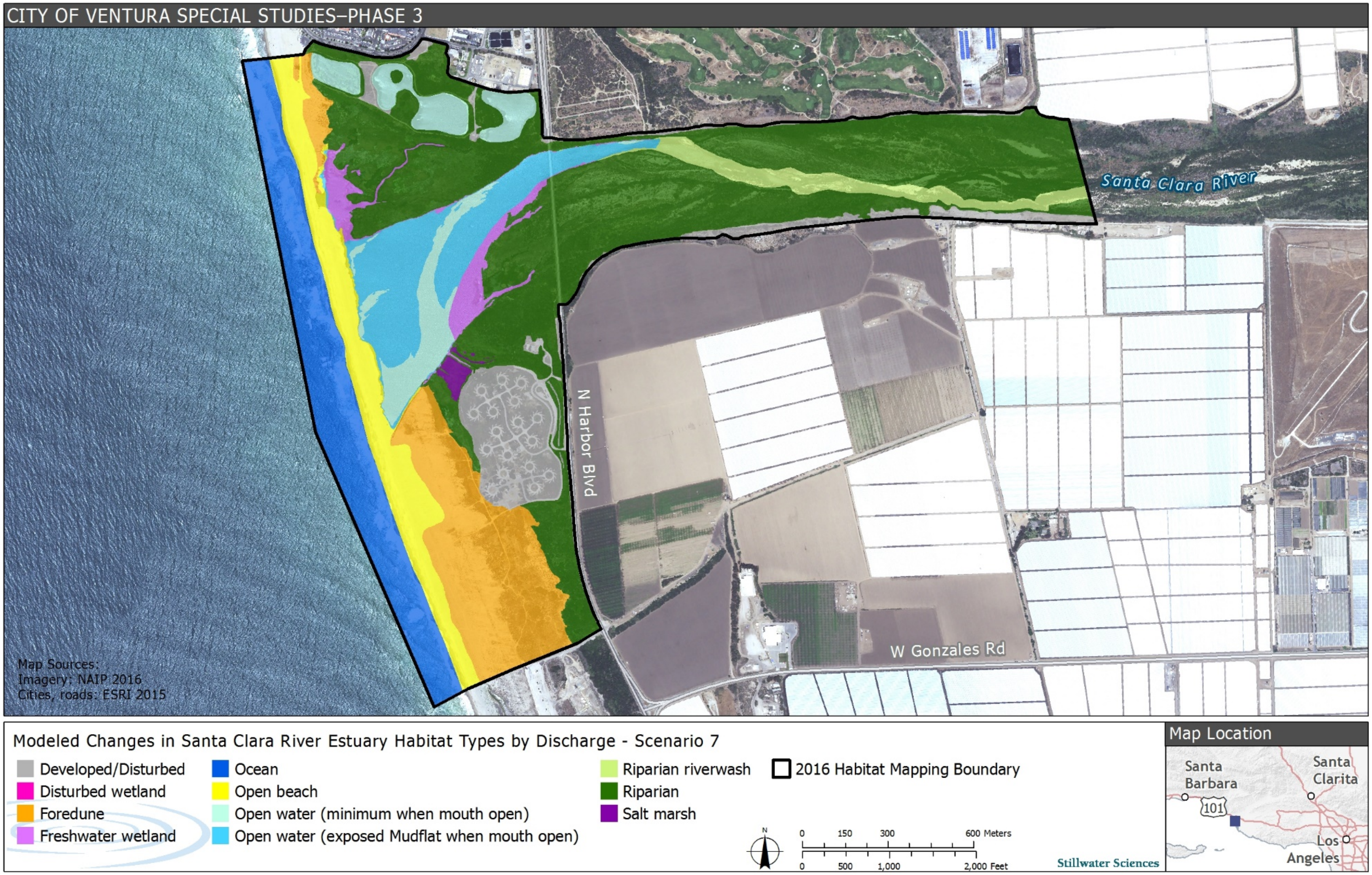

Figure F-7. GIS modeled changes in SCRE habitat types by discharge (Scenario 7).

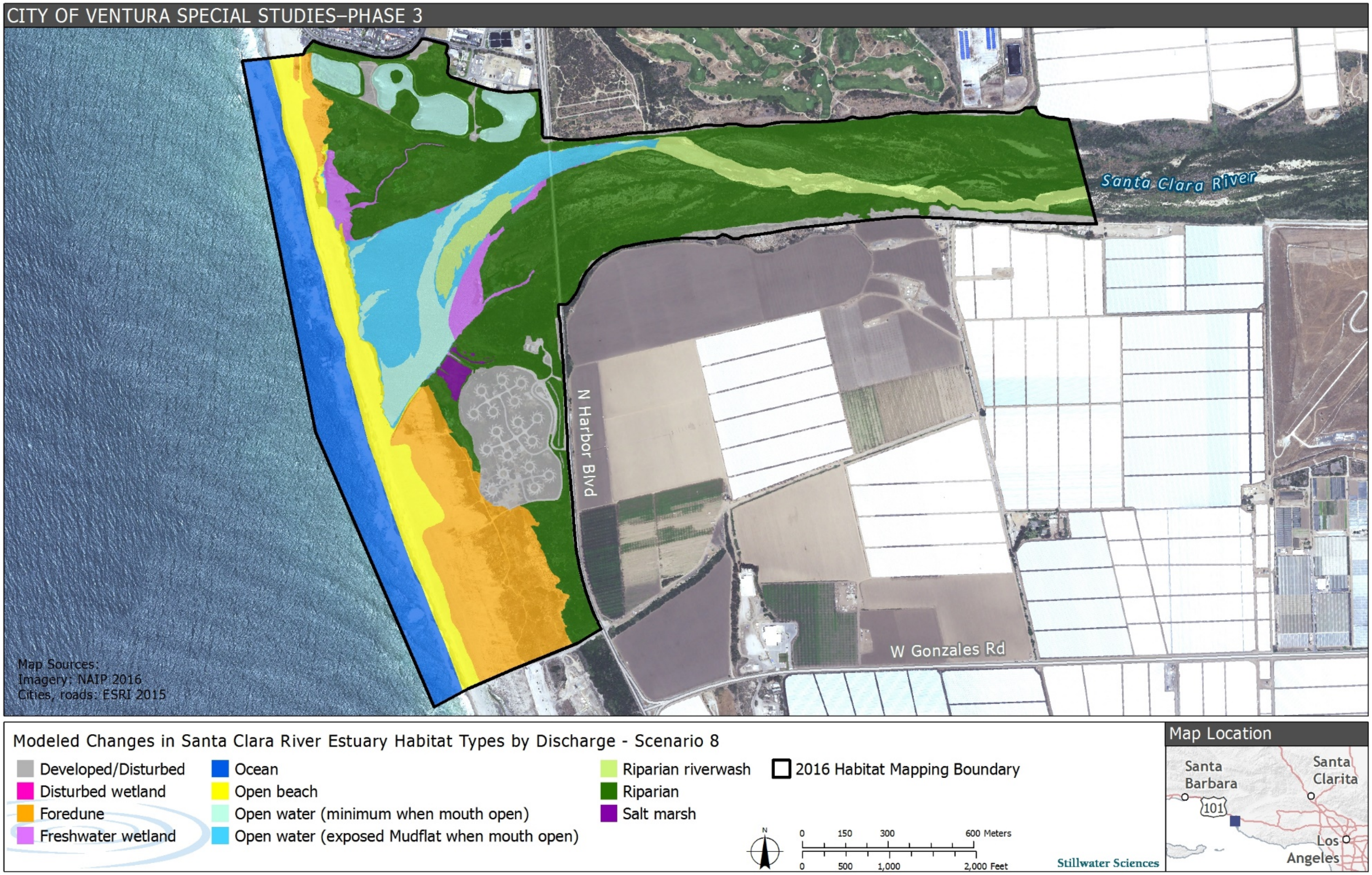

Figure F-8. GIS modeled changes in SCRE habitat types by discharge (Scenario 8).

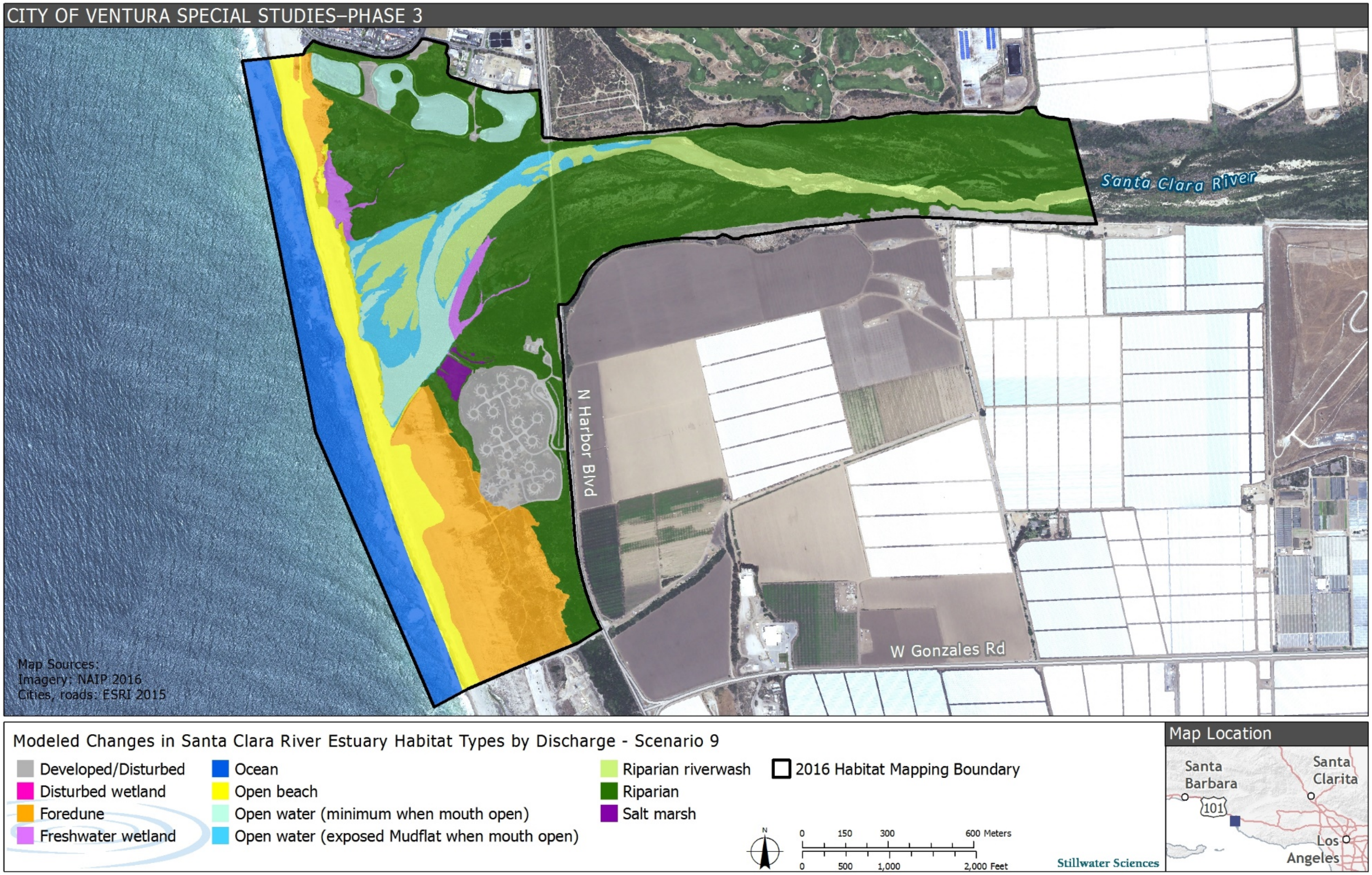

Figure F-9. GIS modeled changes in SCRE habitat types by discharge (Scenario 9).

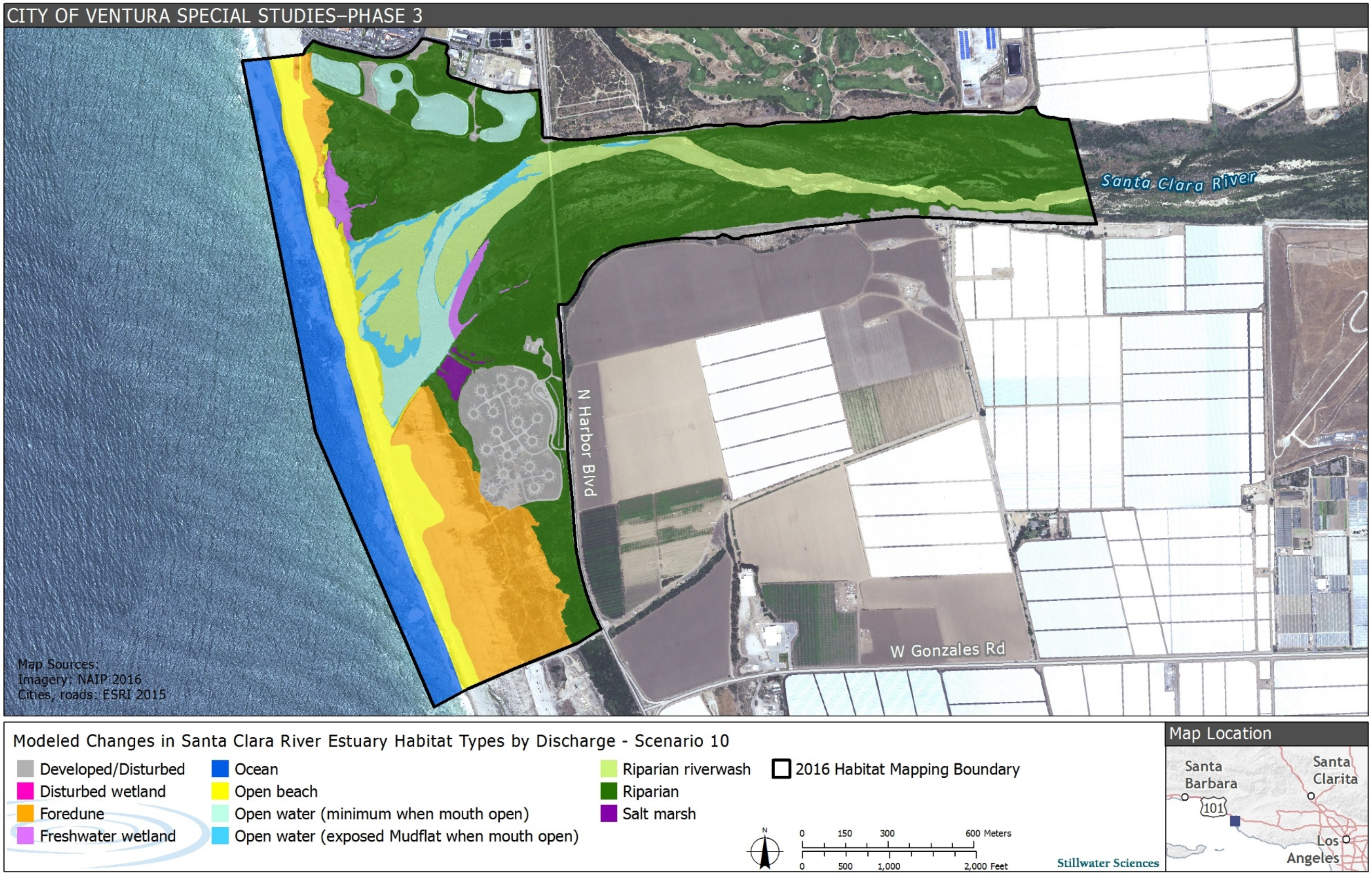

Figure F-10. GIS modeled changes in SCRE habitat types by discharge (Scenario 10).

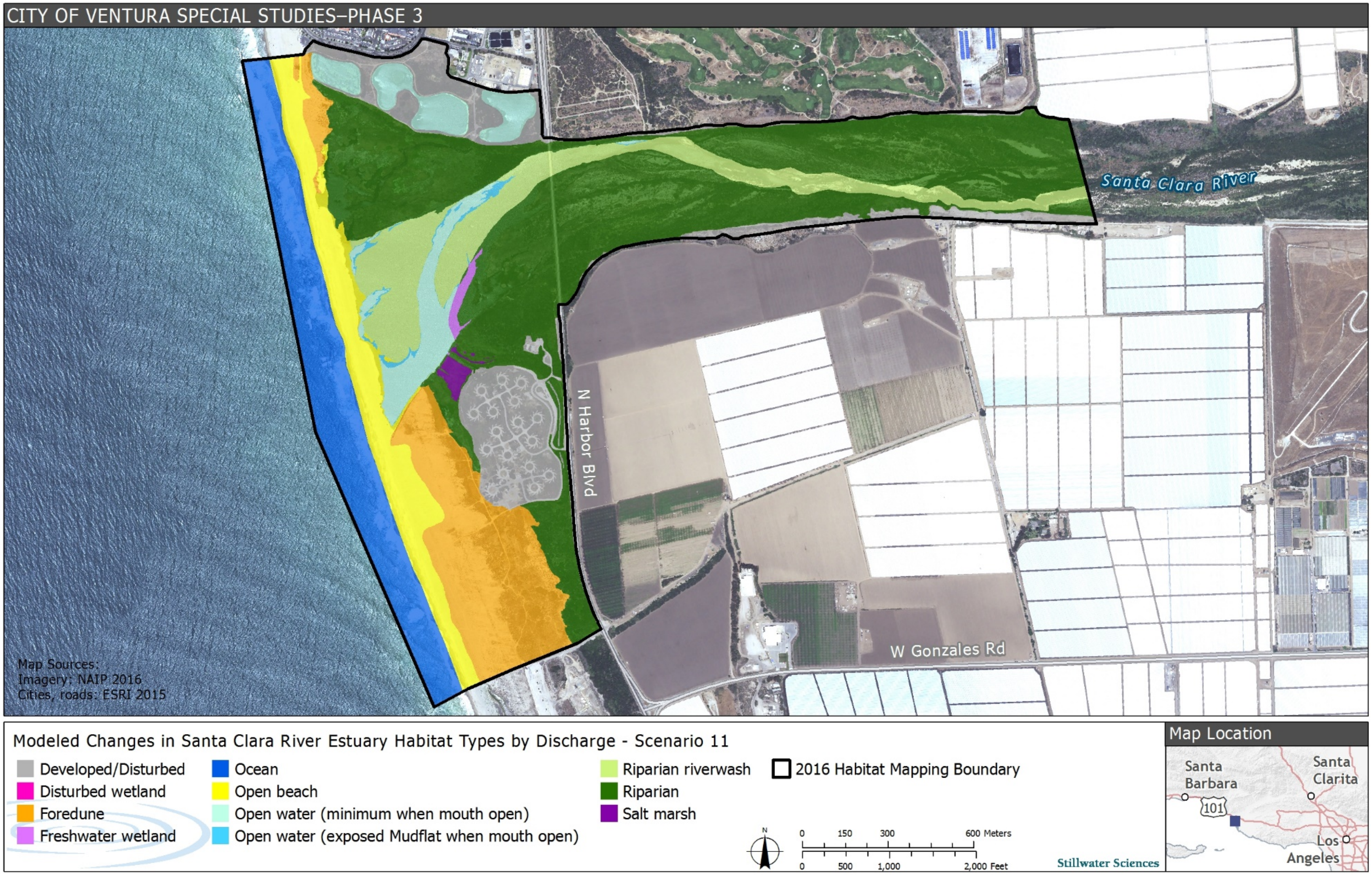

Figure F-11. GIS modeled changes in SCRE habitat types by discharge (Scenario 11).

Appendix G

Water-Year Type Analysis (1928-2016)

Table G-1. Historical water-year types of the lower Santa Clara River based on local river discharge and rainfall recordings made between 1928 and 2016.

Water Year	Water-Type from River Discharge [A, B]						Water-Type from Rainfall [A, C]				Water-Year Types for Lower Watershed 1928–2016 [E]
	Lower Santa Clara River		Santa Paula Creek		Sespe Creek		Downtown Ventura		Santa Paula		
	Total Runoff (acre-feet)	WY Type [D]	Total Runoff (acre-feet)	WY Type [D]	Total Runoff (acre-feet)	WY Type [D]	Total Rainfall (inches)	WY Type [D]	Total Rainfall (inches)	WY Type [D]	
1928	15,737	Normal	1,332	Dry	16,813	Dry	11.82	Normal	10.41	Dry	**Normal**
1929	29,352	Normal	1,801	Dry	16,729	Dry	12.03	Normal	13.42	Normal	**Normal**
1930	15,547	Normal	1,554	Dry	15,548	Dry	10.15	Dry	10.42	Dry	**Normal**
1931	15,752	Normal	3,014	Dry	14,339	Dry	12.67	Normal	13.94	Normal	**Normal**
1932	132,827	Wet	19,960	Wet	80,190	Wet	18.49	Wet	19.91	Wet	**Wet**
1933	n.d.	n.d.	7,488	Normal	28,148	Normal	8.66	Dry	10.24	Dry	**Normal**
1934	n.d.	n.d.	11,355	Normal	49,207	Normal	11.71	Normal	13.6	Normal	**Normal**
1935	n.d.	n.d.	12,832	Normal	81,249	Wet	17.89	Wet	21.26	Wet	**Wet**
1936	n.d.	n.d.	13,449	Normal	48,892	Normal	13.42	Normal	15.42	Normal	**Normal**
1937	n.d.	n.d.	31,912	Wet	165,833	Wet	23.13	Wet	23.84	Wet	**Wet**
1938	n.d.	n.d.	44,322	Wet	232,282	Wet	20.89	Wet	26.02	Wet	**Wet**
1939	n.d.	n.d.	8,464	Normal	39,902	Normal	14.52	Normal	14.3	Normal	**Normal**
1940	n.d.	n.d.	5,303	Normal	27,921	Normal	11.08	Normal	12.97	Normal	**Normal**
1941	n.d.	n.d.	57,691	Wet	371,670	Wet	36.71	Wet	38.51	Wet	**Wet**
1942	n.d.	n.d.	6,889	Normal	37,230	Normal	12.77	Normal	13.43	Normal	**Normal**
1943	n.d.	n.d.	39,746	Wet	165,541	Wet	19.88	Wet	27.01	Wet	**Wet**
1944	n.d.	n.d.	22,429	Wet	136,657	Wet	18.02	Wet	17.79	Normal	**Wet**
1945	n.d.	n.d.	12,178	Normal	49,376	Normal	12.13	Normal	13.27	Normal	**Normal**
1946	n.d.	n.d.	11,195	Normal	59,484	Normal	8.67	Dry	11.76	Dry	**Normal**
1947	n.d.	n.d.	7,300	Normal	40,732	Normal	9.02	Dry	12.37	Normal	**Normal**
1948	n.d.	n.d.	1,716	Dry	4,390	Dry	5.51	Dry	7.16	Dry	**Dry**
1949	n.d.	n.d.	1,964	Dry	6,226	Dry	5.85	Dry	7.95	Dry	**Dry**
1950	5,451	Dry	3,493	Dry	13,928	Dry	10.08	Dry	12.33	Normal	**Dry**
1951	n.d.	n.d.	993	Dry	1,289	Dry	6.95	Dry	8.03	Dry	**Dry**
1952	191,954	Wet	30,883	Wet	145,820	Wet	23.78	Wet	30.07	Wet	**Wet**
1953	3,309	Dry	4,346	Dry	16,935	Dry	9.8	Dry	11.81	Dry	**Dry**

Water Year	Water-Type from River Discharge [A, B]						Water-Type from Rainfall [A, C]				Water-Year Types for Lower Watershed 1928–2016 [E]
	Lower Santa Clara River		Santa Paula Creek		Sespe Creek		Downtown Ventura		Santa Paula		
	Total Runoff (acre-feet)	WY Type [D]	Total Runoff (acre-feet)	WY Type [D]	Total Runoff (acre-feet)	WY Type [D]	Total Rainfall (inches)	WY Type [D]	Total Rainfall (inches)	WY Type [D]	
1954	12,369	Dry	5,863	Normal	29,909	Normal	13.17	Normal	15.51	Normal	**Dry**
1955	945	Dry	3,013	Dry	14,349	Dry	12.54	Normal	12.83	Normal	**Dry**
1956	14,186	Dry	5,257	Normal	26,887	Normal	14.99	Normal	14.99	Normal	**Dry**
1957	5,620	Dry	3,529	Dry	21,387	Dry	9.13	Dry	10.75	Dry	**Dry**
1958	278,445	Wet	47,081	Wet	222,275	Wet	25.65	Wet	27.5	Wet	**Wet**
1959	19,320	Normal	5,597	Normal	27,058	Normal	6.75	Dry	6.24	Dry	**Normal**
1960	331	Dry	2,124	Dry	10,127	Dry	11.03	Normal	11.28	Dry	**Dry**
1961	459	Dry	1,255	Dry	6,277	Dry	6.51	Dry	6.62	Dry	**Dry**
1962	224,462	Wet	26,207	Wet	175,334	Wet	23.25	Wet	25.7	Wet	**Wet**
1963	6,217	Dry	3,342	Dry	12,896	Dry	11.52	Normal	13.69	Normal	**Dry**
1964	4,720	Dry	3,027	Dry	10,475	Dry	8.7	Dry	9.42	Dry	**Dry**
1965	7,589	Dry	4,667	Normal	23,411	Dry	13.65	Normal	13.46	Normal	**Dry**
1966	154,100	Wet	28,463	Wet	154,204	Wet	12.33	Normal	17.24	Normal	**Wet**
1967	114,221	Wet	37,425	Wet	153,737	Wet	14.9	Normal	22.52	Wet	**Wet**
1968	9,782	Dry	7,876	Normal	20,827	Dry	13.01	Normal	14.42	Normal	**Dry**
1969	889,483	Wet	112,720	Wet	463,859	Wet	22.31	Wet	30.58	Wet	**Wet**
1970	52,139	Normal	7,784	Normal	52,698	Normal	10.98	Normal	13.95	Normal	**Normal**
1971	66,685	Wet	12,798	Normal	63,974	Normal	14.52	Normal	17.93	Normal	**Wet**
1972	29,708	Normal	4,495	Dry	27,165	Normal	7.33	Dry	9.11	Dry	**Normal**
1973	200,789	Wet	35,240	Wet	158,864	Wet	19.49	Wet	23.32	Wet	**Wet**
1974	62,606	Normal	11,558	Normal	51,700	Normal	15.3	Wet	15.88	Normal	**Normal**
1975	52,296	Normal	11,509	Normal	62,614	Normal	15.42	Wet	18.06	Wet	**Normal**
1976	17,176	Normal	3,905	Dry	21,828	Dry	12.35	Normal	11.87	Dry	**Normal**
1977	6,687	Dry	2,366	Dry	11,896	Dry	9.54	Dry	12.88	Normal	**Dry**
1978	670,619	Wet	87,164	Wet	420,650	Wet	33.56	Wet	36.08	Wet	**Wet**
1979	177,882	Wet	20,460	Wet	102,529	Wet	18.59	Wet	22.17	Wet	**Wet**
1980	408,836	Wet	34,114	Wet	155,905	Wet	24.67	Wet	28.85	Wet	**Wet**
1981	31,176	Normal	5,824	Normal	28,269	Normal	12.36	Normal	11.9	Dry	**Normal**

Water Year	Water-Type from River Discharge [A, B]						Water-Type from Rainfall [A, C]				Water-Year Types for Lower Watershed 1928–2016 [E]
	Lower Santa Clara River		Santa Paula Creek		Sespe Creek		Downtown Ventura		Santa Paula		
	Total Runoff (acre-feet)	WY Type [D]	Total Runoff (acre-feet)	WY Type [D]	Total Runoff (acre-feet)	WY Type [D]	Total Rainfall (inches)	WY Type [D]	Total Rainfall (inches)	WY Type [D]	
1982	31,913	Normal	9,178	Normal	40,097	Normal	11.96	Normal	14.82	Normal	**Normal**
1983	646,799	Wet	70,496	Wet	312,229	Wet	28.23	Wet	35.72	Wet	**Wet**
1984	41,896	Normal	8,137	Normal	35,729	Normal	9.73	Dry	11.08	Dry	**Normal**
1985	5,096	Dry	3,394	Dry	15,088	Dry	10.24	Dry	11.16	Dry	**Dry**
1986	154,645	Wet	20,489	Wet	n.d.	n.d.	24.13	Wet	23.53	Wet	**Wet**
1987	702	Dry	3,182	Dry	n.d.	n.d.	7.05	Dry	7.42	Dry	**Dry**
1988	22,999	Normal	7,362	Normal	n.d.	n.d.	13.92	Normal	15.95	Normal	**Normal**
1989	906	Dry	2,895	Dry	n.d.	n.d.	7.94	Dry	10.47	Dry	**Dry**
1990	1,587	Dry	2,486	Dry	n.d.	n.d.	4.88	Dry	7.08	Dry	**Dry**
1991	79,575	Wet	15,216	Wet	78,094	Normal	15.15	Normal	17.93	Normal	**Normal**
1992	253,443	Wet	33,775	Wet	203,649	Wet	18.02	Wet	27.04	Wet	**Wet**
1993	834,651	Wet	71,488	Wet	n.d.	n.d.	24.44	Wet	32.11	Wet	**Wet**
1994	n.d.	n.d.	8,357	Normal	28,845	Normal	9.99	Dry	13.35	Normal	**Normal**
1995	n.d.	n.d.	63,219	Wet	332,736	Wet	32.6	Wet	34.8	Wet	**Wet**
1996	59,733	Normal	8,759	Normal	29,948	Normal	12.12	Normal	14.11	Normal	**Normal**
1997	61,535	Normal	18,019	Wet	80,970	Wet	14.17	Normal	18.34	Wet	**Normal**
1998	680,578	Wet	n.d.	n.d.	386,504	Wet	38.65	Wet	44.72	Wet	**Wet**
1999	11,940	Dry	5,576	Normal	22,665	Dry	9.39	Dry	10.51	Dry	**Dry**
2000	50,354	Normal	8,611	Normal	44,231	Normal	15.1	Normal	14.76	Normal	**Normal**
2001	152,261	Wet	24,465	Wet	145,439	Wet	22.59	Wet	26.54	Wet	**Wet**
2002	3,050	Dry	2,517	Dry	7,650	Dry	7.15	Dry	6.98	Dry	**Dry**
2003	45,469	Normal	8,562	Normal	52,211	Normal	19.85	Wet	19.93	Wet	**Normal**
2004	26,646	Normal	5,058	Normal	28,920	Normal	11.64	Normal	12.64	Normal	**Normal**
2005	n.d.	n.d.	107,327	Wet	541,665	Wet	35.93	Wet	40.37	Wet	**Wet**
2006	n.d.	n.d.	22,711	Wet	152,862	Wet	18.11	Wet	18.44	Wet	**Wet**
2007	n.d.	n.d.	3,313	Dry	11,006	Dry	6.66	Dry	4.98	Dry	**Dry**
2008	137,447	Wet	27,952	Wet	137,039	Wet	14.1	Normal	16.1	Normal	**Wet**
2009	15,382	Normal	4,395	Dry	28,631	Normal	10.4	Dry	11.5	Dry	**Normal**

Water Year	Water-Type from River Discharge [A, B]						Water-Type from Rainfall [A, C]				Water-Year Types for Lower Watershed 1928–2016 [E]
	Lower Santa Clara River		Santa Paula Creek		Sespe Creek		Downtown Ventura		Santa Paula		
	Total Runoff (acre-feet)	WY Type [D]	Total Runoff (acre-feet)	WY Type [D]	Total Runoff (acre-feet)	WY Type [D]	Total Rainfall (inches)	WY Type [D]	Total Rainfall (inches)	WY Type [D]	
2010	74,196	Wet	16,344	Wet	71,592	Normal	16.2	Wet	18.5	Wet	**Wet**
2011	121,264	Wet	32,892	Wet	158,543	Wet	19.7	Wet	25.8	Wet	**Wet**
2012	9,419	Dry	4,466	Dry	15,194	Dry	8.9	Dry	9.9	Dry	**Dry**
2013	454	Dry	1,168	Dry	4,313	Dry	6.6	Dry	6.0	Dry	**Dry**
2014	29,222	Normal	1,788	Dry	18,526	Dry	6.2	Dry	6.2	Dry	**Normal**
2015	3,538	Dry	1,028	Dry	8,547	Dry	8.4	Dry	11.2	Dry	**Dry**
2016	2,641	Dry	1,647	Dry	6,973	Dry	8.2	Dry	9.9	Dry	**Dry**

A “n.d.” indicates no data is available due to station inactivity for the given water-year period

B Total annual runoff computed from daily mean discharge recordings on the lower Santa Clara River (USGS 11114000 during WYs 1928–2004, VCWPD 723 during WYs 2008–2015, UWCD below Freeman during WY 2016), Santa Paula Creek (USGS 11113500) and Sespe Creek (USGS 11113000)

C Total annual rainfall computed from monthly total rainfall recordings in downtown Ventura (VCPWD 066) and Santa Paula (VCWPD 018, 245)

D Water-year typing based on assignment of “wet,” “normal,” and “dry” for water years (Oct 1–Sept 30) having <33%, 33–66%, and >66% exceedance during the 1928–2016 period

E Water-year typing for the lower Santa Clara River watershed based primarily on typing from the lower Santa Clara River gaging stations, and supplemented by other local runoff and rainfall data as needed

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Appendix H

Application of the Analytic Hierarchy Process to Assessing VWRF Discharge Scenarios

H.1 Introduction

Because weighing potentially competing beneficial uses inherently entails a value-based judgement, determining whether alternative Ventura Water Reclamation Facility (VWRF) discharge scenarios enhance the Santa Clara River Estuary (SCRE) and recommending an Maximum Ecologically Protective Diversion Volume (MEPDV) and resulting VWRF discharge flow for the SCRE presents a considerable challenge. To resolve this, beneficial uses and factors relevant to each use will be assigned relative weights based on the results of a collaborative Analytic Hierarchy Process (AHP) adapted to the Phase 3 Estuary Study, which provides a framework for scoring and comparing discharge alternatives based on the extent to which they support each beneficial use.

A collaborative, iterative approach was used to develop the AHP to integrate a broad understanding of the estuary, to incorporate the relevant factors supporting the beneficial uses identified in the Basin Plan (RWQCB 2014), and to determine the relative importance of the factors. Each iteration of the AHP involved the development of an initial AHP framework and results, a critical evaluation of the AHP by experts on the SCRE estuary processes and concerns with recommended revisions, and the refinement of the AHP by incorporating the expert feedback. In the first iteration, a workshop was convened on August 31, 2017 to discuss and reach consensus regarding relative weighting of factors affecting each beneficial use and the beneficial uses themselves. Participants included Stillwater Sciences staff along with a technical review team (TRT) selected by Heal the Bay (HtB) and Wishtoyo Foundation's Ventura Coastkeeper (Wishtoyo) who had reviewed in-progress versions of the Draft Phase 3 Study report. After incorporation of workshop findings, the AHP framework and results from the first iteration (AHP-1) was used in the Draft Phase 3 Study Report and publicly released in November 1, 2017.

The second AHP iteration (AHP-2) occurred to further refine the AHP framework and results based on feedback received on the AHP-1 included in the Draft Phase 3 Study Report. In the second iteration, workshops were held on November 8, 2017 and November 15, 2017, then verbal comments from the workshops and written comments submitted afterwards from the California Department of Fish and Wildlife (CDFW), the California Department of State Lands (CDSL), the National Marine Fisheries Service (NMFS), the State Water Resources Control Board (SWRCB), the United Water Conservation District (UWCD), and the TRT were used to revise the AHP-1 framework to create an initial AHP-2. The initial AHP-2 framework and preliminary results were presented during a December 20, 2017 workshop, participants provided additional expert feedback, and the AHP-2 was finalized by incorporating the feedback received throughout the second iteration process. Additionally, an analysis of the sensitivity of the relative priority to variations in weights of individual factors and variations in weights from different experts informed the development of the final AHP-2 used in the Final Phase 3 Estuary Study Report.

H.2 Analytic Hierarchy Process

The AHP is a decision support tool has been applied to a range of applications in solving large and complex decision problems (Saaty 1980, 2008; Saaty and Vargas 1991). It was developed to overcome challenges in simultaneously weighing multiple potentially competing factors when making decisions. In the face of a large numbers of comparisons, people simplify the attributes or make a judgment by excluding part of them (Payne 1973) or trade cognitive effort off against the accuracy of decision, which thereby lowers the accuracy of decision-making (Payne et al 1993).

The AHP provides a mathematical, rational, and repeatable framework to evaluate multiple criteria decision-making. The development of an AHP framework can be subdivided into the following four steps summarized below:

1. **Hierarchy Development** – The elements of the system to consider in a decision are identified and organized as a hierarchy of interrelated decision elements or factors. This is typically visualized as a tree containing the overall decision or goal at the top with lower levels (tiers) being made up of contributing factors that may be quantitatively or qualitatively linked to the overall decision or goal. All the elements located on a higher hierarchical level act on the elements situated a level lower.

2. **Pairwise Comparisons of Criteria** – The AHP framework separates a multiple criteria decision into a hierarchical series of pairwise comparisons that includes a determination of which factor is more important and by how much. The "by how much" aspect of the pairwise comparison uses a scale developed by Saaty of relative importance, where 1 indicates the factors are of equal importance and 9 indicates the evidence favoring one factor is of the highest possible order of affirmation (see Table 5-1 in Section 5.1).

3. **Calculation of Weights** – For each tier, the results of these comparisons are entered into a square matrix A (i.e., dimensions $n \times n$), which has the entry a_{ij} in the ith row and jth column. The matrix consists of positive numbers, with $a_{ji} = 1/a_{ij}$ for all i and j. Accordingly, the entries along principal diagonal of matrix A are equal to 1.

   After the square matrix is created, the consistency of the pairwise comparisons in the matrix is evaluated. Consistency is a measure of the consistency of comparisons constructed from the principal eigenvalue of a reciprocal matrix to the weighting matrix. A rule-of-thumb target for any given AHP matrix is to have all consistency ratio (CR) values <0.1. Values greater than 0.1 identify pairwise comparisons that may be somewhat inconsistent and should be reconsidered. CR serves primarily as a quality assurance measure; not all comparisons with CR>0.1 need to be changed.

   Once the consistency is checked and approved, the weight of each factor is calculated. The weight (w_i) of each factor ($w_1,\ldots,w_n$) comprises the principal eigenvector of the matrix, in which the principal eigenvalue is n, with multiplicity 1, and the only other eigenvalue is 0, occurring with multiplicity $n - 1$.

4. **Scoring to Calculate Relative Priorities** – After the calculation of the weights for each factor in the hierarchy, metrics must be established to assign a numerical score to each alternative scenario for each of the factors on the terminal branch of the hierarchy. These scores are multiplied by the weights through the hierarchy, yielding a final numerical representation of the normative value of each alternative scenario.

H.3 Development of AHP Framework

Based on its suitability for addressing complex problems, we applied the AHP to the SCRE to evaluate whether alternative VWRF discharge scenarios enhance the SCRE and develop recommendations for future discharge of the VWRF to the SCRE. The AHP framework was generated through a collaborative, iterative approach with each iteration involving the development of an initial AHP framework and results, the technical evaluation of the AHP by experts on the SCRE estuary processes and concerns, and the refinement of the AHP by incorporating the expert feedback. The AHP for the SCRE had two formal review iterations with the first focusing on refining an initial AHP developed by Stillwater Sciences with input from the TRTs, while the second iteration incorporated feedback from a broader public and Resources Agency perspective.

H.3.1 AHP-1

The first iteration of the AHP framework was generated for comparing the VWRF discharge scenarios and the extent to which they support the balance of beneficial uses of the SCRE. In the first step, the hierarchical structure of the system is prepared by identifying the elements of the system and grouping these elements according to the hierarchy. We developed a three-tier hierarchy, where Tier 1 factors are the beneficial uses themselves, Tier 2 factors support the realization of the beneficial use, and Tier 3—which was only used for the RARE beneficial use—includes factors supporting the Tier 2 factors. In the second step of the AHP, the pairwise comparisons and weighting of the individual elements were evaluated in a workshop setting. The weighting evaluation compared all pairs of elements at a given level from the point of view of each element located a level higher in the previously constructed hierarchical structure. Comparing VWRF discharge scenarios based on the extent to which they support each of eleven beneficial uses is an inherently complex problem that requires consideration of potentially competing beneficial uses (and potentially competing factors supporting each beneficial use). This necessitates value-based judgments. While there is considerable precedent for the utility of expert judgment and the application of the best available science in such judgments (Dietz 2013, Ryder et al. 2010), the judgments are inherently complex (Raymond et al. 2010) and are subject to the perspective of the individual expert. The incorporation of multiple expert perspectives can alleviate potential biases and make such judgments more robust (Stier et al. 2017).

H.3.1.1 Workshop Summary: Iteration 1

In order to incorporate multiple expert perspectives into the AHP and Phase 3 analysis, a workshop was held on August 31, 2017 to discuss, and ultimately reach a consensus on, the metrics and threshold criteria used to score alternative VWRF discharge scenarios, and to collaboratively conduct the pairwise comparisons necessary for constructing the AHP weighting matrix. As part of the terms of the 2011 Consent Decree between the City and VCK/HtB, experts from VCK/HtB had familiarity with the Phase 3 Study methods, access to the data and modeling tools used in the study, and provided input to the City at multiple stages of the Phase 3 analysis and report preparation. Prior to the workshop, participants were provided with background materials on the AHP, including Saaty (2008) and a summary of the AHP process (Attachment 1). Participants were also provided with a MS Excel worksheet detailing the preliminary factors, metrics, and thresholds for assessing VWRF discharge scenarios for each beneficial use (draft hierarchy). Each of the natural resource experts had sufficient background and preparation necessary to provide their expert judgement on the AHP framework and accomplish the workshop objectives. The workshop was attended by: Hank Baker[1], Dan Chase[2], Elisa Garvey[3], Chris Hammersmark[4], Noah Hume[1], Mike Jossleyn[2]; and Mike Podlech[5]. After introductions,

[1] Stillwater Sciences
[2] WRA
[3] Carollo Engineers
[4] cbec eco engineering
[5] Independent Fisheries Consultant

there was a brief presentation of recent updates to the draft Phase 3 Report and a more through discussion of the AHP process including selected factors, initial rankings, example matrices, and discussion of consistency, as described above. Definitions of beneficial uses and other assessment factors, representative metrics, and thresholds were discussed and clarified.

In order to establish a weighting of the selected factors to be used in the AHP, the group decided on a preliminary rank of beneficial uses to guide discussion during the pairwise comparisons. At the highest level (Tier 1), pairwise comparisons were conducted by first establishing as a group which of the beneficial uses was a higher priority. Then, participants would silently determine the Saaty scale value they would assign to that comparison (1–9). When all of the participants were ready, each individual would hold up the number of fingers corresponding to his answer. This method was intended to ensure independent answers and avoid potential biases that could occur from seeing another's answer prior to developing one's own answer (e.g., anchoring and adjusting). If the answers were variable, individuals would justify their positions and a discussion would ensue until a consensus was reached. This process was repeated for Tier 2 and Tier 3 factors. After pairwise comparisons were conducted, the CR for the Tier 1 matrix was calculated to identify pairwise comparisons that were potentially inconsistent with ratings for other pairwise comparisons in the matrix. Upon further inspection, pairwise comparisons that were identified to contribute to elevated CR remained qualitatively reflective of the expert consensus opinion. Additionally, sensitivity testing showed little effect to overall weightings when pairwise comparisons were adjusted to bring the CR below 0.1, indicating that inconsistencies in comparisons did not bias or significantly alter resulting weights. After the workshop, the CR for the Tier 2 and 3 matrices also were calculated with results similar to Tier 1 matrices, so the unadjusted workshop pairwise comparisons were retained for the initial AHP-1.

In general, the results of the pairwise comparisons reflected a prioritization of threatened or endangered species, followed by support of other native species, followed by support of general ecological functions of the SCRE. Comparisons were informed by the Phase 3 data collection and analysis, the best available science, as well as the experience and professional judgment of the workshop participants. Comparisons requiring further discussion (i.e. where there was a wide range in the initial answer) generally reflected the varied experience or technical expertise of the participants, and highlighted the importance of incorporating multiple expert perspectives into the analytical framework.

H.3.1.2 AHP-1 Refinement

After review and evaluation of the initial AHP-1 hierarchy and its results, a final revised AHP-1 was developed by updating the initial AHP-1 based on the workshop discussions, the workshop pairwise comparisons, and feedback after the workshop. The list of factors to consider for a beneficial use in the initial AHP-1 was revised according to the received feedback. Total wetland habitat amount was added to the Tier 2 factors for the Tier 1 Estuarine Habitat (EST) beneficial use because wetland habitat provides cover for juvenile fishes, supports invertebrate production, and provides trophic subsidies to open water habitats. Riparian habitat was added to the Tier 2 factors for the Tier 1 Wetland Habitat (WET) beneficial use since it performs important functions including bank stabilization and erosion control. Under WET, the Tier 2 amount of freshwater marsh and Tier 2 amount of saltmarsh habitat were joined into one Tier 2 factor called Wetland Habitat Area. Variations in the saltmarsh habitat area with variations in alternative discharge were negligible so freshwater and saltmarsh wetland habitat could be considered as one factor without altering the overall score distributions.

The AHP-1 metrics and scoring thresholds were also revised after the workshop for several of the Tier 2 or Tier 3 factors to better distinguish between alternative VWRF discharge scenarios. Scoring thresholds for several factors were adjusted to provide a wider distribution of scores to better distinguish between discharge alternatives. The minimum scoring threshold also was shifted from < 30% to < 20% for many factors to create a larger variation between alternatives to better distinguish between the scenarios without altering overall trends. The following paragraphs summarize the specific changes made to the AHP-1 hierarchy and scoring presented at the August 31 workshop.

- Under the Tier 1 Non-contact Water Recreation beneficial use (REC-2), the Tier 2 Opportunities for Camping factor scoring was adjusted by replacing the modeled percent inundation of the campground at the equilibrium stage metric with the SCRE stage. The SCRE stage was the basis of the modeled percent inundation of the campground at the equilibrium stage so it was considered a more direct metric for the Tier 2 Opportunities for Camping factor.

- Under Tier 3 of the Rare, Threatened or Endangered Species (RARE) beneficial use, the minimum scoring threshold for tidewater goby was adjusted to take into account that tidewater goby populations with 5 – 125 acres of habitat are the most stable (USFWS 2005). Tidewater goby rearing and spawning habitat the scoring minimum threshold was shifted from < 30% to < 5% since 5% of the maximum open water area with 0.3 – 6.5 ft NAVD88 depth corresponds to approximately 5 acres of habitat.

- Scoring thresholds for the unseasonal breach factor used in the RARE and the Spawning, Reproduction, and/or Early Development (SPWN) beneficial uses were also adjusted to better distinguish between discharge alternatives. The unseasonal breach score was continuous from 0 to 1 from the minimum difference between summer berm height and equilibrium WSEL and a 2 ft difference between summer berm height and equilibrium WSEL, then continuous from 1 to 2 from a 2 ft difference between summer berm height and equilibrium WSEL and the maximum difference between summer berm height and equilibrium WSEL. It was assumed that the likelihood of unseasonal breaching changes when there is a 2 ft difference between summer berm height and equilibrium WSEL because of the increase in effort to trench the berm and cause an unseasonal breach.

- Salinity was identified as an insensitive factor for the Commercial and Sport Fishing (COMM) and Wetland Habitat (WET) beneficial uses because the factor score did not vary significantly across discharge alternatives and variations in its scoring produced less than 1% variation in the AHP-1 results. Salinity was removed from COMM because the modeled duration of salinity conditions exceeding 2 ppt (i.e., unsuitable for COMM species) following a simulated breach event was high (> 55 days) and relatively constant across all VWRF discharge scenarios. Salinity was removed from WET since salinity modeling suggests that flow variations under the alternative VWRF discharge scenarios do not result in salinity in the SCRE exceeding *Arundo* salinity tolerances (> 26 ppt) for extended periods of time.

After updates to the initial AHP-1 hierarchy were completed to account for the changes in the list of factors, the metrics, and the scoring thresholds, the final AHP-1 and results for each scenario were generated by updating and recalculating the pairwise comparisons, the corresponding matrices, the calculated weights, and the normalized priority scores, as necessary, for each discharge scenario. Pairwise comparisons only had to be updated for the COMM, EST, and WET beneficial uses since those were the only beneficial uses where the revisions changed the list of factors considered. The overall ranks in the normalized priority scores were unchanged before and after revisions, but the normalized priority scores calculated by the final AHP-1 did vary from the initial AHP-1. The final pairwise comparisons, the corresponding matrices, the calculated weights, and the standardized scores for each discharge scenario are shown in Attachment 2. The results of the final AHP-1 are detailed in the Draft Phase 3 Study Report body.

H.3.2 AHP-2

A second iteration of the AHP framework (AHP-2) was developed from the final AHP-1 according to verbal feedback received at workshops on November 8, 2017, November 15, 2017, and December 20, 2017 and feedback in written comments submitted by the CDFW, the CDSL, the NMFS, the SWRCB, the UWCD, and the TRT. The goal of these additional workshops and requests for feedback was to obtain more expert perspectives that can be integrated into the AHP-2. As previously discussed, the incorporation of multiple expert perspectives can alleviate potential biases and make inherently complex judgments more robust (Stier et al. 2017).

In the second iteration, an initial AHP-2 was developed from the final AHP-1 based on verbal and written feedback received before the December 20, 2017 workshop. The initial AHP-2 continued to use the three-tier hierarchy with Tier 1 factors representing the beneficial uses, Tier 2 supports the realization of the beneficial use, and Tier 3 employed only for RARE beneficial uses includes factors supporting the Tier 2 factors. While the three tiers remained the same, factors were added into the initial AHP-2 framework based on the received feedback. Pairwise comparison and weighting of the factors in the initial AHP-2 were generated so an example of how revisions from feedback would potentially shift the standardized scores for discharge alternatives could be presented to participants at the third workshop on December 20, 2017 for additional feedback. After the third workshop, the initial AHP-2 was refined to produce the final AHP-2. A summary of the changes made for the second iteration of the AHP are detailed below in Section H.3.3.2: AHP-2 Refinement.

H.3.2.1 Workshops Summary: Iteration 2

Three workshops were held to discuss the AHP-1 framework, the Phase 3 analysis, and its results to solicit additional expert feedback from resource agencies and other SCRE stakeholders to further refine the AHP. The first of the three workshops was held with resource agencies on November 8, 2017. In addition to focusing on the data, technical analysis, interpretation of results, and recommendations of the Draft Phase 3 Estuary Studies Report, the November 8 workshop presented and sought input on the AHP used to evaluate different discharge scenarios, results of the AHP, interpretation of the results, and conclusions/recommendations (Attachment 3).

The second of the three workshops held on November 15, 2017 was similar to the November 8, 2017 workshop, but presented to a broader audience of SCRE stakeholders. The workshop detailed the AHP methodology used to evaluate different discharge scenarios, the results of the AHP, the interpretation of the AHP results, and the conclusions/recommendations. The public was invited to provide feedback and recommendations which could be further incorporated into the AHP-2 and the subsequent analysis using the AHP-2.

After the first two workshops, revisions were made to the AHP-1 framework to create an initial AHP-2 which was then presented to resource agencies at the third workshop on December 20, 2017. Prior to the third workshop, representatives from the CDFW, the California Department of Parks and Recreation (State Parks), the NMFS, the National Park Service, the SWRCB, and the Technical Review Team assembled by the Wishtoyo Foundation, VCK, and HtB, the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and the U.S. Fish and Wildlife were provided with background materials, including Saaty (2008), a summary of the AHP process, and a MS Excel weighting workbook containing two worksheets detailing the preliminary factors for pairwise comparison (Attachment 4). In the MS Excel workbook, the main worksheet was a blank pairwise comparison setup for preliminary factors in the initial AHP-2 for participants to fill out. A secondary worksheet was also included that contained a completed version of the blank pairwise comparison worksheet completed by Stillwater Sciences with the rationale for inclusion of the factor in the initial AHP-2 framework and the reason for revisions to the AHP-1 framework. Input on the weighting of AHP factors was requested from the resource experts and they were invited to submit the own individual pairwise comparison weighting worksheet for the factors in the AHP-2 framework either before the third workshop or shortly after it. Multiple pairwise comparisons were performed for the AHP-2 by individual experts instead of the consensus pairwise comparison done for the AHP-1 to allow variance estimates in the scenario ranking based on the relative weights of contributing factors. The previous two workshops and the background materials were organized to ensure each of the natural resource experts at the third workshop had sufficient information and preparation necessary to provide their expert judgement on the AHP framework and accomplish the workshop objectives.

The third workshop concentrated on discussing the comments received on the AHP-1 framework, the initial AHP-2 framework that integrated the verbal and written feedback and recommendations, and the additional recommendations for refinement to the initial AHP-2 framework. As requested in feedback, the Tier 1 Rare, Threatened or Endangered Species (RARE) beneficial use for the initial AHP-2 was disaggregated so workshop participants could better understand how the individual factors in RARE combined into the final composite RARE normalized priority. In addition, an analysis was presented detailing the sensitivity of the AHP framework to variations in the weights of individual factors. The sensitivity of the initial AHP-2 was demonstrated by varying the weight of the dissolved oxygen factor to determine how much those variations altered the final normalized priority of the discharge scenarios.

H.3.2.2 AHP-2 Refinement

The list of factors to consider for a beneficial use in the AHP-2 was revised according to the received feedback. A municipal and domestic supply (MUN) beneficial use was added to the Tier 1 factors. MUN is not currently a designated beneficial use of the SCRE, but reductions in VWRF discharge to the SCRE would supplement municipal water supply. Two Tier 3 factors under the Tier 2 – Birds hierarchy under the Tier 1 Rare, Threatened or Endangered Species (RARE) beneficial use were added. The risk of nest flooding for California least tern and western snowy plover Tier 3 factor was added to the Tier 1 RARE beneficial use. Sandy areas within the SCRE that are exposed (i.e., not wetted) at high tide during open mouth conditions might invite nesting of California least tern or western snowy plover. If these areas lie below equilibrium WSEL, however, the nests could be flooded upon mouth closure and subsequent estuary refilling. A habitat for riparian-associated special status bird species Tier 3 factor was also added to the Tier 1 RARE beneficial use. Although the SCRE is listed as critical habitat for the southwest willow flycatcher (*Empidonax traillii extimus*) (federally listed as Endangered [ESA]), surveys have identified their habitat as well upstream of the SCRE, other special status bird species that have potential to occur in the SCRE, including yellow warbler (*Setophaga petechial*) and yellow breasted chat (*Icteria virens*) (both state Species of Special Concern) are also associated with riparian habitat, and thus not well-represented by the focal RARE bird species. Flood control capacity was added to the Tier 2 factors for the Tier 1 Wetland Habitat (WET) beneficial use since flood attenuation is a critical function of wetland systems.

Once the initial AHP-2 hierarchy was updated to account for the changes in the list of factors, the final revised AHP-2 and results for each scenario were generated by updating and recalculating the pairwise comparisons, the corresponding matrices, the calculated weights, and the normalized priority scores, as necessary, for each discharge scenario. Pairwise comparisons had to be updated for the MUN, WET, and RARE beneficial uses since those were the beneficial uses where the revisions changed the list of factors considered. Additionally, the pairwise comparisons had to be updated for the Migration of Aquatic Organisms (MIGR), RARE, and Spawning, Reproduction, and/or Early Development (SPWN) beneficial uses based on feedback recommending enhancement of the weighting for the MIGR beneficial use and the unseasonal breach factor contained in RARE and SPWN. The pairwise comparisons and the resulting weights for factors used in the final AHP-2 were determined from an analysis of the results of the multiple pairwise comparisons submitted by resource experts. As part of the third workshop, input on the weighting of AHP-2 factors was requested from resource experts. Pairwise comparisons were submitted by Hank Baker[6], Dan Chase[7], Noah Hume[8], Mike Jossleyn[9], Mike Podlech[8], and Brittany Struck[9]. The six sets of relative weights for the factors generated from each individual pairwise comparisons are presented in Attachment 5 along with the composite relative weights generated from an assessment of all the individual pairwise comparisons. A sensitivity evaluation was conducted examining the variance in the relative priority for each scenario based on the five sets of relative weights to determine the representative relative weights to use in the final AHP-2. The results show general agreement over discharge scenarios optimizing realization of beneficial uses and suggest a robust evaluation of site specific data represent best available information supports conclusions regarding enhancement of the beneficial uses of the SCRE as well as conclusions regarding the report recommendations. It

While metrics and scoring were created for the new factors added to the AHP-2, the metrics and scoring thresholds for factors from AHP-1 remained the same in AHP-2 based on verbal and written feedback. The final pairwise comparisons, the corresponding matrices, the calculated weights, the standardized scores, and the priorities for each discharge scenario are were determined and Attachment 6 summarizes the final calculated weights and priorities. The results of the final revised AHP-2 are detailed in the Final Phase 3 Study Report body.

[6] Stillwater Sciences
[7] WRA
[8] Independent Fisheries Consultant
[9] Input should be interpreted as input from informed persons but not representing official agency positions/perspectives by the National Marine Fisheries Service

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Attachment 1
Ventura Phase 3 AHP Workshop Materials
August 31, 2017

Analytic Hierarchy Process Workshop
Phase 3 Ventura Estuary Study

8:30am–4:45pm on August 31, 2017

Stillwater Sciences
2855 Telegraph Ave. Suite 400,
Berkeley CA 94705

AGENDA

8:30 a.m. – 10:00 a.m.	**Introductions and Review of Materials** 1. Purpose of Meeting 2. Review of report changes based comments of June 30th 3. Overview of AHP process and weighting of factors 4. Review of Draft Hierarchy comments of August 29th
10:15 a.m. – 12:00 p.m.	**Session 1 – Weighting of Tier 1 Factors** 1. Pairwise Comparisons of Beneficial Uses
12:00 p.m. – 12:30 p.m.	**Lunch (may work through lunch)**
12:30 p.m. – 4:15 p.m.	**Session 2 – Review and Finalization of Tiers 2 and 3 Factors** 1. Revisions of Metrics, and Scoring Thresholds 2. Pairwise Comparisons of Factors by Beneficial Use
4:15 p.m. – 4:45 p.m.	**Next Steps and Closure**

Analytic Hierarchy Process Workshop Background
Phase 3 Ventura Estuary Study

August 17, 2017

Background

The Phase 3 Estuary Studies are being implemented for the purposes of determining the Maximum Ecologically Protective Diversion Volume (MEPDV) pursuant to the Consent Decree among the City of Ventura (city of Ventura), Heal the Bay and the Wishtoyo Fdn Coastkeeper Program (Ventura Coastkeeper), and to comply with the conditions of the current Ventura Wastewater Reclamation Facility (VWRF) NPDES Permit (R4-2013-0174). To comply with the NPDES Permit, the Phase 3 Studies must, among other things, provide a "recommendation of the effluent discharge flow rate needed to sustain the estuary's native species," prioritizing listed species (i.e., the flipside of, or the complement to the MEPDV), and include a recommendation regarding the degree to which VWRF discharges enhance the beneficial uses of the Santa Clara River Estuary (SCRE). Accordingly, the Phase 3 Estuary Studies Report must analyze the effects on beneficial uses of the SCRE of: existing VWRF discharge, no VWRF discharge, and other alternative discharge scenarios. The analysis must take into account the effects of these various discharge scenarios on the realization of each of the eleven (11) beneficial uses of the SCRE designated in the Basin Plan using both quantitative and qualitative assessments, prioritizing uses related to the protection of sensitive (listed), native species. These assessments will be used to determine (a) whether current VWRF discharge results in a fuller realization of existing beneficial uses (i.e., enhancement) relative to the absence of all discharge (Scenarios 1 vs. 11), and (b) whether alternative discharge measures (Scenarios 2 through 11) provide fuller realization of beneficial uses relative to current operations. The analysis will also be used to inform and deduce a recommended MEPDV and average annual VWRF discharge flow needed to sustain the ecology of the SCRE, and particularly its listed native species

Because weighing potentially competing beneficial uses inherently entails a value-based judgement, determining whether alternative VWRF discharge scenarios enhance the SCRE and recommending an MEPDV and average annual VWRF discharge flow for the SCRE presents a considerable challenge. To resolve this, beneficial uses and factors relevant to each use will be assigned relative weights based on the results of a collaborative Analytic Hierarchy Process (Saaty 1980, 2008) adapted to the Phase 3 Estuary Study, which provides a framework for scoring and comparing discharge alternatives based on the extent to which they support each beneficial use. In this process, experts for the City, Heal the Bay, and Ventura Coastkeeper will be asked to reach consensus regarding relative weighting of factors affecting each beneficial use and the beneficial uses themselves. In order to score and compare discharge alternatives, consensus must also be reached upon measurable or modellable metrics and threshold values used to score factors.

Overview of Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a mathematical approach to multiple criteria decision making that has been applied to a range of applications in solving large and complex decision problems (Saaty and Vargas 1994). To develop a rational and repeatable framework to select between various discharge alternatives, we have applied the AHP by the following four steps:

1. **Analytic Hierarchy** – Initially, factors considered in a decision are identified and organized as a hierarchy of interrelated decision elements. Typically, this is visualized as a tree containing the overall decision or goal at the top and lower levels (Tiers) of contributing factors, which in the case of the SCRE are the physical, chemical, and biological factors that may be quantitatively or qualitatively linked to alternative VWRF discharge levels.
2. **Pairwise comparisons** – To determine which factors are more important in reaching a decision, a series of pairwise comparisons are made amongst all the decision elements. This is generally arranged as a series of questions as to whether each factor is more or less important in making a decision than other factors within the same tier, and secondarily by how much on a numeric (Saaty) scale from 1-9 (Table 1).
3. **Weighting** – The eigenvalue method is used to estimate the relative importance (weights) of the decision factors being compared. To make pairwise comparison of the selected factors it is essential to put them in a square matrix $B_{M \times M}$. The comparison is made by identifying the impact of the factors on the left side of the matrix to the elements at the top of the matrix. A factor compared with itself is always assigned the value 1, so the main diagonal entries of the pair-wise comparison matrix are all 1. Below the main diagonal there are the inverse of the pairwise comparisons above the diagonal.

$$\boldsymbol{B}_{\boldsymbol{M}\times\boldsymbol{M}} = \begin{matrix} \boldsymbol{B}_1 \\ \boldsymbol{B}_2 \\ \boldsymbol{B}_3 \\ \vdots \\ \boldsymbol{B}_M \end{matrix} \begin{bmatrix} \mathbf{1} & \boldsymbol{b}_{12} & \boldsymbol{b}_{13} & \cdots & \cdots & \boldsymbol{b}_{1M} \\ \boldsymbol{b}_{21} & \mathbf{1} & \boldsymbol{b}_{23} & \cdots & \cdots & \boldsymbol{b}_{2M} \\ \boldsymbol{b}_{31} & \boldsymbol{b}_{32} & \mathbf{1} & \cdots & \cdots & \boldsymbol{b}_{3M} \\ \vdots & \vdots & \vdots & \vdots & \cdots & \vdots \\ \boldsymbol{b}_{M1} & \boldsymbol{b}_{M2} & \boldsymbol{b}_{M3} & \cdots & \cdots & \mathbf{1} \end{bmatrix}$$

   With the matrix completed the relative normalized weight of each factor is calculated from the geometric mean of the m^{th} row, and by normalizing the geometric means of rows in the comparison matrix. After computation of weights has been completed for the hierarchy as a whole, less important decision elements may sometimes be dropped from further consideration and the weights recomputed because of their relatively small impact on the overall objective. This must be considered carefully, however, because of unintended effects upon the relative ranking of the remaining factors.
4. **Alternatives Decisio**n – Lastly, the relative weights of decision elements are aggregated by a weighted summation of scores to arrive at a set of ratings for the alternatives under comparison. Only metrics and criteria at terminal branches of the hierarchy are assigned scores based upon an agreed upon system, with the results of the weighting exercise (Steps 1–3) used to calculate the weighted summations in each tier and to arrive at a final score.

Table 1. Scale of Relative Importance (according to Saaty [1980])

Intensity of Importance	Definition of Factor Importance	Explanation
1	Equal Importance	Two factors contribute equally to comparison
3	Moderate Importance	Experience and judgement moderately favor one factor over another
5	Strong Importance	Experience and judgement strongly favor one factor over another
7	Very Strong Importance	A factor is strongly favored and its dominance demonstrated in practice
9	Absolute Importance	The evidence favoring one factor over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgements	When compromise is needed

Proposed Assessment Factors and Weighting

For the Phase 3 Study, the degree to which each VWRF discharge scenario supports each of the 11 beneficial uses is determined by a combination of approaches. The primary quantitative tool used in this assessment is the calibrated water balance model (Report Section 4.2) which is used to quantify equilibrium stage under closed mouth conditions (updated report Figure 5 1), changes in inundated habitats in the SCRE, relative changes in water quality and temperature, as well as breaching dynamics. As separate attachments, we have included a Draft Hierarchy table (MS Excel), Beneficial Use Summary Figure (.jpg), and AHP Weighting Worksheet (MS Excel). These materials detail the quantitative and qualitative factors considered applicable to the realization of each beneficial use, as well as proposed metrics and criteria used to assess each discharge alternative in regards to each of those factors.

Quantitative (e.g., habitat amounts, suitability based on water quality criteria) or qualitative metrics have been selected to relate VWRF discharge scenarios to amounts of various habitat types, habitat quality and suitability as well as potential for ecological disturbances (e.g., invasive species) due to breaching dynamics. In some cases, we have not included a factor in the assessment of alternatives due to judgements that the factor is only marginally relatable to VWRF discharge scenarios; may produce similar assessment scores across all scenarios; may be highly correlated with other factors and thereby result in over-weighting of that factor; or that it cannot be accurately predicted across the alternative discharge scenarios.

For the purposes of the AHP Workshop, please review the proposed assessment factors for each beneficial use based upon information in the Phase 3 study. In the event that you feel that a modellable or otherwise predictable factor should be included, please suggest this factor be included in advance of the workshop along with any supporting rationale or information. Understanding that addition of factors may require edits to the proposed hierarchy and pairwise comparisons, once review of the proposed hierarchy and factors is complete, weighting amongst factors will be conducted in a group setting by the steps below.

- **Step 1) Initial Rankings**. Prior to the workshop, open the Draft Hierarchy table (Excel) and review the proposed assessment Factors within each tier (Tier One=Beneficial Uses; Tier Two=Measures of Habitat Quantity and Quality; Tier Three=Secondary Factors contributing Tier Two). Next rank each factor within each tier from most important to least important. This part is difficult, but will allow for more consistent pairwise comparisons, so trust your judgment.
- **Step 2) Initial Pairwise Comparisons**. Open the AHP Weighting Worksheet (Excel). Within each pair of Factors, indicate which contributes more to the realization of the parent Beneficial Use (lower Tiers) as well as which Beneficial Uses are most important in selecting a VWRF discharge alternative (Tier One). Use the Saaty Scale (1-9) to determine how much more important the factor you chose is. If you feel the two criteria contribute equally with respect to realization of a beneficial use, enter a '1' in both cells. See the Saaty 2008 paper for an example.
- **Step 3) Final Pairwise Comparisons.** During the workshop, we will repeat steps 1 and 2 in a group setting. That is the factors, metrics, and initial pairwise comparisons will be reviewed and updated as necessary to allow calculation of the final weighting amongst factors and beneficial uses. The final weighting factors and alternative scoring will be calculated and compiled following the workshop.

Scoring of Discharge Alternatives

With the weighting of Beneficial Uses completed, alternatives are scored based upon the selected metrics or criteria and thresholds used to distinguish whether alternative VWRF discharge scenarios more fully realize (Score of 2), may or may not more fully realize (Score of 1), or would not support (Score of 0) the criteria for a given beneficial use. The final scores that a scenario receives will be based on the scores it receives for each metric, the weight that each factor receives in assessing each beneficial use, and the weighting that each beneficial use receives relative to other beneficial uses. The final score for each alternative represents a weighted summation of these scores across all beneficial uses represented in the assessment.

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Ventura Phase 3 Estuary Study Analytic Hierarchy Process
Updated Draft Hierarchy
15-Sep-17

Scores of metric thresholds based on ranking as to whether they:
More fully realize existing benefiical use (Score of 2)
May or may not more fully realize beneficial use (Score of 1)
Would not support existing benefiical use (Score of 0)

No.	Tier 1 Factors - Beneficial Uses	Tier 2 Factors	Tier 3 Factors	Metric/Criteria	Thresholds	Score	Comments
1	**Commercial and Sport Fishing (COMM)**	Amount of habitat for sport and bait fish species.		% of Maximum Modeled Open Water Habitat	100% <30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
		Frequency of DO < 5 mg/L due to algal blooms.		% reductions of existing VWRF nutrient (N,P) loads	100% 0%	2 1	Continuous score from 1-2 based on incremental reductions in nutrient loading. There is no score of zero associated with this metric because high background nutrient levels are expected to promote some algae blooms, regardless of VWRF discharge scenario
		Salinity events above freshwater sport fish thresholds		Duration of elevated salinity conditions (>2 ppt) following breached berm closure	0-7 days >7 days	2 1	Low salinity is suitable for the greatest number of fishes considered to support the COMM beneficial use. Short duration events may allow freshwater sport fish to find refuge following breached berm closure.
	Other Factors considered but not directly assessed for this Beneficial Use:						
	Benthic habitat for potential harvesting of shellfish						Note that SCRE is not designated as supporting the SHELL beneficial use.
	Long term equilibrium salinity effects upon COMM spp.						Persistent freshwater not expected to vary by VWRF discharge scenario
	Food Resources for COMM species						Food resources as represented by BMI and prey fish abundance and species composition is largely controlled by WQ factors (e.g., DO, salinity) already assessed for this Beneficial Use. Additional predictive modeling of food resources not feasible with available data.
	Water temperature for COMM spp.						Broad tolerance of COMM species and limited impact of VWRF upon SCRE temperature relative to solar insolation and radiation suggests no differences across discharge scenarios
2	**Estuarine Habitat (EST)**	Amount of habitat for native estuarine fish species		% of Maximum Modeled Open Water Habitat	100% <30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
		Frequency of DO < 5 mg/L due to algal blooms.		% reductions of existing VWRF nutrient (N,P) loads	100% 0%	2 1	Continuous score from 1-2 based on incremental reductions in nutrient loading. There is no score of zero associated with this metric because high background nutrient levels are expected to promote some algae blooms, regardless of VWRF discharge scenario
		Salinity events above freshwater competitor/predator fish thresholds		Duration of high salinity conditions (> 18 ppt) following breached berm closure	>7 days	2	long duration events may select against freshwater adapted spp. and promote establishment of estuarine species.

No.	Tier 1 Factors - Beneficial Uses	Tier 2 Factors	Tier 3 Factors	Metric/Criteria	Thresholds	Score	Comments
					0-7 days	1	Short duration events may allow freshwater-adapted fish to find refuge following breached berm closure.
	Other Factors considered but not directly assessed for this Beneficial Use:						
	Long term equilibrium salinity effects upon EST aquatic spp.						Persistent freshwater not expected to vary by VWRF discharge scenario
	Water temperature for aquatic EST spp.						Broad tolerance of EST species and limited impact of VWRF upon SCRE temperature relative to solar insolation and radiation suggests no differences across discharge scenarios
	Amount of wetland habitat						WET assessed directly as a Beneficial Use
	Food Resources for EST species						Food resources as represented by BMI and prey fish abundance and species composition is largely controlled by WQ factors (e.g., DO, salinity) already assessed for this Beneficial Use
3	**Marine Habitat (MAR) - Not Considered**						Because common marine species found in the southern California bight are also found in estuarine habitats, SCRE EST uses fully encompass controllable factors affecting SCRE MAR beneficial uses.
4	**Migration of Aquatic Organisms (MIGR)**	Opportunities for migration		% of maximum modeled of the total days with open-mouth conditions during the STL and lamprey migration window (Nov 1- May 31) summed across water year types (dry, normal, wet)	100%	2	Longer duration events may allow greater upstream passage subject to flows downstream of Freeman Diversion Dam. Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 50% and 100%.
					0-50%	0	
		Avoidance of low DO water (< 5 mg/L) due to algal blooms.		% reductions of existing VWRF nutrient (N,P) loads	100%	2	Continuous score from 1-2 based on incremental reductions in nutrient loading. There is no score of zero associated with this metric because high background nutrient levels are expected to promote some algae blooms, regardless of VWRF discharge scenario
					0%	1	
	Other Factors considered but not directly assessed for this Beneficial Use:						
	Amount of open water habitat suitable for acclimitization						Open water habitat area and water quality suitability for steelhead smolt acclimitization is represented under EST and RARE assessments.
	Upstream passage flows						Unaffected by VWRF discharges
	Water temperature for MIGR spp.						Limited impact of VWRF upon SCRE temperature relative to solar insolation and radiation suggests no differences across discharge scenarios
	Food resources for MIGR species						Migratory fish are assumed to use the SCRE as a migratory corridor with only transient residence. Only migration opportunities are assessed under the MIGR beneficial use; juvenile steelhead rearing is assessed under the RARE beneficial use.
	Effects of copper on steelhead homing						VWRF Cu levels low in comparison to background levels so will not differ between alternatives

No.	Tier 1 Factors - Beneficial Uses	Tier 2 Factors	Tier 3 Factors	Metric/Criteria	Thresholds	Score	Comments
5	**Navigation (NAV)**						Because there is no evidence that the SCRE is used extensively for navigational purposes such as shipping, travel, or other transportation by private, military, or commercial vessels, and recreational boating is assessed under REC-2, NAV is not assessed separately.
6	**Rare, Threatened, or Endangered Species (RARE)**	Suitable Habitat for Aquatic spp.	Physical habitat area for steelhead rearing	% of Maximum Modeled Inundated Habitat >1.6 ft	100% 0-30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
			Physical habitat area for tidewater goby rearing	% of Maximum Modeled Inundated Habitat 0.3-6.5 ft	100% 0-30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
			Physical habitat area for tidewater goby spawning	% of Maximum Modeled Inundated Habitat 0.3-6.5 ft, sandy substrates	100% 0-30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
			Unseasonal breach effects on TWG spawning and early rearing and steelhead rearing	WSEL relative to SCRE berm elevation	>3ft 0 ft	2 0	Continuous score from 0-2 based on incremental increases in the difference between WSEL and berm elevation
			DO depression below levels suitable for both tidewater goby and steelhead (4 mg/L and 6 mg/L, respectively) due to algal blooms.	% reductions of existing VWRF nutrient (N,P) loads	100% 0%	2 1	Continuous score from 1-2 based on incremental reductions in nutrient loading. There is no score of zero associated with this metric because high background nutrient levels are expected to promote some algae blooms, regardless of VWRF discharge scenario
			Salinity conditions selecting against against non-native freshwater-adapted tidewater goby predators and competitors	Duration of high salinity conditions (> 18 ppt) following breached berm closure	>7 days 0-7 days	2 1	long duration high salinity events may select against freshwater adapted spp. and promote tidewater goby production.
		Habitat for Avian spp.	Amount of Western Snowy Plover foraging habitat	% of Maximum modeled exposed back berm habitat	100% 0-30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
			Amount of California Least Tern foraging habitat	% of Maximum modeled open water habitat	100% 0-30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
		Extent of habitat types associated with RARE plant species	Amount of wetland habitat	% of Maximum modeled wetland habitat	100% 0-30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.

No.	Tier 1 Factors - Beneficial Uses	Tier 2 Factors	Tier 3 Factors	Metric/Criteria	Thresholds	Score	Comments
			Amount of riparian habitat	% of Maximum modeled riparian habitat	100% 0-30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
	Other Factors considered but not directly assessed for this Beneficial Use:						
	Water Temperature for aquatic RARE spp.						Limited impact of VWRF upon SCRE temperature relative to solar insolation and radiation suggests no differences across discharge scenarios
	Ammonia for aquatic RARE spp.						Potential exceedances of Basin Plan criterion continuous concentration (CCC) of ammonia criteria due to pH variations are represented by other WQ considerations (DO vs N,P) for this Beneficial Use
	Copper for Aquatic RARE spp.						VWRF Cu levels low in comparison to background levels so will not differ between alternatives
	Food Resources for aquatic species						Food resources as represented by BMI abundance and species composition is largely controlled by WQ factors (e.g., DO, salinity) already assessed for this Beneficial Use. Additional predictive modeling of food resources not feasible with available data.
	Amount of Open Beach and Foredune Habitat for western snowy plover and California least tern nesting						Not assessed due to large amounts of nearby habitat in combination with low variations with VWRF discharge
	Food Resources for avian species						Availability and composition of food resources is proportional to foraging habitat area
	Terrestrial Wildlife Habitat						Access to and quality of terrestrial habitat not expected to vary with VWRF discharge
7	**Water Contact Recreation (REC-1)**	Opportunities for water contact recreation		% of Maximum modeled open water area	100% 0-10%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 10% and 100%.
	Other Factors considered but not directly assessed for this Beneficial Use:						
	Bacterial water quality						Ongoing compliance with Basin Plan bacterial standards is not expected to vary by VWRF discharge scenario
8	**Non-contact Water Recreation (REC-2)**	Amount of boatable water		% of Maximum modeled open water area > 1 ft deep	100% 0-30%	2 0	1 ft. is depth for rowing, innertube (USFWS 1978). Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
		Opportunities for Camping		Modeled % inundation of Campground at equilibrium stage	0-5% 6-20% >20%	2 1 0	campground flooding occurs at WSEL > 9.5 ft NAVD. At 6-20% inundation, campsites themselves are not inundated, but areas surrounding are.
		Opportunities for Viewing Waterfowl		% of Maximum modeled open water habitat	100% 0-30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.

No.	Tier 1 Factors - Beneficial Uses	Tier 2 Factors	Tier 3 Factors	Metric/Criteria	Thresholds	Score	Comments
		Visual and olfactory aesthetics related to algal blooms		% reductions of existing VWRF nutrient (N,P) loads	100% 0%	2 1	Continuous score from 1-2 based on incremental reductions in nutrient loading. There is no score of zero associated with this metric because high background nutrient levels are expected to promote some algae blooms, regardless of VWRF discharge scenario
	Other Factors considered but not directly assessed for this Beneficial Use: Wildlife viewing related to spp. associated with amount of Wetland habitat						WET assessed directly as a Beneficial Use
9	**Spawning, Reproduction, and/or Early Development (SPWN)**	Amount of spawning and early development habitat for native fishes		% of Maximum Modeled Open Water Habitat	100% 0-30%	2 0	Assume that maximizing open water habitat maximizes opportunities for varied physical habitat needs and life history patterns for native fishes spawning in the SCRE. Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
		Frequency of DO < 5 mg/L due to algal blooms.		% reductions of existing VWRF nutrient (N,P) loads	100% 0%	2 1	Continuous score from 1-2 based on incremental reductions in nutrient loading. There is no score of zero associated with this metric because high background nutrient levels are expected to promote some algae blooms, regardless of VWRF discharge scenario
		Unseasonal breach effects on spawning and early rearing of native fishes		WSEL relative to SCRE berm elevation	>3ft 0 ft	2 0	Continuous score from 0-2 based on incremental increases in the difference between WSEL and berm elevation
	Water Temperature for SPWN uses Salinity conditions initiating spawning behavior						Limited impact of VWRF upon SCRE temperature relative to solar insolation and radiation suggests no differences across discharge scenarios Breaching events expected to present variable salinity conditions which may initiate spawning behavior in some native fishes are largely controlled by Santa Clara River discharge.
10	**Wetland Habitat (WET)**	Amount of Freshwater Wetland Habitat		% of Maximum modeled freshwater Wetland habitat	100% <30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
		Amount of Saltmarsh Wetland Habitat		% of Maximum modeled saltwater wetland habitat	100% <30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
		Nutrient conditions selecting against Arundo		% reductions of existing VWRF nutrient (N,P) loads	100% 0%	2 1	Continuous score from 1-2 based on incremental reductions in nutrient loading. There is no score of zero associated with this metric because high background nutrient levels are expected to promote some algae blooms, regardless of VWRF discharge scenario
		Salinity conditions selecting against Arundo		Duration of high salinity conditions (> 26 ppt) following breached berm closure	>7 days 0-7 days	2 1	long duration events may select against freshwater adapted spp. and promote native species.

No.	Tier 1 Factors - Beneficial Uses	Tier 2 Factors	Tier 3 Factors	Metric/Criteria	Thresholds	Score	Comments
	Water surface elevation impacts on Arundo invasion						Arundo abundance as a function of stage is expected to follow patterns of modeled freshwater wetland habitat. Species composition within the freshwater wetland habitat may be impacted by nutrient and salinity conditions already assessed for this Beneficial Use
11	**Wildlife Habitat (WILD)**	Amount of open water habitat for wildlife species		% of Maximum modeled open water habitat	100% 0-30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
		Amount of tidally exposed Mudflat Habitat for wildlife species		% of Maximum Modeled Open water overlying 4.5ft NAVD88 contour	100% 0-30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
		Amount of Riparian Habitat for wildlife species		% of Maximum Modeled Riparian habitat	100% 0-30%	2 0	Continuous score from 0-2 based on incremental increases in percent of maximum modeled habitat area between 30% and 100%.
	Other Factors considered but not directly assessed for this Beneficial Use:						
	Amount of Aquatic Habitat for wildlife species						Open Water habitat for avian spp. assessed directly under RARE Beneficial Use
	Amount of Open Beach and Foredune Habitat for WILD spp.						Not assessed due to large amounts of nearby habitat in combination with low variations with VWRF discharge
	Food Resources for wildlife species						Availability and composition of food resources is proportional to aquatic (i.e., open water) and terrestrial (i.e., riparian, mudflat) foraging habitat area. Additional predictive modeling of food resources not feasible with available data.
	Amount of Wetland Habitat for WILD spp.						Assessed directly as a Beneficial Use

Ventura Phase 3 Estuary Study Analytic Hierarchy Process
Weighting Worksheet - August 31, 2017

Reviewer (s): **Stillwater Sciences:** Hank Baker, Noah Hume
Ventura Coast Keeper: Dan Chase, Chris Hammersmark, Mike Josselyn, Mike Podlech
Carollo Engineers: Elisa Garvey (observer)

Instructions: Within each tier, rank factors from most to least important to help with consistency. Use this worksheet to go through each pair of metrics and indicate which metric is most important and by how much using the Saaty Scale below.

Intensity of Importance (Saaty Scale)	Definition of Factor Importance	Explanation
1	Equal Importance	Two factors contribute equally to comparison
3	Moderate Importance	Experience and judgement moderately favor one factor over another
5	Strong Importance	Experience and judgement strongly favor one factor over another
7	Very Strong Importance	A factor is strongly favored and its dominance demonstrated in practice
9	Absolute Importance	The evidence favoring one factor over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgements	When compromise is needed

Tier 1 Factors	When choosing a VWRF discharge alternative, which factor weighs more heavily on that decision with respect to realization of all Beneficial Uses?	Choice 1 or 2?	by how much (Saaty scale 1-9)?
Beneficial Use	1) COMM vs. 2) EST	2	7
	1) COMM vs. 2) MIGR	2	7
	1) COMM vs. 2) RARE	2	9
	1) COMM vs. 2) REC-1	2	2
	1) COMM vs. 2) REC-2	2	5
	1) COMM vs. 2) SPWN	2	7
	1) COMM vs. 2) WET	2	7
	1) COMM vs. 2) WILD	2	8
	1) EST vs. 2) MIGR	1	2
	1) EST vs. 2) RARE	2	5
	1) EST vs. 2) REC-1	1	9
	1) EST vs. 2) REC-2	1	7
	1) EST vs. 2) SPWN	2	3
	1) EST vs. 2) WET	1	3
	1) EST vs. 2) WILD	1	4
	1) MIGR vs. 2) RARE	2	6
	1) MIGR vs. 2) REC-1	1	9
	1) MIGR vs. 2) REC-2	1	7
	1) MIGR vs. 2) SPWN	2	5
	1) MIGR vs. 2) WET	2	3
	1) MIGR vs. 2) WILD	2	3
	1) RARE vs. 2) REC-1	1	9
	1) RARE vs. 2) REC-2	1	9
	1) RARE vs. 2) SPWN	1	6
	1) RARE vs. 2) WET	1	3
	1) RARE vs. 2) WILD	1	3
	1) REC-1 vs. 2) REC-2	2	7
	1) REC-1 vs. 2) SPWN	2	9
	1) REC-1 vs. 2) WET	2	8
	1) REC-1 vs. 2) WILD	2	9
	1) REC-2 vs. 2) SPWN	2	9
	1) REC-2 vs. 2) WET	2	7
	1) REC-2 vs. 2) WILD	2	7
	1) SPWN vs. 2) WET	1	5
	1) SPWN vs. 2) WILD	1	5
	1) WET vs. 2) WILD	2	1

Tier 2 Factors	When choosing a VWRF discharge alternative, which factor weighs more heavily on that decision with respect to realization of all Beneficial Uses?	Choice 1 or 2?	by how much (Saaty scale 1-9)?
COMM	1) Suitable Habitat Amount vs. 2) Freq. DO < 5 mg/L	1	5
	1) Suitable Habitat Amount vs. 2) Salinity > Sportfish Thresholds	1	4
	1) Freq. DO < 5 mg/L vs 2) Salinity > Sportfish Thresholds	2	4
EST	1) Suitable Habitat Amount vs. 2) Freq. DO < 5 mg/L	1	3
	1) Suitable Habitat Amount vs. 2) Salinity for native spp.	1	3
	1) Freq. DO < 5 mg/L vs 2. Salinity for native spp.	1	4
MIGR	1) Migr. Opp vs. 2) Avoidance of DO < 5 mg/L	1	8
RARE	1) Suitable Habitat for Aquatic spp. vs. 2) Suitable Habitat for Avian spp.	1	7
	1) Suitable Habitat for Aquatic spp. vs. 2) extent of rare plant habitat	1	7
	1) Suitable Habitat for Avian spp. vs. 2) extent of rare plant habitat	1	5
REC-1	Not Assessed for Single Factor		
REC-2	1) Opps. for Boating vs. 2) Opps for Camping	2	8
	1) Opps. for Boating vs. 2) Wildlife Viewing	2	7
	1) Opps. for Boating vs. 2) Aesthetics	2	6
	1) Opps for Camping vs. 2) Wildlife Viewing	1	3
	1) Opps for Camping vs. 2) Aesthetics	1	3
	1) Wildlife Viewing vs. 2) Aesthetics	1	2
SPWN	1) Suitable Habitat Amount vs. 2) Freq. DO < 5 mg/L	2	3
	1) Suitable Habitat Amount vs. 2) Unseasonal Breaching	2	4
	1) Freq. DO < 5 mg/L vs 2) Unseasonal Breaching	2	4
WET	1) Freshwater Wetland Habitat Amount vs. 2) Saltmarsh Habitat	1	5
	1) Freshwater Wetland Habitat Amount vs. 2) Nutrient levels limiting Arundo	1	7
	1) Freshwater Wetland Habitat Amount vs. 2) Salinity limiting Arundo	1	5
	1) Saltmarsh Habitat vs. 2) Nutrient levels limiting Arundo	1	7
	1) Saltmarsh Habitat vs. 2) Salinity limiting Arundo	1	5
	1) Nutrient levels limiting Arundo vs. 2) Salinity limiting Arundo	2	5
WILD	1) Amount of Open Water Habitat vs. 2) Amount of Mudflat Habitat	2	3
	1) Amount of Open Water Habitat vs. 2) Amount of Riparian Habitat	2	6
	1) Amount of Mudflat Habitat vs. 2) Amount of Riparian Habitat	2	4

Tier 3 Factors

Suitable Habitat for Aquatic spp.	1) Steelhead Rearing Habitat vs. 2) Tidewater Goby Rearing Habitat	2	4
	1) Steelhead Rearing Habitat vs. 2) Tidewater Goby Spawning Habitat	2	4
	1) Steelhead Rearing Habitat vs. 2) Freq. DO below both 5 and 6 mg/L	2	3
	1) Steelhead Rearing Habitat vs. 2) Salinity > Predator/Competitior thresholds	1	6
	1) Steelhead Rearing Habitat vs. 2) Unseasonal breaching	2	4
	1) Tidewater Goby Rearing Habitat vs. 2) Tidewater Goby Spawning Habitat	2	2
	1) Tidewater Goby Rearing Habitat vs. 2) Freq. DO below both 5 and 6 mg/L	1	3
	1) Tidewater Goby Rearing Habitat vs. 2) Salinity > Predator/Competitior thresholds	1	3
	1) Tidewater Goby Rearing Habitat vs. 2) Unseasonal breaching	1	1
	1) Tidewater Goby Spawning Habitat vs. 2) Freq. DO below both 5 and 6 mg/L	1	3
	1) Tidewater Goby Spawning Habitat vs. 2) Salinity > Predator/Competitior thresholds	1	5
	1) Tidewater Goby Spawning Habitat vs. 2) Unseasonal breaching	1	3
	1) Freq. DO below both 5 and 6 mg/L vs. 2) Salinity > Predator/Competitior thresholds	1	6
	1) Freq. DO below both 5 and 6 mg/L vs. 2) Unseasonal breaching	1	2
	1) Salinity > Predator/Competitior thresholds vs. 2) Unseasonal breaching	2	7
Suitable Habitat for Avian spp.	1) Amount of Western Snowy Plover foraging habitat vs. 2) California Least Tern Foraging Habitat	2	7
Extent of Rare Plant Habitat	1) Amount of Wetland Plant Habitat vs. 2) Amount of Riparian Plant Habitat	1	2

Attachment 2
Ventura Phase 3 AHP Calculations

Analytic Hierarchy Process for the Phase 3 Estuary Study
31-Aug-17

Weighting of Tier 1 Factors - Beneficial Use

	COMM	EST	MIGR	RARE	REC-1	REC-2	SPWN	WET	WILD
COMM	1	1/7	1/7	1/9	1/2	1/5	1/7	1/7	1/8
EST	7	1	2	1/5	9	7	1/3	3	4
MIGR	7	1/2	1	1/6	9	7	1/5	1/3	1/3
RARE	9	5	6	1	9	9	6	3	3
REC-1	2	1/9	1/9	1/9	1	1/7	1/9	1/8	1/9
REC-2	5	1/7	1/7	1/9	7	1	1/9	1/7	1/7
SPWN	7	3	5	1/6	9	9	1	5	5
WET	7	1/3	3	1/3	8	7	1/5	1	1
WILD	8	1/4	3	1/3	9	7	1/5	1	1

Analytic Hierarchy Process for the Phase 3 Estuary Study
31-Aug-17

Weighting of Tier 2 Factors by Beneficial Use

COMM

	Suitable Habitat Amount	Freq. DO < 5 mg/L	Salinity > Sportfish Thresholds
Suitable Habitat Amount	1	5	4
Freq. DO < 5 mg/L	1/5	1	1/4
Salinity > Sportfish Thresholds	1/4	4	1

EST

	Suitable Habitat Amount	Freq. DO < 5 mg/L	Salinity for native spp.
Suitable Habitat Amount	1	3	3
Freq. DO < 5 mg/L	1/3	1	4
Salinity for native spp.	1/3	1/4	1

MIGR

	Migr. Opp	Avoidance of DO < 5 mg/L
Migr. Opp	1	8
Avoidance of DO < 5 mg/L	1/8	1

RARE

	Suitable Habitat for Aquatic spp.	Suitable Habitat for Avian spp.	extent of rare plant habitat
Suitable Habitat for Aquatic spp.	1	7	7
Suitable Habitat for Avian spp.	1/7	1	5
extent of rare plant habitat	1/7	1/5	1

REC-1

	Opps. for Boating	Opps for Camping	Wildlife Viewing	Aesthetics
Opps. for Boating	1	1/8	1/7	1/6
Opps for Camping	8	1	3	3
Wildlife Viewing	7	1/3	1	2
Aesthetics	6	1/3	1/2	1

SPWN

	Suitable Habitat Amount	Freq. DO < 5 mg/L	Unseasonal Breaching
Suitable Habitat Amount	1	1/3	1/4
Freq. DO < 5 mg/L	3	1	1/4
Unseasonal Breaching	4	4	1

WET

	Freshwater Wetland Habitat Amount	Saltmarsh Habitat	Nutrient levels limiting Arundo	Salinity limiting Arundo
Freshwater Wetland Habitat Amount	1	5	7	5
Saltmarsh Habitat	1/5	1	7	5
Nutrient levels limiting Arundo	1/7	1/7	1	1/5
Salinity limiting Arundo	1/5	1/5	5	1

WILD

	Amount of Open Water Habitat	Amount of Mudflat Habitat	Amount of Riparian Habitat
Amount of Open Water Habitat	1	1/3	1/6
Amount of Mudflat Habitat	3	1	1/4
Amount of Riparian Habitat	6	4	1

Weighting of Tier 2 Factors by Beneficial Use

RARE/Suitable Habitat for Aquatic spp.

	Steelhead Rearing Habitat	Tidewater Goby Rearing Habitat	Tidewater Goby Spawning Habitat	Freq. DO below both 5 and 6 mg/L	Salinity > Predator/Competitior thresholds	Unseasonal breaching
Steelhead Rearing Habitat	1	1/4	1/4	1/3	6	1/4
Tidewater Goby Rearing Habitat	4	1	1/2	3	3	1
Tidewater Goby Spawning Habitat	4	2	1	3	5	3
Freq. DO below both 5 and 6 mg/L	3	1/3	1/3	1	6	2
Salinity > Predator/Competitior thresholds	1/6	1/3	1/5	1/6	1	1/7
Unseasonal breaching	4	1	1/3	1/2	7	1

RARE/Suitable Habitat for Avian spp.

	California Least Tern Foraging Habitat	Amount of Western Snowy Plover foraging habitat
California Least Tern Foraging Habitat	1	7
Amount of Western Snowy Plover foraging habitat	1/7	1

RARE/extent of rare plant habitat

	Amount of Wetland Plant Habitat	Amount of Riparian Plant Habitat
Amount of Wetland Plant Habitat	1	2
Amount of Riparian Plant Habitat	1/2	1

Analytic Hierarchy Process for the Phase 3 Estuary Study
Summary of Weighting and Scoring Calculations
14-Sep-17

Factors by Analytical Hierarchy			Calculated Weights				Standarized Score by VWRF Discharge Scenario										
Tier 1	**Tier 2**	**Tier 3**	**Tier 1**	**Tier 2**	**Tier 3**	**Final**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
COMM	COMM:habitat		0.0136	0.6648		**0.0090**	0.1587	0.1508	0.1349	0.1190	0.1032	0.0952	0.0794	0.0714	0.0556	0.0238	0.0079
COMM	COM:do		0.0136	0.0902		**0.0012**	0.0606	0.0667	0.0727	0.0788	0.0848	0.0909	0.0970	0.1030	0.1091	0.1152	0.1212
COMM	DOM:salinity		0.0136	0.2449		**0.0033**	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909
EST	EST:habitat		0.1338	0.5750		**0.0769**	0.1587	0.1508	0.1349	0.1190	0.1032	0.0952	0.0794	0.0714	0.0556	0.0238	0.0079
EST	EST:do		0.1338	0.3043		**0.0407**	0.0606	0.0667	0.0727	0.0788	0.0848	0.0909	0.0970	0.1030	0.1091	0.1152	0.1212
EST	EST:salinity		0.1338	0.1207		**0.0162**	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.1667
MIGR	MIGR:opportunity		0.0652	0.8889		**0.0580**	0.1274	0.1210	0.1083	0.1019	0.0955	0.0764	0.0764	0.0764	0.0764	0.0701	0.0701
MIGR	MIGR:avoidance		0.0652	0.1111		**0.0072**	0.0606	0.0667	0.0727	0.0788	0.0848	0.0909	0.0970	0.1030	0.1091	0.1152	0.1212
RARE	RARE:aquatic	RARE:aquatic:steelhead	0.3446	0.7531	0.0776	**0.0201**	0.1887	0.1792	0.1698	0.1604	0.1415	0.1038	0.0472	0.0094	0.0000	0.0000	0.0000
RARE	RARE:aquatic	RARE:aquatic:TGrear	0.3446	0.7531	0.2173	**0.0564**	0.2326	0.1977	0.1395	0.1047	0.1047	0.0930	0.0814	0.0465	0.0000	0.0000	0.0000
RARE	RARE:aquatic	RARE:aquatic:TGspawn	0.3446	0.7531	0.3342	**0.0867**	0.1104	0.1169	0.1234	0.1234	0.1299	0.1299	0.1169	0.0844	0.0455	0.0195	0.0000
RARE	RARE:aquatic	RARE:aquatic:do	0.3446	0.7531	0.1673	**0.0434**	0.0606	0.0667	0.0727	0.0788	0.0848	0.0909	0.0970	0.1030	0.1091	0.1152	0.1212
RARE	RARE:aquatic	RARE:aquatic:salinity	0.3446	0.7531	0.0354	**0.0092**	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.0833	0.1667
RARE	RARE:aquatic	RARE:aquatic:breaching	0.3446	0.7531	0.1682	**0.0436**	0.0121	0.0303	0.0545	0.0727	0.1030	0.1212	0.1212	0.1212	0.1212	0.1212	0.1212
RARE	RARE:avian	RARE:avian:tern	0.3446	0.1840	0.8750	**0.0555**	0.2299	0.1954	0.1494	0.1034	0.0920	0.0805	0.0690	0.0575	0.0230	0.0000	0.0000
RARE	RARE:avian	RARE:avian:plover	0.3446	0.1840	0.1250	**0.0079**	0.1036	0.0984	0.0984	0.0984	0.0984	0.0984	0.0984	0.0984	0.0933	0.0881	0.0259
RARE	RARE:plant	RARE:plant:wetland	0.3446	0.0629	0.6667	**0.0145**	0.3704	0.2593	0.2963	0.0185	0.0185	0.0185	0.0185	0.0000	0.0000	0.0000	0.0000
RARE	RARE:plant	RARE:plant:riparian	0.3446	0.0629	0.3333	**0.0072**	0.0585	0.0643	0.0643	0.0877	0.0936	0.0936	0.0936	0.0994	0.1111	0.1170	0.1170
REC-1			0.0138			**0.0138**	0.1587	0.1508	0.1349	0.1190	0.1032	0.0952	0.0794	0.0714	0.0556	0.0238	0.0079
REC-2	REC-2:boating		0.0284	0.0418		**0.0012**	0.1613	0.1532	0.1532	0.1452	0.1371	0.1210	0.0806	0.0403	0.0081	0.0000	0.0000
REC-2	REC-2:camping		0.0284	0.5219		**0.0148**	0.0000	0.0556	0.0556	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111	0.1111
REC-2	REC-2:wildlife		0.0284	0.2601		**0.0074**	0.1587	0.1508	0.1349	0.1190	0.1032	0.0952	0.0794	0.0714	0.0556	0.0238	0.0079
REC-2	REC-2:aesthetic		0.0284	0.1762		**0.0050**	0.0606	0.0667	0.0727	0.0788	0.0848	0.0909	0.0970	0.1030	0.1091	0.1152	0.1212
SPWN	SPWN:habitat		0.2186	0.1130		**0.0247**	0.1587	0.1508	0.1349	0.1190	0.1032	0.0952	0.0794	0.0714	0.0556	0.0238	0.0079
SPWN	SPWN:do		0.2186	0.2351		**0.0514**	0.0606	0.0667	0.0727	0.0788	0.0848	0.0909	0.0970	0.1030	0.1091	0.1152	0.1212
SPWN	SPWN:breaching		0.2186	0.6519		**0.1425**	0.0121	0.0303	0.0545	0.0727	0.1030	0.1212	0.1212	0.1212	0.1212	0.1212	0.1212
WET	WET:freshwater		0.0902	0.5942		**0.0536**	0.4167	0.2708	0.3125	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
WET	WET:saltmarsh		0.0902	0.2606		**0.0235**	0.0000	0.0514	0.0514	0.1086	0.1086	0.1086	0.1143	0.1143	0.1143	0.1143	0.1143
WET	WET:nutrients		0.0902	0.0403		**0.0036**	0.0606	0.0667	0.0727	0.0788	0.0848	0.0909	0.0970	0.1030	0.1091	0.1152	0.1212
WET	WET:salinity		0.0902	0.1049		**0.0095**	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909
WILD	WILD:openwater		0.0917	0.0914		**0.0084**	0.0585	0.0643	0.0643	0.0877	0.0936	0.0936	0.0936	0.0994	0.1111	0.1170	0.1170
WILD	WILD:mudflat		0.0917	0.2177		**0.0200**	0.2151	0.1935	0.1720	0.1290	0.0968	0.0753	0.0645	0.0430	0.0108	0.0000	0.0000
WILD	WILD:riparian		0.0917	0.6909		**0.0633**	0.1587	0.1508	0.1349	0.1190	0.1032	0.0952	0.0794	0.0714	0.0556	0.0238	0.0079

Attachment 3
Ventura Phase 3 AHP Workshop Materials
November 8, 2017

Santa Clara River Estuary Special Studies - Resources Agencies Meeting

November 8, 2017
9:00 am – 12:00 pm
Santa Cruz Room (223)
Ventura City Hall
501 Poli Street, Ventura

Estuary Special Studies will answer:
How much tertiary treated effluent from the Ventura Water Reclamation Facility (up to 100%) should be diverted from for reclamation, and how much (if any) should continue to be discharged to, the Santa Clara River Estuary to best protect the estuary's ecology and beneficial uses?

Focus of this Workshop:
The last stakeholder workshop on this project was held in November 2016. At that meeting, we presented an update on the Phase 3 Monitoring Program, the diversion infrastructure study, an update on potable reuse regulations, preliminary results of the potable reuse demonstration facility, and an initial discussion on the CEQA process/scope. Since then, the Phase 3 monitoring program has been completed, and used for the development of a Draft Phase 3 Estuary Studies Report. The Draft Phase 3 Estuary Studies Report includes technical basis for a finding of enhancement of the beneficial uses of the Estuary and for determination of the maximum ecologically protective diversion volume (MEPDV).

At this meeting, we will focus on the data, technical analysis, interpretation of results, and recommendations of the Draft Phase 3 Estuary Studies Report. In particular, we will present and seek input on the analytical hierarchy process (AHP) used to evaluate different discharge scenarios, results of the AHP, interpretation of the results, and conclusions/recommendations.

Agenda

1. Introductions

2. Phase 3 Study - Technical Basis
   - -Overview
   - -Water Balance and other modeling tools
   - -Relationship between stage and metrics (associated with beneficial uses)

3. Phase 3 Study - Scenario Evaluation
   - -Overview of Analytical Hierarchy Process (AHP) methodology
   - -Prioritization of Beneficial Uses
   - -Factors, Metrics, and Weighting Used in the AHP
   - -AHP Results

4.Phase 3 Study – Recommendations and Conclusions (based on Draft Phase 3 Report information and application of Best Professional Judgment)

-Explanation of MEPDV Recommendation and Continued Discharge Recommendation

-Interpretation of AHP Results and Assessment of Enhancement

-Interpretation of AHP Results and Assessment of Take

5.City and Wishtoyo/Heal the Bay Experts' Critique/Qualifications Regarding:

-AHP Methodology, Factors, Weighting

-Recommendations and Conclusions

6.Scientific Review Panelists and Resource Agency Representatives Input Regarding:

-AHP Methodology, Factors, Weighting

-Recommendations and Conclusions

Attachment 4
Ventura Phase 3 AHP Workshop Materials
December 20, 2017

Santa Clara River Estuary Special Studies - Resources Agencies Meeting

December 20, 2017
9:30 am – 12:00 pm

Conference Line: (866) 884-0497; 978-123-5625
GoTo Meeting (may require plug-in download): https://global.gotomeeting.com/join/926804917

Los Angeles Meeting Location
Carollo Engineers
707 Wilshire Boulevard, Suite 3920
Los Angeles, CA 90017

San Rafael Meeting Location
WRA, Inc.
2169 G East Francisco Blvd.
San Rafael, CA 94901

Focus of this Workshop:
Review of comments on the Draft Phase 3 Estuary Studies Report and discussion of analysis and report changes being considered based on comments received to date. The Phase 3 Report is required to provide the technical basis for a finding of enhancement of the beneficial uses of the Estuary and for determination of the maximum ecologically protective diversion volume (MEPDV) from the Estuary for water supply use through potable reuse.

Agenda

1. Introductions (5 min)

2. Overview of Comments Received on Phase 3 Study and Experts/Agencies recommendations for capturing unrepresented factors affected by VWRF discharge (Commenters and Stillwater)
   - Water Quality
   - Water Balance
   - Habitat/Ecology
   - AHP Process and Weighting

3. Discussion of Updated Analysis based on November 8, 2017 Workshop (Stillwater)
   - Relative contribution of RARE factors ("disaggregation")
   - Additional factors suggested for incorporation
      i. Minimizing local flooding as a function of WET
      ii. Minimizing potential flooding of California least tern nests
      iii. Improvements to MUN from diversion of treated flow
      iv. Addition of riparian-associated bird species to RARE analysis
   - Revised AHP weighting and scoring results
      i. Addition of factors at Tier 1 (MUN), Tier 2 (WET flood attenuation), and Tier 3 (RARE Avian Nest flooding, RARE Avian riparian species)
      ii. Increased weighting of factors associated with unseasonal breaching, DO
   - Evaluation of alternative AHP assumptions
      i. Sensitivity testing of scoring thresholds for open water area

4. Discussion and Recommendations for Revisions to Phase 3 Study (All)
   - Comments on scoring metrics and thresholds
   - Other recommendations?

5. Next Steps/Schedule

Weighting Worksheet for Updated Analytic Hierarchy Process

The analytic hierarchy was updated following the following the November 8th and 15th, 2017 Workshops to incorporate feedback. The worksheet contained herein was sent to Agency Reviewers and Wishtoyo Foundation/Heal the Bay Technical Review Team to solicit weighting input.

Ventura Phase 3 Estuary Study Analytic Hierarchy Process
Weighting Worksheet - To be completed by reviewers

Reviewer (s):

Instructions: Within each tier, rank factors from most to least important to help with consistency. Use this worksheet to go through each pair of metrics and indicate which metric is most important and by how much using the Saaty Scale below.

Intensity of Importance (Saaty Scale)	Definition of Factor Importance	Explanation
1	Equal Importance	Two factors contribute equally to comparison
3	Moderate Importance	Experience and judgement moderately favor one factor over another
5	Strong Importance	Experience and judgement strongly favor one factor over another
7	Very Strong Importance	A factor is strongly favored and its dominance demonstrated in practice
9	Absolute Importance	The evidence favoring one factor over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgements	When compromise is needed

Tier 1 Factors	When choosing a VWRF discharge alternative, which factor weighs more heavily on that decision with respect to realization of all Beneficial Uses?	Choice 1 or 2?	by how much (Saaty scale 1-9)?
Beneficial Use	1) COMM vs. 2) EST		
	1) COMM vs. 2) MIGR		
	1) COMM vs. 2) MUN		
	1) COMM vs. 2) RARE		
	1) COMM vs. 2) REC-1		
	1) COMM vs. 2) REC-2		
	1) COMM vs. 2) SPWN		
	1) COMM vs. 2) WET		
	1) COMM vs. 2) WILD		
	1) EST vs. 2) MIGR		
	1) EST vs. 2) MUN		
	1) EST vs. 2) RARE		
	1) EST vs. 2) REC-1		
	1) EST vs. 2) REC-2		

	1) EST vs. 2) SPWN		
	1) EST vs. 2) WET		
	1) EST vs. 2) WILD		
	1) MIGR vs. 2) MUN		
	1) MIGR vs. 2) RARE		
	1) MIGR vs. 2) REC-1		
	1) MIGR vs. 2) REC-2		
	1) MIGR vs. 2) SPWN		
	1) MIGR vs. 2) WET		
	1) MIGR vs. 2) WILD		
	1) MUN vs. 2) RARE		
	1) MUN vs. 2) REC-1		
	1) MUN vs. 2) REC-2		
	1) MUN vs. 2) SPWN		
	1) MUN vs. 2) WET		
	1) MUN vs. 2) WILD		
	1) RARE vs. 2) REC-1		
	1) RARE vs. 2) REC-2		
	1) RARE vs. 2) SPWN		
	1) RARE vs. 2) WET		
	1) RARE vs. 2) WILD		
	1) REC-1 vs. 2) REC-2		
	1) REC-1 vs. 2) SPWN		

	1) REC-1 vs. 2) WET		
	1) REC-1 vs. 2) WILD		
	1) REC-2 vs. 2) SPWN		
	1) REC-2 vs. 2) WET		
	1) REC-2 vs. 2) WILD		
	1) SPWN vs. 2) WET		
	1) SPWN vs. 2) WILD		
	1) WET vs. 2) WILD		

Tier 2 Factors	When choosing a VWRF discharge alternative, which factor weighs more heavily on that decision with respect to realization the Beneficial Uses?		
COMM	1) Habitat Amount vs. 2) Freq. DO < 5 mg/L		

EST	1) Open water habitat amount vs. 2) Wetland habitat amount		
	1) Open water habitat amount vs. 2) Salinity for native spp.		
	1) Open water habitat amount vs. 2) Freq. DO < 5 mg/L		
	1) Freq. DO < 5 mg/L vs. 2) Wetland habitat amount		
	1) Freq. DO < 5 mg/L vs. 2) Salinity for native spp.		

	1) Wetland habitat amount vs. 2) Salinity for native spp.		

MIGR	1) Migr. Opp vs. 2) Avoidance of DO < 5 mg/L		

RARE	1) Habitat for Aquatic spp. vs. 2) Habitat for Avian spp.		
	1) Habitat for Aquatic spp. vs. 2) extent of rare plant habitat		
	1) Habitat for Avian spp. vs. 2) extent of rare plant habitat		

REC-1	Not Assessed for Single Factor		

REC-2	1) Opps. for Boating vs. 2) Opps for Camping		
	1) Opps. for Boating vs. 2) Wildlife Viewing		
	1) Opps. for Boating vs. 2) Aesthetics		
	1) Opps for Camping vs. 2) Wildlife Viewing		
	1) Opps for Camping vs. 2) Aesthetics		
	1) Wildlife Viewing vs. 2) Aesthetics		

SPWN	1) Habitat Amount vs. 2) Freq. DO < 5 mg/L		
	1) Habitat Amount vs. 2) Unseasonal Breaching		
	1) Freq. DO < 5 mg/L vs. 2) Unseasonal Breaching		

WET	1) Freshwater and Saltmarsh Habitat Amount vs. 2) Riparian Habitat Amount		
	1) Freshwater and Saltmarsh Habitat Amount vs. 2) Nutrient levels limiting Arundo		
	1)Freshwater and Saltmarsh Habitat Amount vs. 2) Flood storage capacity		

	1) Riparian Habitat Amount vs. 2) Nutrient levels limiting Arundo		
	1) Riparian Habitat Amount vs. 2) Flood storage capacity		
	1) Nutrient levels limiting Arundo vs. 2) Flood storage capacity		

WILD	1) Amount of Open Water Habitat vs. 2) Amount of Mudflat Habitat		
	1) Amount of Open Water Habitat vs. 2) Amount of Riparian Habitat		
	1) Amount of Mudflat Habitat vs. 2) Amount of Riparian Habitat		

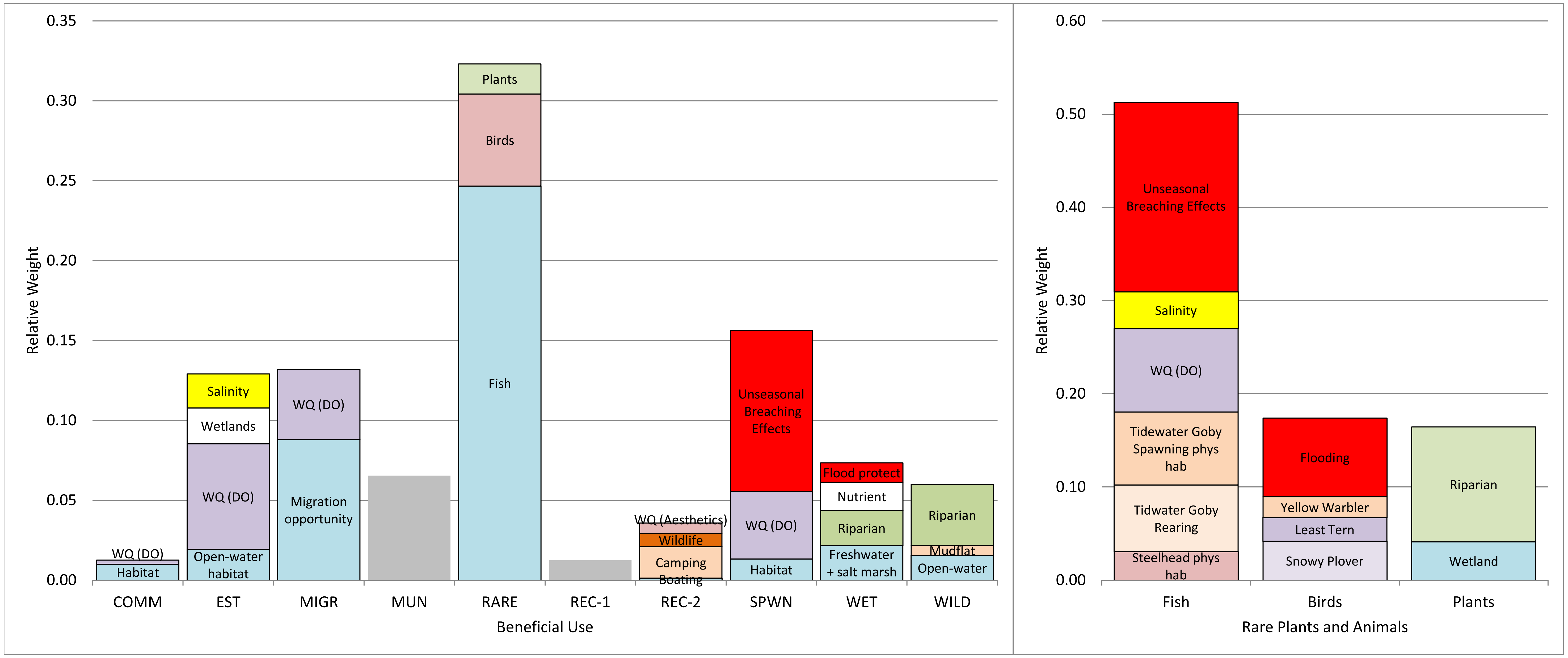
Tier 3 Factors	**When choosing a VWRF discharge alternative, which factor weighs more heavily on that decision with respect to realization the tier 2 factor for the RARE Beneficial Uses?**		
Habitat Conditions for Aquatic spp.	1) Steelhead Rearing Habitat vs. 2) Tidewater Goby Rearing Habitat		
	1) Steelhead Rearing Habitat vs. 2) Tidewater Goby Spawning Habitat		
	1) Steelhead Rearing Habitat vs. 2) Freq. DO below both 5 and 6 mg/L		
	1) Steelhead Rearing Habitat vs. 2) Salinity > Predator/Competitior thresholds		
	1) Steelhead Rearing Habitat vs. 2) Unseasonal breaching		
	1) Tidewater Goby Rearing Habitat vs. 2) Tidewater Goby Spawning Habitat		
	1) Tidewater Goby Rearing Habitat vs. 2) Freq. DO below both 5 and 6 mg/L		
	1) Tidewater Goby Rearing Habitat vs. 2) Salinity > Predator/Competitior thresholds		
	1) Tidewater Goby Rearing Habitat vs. 2) Unseasonal breaching		
	1) Tidewater Goby Spawning Habitat vs. 2) Freq. DO below both 5 and 6 mg/L		
	1) Tidewater Goby Spawning Habitat vs. 2) Salinity > Predator/Competitior thresholds		
	1) Tidewater Goby Spawning Habitat vs. 2) Unseasonal breaching		

	1) Freq. DO below both 5 and 6 mg/L vs. 2) Salinity > Predator/Competitior thresholds		
	1) Freq. DO below both 5 and 6 mg/L vs. 2) Unseasonal breaching		
	1) Salinity > Predator/Competitior thresholds vs. 2) Unseasonal breaching		
Habitat Conditions for Avian spp.	1) Amount of Western Snowy Plover foraging habitat vs. 2) Amount of California Least Tern Foraging Habitat		
	1) Amount of Western Snowy Plover foraging habitat vs. 2) Amount of yellow warbler habitat		
	1) Amount of Western Snowy Plover foraging habitat vs. 2) Risk of flooding CLT/WSP nesting habitat		
	1) Amount of California Least Tern Foraging Habitat vs. 2) Amount of yellow warbler habitat		
	1) Amount of California Least Tern Foraging Habitat vs. 2) Risk of Flooding CLT/WSP nesting habitat		
	1) Amount of yellow warbler Habitat vs. 2) Risk of Flooding CLT/WSP nesting habitat		
Extent of Rare Plant Habitat	1) Amount of Wetland Plant Habitat vs. 2) Amount of Riparian Plant Habitat		

Attachment 5
December 20, 2017 Workshop Participant Submitted Relative Weights from Pairwise Comparisons

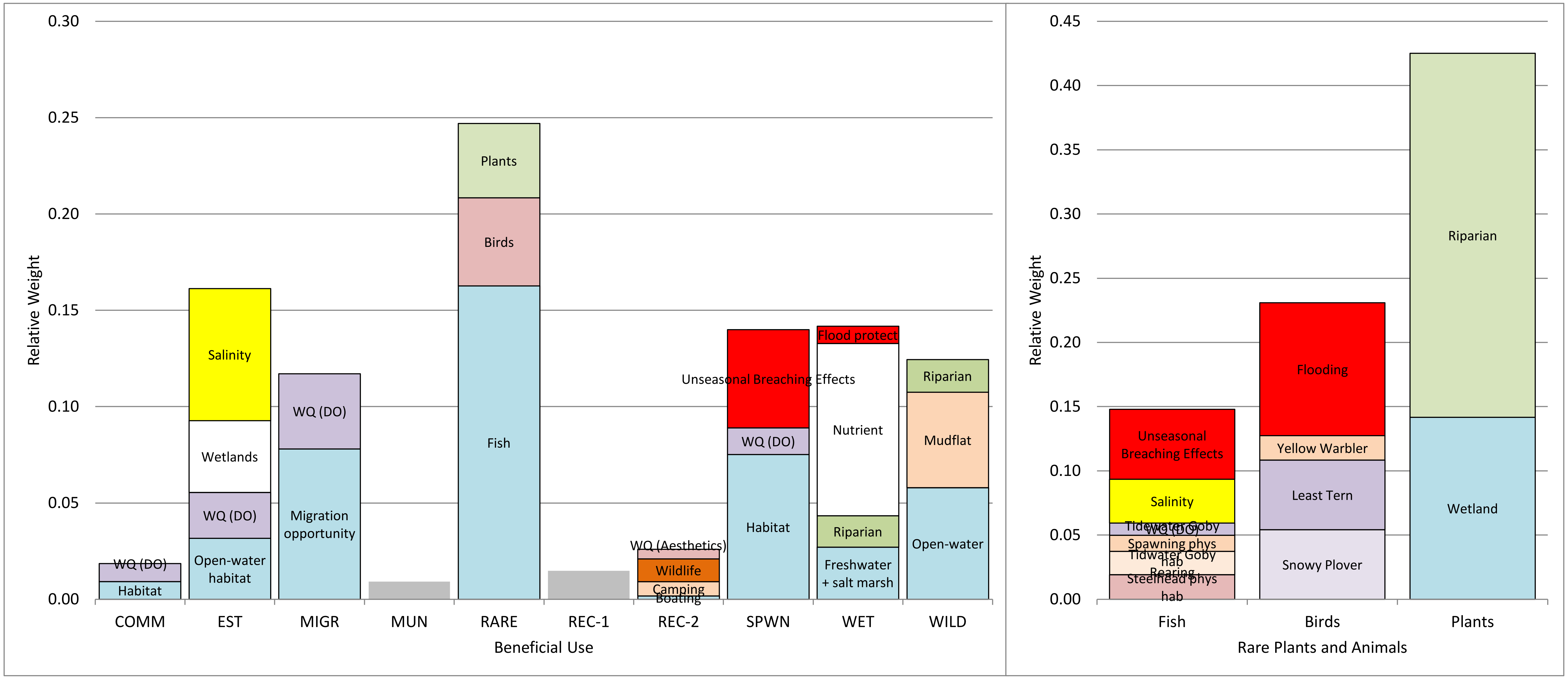
Ventura Phase 3 Estuary Study Analytic Hierarchy Process, AHP-2
AHP-2 Participant Submitted Relative Weights from Pairwise Comparisons

Reviewer (s): Participant 1



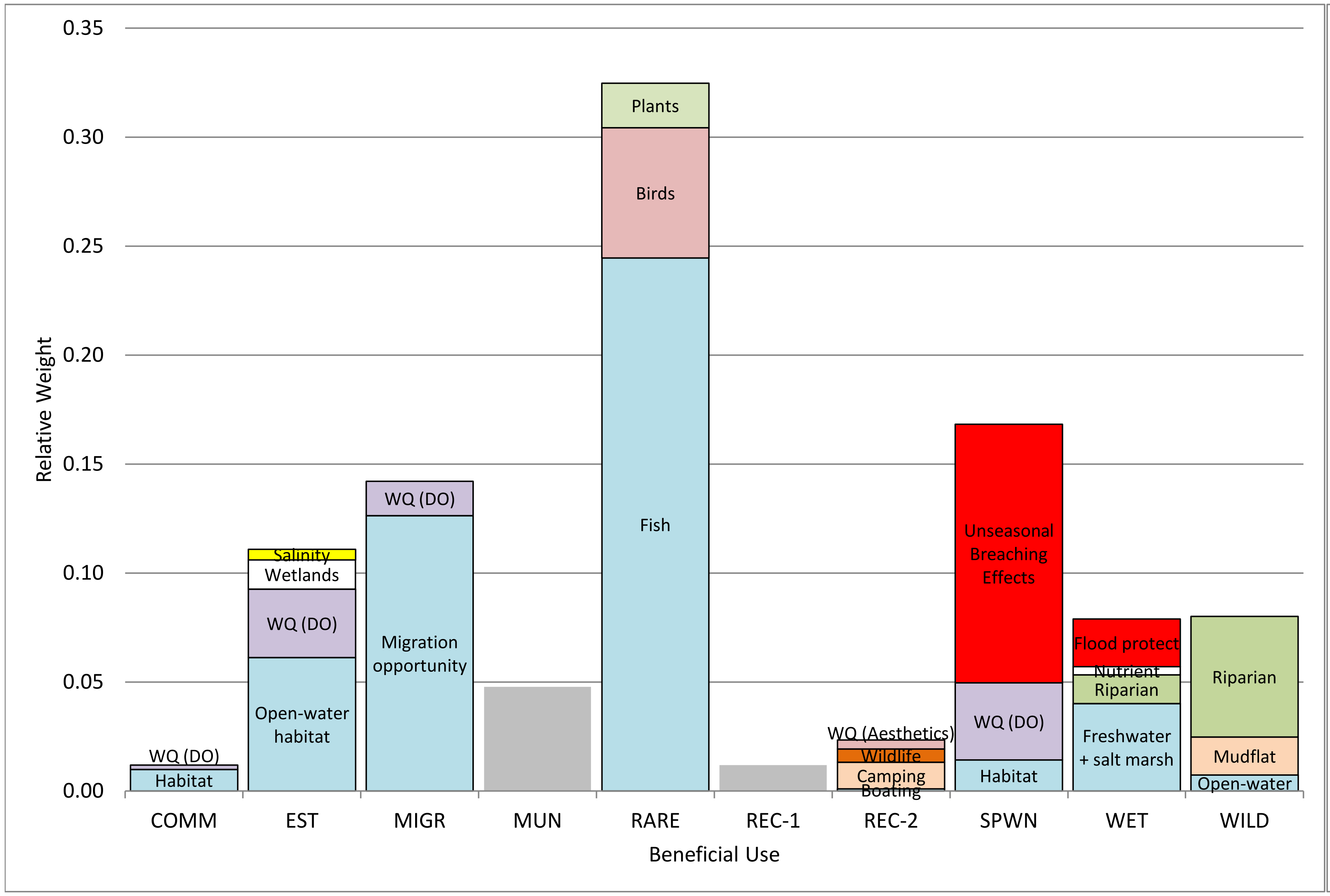
Ventura Phase 3 Estuary Study Analytic Hierarchy Process, AHP-2
AHP-2 Participant Submitted Relative Weights from Pairwise Comparisons

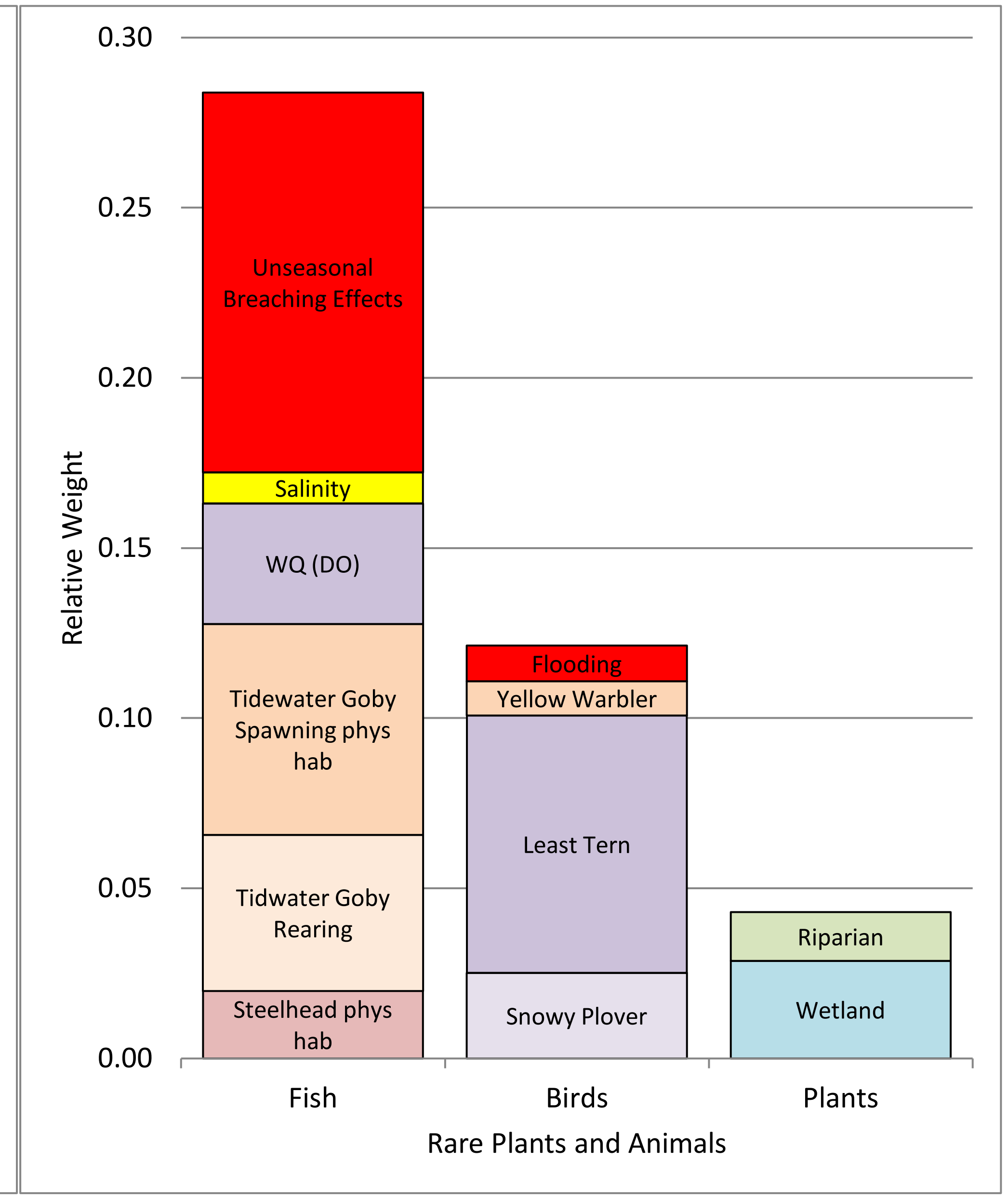
Reviewer Participant 2



Ventura Phase 3 Estuary Study Analytic Hierarchy Process, AHP-2
AHP-2 Participant Submitted Relative Weights from Pairwise Comparisons

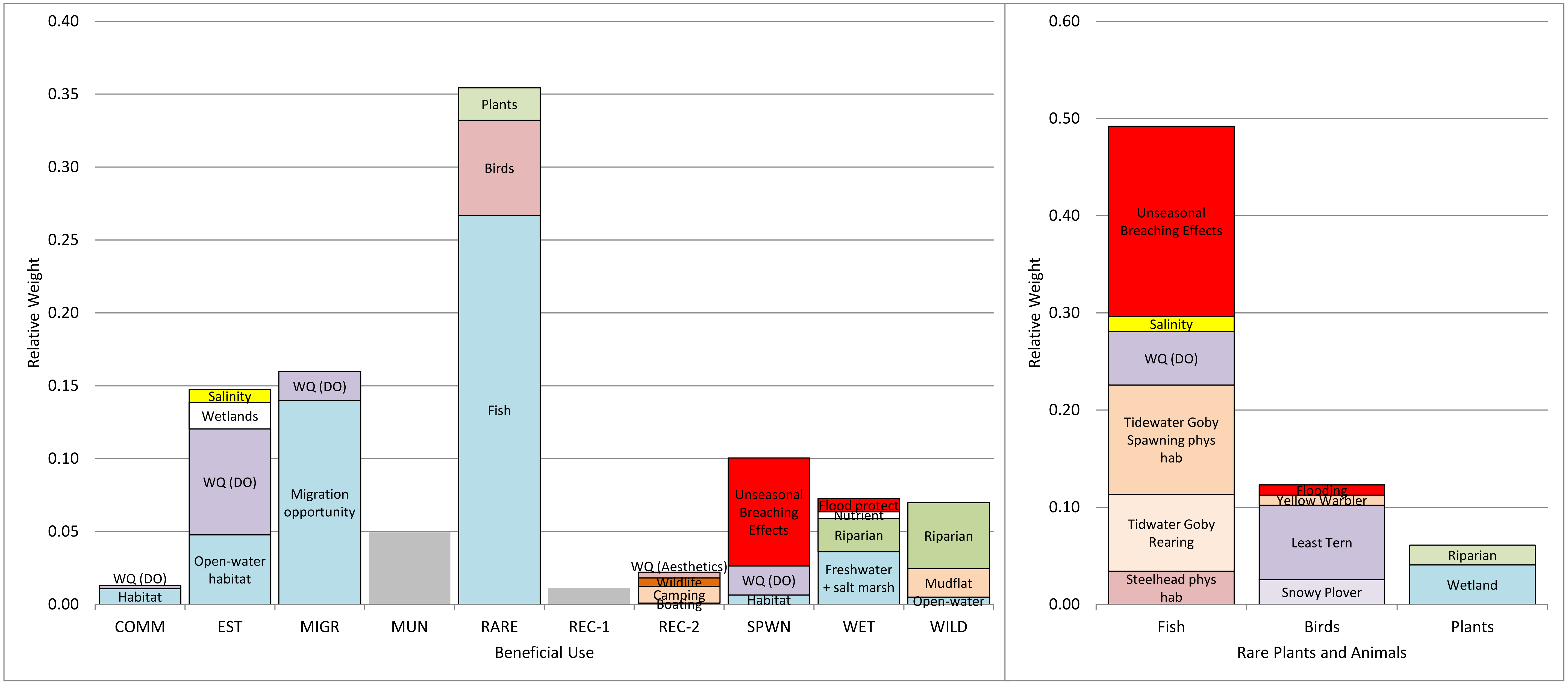
Reviewer Participant 3





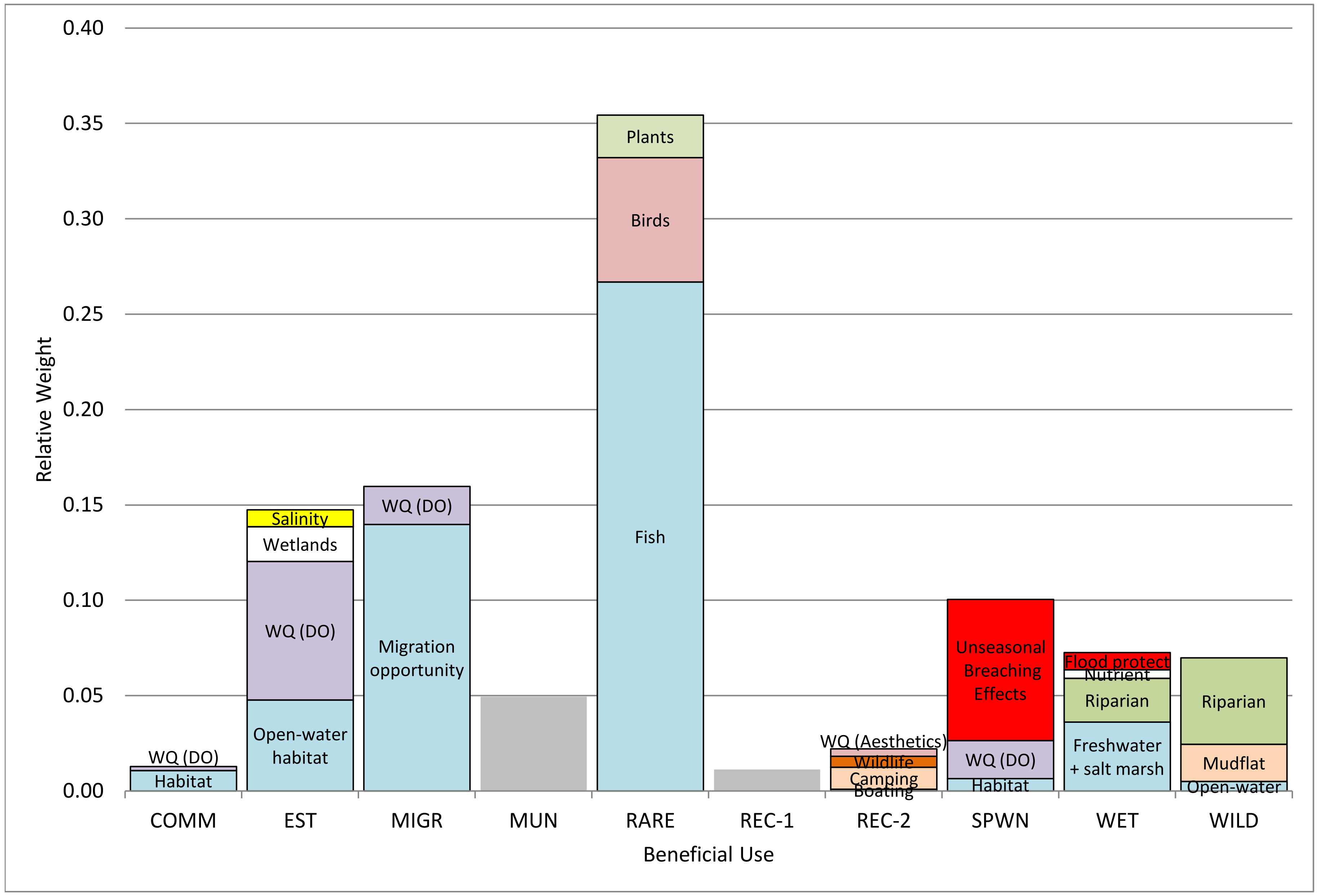
Ventura Phase 3 Estuary Study Analytic Hierarchy Process, AHP-2
AHP-2 Participant Submitted Relative Weights from Pairwise Comparisons

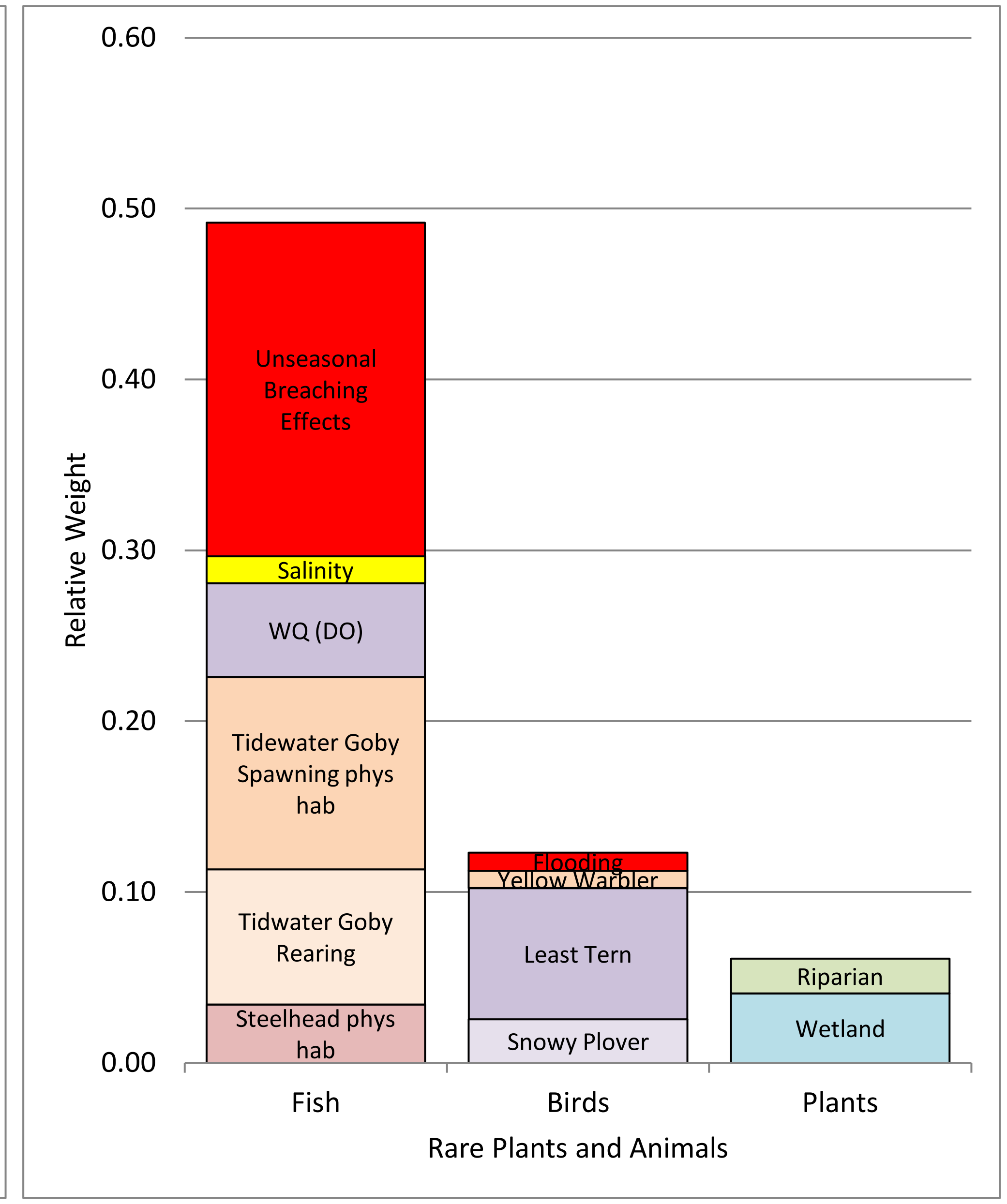
Reviewer Participant 4



Ventura Phase 3 Estuary Study Analytic Hierarchy Process, AHP-2
AHP-2 Participant Submitted Relative Weights from Pairwise Comparisons

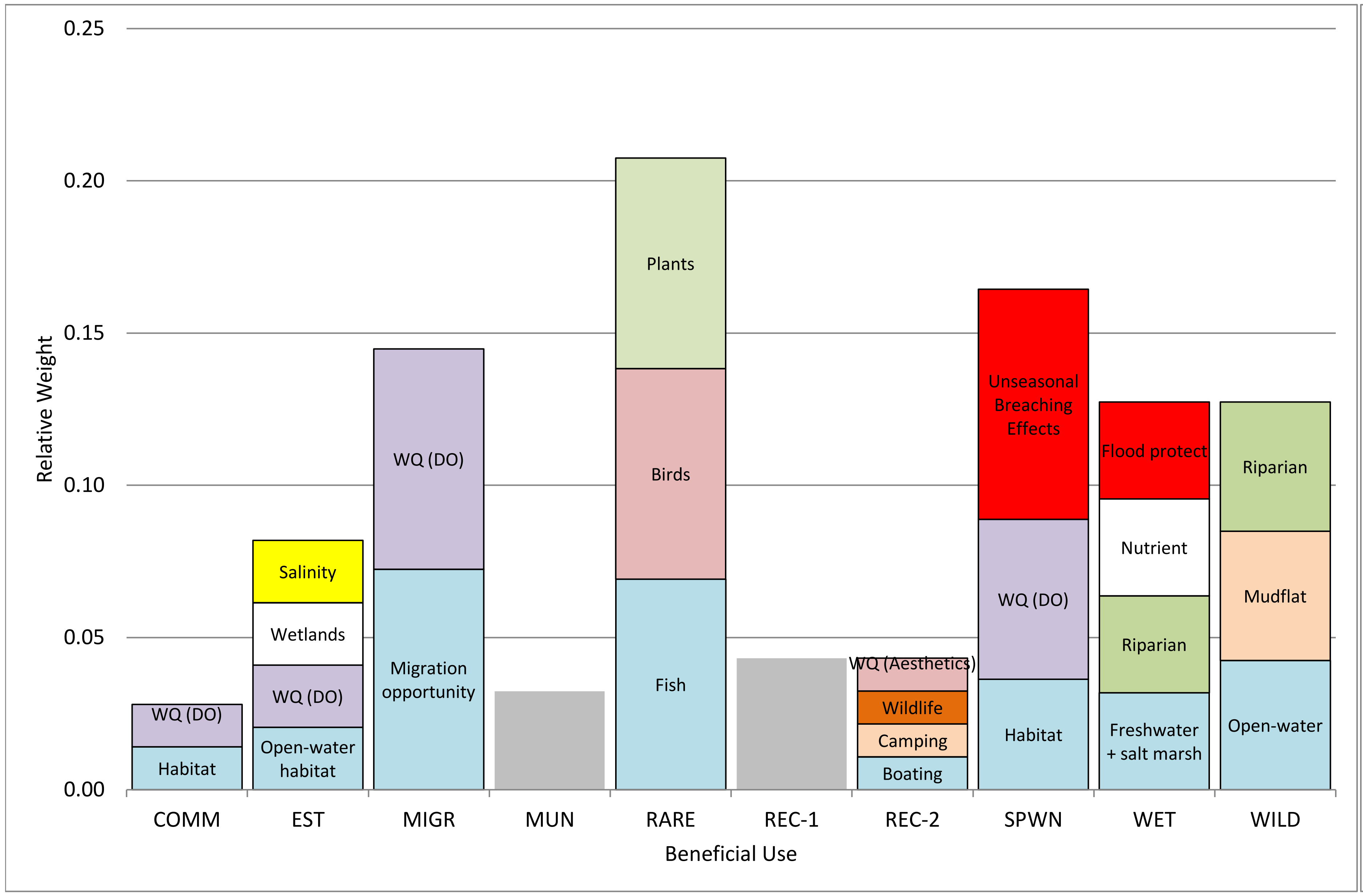
Reviewer Participant 5

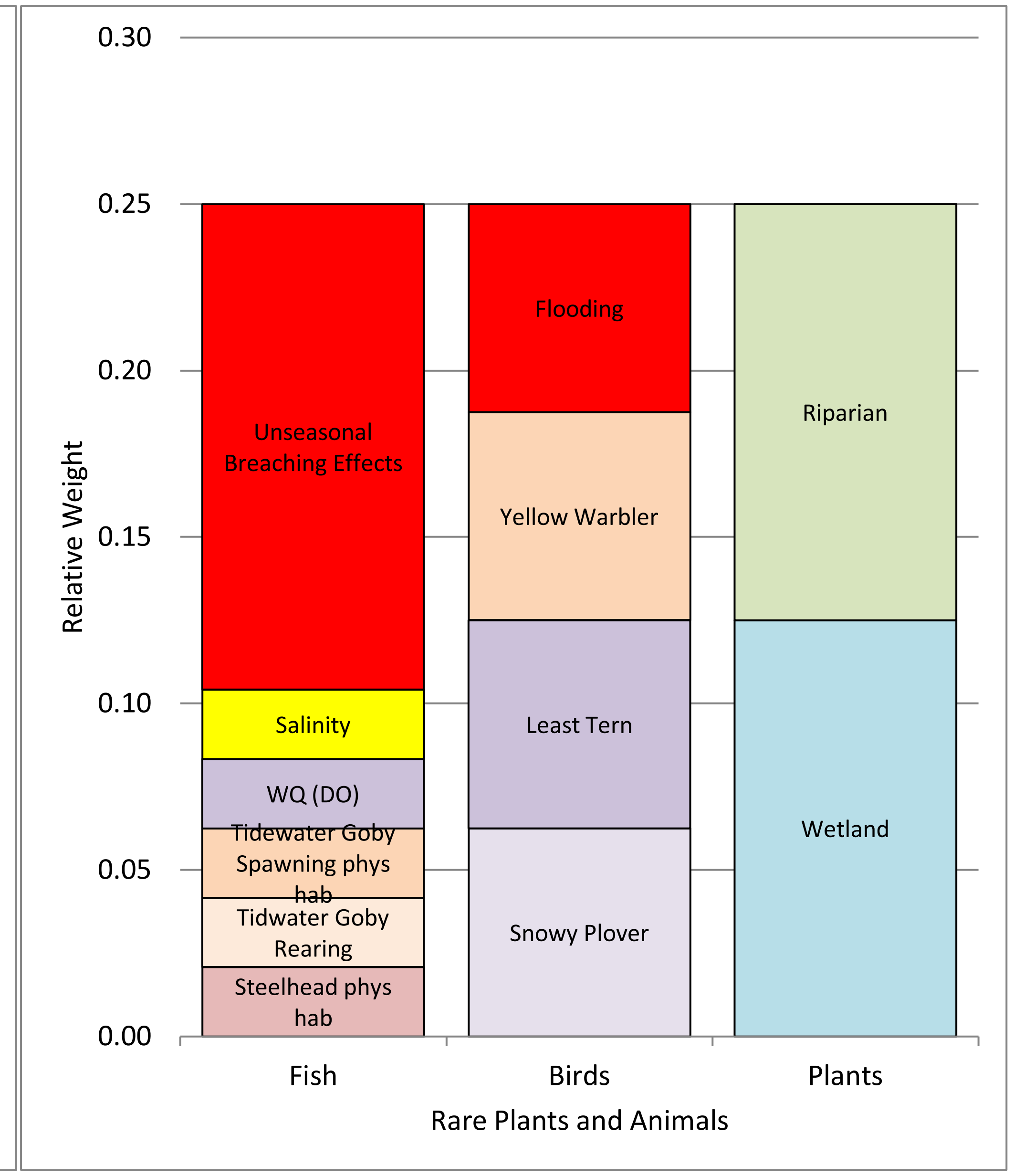




Ventura Phase 3 Estuary Study Analytic Hierarchy Process, AHP-2
AHP-2 Participant Submitted Relative Weights from Pairwise Comparisons

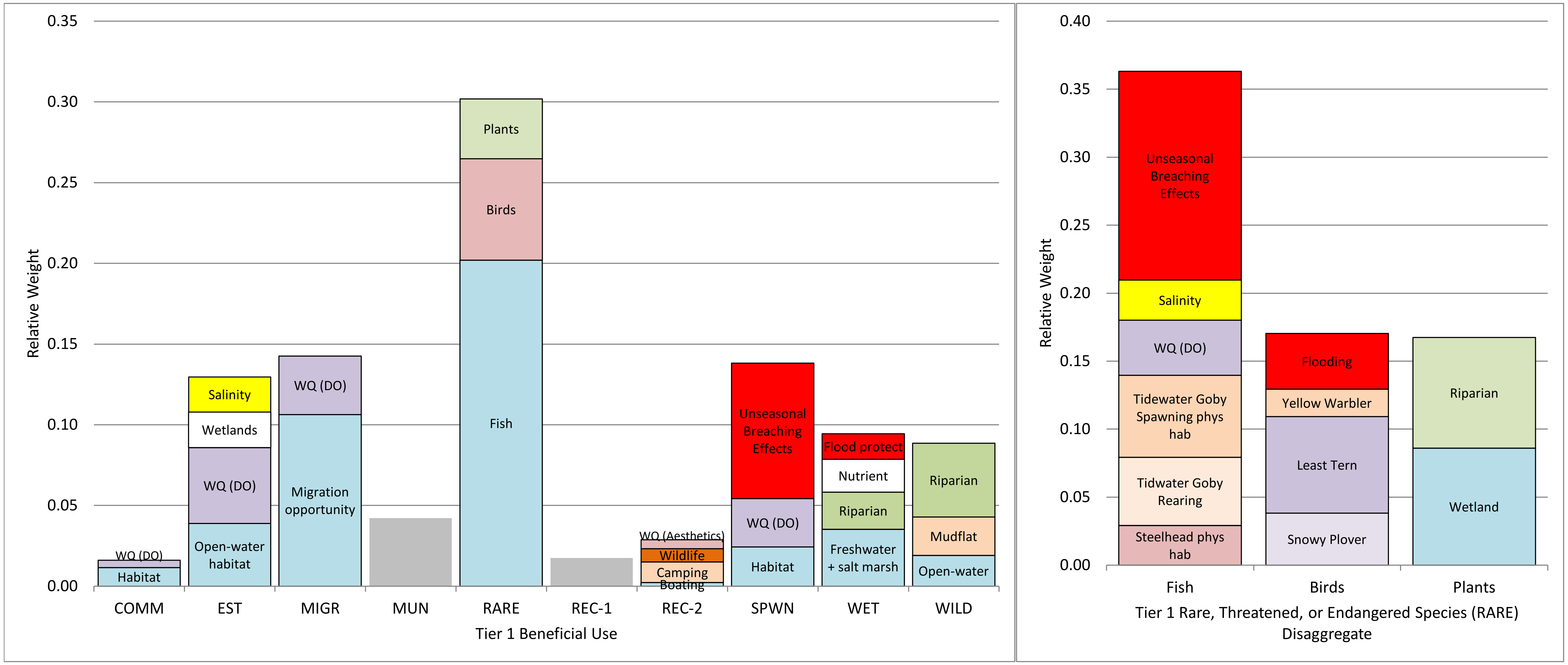
Reviewer (s): Participant 6





Ventura Phase 3 Estuary Study Analytic Hierarchy Process, AHP-2
AHP-2 Participant Submitted Relative Weights from Pairwise Comparisons

Reviewer (s): Composite



Attachment 6
Ventura Phase 3 AHP-2 Calculations

Analytic Hierarchy Process for the Phase 3 Estuary Study
Summary of Weighting and Scoring Calculations: AHP-2

Tier	Factor Abbreviation	Calculated Weight
1	COMM	0.0129
1	EST	0.1475
1	MIGR	0.1597
1	MUN	0.0494
1	RARE	0.3544
1	REC-1	0.0113
1	REC-2	0.0221
1	SPWN	0.1004
1	WET	0.0726
1	WILD	0.0698
2	COMM:habitat	0.8333
2	COMM:DO	0.1667
2	EST:open-water	0.3240
2	EST:DO	0.4919
2	EST:wetland	0.1231
2	EST:salinity	0.0610
2	MIGR:opportunity	0.8750
2	MIGR:DO	0.1250
2	RARE:fish	0.7531
2	RARE:birds	0.1840
2	RARE:plants	0.0629
3	RARE:birds:plover	0.2074
3	RARE:birds:tern	0.6233
3	RARE:birds:warbler	0.0827
3	RARE:birds:flooding	0.0866
3	RARE:fish:steelhead	0.0694
3	RARE:fish:goby rearing	0.1611
3	RARE:fish:goby spawning	0.2282
3	RARE:fish:DO	0.1119
3	RARE:fish:salinity	0.0320
3	RARE:fish:breaching	0.3972
3	RARE:plants:wetland	0.6667
3	RARE:plants:riparian	0.3333
2	REC-2:boating	0.0418
2	REC-2:camping	0.5219
2	REC-2:wildlife	0.2601
2	REC-2:aesthetics	0.1762
2	SPWN:habitat	0.0647
2	SPWN:DO	0.1993
2	SPWN:breaching	0.7360
2	WET:marsh	0.4978
2	WET:riparian	0.3161
2	WET:nutrients	0.0617
2	WET:flood	0.1243
2	WILD:open-water	0.0719
2	WILD:mudflat	0.2790
2	WILD:riparian	0.6491

VWRF Discharge Scenario	Priority
1	0.095
2	0.090
3	0.087
4	0.093
5	0.098
6	0.098
7	0.097
8	0.092
9	0.085
10	0.083
11	0.082