Attachment 1: High-Speed Salinity Transect Mapping

To the Monitoring Special Study Plan

CY 2022–2023

Work Plan

August 2022

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Abbreviations/Acronyms

TERM	DESCRIPTION
2018 Bay–Delta Plan	Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary
CFS	cubic feet per second
DGL	Doughty Cut Above Grant Line Canal Monitoring Station
DWR	Department of Water Resources
EC	Specific Conductance
GIS	geographic information system
GLC	Grant Line Canal Monitoring Station
GLE	Grant Line Canal East Monitoring Station
HOR	Head of Old River Monitoring Station
HSSTM	high-speed salinity transect mapping
MSS	Monitoring Special Study
NOAA	National Oceanic and Atmospheric Administration
ODM	Old River at Delta Mendota Canal Monitoring Station
OH1	Old River Head Monitoring Station
OLD	Old River near Tracy Monitoring Station
ORM	Old River near Mountain House Creek Monitoring Station
PDC	Paradise Cut Monitoring Station
PDUP	Paradise Cut Upstream Monitoring Station
Reclamation	U.S. Bureau of Reclamation
SGA	Sugar Cut Monitoring Station
WQES	Water Quality Evaluation Section
WY	Water Year

1 Background

High-speed salinity transect mapping (HSSTM) is one of the four technical studies developed by the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (Reclamation) that are part of the Monitoring Special Study (MSS), outlined in the *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary* (2018 Bay–Delta Plan). The purpose of this study is to assess the distribution of salinity throughout the southern Delta channels using a boat-based, flow-through instrument. Specific Conductance (EC) will be measured at a 1-second frequency while traveling at speeds up to 25 miles per hour. This approach is particularly relevant to the tidally complex areas between Clifton Court Forebay and the confluence of Old River and the San Joaquin River. This boat-based measurement approach provides spatially explicit data representing a temporal "snapshot" of conditions that can fill in gaps between fixed monitoring stations and discrete sampling programs. The HSSTM study will be conducted to inform future reach-based salinity compliance objectives in the southern Delta as part of the MSS. The HSSTM study will also help address the following MSS goals, consistent with the 2018 Bay–Delta Plan.

1) Characterize the spatial and temporal distribution and associated dynamics of water level, flow, and salinity conditions in the southern Delta waterways.
2) Identify the extent of low- or null-flow conditions and any associated concentration of local salt discharges.[1]
3) Inform the development of a Long-Term Monitoring and Reporting Plan that will:
    a. Assess attainment of the salinity objective in the interior southern Delta; and
    b. Include long-term monitoring and reporting protocols, including specific compliance monitoring locations in, or monitoring protocols for, the three river segments that comprise the interior southern Delta salinity compliance locations.

The data generated through HSSTM will support the efforts to address the MSS goals in the following ways.

- More complete spatial representation of water quality conditions
- Focused spatial water-quality mapping of specific channel areas or regions under targeted seasonal, inflow, or tidal conditions to address specific questions
- Identification and quantification of local discharges
- Identification of low- or null-flow zones
- Better understanding of salinity mixing and dispersion within a complex tidal environment
- Increased capacity for calibration and validation of Delta models

[1]Page 37 of the 2018 Bay–Delta Plan.

- A means to test and validate channel representation of fixed water quality stations
- Instrumental to the creation and validation of monitoring protocols for salinity compliance

2 Method

HSSTM refers to using a boat outfitted with a water intake system to collect continual water-quality measurements while traveling through a predetermined channel reach. Environmental water is pulled directly from the water body with a pump and pushed through a flow cell at a rate of at least 2 gallons per minute. The flow cell houses a Yellow Springs Instruments EXO2 sonde with a temperature/conductivity sensor that collects a measurement every second. The EXO2 sonde can also be outfitted with an EXO Rhodamine Sensor during Rhodamine water-tracer dye-tracer experiments for tracking net transport and dispersal rates. The HSSTM data is used to supplement continuous data collected by the network of fixed water quality stations within the southern Delta. The water intake system will also be used to acquire filtered discrete samples, will allow for the collection of ion samples to support the additional MSS Point Source and Ion Sampling technical study (more details of this technical study can be found in Attachment 2: *Point Source and Ion Sampling Work Plan of the Monitoring Special Study Plan*).

Figures 1 and 2 show the equipment used in the flow-through system. Water is pulled from the back of the boat at a fixed depth using tubing held in place by the intake structure. Sample water travels through a pre-pump filter, through the pump, and into the intake manifold. The manifold consists of a debubbler, flow regulators, pressure gauge, and a back-pressure flow regulator to ensure that the sample water travels through the measurement flow cell at a steady rate, and interference from bubbles is limited.

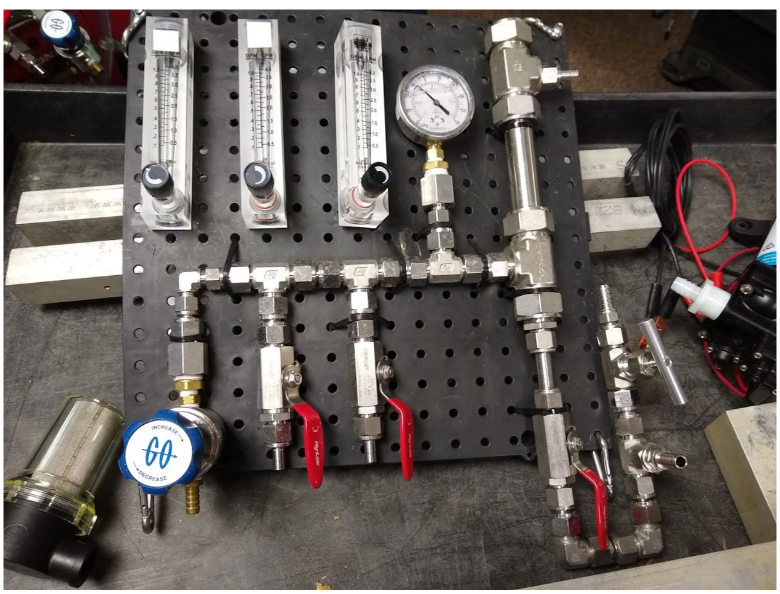

Figure 1: Intake Manifold

Figure 2: Boat and Intake Structure

Further details and procedures for acquiring and processing high-speed mapping data can be found in associated HSSTM standard operating procedures, which will be included in a final version of this workplan. The raw data will be converted to geographic information system (GIS) maps for distribution. Data packages will include quality assured and quality controlled data, associated calibration and field records, discrete sample results, and maps and additional GIS products produced by the Water Quality Evaluation Section (WQES).

3 Adaptive Monitoring

The high-speed salinity mapping component of the MSS is a support tool for water quality analysis and interior southern Delta modeling. The mapping capabilities are a new tool being employed by WQES. The work plan acknowledges that a learning curve exists for staff performing the physical collection, processing, and analysis of the mapping data. The planning and execution of these mapping events will remain open to feedback from all staff and participating organizations[2] throughout the duration of the study. The HSSTM will also incorporate an adaptive monitoring framework.

An adaptive monitoring framework enables monitoring programs to evolve iteratively as new information emerges and if research questions evolve. The data collected during transects will be continually evaluated for effectiveness in the larger context of water quality analysis and modeling objectives of the MSS, informing other technical studies, such as the Point Source and Ion Sampling study. Data requests arising through meetings coordination and technical workgroups meetings with participating organizations will be addressed promptly. Rescheduling or reconfiguring of transect routes may be triggered when physical constraints of the technology are identified, data is deemed redundant or uninformative, and weather or seasonal conditions deviate from expectations.

This work plan includes a schedule for all mapping runs for the entirety of Water Year (WY) 2021–22. The complete schedule for WY 2022–23 will be defined by August 2022.

4 Mapping Objectives and Schedule

In support of the MSS objectives, WQES has defined five transect routes within the interior southern Delta and San Joaquin River. These routes were chosen to collect the most useful data for understanding salinity movement, mixing, and dispersion throughout the interior southern Delta to address MSS study questions and inform the development of protocols for monitoring segment-based compliance. Physical constraints were considered, such as channel morphology and predicted levels of submerged and floating vegetation. For example, a transect from the head of Middle River to its confluence with Victoria Canal would be beneficial to inform decisions on that compliance segment. Unfortunately, that section of Middle River is too shallow to navigate by boat; thus, a transect is not possible for this section.

The five salinity transect routes are: (1) Grant Line Canal (GLC); (2) Lower Old River; (3) Old River Head (OH1) to Doughty Cut; (4) 5-Point Confluence; and (5) San Joaquin River: Brandt Bridge to Vernalis. Brief descriptions of the transect routes are provided below. For more in-depth details about the five salinity transect routes and specific monitoring goals and constraints, see the next section, *Transects*.

The Grant Line Canal, Lower Old River, and Old River Head through 5-Point Confluence transects will be mapped at least once each season, for a minimum of four times each over the 2-year study period. Grant Line Canal and Lower Old River will be mapped during high and low

[2] This document uses the term *participating organization* instead of *stakeholder.*

tides and, when possible, completed on adjacent days to compare differences in salinity levels between these two reaches. Old River Head through 5-Point Confluence will be mapped during a high and low tide on the same day. San Joaquin River: Brandt Bridge to Vernalis will be mapped at least twice with the goal of capturing a low-flow period and a moderate to high–flow period.

The 5-Point Confluence transect is vital for collecting data that will help achieve the objectives of the MSS. The mechanism of mixing and tidal dispersion within the 5-Point Confluence currently is not well understood. Tidal, seasonal, and water use variability all complicate the analysis and modeling of water quality in this area. The goal of frequent mapping is to gain an understanding of salinity movement among the channels connected to the confluence under a wide range of conditions. That knowledge is necessary to inform any decisions made to improve water quality conditions within Lower Old River, Paradise Cut, Sugar Cut, and/or Tom Paine Slough. The 5-Point Confluence will be mapped at least once during each month over the 2-year study period to capture a wide range of tidal scenarios.

The scheduled frequency of mapping events for each transect route, detailed below, is a minimum baseline for data collection in the study. Additional mapping events or transect routes may be completed based on analysis from the ongoing monitoring and the adaptive monitoring framework. The tentative dates for the transect mapping are provided in Tables 1–3. Extenuating and unforeseen circumstances may occur during the study period that cause monitoring limitations. The spring and summer have more transect opportunities because of the longer daylight hours. June, July, and August have more potential days to perform transects that capture desired tidal scenarios. During those months, it will be advantageous to schedule more extensive monitoring efforts.

5 Transects

Route 1: Grant Line Canal

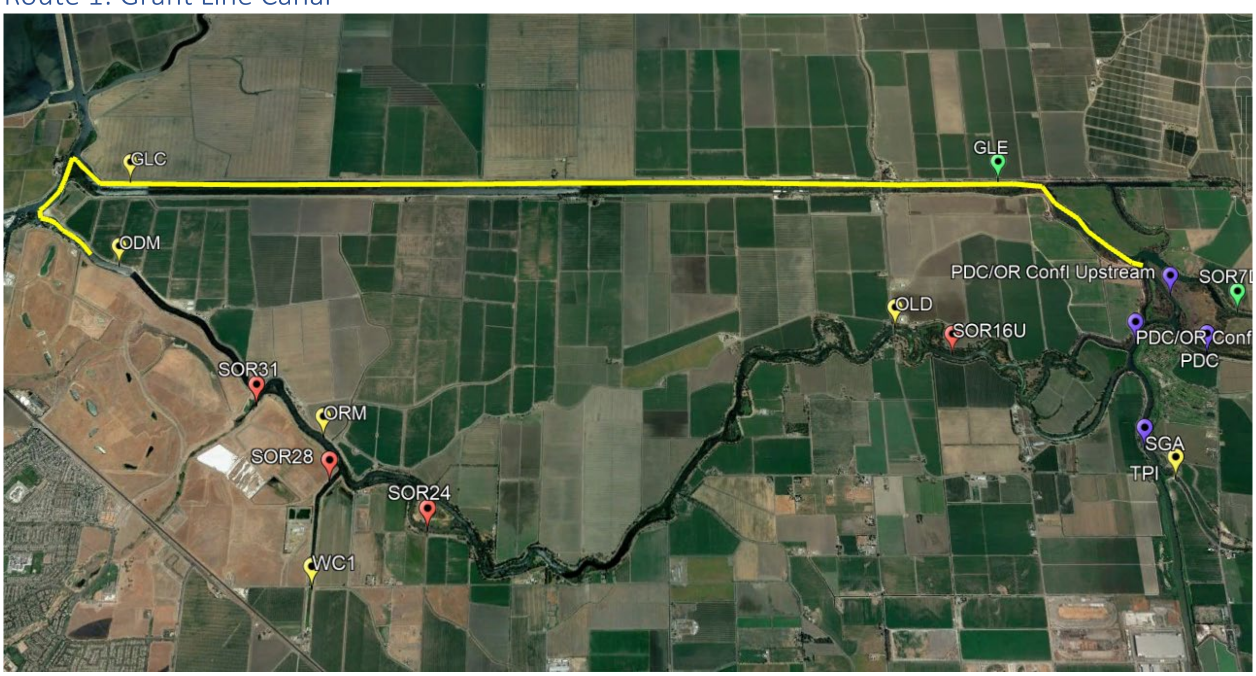

Figure 3: Route 1: Grant Line Canal Transect

Description: Route 1 comprises the length of Grant Line Canal starting at the confluence of Doughty Cut and Old River in the East and wrapping back upstream into Old River toward the Old River at Delta Mendota Canal (ODM) flow and water quality station to the west. The direction of travel will depend on the timing of the tides and additional water quality station maintenance crews perform during the field day.

Purpose: The objectives of Route 1 include: (1) providing background information on the difference in water quality between Grant Line Canal and Lower Old River; (2) collecting data on local salinity inputs along Grant Line Canal; (3) quantifying longitudinal stratification of salinity along Old River and Grant Line Canal; and (4) providing preliminary data for segment-based compliance objectives in the interior southern Delta.

Approximate Length: 8 miles

Tidal Cycles: Route 1 will be conducted during high- and low-tide conditions.

Time Estimate: 30 minutes to 1 hour. This transect can be completed before or after staff service water quality stations in the surrounding area. The transect will be completed once during a field day.

Frequency: Route 1 will be conducted at least once per season. When possible, this route will be scheduled to coincide with transects of Route 2 on adjacent days to capture similar tidal activity on Grant Line Canal and Lower Old River. Grant Line Canal is navigable year-round, but Lower Old River becomes unnavigable due to floating aquatic vegetation routinely in the fall and winter months. There may be times of particular significance when this transect will be mapped in addition to the seasonal runs.

Constraints: During the agricultural production months, temporary agricultural rock barriers are on Grant Line Canal and Old River. Boats can be ferried over the rock barriers, but this can increase the time necessary to complete the transect.

Potential Discrete Sample Locations: GLE, GLC, ODM, and in the 5-Point Confluence.

Route 2: Lower Old River

Figure 4: Lower Old River Transect

Description: Route 2 comprises the reach of Old River that stretches from the 5-Point Confluence in the east to the Old River near Tracy Barrier in the west. For this study, this reach is being referred to as *Lower Old River*. The direction of travel will depend on the timing of the tides, boat-launch accessibility, and whether crews will be performing additional water quality station maintenance during the field day.

Purpose: The objectives of Route 2 include: (1) providing background information on the difference in water quality between Grant Line Canal and Lower Old River, (2) collecting data on local salinity inputs along Lower Old River, (3) quantifying longitudinal stratification of salinity along Old River and Grant Line Canal, and (4) providing preliminary data for segment-based compliance objectives in the interior southern Delta.

Approximate Length: 9 miles

Tidal Cycles: Route 2 will be conducted to coincide with high and low tides and find the opportunity to capture the transition from high tide to low tide. Capturing downstream flow conditions are important because an objective of this transect is to provide increased resolution on salinity contributions from discharge points that are often in backwater channels, dead-end sloughs, and drainage ditches, areas that are inaccessible by boat. Performing transects during flood tide are useful to understanding the tidal dispersion of those salinity contributions. Figure 5 highlights the flow conditions and tidal period during which a transect can best identify salinity contributions for the abovementioned sources.

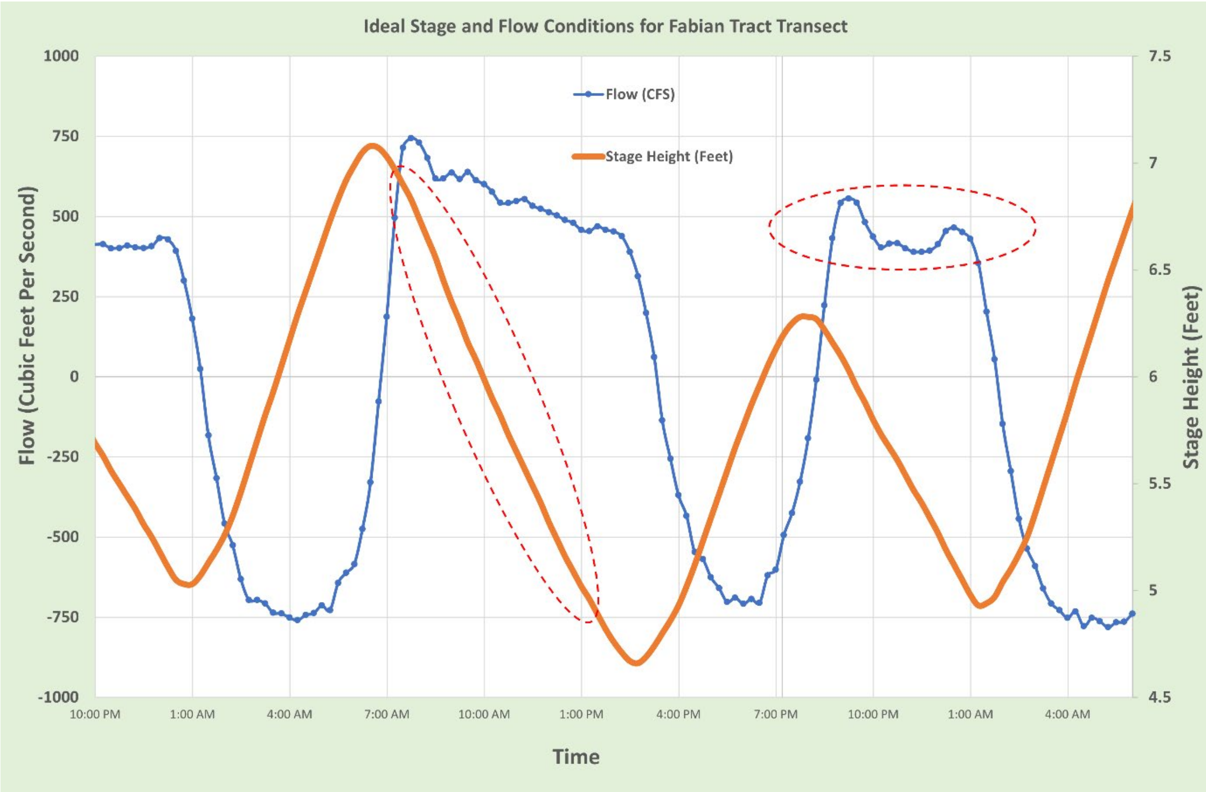

Figure 5: Downstream Stage and Flow Considerations for Lower Old River

Time Estimate: 1–2 hours. This transect can be completed before or after staff service water quality stations in the surrounding area. The transect will be completed once during a field day. Presence and abundance of submerged and floating aquatic vegetation in Lower Old River can increase the time needed to complete this transect.

Frequency: Route 2 will be conducted at least once per season. When possible, this route will be scheduled to coincide with transects of Route 1 on adjacent days to capture similar tidal activity on Grant Line Canal and Lower Old River. There may be times of particular significance when this transect will be mapped in addition to the seasonal runs.

Constraints: During the agricultural production months, there are temporary agricultural rock barriers on Grant Line Canal and Old River. Boats can be ferried over the rock barriers, but this can increase the time necessary to complete the transect. Portions of Lower Old River become unnavigable due to floating aquatic vegetation. In past years, significant blockages have occurred surrounding the Old River near Tracy Barrier and from Tracy Wildlife Association to the Bacchetti Dairy Bridge.

Potential Discrete Sample Locations: OLD, ORM, and in the 5-Point Confluence.

Route 3: Old River Head through 5-Point Confluence

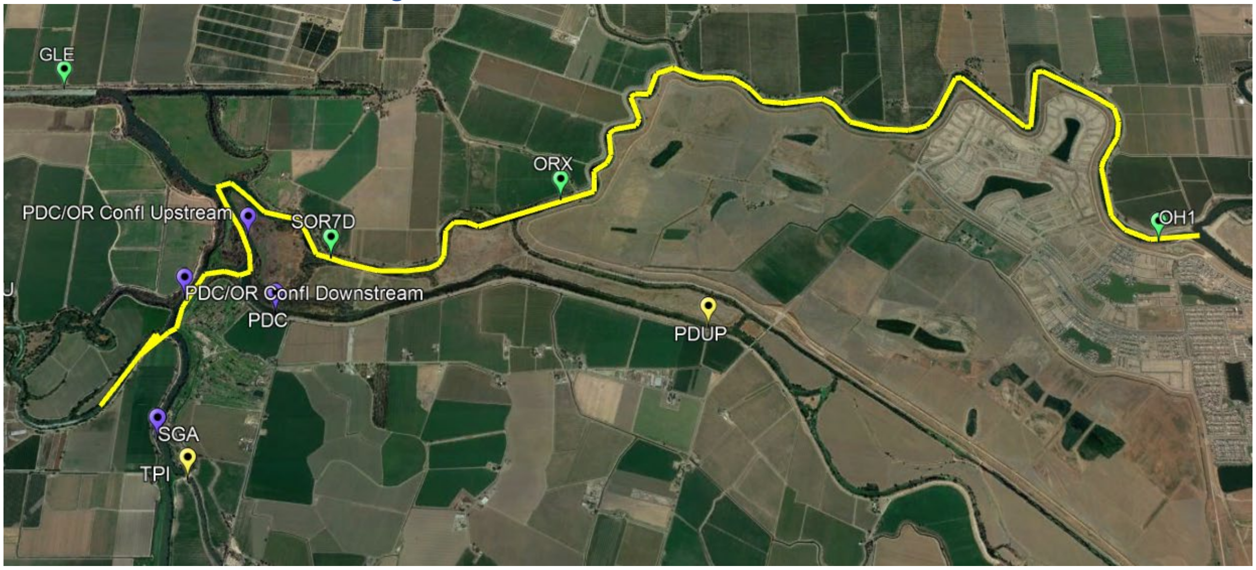

Figure 6: Route 3: Old River Head through 5-Point Confluence

Description: Route 3 begins in the San Joaquin River, slightly upstream of the Head of Old River, to measure salinity of the SJR as it enters Old River. The transect continues east to west along Old River until reaching the western side of the 5-Point Confluence.

Purpose: The goals of Route 3 include: (1) examining any differences in water quality between the Head of Old River and its contributions into the 5-Point Confluence; (2) collecting data on local salinity inputs along Old River; (3) measuring variation in water quality directly upstream and downstream of the 5-Point Confluence; and (4) providing preliminary data for segment-based compliance objectives in the interior southern Delta.

Approximate Length: 8 miles

Tidal Cycles: Route 3 should be captured during low- and high-tide windows, ideally completed in 1 day, but can be broken up over 2 days.

Time Estimate: 1–1.5 hours for each transect. The goal is to do a transect on the high tide and the low tide on the same day for this route, but that may not be possible due to limitations of daylight hours or unexpected circumstances, like mechanical issues with the boat or flow-through equipment. If only one tide is mapped, then the crew will arrange to perform a transect during the opposite tide on the following day.

Frequency: Route 3 will be conducted at least once per season. There may be times of particular significance when this transect will be mapped in addition to the seasonal runs.

Constraints: Sections of Old River at times will be impassable due to floating vegetation and possibly shallow areas in the 5-Point Confluence area.

Potential Discrete Sample Locations: ORX, OH1, and in the 5-Point Confluence.

Route 4: 5-Point Confluence

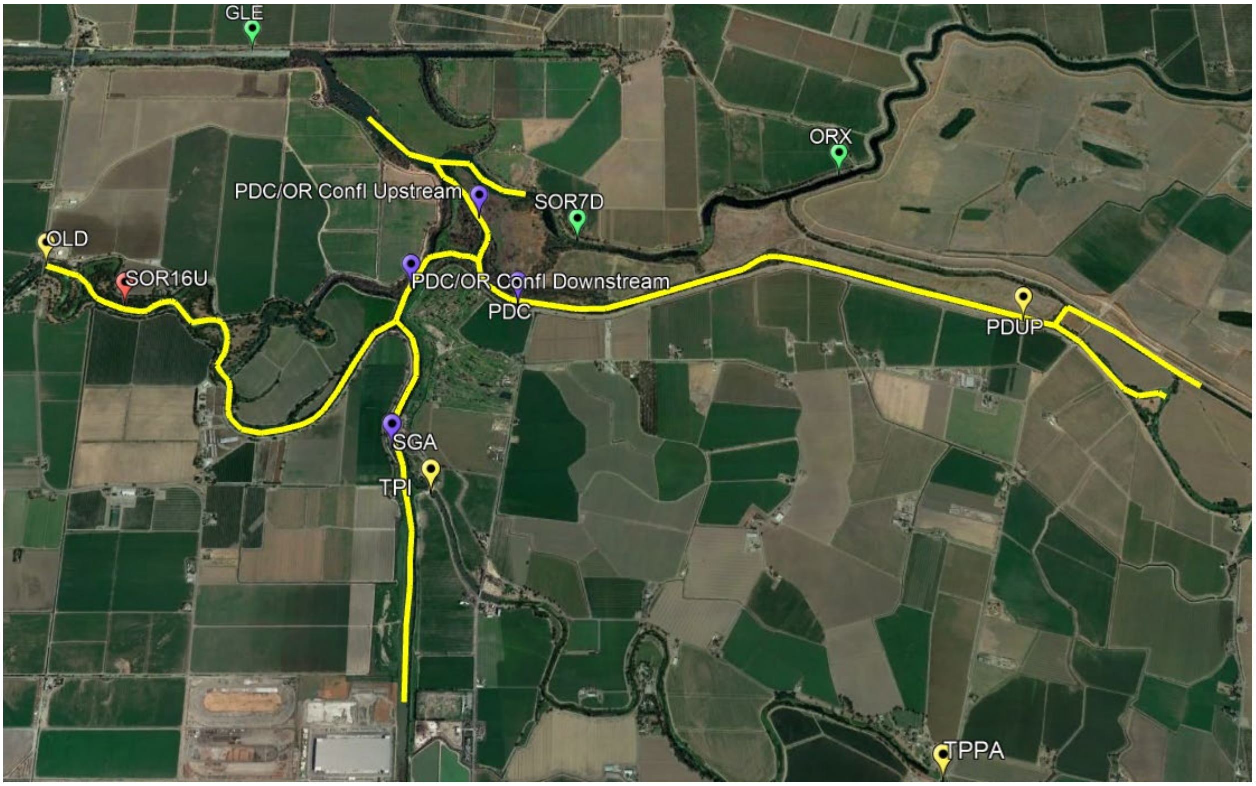

Figure 7: Route 4: 5-Point Confluence

Description: Route 4 begins in Old River, approximately 2,000 feet upstream of the confluence with Doughty Cut. Crews will travel downstream into Doughty Cut until they reach the monitoring station Doughty Cut above Grant Line Canal (DGL). Then, crews will head back upstream through the 5-Point Confluence and into Paradise Cut. The crews will aim to travel upstream to Paradise Cut Upstream (PDUP). The distance traveled upstream in Paradise Cut will depend on the presence of vegetation and water levels. Travel past the PDUP station has been limited in past years due to floating aquatic vegetation during significant portions of the summer, fall, and winter seasons. The crews will travel back down Paradise Cut, through the confluence, and into Lower Old River to the OLD historic salinity compliance station. Like Paradise Cut, this section of the river is often unnavigable due to floating aquatic vegetation. Crews will attempt to travel as far downstream as possible toward OLD. Crews will then head back to the confluence and into Sugar Cut and travel as far down Sugar Cut as possible.

Purpose: The goal of Route 4 is to map the 5-Point Confluence and the five connected channels. This transect will provide data on how tidal mixing and dispersion occurs within this complex confluence.

Approximate Length: 12 miles

Tidal Cycles: During spring tides, it is important to complete Route 4 multiple times surrounding the low-low tide, either running the transects starting at high-high tide to low-low tide or from low-low tide to mid-high tide. During neap tides, this transect should either be completed during times of equal low tides or equal high tides. It is important to avoid scheduling runs during mid-tides, where high salinity water is not being drawn into the confluence.

Time Estimate: 1–2 hours. Shallow water and aquatic vegetation can slow down this transect considerably, but at their slowest, crews should be able to complete a transect in 2 hours. The crews will perform as many transects in 1 day as possible to capture the full tidal cycle. These will typically be days that are longer than 8 hours, especially during the summer months, when daylight permits.

Frequency: Route 4 provides the most useful data for understanding the tidal dynamics within and surrounding the 5-Point Confluence. Transects will be completed once during each month to capture the full range of tidal scenarios that can alter dispersion in this area.

Constraints: Route 4 has many shallow areas compacted with submerged and floating aquatic vegetation. The water intake system is very sensitive to interference from submerged vegetation. Discharge points within Paradise Cut cause sediment accumulation that requires careful navigation to avoid grounding the boat.

Potential Discrete Sample Locations: PDUP, PDC, DGL, SGA, and Old River at Bacchetti Bridge.

Route 5: SJR Brandt Bridge to Vernalis

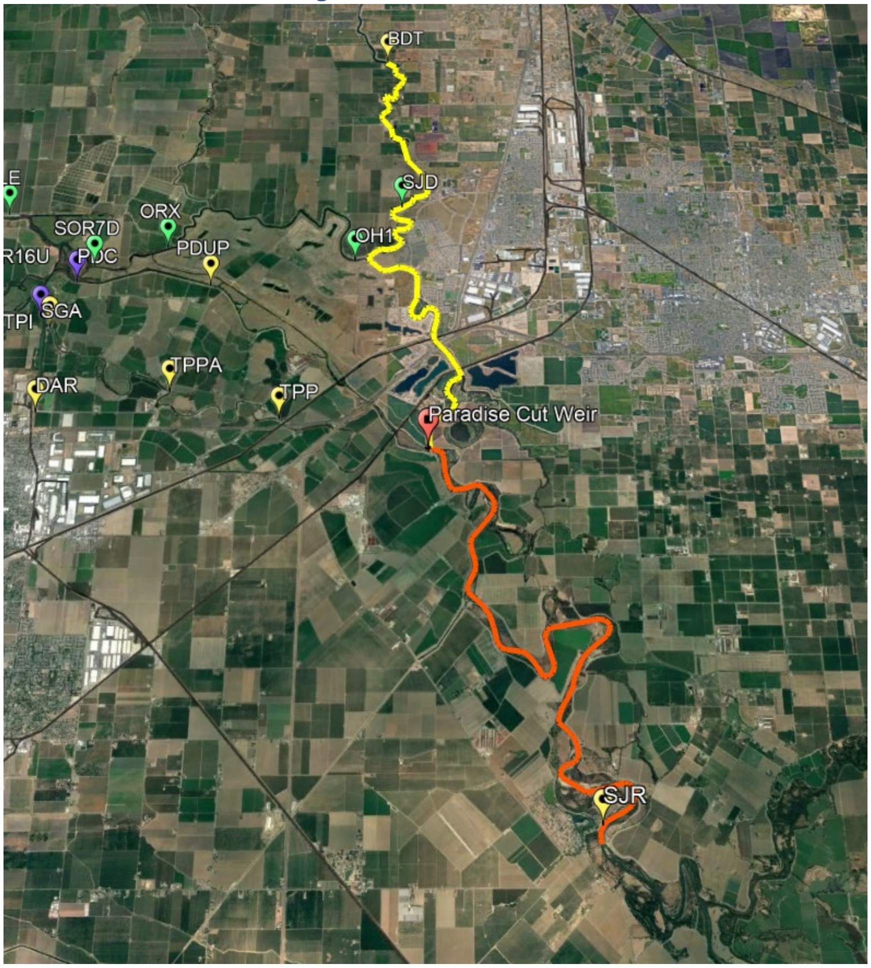

Figure 8: Route 5: San Joaquin River Brandt Bridge to Vernalis

Description: Route 5 begins in San Joaquin River at Brandt Bridge and follows the San Joaquin River upstream until reaching the Vernalis monitoring stations. The San Joaquin River is often not navigable upstream of Paradise Cut Weir by boat due to shallow channel depth. Crews will make efforts to map as much of this transect as possible. The full transect is only navigable during higher-flow periods.

Purpose: The goal of Route 5 is to provide data to support the development and validation of reach-based salinity compliance in the interior southern Delta.

Approximate Length: 22 miles

Tidal Cycles: Tidal cycles are not a concern with this transect.

Time Estimate: 2–3 hours

Frequency: Route 5 will be completed twice during the study period, once during low-flow conditions and once during moderate to high–flow conditions. The aim of this transect is mostly to secure preliminary or validating data for the San Joaquin salinity compliance segment.

Constraints: WQES are not familiar with these sections of the San Joaquin River. It is assumed that there are dangerously shallow areas of the San Joaquin the further south traveled, through which a boat would not be able to pass.

Potential Discrete Sample Locations: Vernalis, Brandt Bridge, PDC Weir, Head of Old River

Water Year 2022 Schedule of Potential Dates

Tables 1–3 provide the tentative transect dates during WY 2022. Transect runs for WY 2023will be scheduled in summer 2022, so that project managers and field crews can make informed decisions after gaining experience in the study area during 2022. The goal over the study period is to conduct transect runs for Fabian Tract and Old River Head to DMC Barrier at least once during each season (four runs), at least once during each month for the 5-Point Confluence (12 runs), and at least once during a low-flow and high-flow period (two runs) for the SJR Brandt Bridge to Vernalis transect.

Table 1: Route 1 and 2: Grant Line Canal and Lower Old River Tentative Dates

Fall (Oct–Dec 2021)	Winter (Jan–Mar 2022)	Spring (Apr–Jun 2022)	Summer (July–Aug 2022)
12/5	1/3	5/1–3	7/11–14
–	3/18	5/11	7/20
–	–	6/9	7/28
–	–	6/24	8/10–11
–	–	–	8/25
–	–	–	9/8
–	–	–	9/22

Table 2: Route 3: Old River Head through 5-Point Confluence Tentative Dates

Fall (Oct–Dec 2021)	Winter (Jan–Mar 2022)	Spring (Apr–Jun 2022)	Summer (Jul–Aug 2022)
11/12	1/7	5/1–3	7/5
11/15	2/7	5/16–17	7/11–13
12/30	3/2	5/28–29	7/19
–	3/30	6/22–24	7/25–28
–	–	–	8/4–5
–	–	–	8/24–25
–	–	–	9/8
–	–	–	9/22

Table 3: Route 4: 5-Point Confluence Tentative Dates

Fall (Oct–Dec 2021)	Winter (Jan–Mar 2022)	Spring (Apr–Jun 2022)	Summer (Jul–Aug 2022)
10/26	1/7	4/18	7/5
11/11–12	2/20	5/1–3	7/11–14
11/16	3/2	5/16–17	7/20–21
12/11	3/31	5/26	7/25–28
–	–	5/28–29	8/4–5
–	–	6/14	8/10–11
–	–	6/22–23	8/17
–	–	–	8/24–25
–	–	–	9/3
–	–	–	9/8
–	–	–	9/13
–	–	–	9/17

Route 5: SJR: Brandt Bridge to Vernalis – Twice during Study Period

This transect is not dependent on tidal movement and will be completed at least twice during the study period, once each during low-flow and high-flow conditions. Flow conditions are measured at the Vernalis monitoring station. *Low-flow conditions* are defined as any flows below 1,500 cubic feet per second (CFS), and high-flow conditions are higher than 2,000 CFS. Low-flow conditions typically occur during the summer and fall months, and high flows occur during winter and spring. Flow conditions on the San Joaquin can vary drastically based on water year type and precipitation.

6 Tidal Considerations

The majority of the transect mapping for this study is reliant on tidal conditions. It is necessary that mapping events include both low and high tides to understand tidal movement and salinity dispersion because the interior southern Delta experiences mixed semidiurnal tidal cycles, described in more detail below, that result in considerable variation throughout the spring and neap cycle. For the maximum effectiveness of high-speed mapping data, a snapshot of the various tidal conditions must be captured. The timing of transects will differ depending on the reach being mapped, the goals of the mapping, and seasonal, weather, and atmospheric conditions. A detailed schedule and plan for high-speed mapping is necessary for collection of the most useful data for analyses. A focus on mapping a reach multiple times throughout a tidal cycle may result in long days for the data collection crews.

The Pacific Coast is subject to mixed semidiurnal tides (Figure 9). Mixed semidiurnal tides (or *mixed tides*) have two high tides and two low tides per day, but the height of each tide differs; the two high tides are of different heights, as are the two low tides. However, throughout the lunar tidal cycles, neap tides occur, in which either the low tides or high tides become close to reaching the same stage during one day. Figures 10 and 11 provide examples of spring and neap tidal cycles in the interior southern Delta.

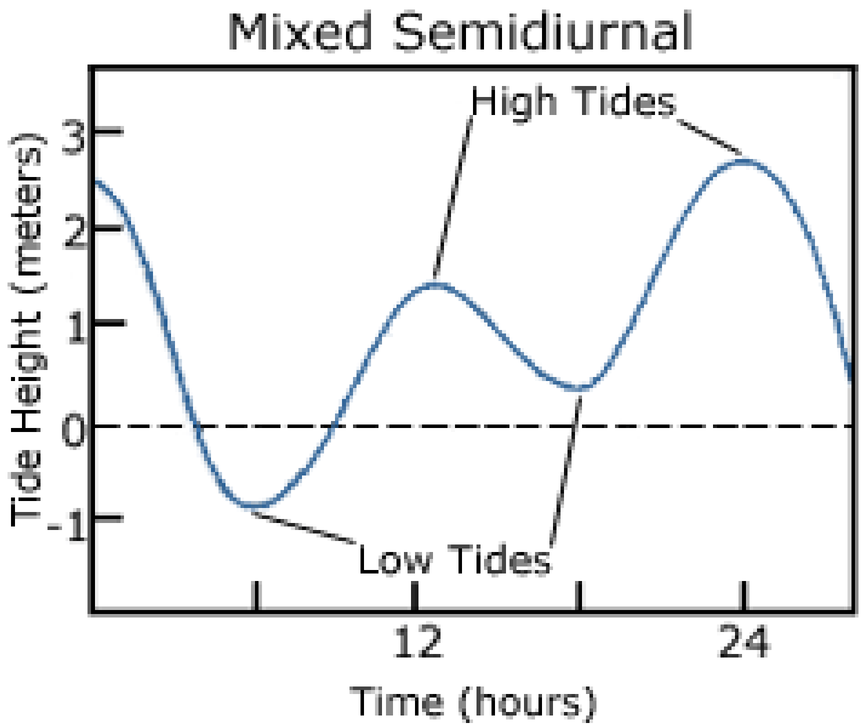

Figure 9: Example of Mixed Semidiurnal Tidal Cycle

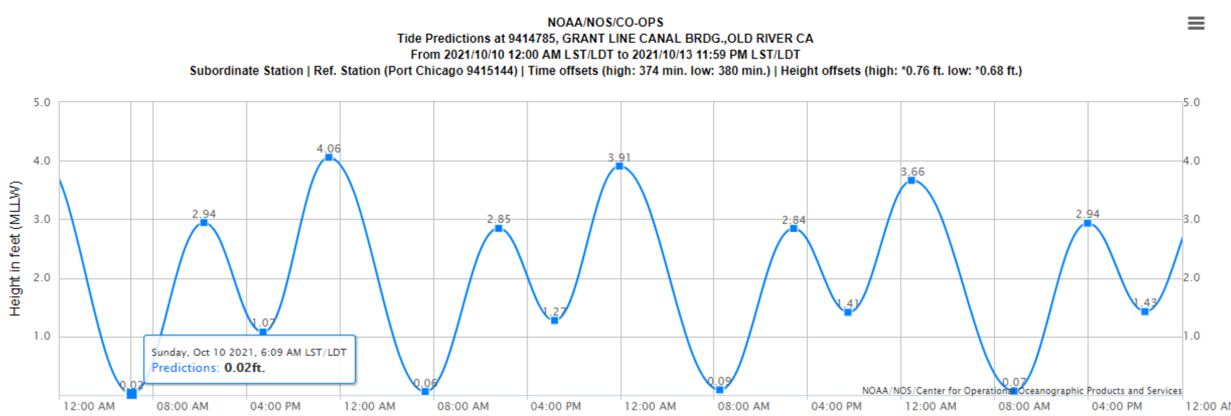

Figure 10: Example of Spring Tide in the Interior Southern Delta

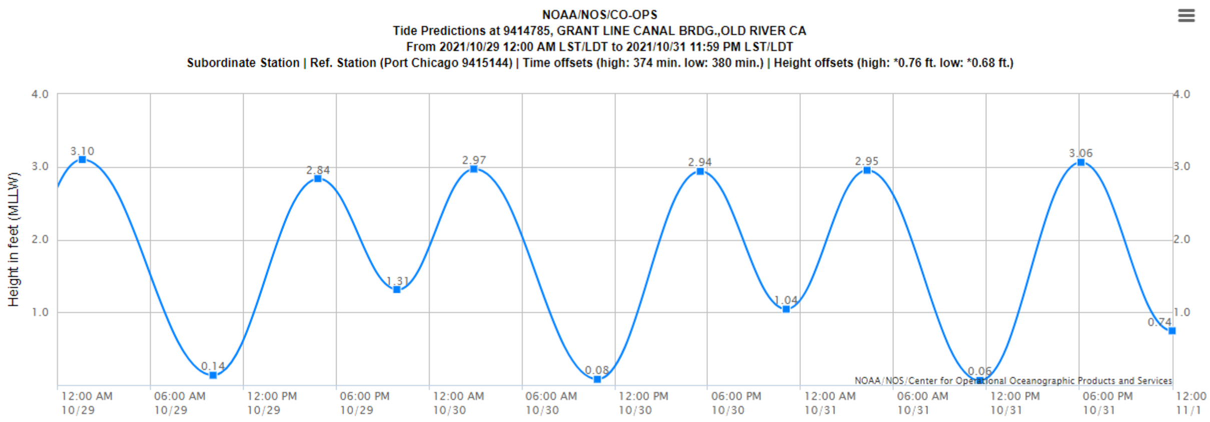

Figure 11:Example of Neap Tide in the Interior Southern Delta

Predicting Tides

Tidal predictions were obtained from the National Oceanic and Atmospheric Administration's (NOAA) Tides and Currents website (https://tidesandcurrents.noaa.gov/). Tides in the interior southern Delta are estimated at Station ID: 9414785 (Grant Line Canal Bridge, Old River, California), which is very close to where the Grant Line Canal temporary agricultural barrier is installed. A brief analysis of comparisons to stage readings at upstream interior southern Delta monitoring stations confirmed that the tidal predictions generally match measured tidal movement. Peak high tide values at upstream station Grant Line Canal East (GLE), were about 8–10 minutes later than the NOAA predictions. Low tides had a bit more variation between GLE and GLC Bridge. The peaks of low and high tides at Paradise Cut (PDC) and Sugar Cut (SGA) monitoring stations were typically 30–60 minutes later than those at GLE. When scheduling mapping runs in the 5-Point Confluence, a 30–60 minute buffer should be added to the NOAA predicted tidal cycle.

Spring Tides

The study analyses involve the examination of the extent of exchange and dispersion of high-salinity water from the upstream reaches of Paradise Cut and Sugar Cut into the 5-Point Confluence. Generally, during flood tides, water is pushed upstream into Paradise Cut and Sugar Cut from Old River and/or Grant Line Canal/Doughty Cut. During ebb tides, water is pulled downstream from Sugar and Paradise Cuts toward Old River and/or Grant Line Canal/Doughty Cut.

During spring tides at the PDC monitoring station, high salinity water from further upstream of Paradise Cut is mostly observed during the low-low tide. During the mid-low tide, the higher salinity signal from upstream of Paradise Cut often does not even reach PDC. Figure 12 is a plot of stage (red) and specific conductivity (blue) at PDC, showing the periods of elevated EC during the low-low tides.

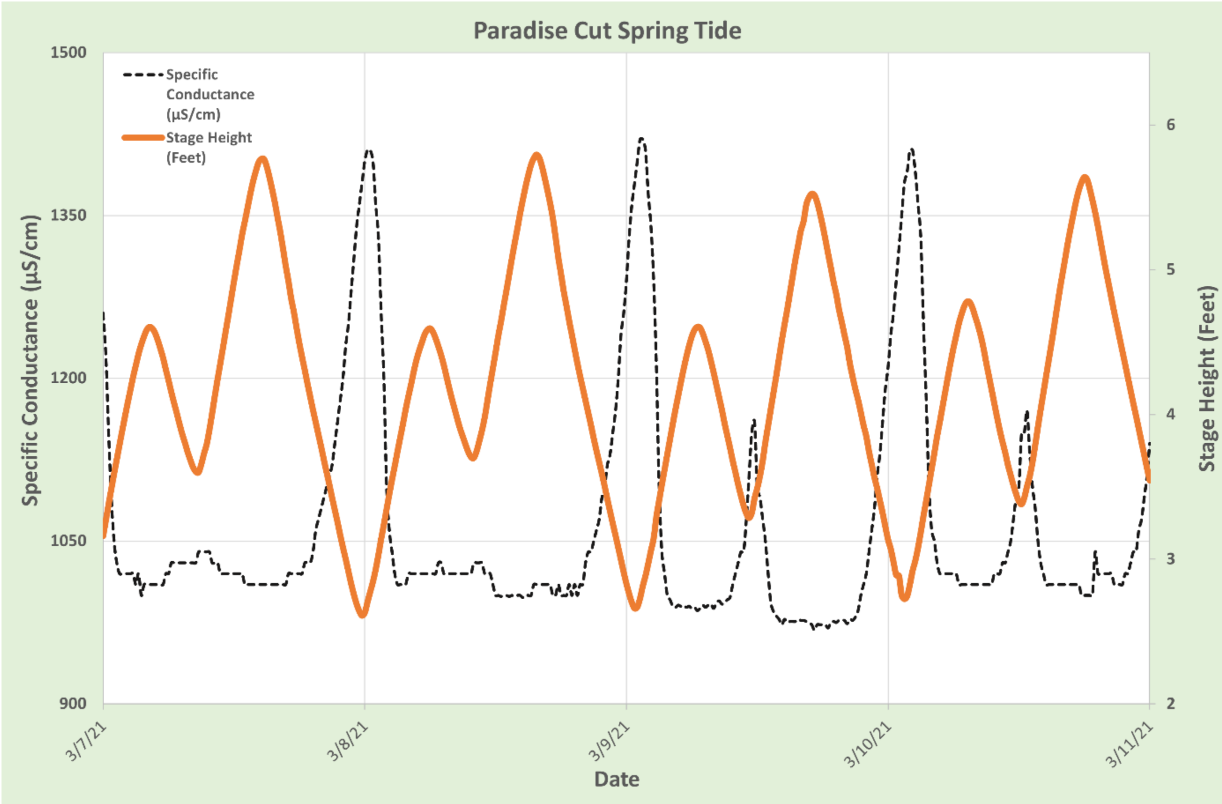

Figure 12: Example of Spring Tides and Specific Conductance at Paradise Cut

During spring tides, high-speed mapping needs to occur in the 5-points Confluence and surrounding channels as tides switch from high-highs to low-lows and low-lows to mid-highs. The peak of the high-high tide to peak low-low tide is typically about an 8-hour cycle. This is a major constraint within mapping logistics because there are few instances throughout the year that this entire cycle occurs during daylight hours and safe working conditions.

These cycles are potential drivers of salinity mixing and dispersion within and surrounding the 5-Point Confluence and are important to capture during the mapping efforts. Transects in Paradise Cut during these cycles will also provide informative data about the gradient of salinity within the channel. Capturing the period between mid-tides during spring tides would not provide information on downstream dispersion of high-salinity water, as seen in Figure 12.

Neap Tides

During neap tides, the magnitude of change in stage and flows are compressed. The low tides do not drop as low, and high tides do not rise as high, compared to spring tides. In a neap tide, high salinity has been measured traveling downstream past PDC during both low tides (Figure 13). This provides more opportunities to capture salinity dispersion within the 5-Point Confluence during neap tides, compared to spring tides.

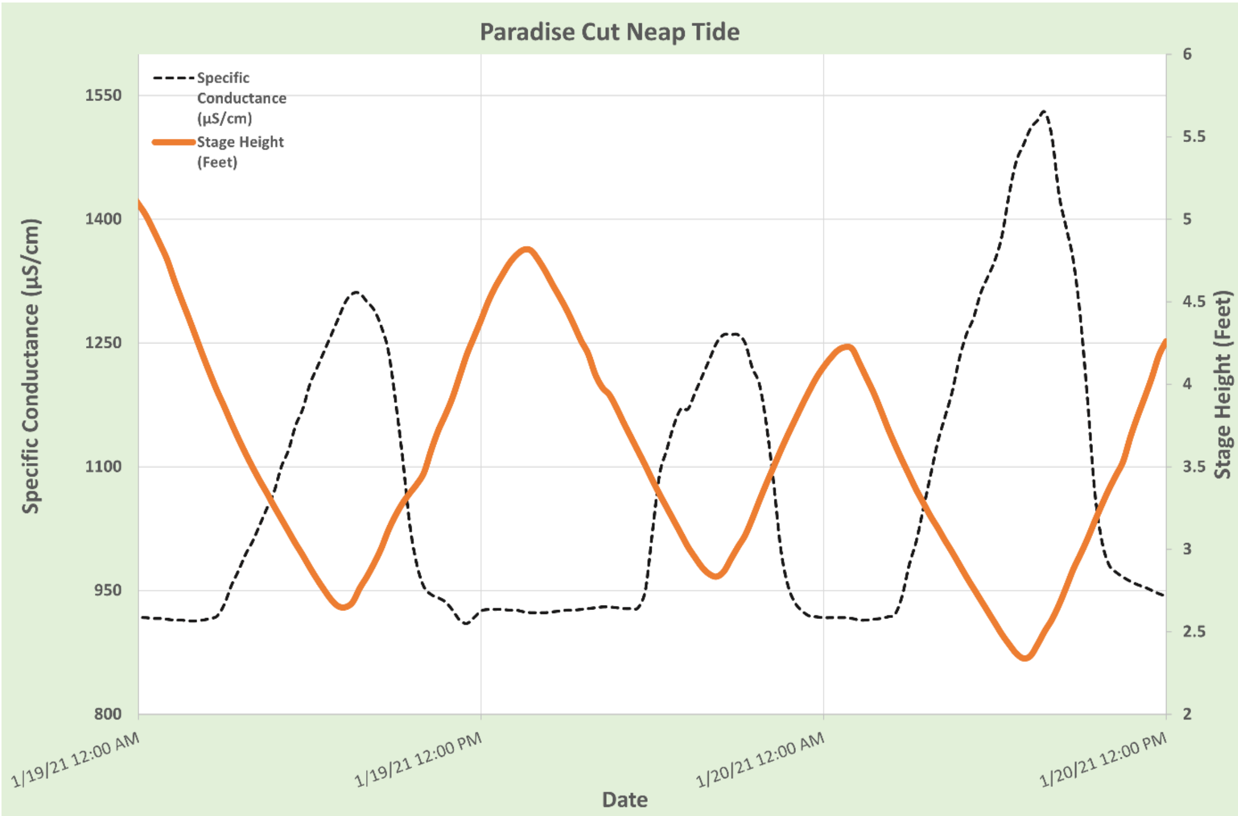

Figure 13: Example of Neap Tides Specific and Conductance at Paradise Cut

Low Tide for Discharges

When conducting transects with an objective of identifying and quantifying local discharge contributions into interior southern Delta channels, it is best to perform them during ebb tides. This is an important factor for the Fabian Perimeter transect, as many of the discharges that drain into Lower Old River are set back in small canals or sloughs. If transects are conducted during high or incoming tides, an EC signal from these discharges will likely be muted. During ebb tides, water from discharge areas will drain into the main channels that are more easily mapped.

Low Tide to High Tide

Capturing water movement from low tides to high tide in the 5-Point Confluence provides crucial data about how downstream water from Lower Old River and Grant Line Canal moves upstream into Upper Old River, Paradise Cut, and Sugar Cut. Understanding the movement, mixing, and dispersion of fresher water upstream may inform better operational decisions by local water users and project operators and inform effectiveness of any proposed water quality improvement projects in the interior southern Delta.

Ebb and Flood in Relation to High and Low Tides

"In coastal oceanography, the terms ebb and flood refer to tidal currents. These terms are particularly relevant for tidal inlet systems: estuaries, tidal rivers and lagoons" (Darwin 1962). The ebb current corresponds to seaward flow and the flood current to landward flow. The ebb current does not fully coincide with the falling tide (i.e., the period of decreasing water level), but reverses sometime after low water; the water level at the sea starts rising before the inlet system is emptied. Likewise, the flood current reverses sometime after high water. Flow (blue) and stage (black) are plotted in Figure 14 to illustrate this relationship between the two currents. In this plot, negative flow values represent water moving upstream at PDC.

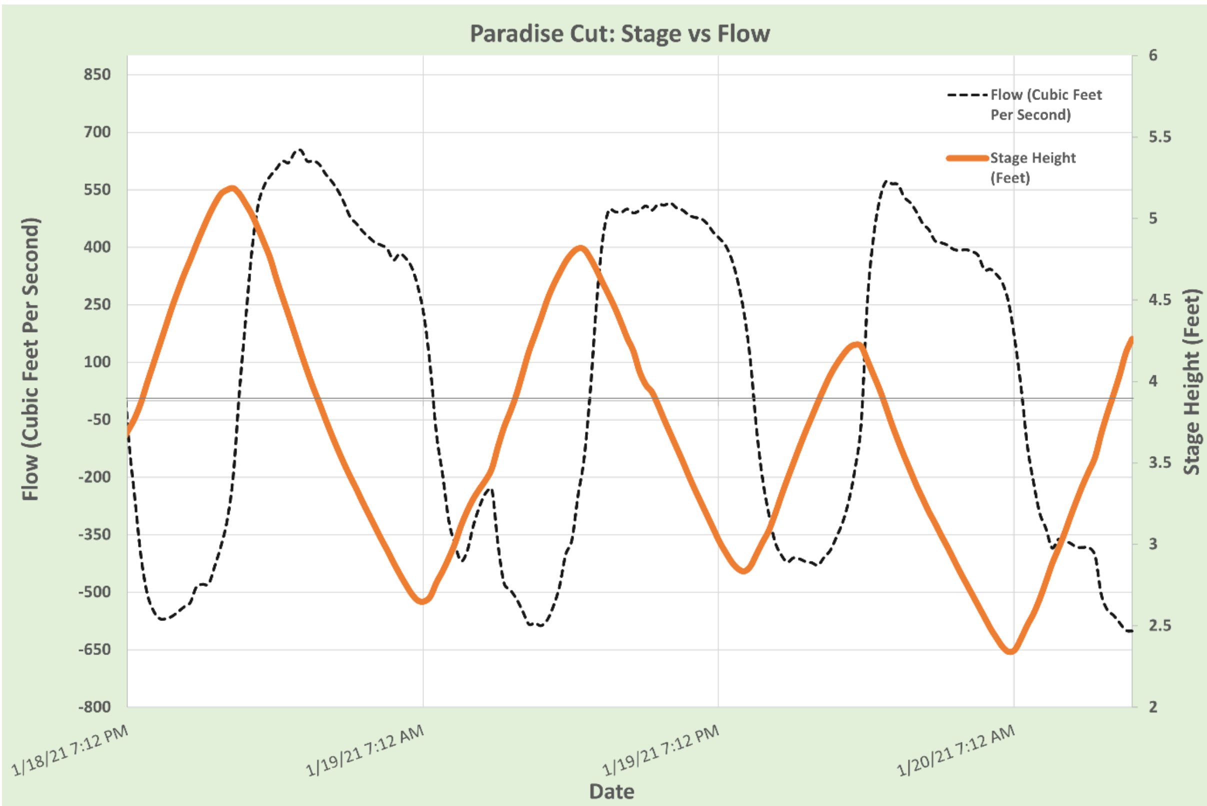

Figure 14: Example of Stage vs Flow at Paradise Cut

Tidal Scenario

Tidal scenario is the term used to define the different tidal cycles captured during mapping. Over the study period, efforts will be made to capture all the different tidal scenarios that occur in the interior southern Delta, specifically mapping the 5-Point Confluence during each tidal scenario. Specific scenarios will be prioritized during the scheduling of monthly mapping runs due to infrequent occurrence. For example, finding an appropriate work day to map a peak spring tide with a large swing in tidal magnitude from high-high tide to low-low tide may only occur a few times each year.

As applied in this work plan, the scenarios are only based on the prediction of tidal cycle. The initial scheduling of mapping runs does not consider the myriad other factors that might affect salinity in the interior southern Delta, such as seasonal variation, first-flush events, temporary barrier placements, and project operations both upstream and downstream. Some of those factors can be accurately predicted, but first-flush events and operations can be highly dependent on unknown weather and water-storage conditions. These conditions will be considered during the monthly planning of salinity transects. This work plan aims to provide flexibility to incorporate specific WY conditions during the study period, as well as input and requests from participating organizations or modelers.

Tidal Scenario Defining Terms

A *tidal scenario* is defined by three components: tidal cycle, tide change, and magnitude of tidal swing, all based on the tidal range predicted at Grant Line Canal at Tracy Blvd.

- **Tidal Cycle:** There are four distinct tidal cycles based on the solunar calendar considered for this study. To simplify, the tides will be labeled as either spring or neap. Neap is broken into three distinct categories: mixed, equal high, and equal low. *Equal* means that two tidal peaks, either the highs or the lows, during a 25-hour cycle are within 0.2 feet of each other. *Spring tide* refers to the tidal period that typically occurs 24–48 hours after a new or full moon, where stage height reaches its highest high and lowest low. The tides during a spring tide are almost always mixed. A tidal scenario will be considered a spring tide if the transect is performed on the actual spring tide day or within 3 days of the actual spring tide. The neap tide always occurs 7 days after the spring tide, when the magnitude of tidal swing is at its most compressed. Again, a tidal scenario will be labeled as neap if the transect is performed within 3 days of the actual neap tide.
- **Tidal Changes:** Four different tides occur in a day; *tidal change* refers to which tide or tides a scheduled transect is planned to capture (e.g., high-high tide to low-low tide, low-low to mid-high).
- **Magnitude of Tidal Swing:** Throughout the solunar cycle, the magnitude of tidal swings is variable. The magnitudes are broken into three categories, based on how large of a shift in stage occurs between high tide and low tide.
    - **Large:** Magnitude greater than 4 feet; typically seen during spring tides with a shift from high-high to low-low
    - **Average:** Magnitude between 2–4 feet
    - **Small:** Magnitude less than 2 feet; typically seen during spring tides from a mid-to-mid tide

7 References

State Water Resources Control Board. 2018. *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary.* December 12.

Darwin, G.H., 1962. The Tides, Publisher: W.H. Freeman and Company