Appendix 4.1

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RUSSIAN RIVER ESTUARY OUTLET CHANNEL ADAPTIVE MANAGEMENT PLAN 2015

Prepared for

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with

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1. INTRODUCTION

Sonoma County Water Agency (the Agency) is required to develop a management plan for the Russian River Estuary mouth in response to a 2008 Biological Opinion (BO) from the National Marine Fisheries Service (NMFS) designed to improve salmonid rearing habitat in the estuary (NMFS, 2008). Prior to the BO, the existing Russian River Estuary management plan focused on artificial breaching to prevent flooding. The Agency retained ESA PWA[1] to assist in developing the revised plan to address the objectives of the BO.

The BO stipulates several phases of outlet channel management over fifteen years with additional management options specified for each phase. The phases are part of an adaptive process for management actions to enhance salmonid habitat. If earlier phases are successful in meeting the performance criteria, subsequent phases will not be needed. The existing plan was first developed in 2009 to address the Phase 1 objectives in the BO and then updated in 2010, 2011, 2012, and 2013. This document, the management plan for 2015, is largely based on the plan drafted in 2014. The changes between the 2014 and 2015 plan include: documented 2014 inlet conditions (Attachment I), and updated permitting requirements (Sections 3.2 and Attachment C).

Because of permitting issues, the outlet channel was not implemented in 2009. In 2010, the outlet channel naturally established itself for about one a week at the end of June, and was then closed by ocean waves. After this closure, the Agency mechanically re-created the outlet channel. However, waves closed the outlet channel less than a day after implementation. Before the outlet channel could be re-established by the Agency, the lagoon breached, returning the estuary to tidal conditions for the remainder of the summer. Additional closures occurred in September and October, but large wave conditions and imminent flooding prevented efforts to create an outlet channel. In 2011, the inlet never closed long enough to warrant management action. Wave events caused a series of closures between the end of September and into November. However, the closures lasted a week or less, ending when rising lagoon water levels overtopped the beach berm and naturally scoured a new tidal channel. 2013 was similar to 2011 and 2012, with early summer and early fall closures ending when overtopping naturally scoured a new channel. In 2014, minimum instream flows on the Russian River were lowered due to drought conditions. So when the inlet closed in September and October, these lower inflows slowed the rate of lagoon water level rise, enabling two back-to-back closures. The September closure lasted more than a month and the October closure lasted about three weeks. These closures persisted beyond the lagoon management period, and were artificially breached.

The approach of the 2015 plan is to meet the objective of the Reasonable and Prudent Alternative (RPA), Alterations to Estuary Management, to the greatest extent feasible while staying within the constraints of existing regulatory permits and minimizing the impact to aesthetic, biological, and recreational resources of the site. It is recognized that the measures developed in the 2015 management plan, when implemented, may not fully meet the objective established by the RPA.

[1] Previously Philip Williams & Associates

The concept of this approach was developed in coordination with NMFS, California Department of Fish and Wildlife (CDFW)[2], and California State Parks (CSP). This draft plan was provided to these agencies and discussed at a meeting on April 9, 2015 that included representatives from NMFS and CDFW, as well as the Sonoma County Water Agency, Bodega Marine Laboratory, the U.S. Army Corps of Engineers, the North Coast Regional Water Quality Control Board, and ESA PWA. Comments on the draft plan from these representatives will inform the revision of the draft plan to create the final plan.

The goal of the management plan is to reduce marine influence on the Russian River Estuary (Figure 1) during the management period, May 15th to October 15th. The management actions are intended to limit tidal exchange between the ocean and the estuary. Instead of the existing tidal estuary, the BO proposes a perched lagoon with water levels above tidal elevations. With tidal inflows limited, river inflow to the lagoon may enhance the extent of freshwater habitat for the benefit of juvenile salmonid rearing. Maintaining the lagoon water levels in a perched state that is also below flood stage requires an outlet channel to convey water from the estuary to the ocean over the beach berm.

The outlet channel adaptive management plan is organized as follows. Conclusions and recommendations of this plan are described in Section 2. Sections 3-6 describe the planning and analysis steps: (1) defining project performance criteria (Section 3), (2) developing a conceptual model of relevant physical processes (Section 4), and (3) conducting technical analysis to quantify target outlet channel conditions (Sections 5 and 6). The resulting operations and management plan derived from these planning steps is also documented in this report (Section 7). The adaptive management strategy will continue by actual implementation of this plan, then monitoring and evaluating the outlet channel response to refine the plan for subsequent years.

[2] CDFW's CESA tracking number is 2080-2009-016-03 and 1600 Notification number is III-1176-96

2. CONCLUSIONS AND RECOMMENDATIONS

Conclusions about the physical processes affecting outlet channel behavior and recommendations for 2015 management are summarized below.

2.1 CONCLUSIONS: PHYSICAL PROCESSES AFFECTING OUTLET CHANNEL BEHAVIOR

1. The location of the outlet channel, at the interface of the Russian River estuary and the surf zone of the Pacific Ocean, is a dynamic system influenced by river discharge, ocean waves, and sand transport. As such, the outlet channel will be subject to variable forcing at hourly, tidal, and monthly timescales. In order for the outlet channel mouth to preserve its function in this active transport zone, the net sediment transport must be small, even though the gross sediment transport is large. To sustainably meet its performance criteria, the outlet channel must be resilient in the face of this variable forcing. This resiliency is difficult to predict.
2. Under current management of the Russian River watershed and estuary, there has been one documented occurrence of target outlet channel conditions occurring during the proposed management season of May 15 to October 15 for the fifteen year period of record (1999 to 2014). Outlet channel conditions occurred in June 2010 and persisted for about one week before closing. More typically, as a result of natural processes and existing artificial breaching practice, the connection between the estuary and the ocean has been observed in one of two states: bi-directional tidal exchange (88% of the time during the 1999-2008 management periods) or fully closed with no exchange (12% of the time).
3. Conditions similar to target outlet channel performance criteria were observed outside the management period five times between 1999 and 2013. These events appeared to be extended transitions to fully tidal conditions rather than stable conditions. Estuary water levels steadily declined throughout all events and the estuary typically returned to tidal exchange within 48 hours.
4. To meet the performance criteria, the outlet channel geometry must simultaneously meet two key constraints: convey sufficient discharge from the estuary to the ocean to preserve constant water levels in the estuary and preserve channel function by avoiding closure or breaching. These two constraints can be in conflict, since both conveyance capacity to preserve estuary water levels and the potential for breaching increase with flow rates but closure is more likely for lower flow rates.
5. The target outlet channel is subject to two failure modes: (1) closure caused by deposition, leading to estuary water levels to rise and possibly cause flooding, and (2) breaching caused by scour, leading to tidal exchange and marine conditions in the estuary. Of the two failure modes, breaching is more detrimental to NMFS's goal of reducing or eliminating exposure of the estuary to tidal water levels and saline inflow. Once breaching occurs, the estuary may persist in a breached state for weeks or months before the target outlet channel can re-form. The immediate impact of closure is only increasing estuary water levels, which allows time for management action to prevent habitat loss.

6. Based on engineering calculations, the channel bed slope must be essentially flat (slope on the order of 0.0001) and water depths less than 2 ft, preferably 0.5 to 1 ft, to reduce the likelihood of channel scour at likely May to October flows.
7. Based on the results of hydrologic modeling, it may be difficult to convey sufficient discharge to maintain estuary water levels while simultaneously keeping the bed shear stress in the outlet channel below the threshold for scour. Even with dry-year reductions to instream flows, the predicted local bed shear stress during the management period is almost always greater than the critical bed shear stress threshold for erosion.
8. Discharge conditions are a significant source of hydraulic uncertainty for assessing the outlet channel. Discharge measurements are made at the USGS Guerneville gaging station[3], 21 miles upstream from the Russian River's mouth, and changes in flow (losses/gains) are known to occur between the Guerneville station and the mouth. A water balance model for the estuary indicates that net losses between the Guerneville gaging station and the mouth vary from 10% to 53% and average 37%. Limited USGS and Agency discharge measurements at other locations suggest that most losses occur in the lower 6 miles of the river; perhaps in large part due to seepage through the beach berm.

2.2 RECOMMENDATIONS: 2015 MANAGEMENT ACTIONS

1. Two channel configurations will be initially considered for implementation.
    - a wide and short channel that seeks to minimize scour potential; or
    - a narrow and long channel aligned to the north that seeks minimize closure potential.

   The channel selected for implementation will be based on site conditions at the time of closure and discussion with the resource agency management team. Monitoring of the outlet channel and estuary response will be used to inform adaptive management during the management period.
2. Initial management actions may be more frequent, and include maintenance actions that are corrections to the existing channel configuration. Based on experience from these initial efforts, larger and less frequent actions may be undertaken.
3. Once the estuary closes, implement the channel so that when reconnecting the channel, the estuary water levels are no more than 0.5 to 1 ft above the constructed channel bed elevation. This approach reduces the potential for scour.
4. Channel excavation activities should be completed (i.e. the temporary sand barrier removed) coincident with high tides in the ocean. This will reduce the scour potential associated with the initial outflow at the time of breaching.
5. A communication protocol will provide guidance between the Agency and identified points of contact representing key resource management agencies in the estuary.
6. Because of uncertainty about the system and its response to outlet channel management, the adaptive management approach specified in the BO and being pursued by the Agency is

[3] Located just downstream of Hacienda Bridge, USGS station ID 11467000.

critical. A year-end evaluation to assess actual channel performance and revised management for subsequent years is also recommended.

3. PERFORMANCE CRITERIA

The principal estuarine habitat goal stipulated in the Reasonable and Prudent Alternative (RPA), Alterations to Estuary Management, in the BO is to reduce marine influence in the estuary from May 15 to October 15. According to the BO, marine influence includes tidal water level oscillations and saline water. NMFS believes that marine conditions diminish habitat quality for salmonid rearing by reducing the habitat extent, elevating salinity above optimal levels for salmonid juveniles and their invertebrate prey, and flushing juveniles into the ocean.

The performance criteria for outlet channel management are intended to assist in meeting the estuarine habitat objective of the RPA specified in the BO. This section presents performance criteria for Phase 1 of outlet channel management, and minor modifications to these criteria for 2015 management.

Performance criteria for water quality and ecological values in the lagoon are addressed separately and are not included in this document. The Water Agency's water quality monitoring plan is described in Sonoma County Water Agency (2013a), with the monitoring results described in Sonoma County Water Agency (2013b).

3.1 PHASE 1

Phase 1 of outlet channel management has the following performance criteria for the May 15 to October 15 management period:

1. **Estuary water levels**. The estuary water level management target is "[a]n average daily water surface elevation of at least 7 feet [NGVD] from May 15 to October 15" (BO, p. 249). Higher estuary water levels, but not exceeding flood stage of 9 ft NGVD, would be preferred by NMFS. However, water levels greater than 4 ft NGVD are expected to accompany reduced marine influence and would be likely to improve habitat.
2. **Sand channel**. The outlet channel will be a temporary feature, created only by excavating and placing beach sand. No new structures or mechanical devices, temporary or permanent, will be a part of the outlet channel implementation.
3. **Minimize artificial breaching**. Though the overall goal is to create a freshwater estuary, and therefore avoid artificial breaching, in light of natural variability of river discharge and nearshore wave conditions, several years of experience managing the estuary may be required to develop operational procedures which minimize the need for artificial breaching. As such, NMFS estimates "that SCWA will need to artificially breach the lagoon using methods that do not create a perched lagoon twice per year between May 15 and October 15 during the first three years covered by this opinion, and once per year between May 15 and October 15 during years 4-15 covered by this opinion" (BO, p. 302).
4. **Economic feasibility**. Operations and maintenance requirements will not place undue burden on the Agency in terms of cost, particularly as it relates to frequency or duration of maintenance activities.

5. **Public Safety**. The outlet channel management plan will not diminish public safety as it pertains to floodplain property owners, visitors and employees of the State Beach, and the Agency maintenance staff.

To meet the criterion for estuary water level (#1 above), the estuary will function as a perched lagoon with "water surface elevation above mean high tide … where freshwater flows out to the ocean over the sandbar at the lagoon's mouth" (BO, p. 92). This implies uni-directional flow in the outlet channel, from the estuary to the ocean, to minimize marine influence, and minimal sediment transport within the outlet channel to prevent the channel bed from scouring and transforming into a tidal channel.

NMFS (2008) introduced the terminology 'natural' to describe breaches that occur without human intervention and 'artificial' to describe breaches that are the result of human sand excavation. This terminology was used in the management plan through 2013. However, inlet and beach observations in 2012 (Attachment G), 2013 (Attachment H), and 2014 (Attachment I) suggest that the jetty, a human intervention, may indirectly facilitate breaching. The jetty appears to encourage some breaches sooner than natural conditions because the jetty shelters a portion of the beach immediately to its north, limiting sand deposition and resulting in a low point in the beach berm. In 2012- 2014, this low point was often the location where rising lagoon water levels scoured a new inlet. Therefore, starting with the 2014 plan, the term 'self-breach' is used to describe breaches caused by the estuary's own rising water levels. This term is used to include all breaches of this type, since the extent of the jetty's influence has not been fully determined. 'Artificial' breach continues to refer to instances involving human excavation, covering both authorized Water Agency contractors with mechanical equipment or unauthorized members of the public with hand tools.

Note that each time the lagoon breaches, NMFS believes the lagoon is subject to undesirable water quality conditions not just during the breached period, but also for some period of time following the subsequent closure. "NMFS anticipates 3-4 weeks of adverse water quality conditions after the sandbar closes at the mouth of the estuary" (BO p. 302). Thus the management plan seeks to minimize self, as well as artificial breaching events.

The BO requires the Agency to petition the State Water Resources Control Board (SWRCB) to change minimum instream flow requirements to improve rearing habitat for steelhead. Permanent changes in instream flow requirements will take years to accomplish, therefore, the BO also requires the Agency to petition the SWRCB to change minimum instream flow requirements on an interim (temporary) basis to facilitate management of the Estuary as a summer lagoon. The management plan anticipates an interim reduction in instream minimum flow requirements between the Dry Creek confluence and the mouth starting in 2010. Minimum flows would be reduced from current SWRCB Water Right Decision 1610 levels of 125 ft^3/s to 80-85 ft^3/s [4]. The expected reduction in

[4] The proposed instream flow requirement is 70 ft^3/s, but "SCWA maintains a 10 to 15 ft^3/s buffer to avoid non-compliance of the minimum standard" (BO, p. 245).

minimum instream flow will provide more favorable conditions for outlet channel management by reducing the potential for scour-induced breaching.

For channel location, the BO suggests the use of "a lagoon outlet channel cut diagonally to the northwest. … Alternative methods may include … use of a channel cut to the south if prolonged south west swells occur" (BO p. 250).

3.2 2015 MODIFICATIONS

As discussed above (Section 1), the approach of the 2015 plan is to meet the objective of the RPA to the greatest extent feasible while staying within the constraints of existing regulatory permits. It is recognized that the measures developed in the 2015 management plan, when implemented, may not fully meet the objective established by the RPA as summarized in Section 3.1 above. The concept of this approach was developed in coordination with NMFS, CDFG, and CSP.

Because of the estuary's coastal location and hydrologic significance, the Agency must manage the estuary's mouth in accordance with multiple land use permits from various state and federal agencies. A table summarizing all these permits is provided in Attachment C. Key aspects of these permits which directly affect 2015 outlet channel management include:

- Excavation is limited to 2,000 cubic yards of sand per event to create a channel 25 to 100 ft wide. The channel width range is consistent with historic widths observed within the management covered by existing permits (Behrens, 2008).
- Management actions are permitted only on Monday-Thursday to minimize interference with public use.
- Management actions cannot be longer than two consecutive days (unless flooding is threatened).
- Access is constrained during marine mammal pupping season (March 15 – June 30) to reduce incidental harassment of harbor seals, sea lions, and elephant seals.

Artificial breaching may be required during 2015. With this management plan, the Agency seeks to minimize or avoid such breaches during the management period, but recognizes that they may be needed to avoid flooding of adjacent properties.

4. CONCEPTUAL MODEL

The conceptual model of the outlet channel articulates the project's working assumptions about process linkages between channel features, external conditions (e.g. river flow and ocean processes), and channel performance. These working assumptions are uncertain, and may not capture all relevant processes. However, by making these assumptions explicit, they can be documented, discussed, and tested, all of which are necessary steps in the adaptive management process. Observations of the actual outlet channel response will then enable refinement of the conceptual model. In addition, because the conceptual model is expressed in a relatively non-technical manner, it provides an avenue for public outreach and education about the outlet channel. The conceptual model is not a hydrodynamic, sediment transport model but rather uses empirical observations and geomorphic interpretations to identify likely responses to key forcing parameters, given antecedent conditions and management actions.

Development of a conceptual model for the outlet channel focuses on the essential physical processes and linkages, as well as the management parameters of the channel. Although this approach leaves out some processes which may slightly alter the channel's performance, it prevents the conceptual model from becoming so complex that it becomes unwieldy. In addition to limiting the conceptual model's scope to only the essential processes, the model also excludes impacts of the outlet channel on water quality and ecological aspects of the estuary. To further enhance model clarity, the conceptual model is presented graphically with a schematic that reflects the layout of the physical system. One caveat to simplification is that the static, schematic diagrams clearly do not encapsulate the full complexity of this dynamic system.

The conceptual model first describes target conditions for the outlet channel, in accordance with the performance criteria in Section 3. Then the model identifies the morphological processes which may lead to the two failure modes for the outlet channel: closure and breaching. Closure refers to sand transport induced by ocean waves that deposits sufficient volume of sand in the outlet channel mouth that it blocks the outlet channel. Closure prevents discharge through the outlet channel, leading to increasing estuary water levels and the threat of flooding. Breaching refers to the flows enlarging the outlet channel to the point that it becomes a tidal inlet subject to bi-directional flow. It is important to note that these "failure modes" are conditions associated with natural tidal inlets and river mouths, but are considered problems at the Russian River Mouth because modified forcing parameters have affected the timing and frequency such that native species may be adversely affected (see the BO), as well as conflicts with other man-made constraints. One of the key questions in this management plan is whether the inherently dynamic system can be "trained" to drain gradually without breaching and then closing repeatedly.

There are additional aspects of the site which may impact the outlet channel, but whose impacts are thought to be secondary or not well defined. Therefore, they are not included in the conceptual model at this time. If implementation of the outlet channel suggests these aspects are important, they will be incorporated into a revised conceptual model. These aspects include large rocks and/or bed rock within the beach berm, jetty impacts on seepage, and decadal changes to beach width.

Specifically, the jetty at the river mouth and the fill across the tombolo to the south of the site may have affected littoral processes and mouth dynamics, but are not addressed in this study.

This conceptual model is based on existing literature, knowledge of similar estuaries, professional judgment, and ongoing discussion with the Agency, NMFS, CDFW, and CSP. New data and experience adaptively managing the outlet channel will be used to revise the conceptual model in subsequent management plans.

4.1 TARGET OUTLET CHANNEL CONDITIONS

The conceptual model for target outlet conditions is shown in Figure 2. Ideally, the outlet channel conveys water from the estuary to the ocean so that estuary can be maintained in a non-tidal state during the management period. A key performance criterion of this non-tidal state is that the water levels in the estuary (h_l) fall within the range of 4 to 9 ft NGVD, with elevations above 7 ft NGVD preferred. The estuary water level will not be managed directly, e.g. by pumping. Instead, it will be managed indirectly by management actions dictated by the BO, the operation and maintenance of the outlet channel and the reduction of instream flow requirement.

The estuary water level is determined by the balance between inflowing river discharge (Q_r) and three outflows: outlet channel discharge (Q_c), evaporation (Q_e), and seepage through beach berm (Q_s). For estuary water levels to remain within the target range, the inflow and outflows must sum to zero when averaged over a period of several days. As indicated by the width of the arrows depicting these flows in Figure 2, the river inflow, seepage and the outlet channel discharge are the three largest flows; evaporation is a minor factor in the water balance. As such, the sum of the seepage and outlet channel discharge capacity needs to nearly match the river discharge. If the combined outflows are too low, the estuary water level will rise to flood stage and artificial breaching will be necessary. If the outlet channel discharge is too high, the channel will scour and deepen, allowing tidal flows to enter through the channel. The outlet channel discharge is determined in part by its width, bed elevation, slope, and planform alignment. These parameters can be managed to a certain degree, but are likely to evolve in response to the natural variability of the discharge and wave forcing, and the effects of tide range. Seepage is determined by the beach berm's permeability, the water level difference between the estuary and the ocean, and the ambient conditions of the regional water table (Largier and Behrens, 2010). Presently, only the water level difference is subject to management influence. In the future, modification of the jetty to increase the beach berm's hydraulic conductivity will be studied (NMFS, 2008). The river inflow is another management parameter, however, since its value is determined as part of a separate water supply determination and permitting process, its manipulation is not considered here.

Although sediment transport will be minimal within the outlet channel under target conditions, the channel's mouth will perpetually be an active transport zone. This portion of the channel, at its interface with the ocean, will be an active transport zone for two reasons. First, it lies within the surf zone and breaking waves move up and down its face in response to the tides and variations in wave direction, magnitude, and period. Second, this wave action creates a slope on the order of 10:1, which is sufficiently steep that flows of nearly any magnitude from the outlet channel will accelerate to above the scour velocity threshold. In order for the outlet channel to persist with this active transport zone at its mouth, this zone will have to experience minimal net sediment transport. In other words, tidal fluctuations in water level and variability in wave intensity will cause the locations of scour and deposition to shift at hourly timescales, but averaging across several tidal cycles, any sand lost by scour will be balanced by an equivalent amount of deposition. This active transport zone also plays a significant role in lateral migration of the existing channel mouth. This process is discussed in Section 4.4 on planform alignment.

Preserving these target conditions, particularly the discharge conveyance capacity, requires that the outlet channel maintain its cross-sectional flow area. This flow area can decrease or increase, leading to the two failure modes of the outlet channel: closure and breaching. These two failure modes are discussed in the sections below.

4.2 CHANNEL FAILURE: CLOSURE

The processes which lead to outlet channel closure are likely to originate from elevated total water levels in the ocean (z_{wave}), as shown on the right side of Figure 3. Elevated ocean water levels will move the active transport zone into the outlet channel, increasing deposition at elevations above that of the outlet channel's bed, z_{out}. Once deposition rates exceed any capacity of the outlet channel discharge to scour sediment, a berm will build at the mouth of the outlet channel, causing it to close. This process is thought to occur over one to several high tides, corresponding to one to several days. During the management season, total ocean water level is the combination of two ocean processes, the tides and ocean waves. As offshore waves interact with the coastline and nearshore, they are transformed such that the significant elevation on the beach is a function of the wave direction, magnitude, period and runup. While the tides fluctuate with a predictable schedule, ocean waves vary according to the unpredictable weather and wind patterns over the ocean. Therefore, the total water level can be best characterized as frequency distribution that is based on observed tide and wave data.

If the outlet channel closes and flow through the channel stops, the estuary water level will increase since the continuing river inflow cannot be exported through evaporation and seepage alone. Although seepage rates are likely to increase as a result of increasing water levels, it is assumed that seepage rates will remain below river inflow. As the water level rises, it will again overflow the beach berm when it reaches the minimum elevation of the berm crest. Early in the management season, the flow may overtop the berm below flood stage of 9 ft NGVD. However, as the berm crest elevation rises over the course of the management period, the water levels can rise above flood stage. If more moderate management actions do not stop this rising water level, a full artificial breach, as is currently practiced, will be necessary to prevent flooding.

4.3 CHANNEL FAILURE: BREACHING

The breach failure considered as part of the conceptual model and shown in Figure 4 is breaching that occurs when the outlet channel is operating according to the target conditions described above. Breaching is likely to result from two processes, high discharge which scours the channel bed or seepage-induced bed mobilization. Self or artificial breaching after a closure event are not discussed in this section because it is assumed that management actions would be enacted to return the outlet channel to target conditions prior to either of these breach mechanisms occurring. Additionally, breaching by wave overtopping or strong river discharge are not considered because these processes are associated with winter storm events, which are rare during the management period.

Because the outlet channel is an unconsolidated bed composed of relatively small particles, it is susceptible to scour by the discharge flowing through the outlet channel. Sand scoured from the channel will be lost to the ocean and there is not a significant upstream source to replace scoured sand. Extensive scour will enlarge the channel to the point of breaching and tidal inflows. To prevent scour, flow conditions within the outlet channel (u_c) must be below the threshold for scouring sand (u_{crit}). This threshold is a function of the sand grain size, which has been observed to be coarse sand, narrowly distributed around 1 mm at the Russian River mouth (EDS, 2009a). Further north on the beach, large rocks imbedded in the beach berm may provide grade control and limit scour. Whether the flow velocity is below the threshold depends on the type of bed material and hydraulic conveyance through the management parameters of the outlet channel’s width, length, and bed slope.

As noted in the description of target channel conditions, the beach face slope is set by wave action in the surf zone and is sufficiently steep that flow velocity exceeds threshold for sand movement for all expected discharge rates. Under target conditions, the sand scoured by this process will be replaced by wave action on high tides, yielding no net change in the channel mouth morphology. However, if the scour is larger than deposition on the beach face, the active scour zone may move landward, into the outlet channel. This upstream movement is similar to nick point migration or head-cutting observed in streams and rivers. It is also the process observed by the Agency’s maintenance staff when the beach berm is artificially breached under current practice. The breaching typically happens very quickly, before wave-induced sand transport can close off the breach in subsequent higher tides.

A second possible mechanism of breaching is seepage-induced sand mobilization, represented in Figure 4 as an arrow associated with Q_s. If seepage rates are sufficiently large, the movement of water through the sand can mobilize sand particles where the seepage flow daylights at the ground surface. Piping of groundwater along preferred pathways, which may exist within or adjacent to the jetty, might encourage this process by increasing flow rates through portions of the beach. Although seepage failure has not been observed at the Russian River estuary, it has been observed at other estuaries including Crissy Field (Battalio et al 2006) and others (Kraus et al 2002). Seepage failure may simultaneously accompany other breach mechanisms and hence be difficult to identify on its own. Or, seepage failure may require a larger head difference between the estuary and the ocean than what occurs at the Russian River mouth because of artificial breaching to prevent flooding.

In contrast to closure which can be managed with further intervention, breaching can immediately and negatively impact NMFS's habitat objectives by allowing the marine influences of tidal water levels and saline water to enter the estuary. For this reason, breaching is more detrimental to NMFS's habitat goals than closure.

4.4 PLANFORM ALIGNMENT

Because of the presence of hard barriers in the form of the southern jetty and the northern cliffs, the outlet channel is expected to occupy an alignment within the same region that the current tidal inlet occupies, as show in Figure 1. At this initial stage in the adaptive management process, the conceptual model for the outlet channel's planform alignment is indeterminate as to a target alignment most likely to facilitate outlet channel sustainability. Therefore, observations and interpretations of the existing channel are presented in this section to provide an indication of factors acting on the proposed outlet channel. Once the outlet channel is implemented and monitored, a more definitive conceptual model for target alignment will be developed.

The exiting channel's initial alignment after a closure is typically straight and set by one of three factors, depending on the breaching mechanisms. When breached by high river discharge, the channel aligns itself to the northwest, primarily in response to the direction of the river flow during these events. When the channel self breaches at water levels below flood stage, it will overflow the berm at the minimum elevation in the berm crest. For example, in April 2009, this low point was toward the north since this was where the antecedent inlet had lowered the berm crest elevation. The Agency has attempted artificial breaching in several locations; under current practice, the initial alignment is perpendicular to the beach and just to the north of the large rock ("Haystack Rock") at the northwest corner of the estuary (Agency staff, personal communication).

Once breached, the existing channel typically changes alignment because the mouth migrates laterally in response to wave and littoral transport processes (Behrens et al., 2009). Lateral migration by the mouth while the upstream channel lags behind creates a sinuous channel. The direction and magnitude of wave energy and the resultant littoral sand transport are thought to determine the migration direction and extent. For the case of a tidal inlet, the mouth typically moves in the direction of the littoral transport (Dean and Dalrymple, 2002). However, several mechanisms have been identified that enable an inlet to move updrift, opposite to the direction of the littoral transport. Aubrey and Speer (1984) demonstrate that sand bars associated with the inlet's ebb tide delta can attach to the downdrift beach, displacing the inlet in the updrift direction. Pranzini (2001) documents a mechanism whereby riverine sediments discharged to a prograding delta preferentially deposit on the downdrift side side, which translate and rotate the inlet mouth towards incoming wave energy. Aubrey and Speer (1984) also propose that flow patterns created by inlet channel bends can create erosion on the outside of the bend and deposition on the inside, much like the development of river meanders, with a net result of the inlet migrating updrift. Mechanisms similar to these may explain observations by NMFS that suggest that the direction of migration of the outlet channel may be against the direction of littoral transport (J. McKeon, personal communication).

Observations by Behrens et al. (2009) show that the existing tidal mouth typically moves both northward and southward during the management period. Their analysis correlates large changes in mouth location with rapid changes in significant wave height, indicating that the wave processes control the migration process. The bi-directional migration of the mouth suggests that wave energy also changes directions. This is further supported by the resulting shape of the channel, which can develop multiple channel bends in response to the mouth reversing directions. The temporal and spatial distribution of wave energy along the mouth is not well documented since wave observations have only been made offshore and estimates of how the offshore waves are transformed by local bathymetry have not been verified. Studies using trace elements and sand budgets along this stretch of coast indicate reversing directions of littoral transport because of varying periods of convergence and divergence of wave energy (DeGraca, 1976). The predominant direction may be sensitive to the relative contributions of northwest wind waves versus southerly swell. For instance, Behrens et al. (2009) show that mouth migration patterns are significantly different during El Niño years with the channel remaining in at the northern end of its range for the entire summer. They speculate that the decrease in northerly wind waves during El Niño events may explain this phenomenon. Another potential cause for this pattern is the more southerly approach angle of incident swell waves during El Nino years, as suggested by Allen and Komar (2006).

An additional factor which may affect the mouth location is the landward migration of the offshore bar. This bar, which is created by sand eroded off the beach during winter storms, moves landward with the low steepness summer waves. If this bar, which runs parallel to the shore, moves sufficiently close to the channel mouth, it may force the mouth to either side.

5. EMPIRICAL ASSESSMENT OF HISTORIC INLET CONDITIONS

The Russian River inlet is highly variable in form, position, and capacity for tidal conveyance. Analyses of field data and an extensive photographic record of daily conditions show that this variability is largely influenced by tides as well as seasonal changes in wave and river conditions (Rice, 1974; Behrens, 2008). Management actions also influence the timing and duration of closure events (Goodwin and Cuffe, 1994).

When the estuary is open to the ocean, the inlet can take one of the following forms:

- A river-dominated channel with minimal influence from tides and waves. This occurs during short-lived river flood events between December and April.
- A channel controlled by a mix of river flow, tides, and wave action. This is the most common inlet state, with waves tending to deposit sand in the inlet and estuary-to-ocean flows due to tide and river being active in removing sand from the inlet. Estuary tidal range is a fraction of the ocean tidal range, ranging from zero to over 70%, varying in response to sediment infilling and scouring of the inlet channel. Here we give special attention to "marginally tidal inlets", where tidal conveyance is less than 10%.
- A one-way overflow channel with water draining from a perched estuary, i.e., the sand barrier is built across the mouth of the estuary, but the estuary water level is high enough to overflow. Waves have limited control over such an "overflow inlet", and tidal influence is nonexistent. River flow rate controls estuary water level and overflow volume, which determines the susceptibility to breaching.

This section provides an overview of inlet states observed during the years 1999 to 2008, the time period for which the photographic record has been analyzed in detail. The analysis emphasizes the dates corresponding to the proposed management period of May 15 to October 15. The purpose of this assessment is to use existing data to identify relationships between forcing due to river, tides and waves and the response of the estuary mouth ("inlet") – and to explore the frequency of the latter two conditions described above.

5.1 FREQUENCY AND FATE OF RUSSIAN RIVER INLET STATES

The possible occurrence of an "overflow" channel at the mouth of the Russian River estuary was investigated by comparing water level records from the Jenner gage with tidal data from the NOAA Point Reyes station. The focus was to analyze events when the inlet was open for at least 24 hours with water levels remaining above tidal influence and slowly varying. Attention was also given to events when the inlet allowed minimal amounts of tidal interaction. Dates for which the inlet was at least partially open were disaggregated into a series of categories based on the ratio of the estuary tide range observed at the Jenner gage to ocean tide range (defined here as "tidal conveyance") – see Table 1. Estuary tide is driven by ocean tide, but estuary tide range is reduced either due to the elevation of the channel base that precludes complete draining of the estuary to low tide levels or due to the channel size being too small for enough water to be transported between estuary and ocean. The estuary-ocean tidal ratio is thus an indicator of mouth state, with smaller values representing an increasingly choked mouth (near to closure or overflow state).

Table 1 Frequency of observed inlet states from May 15 to October 15 for years 1999-2008.

Inlet state		Number of days observed	Proportion of period
Tidal conveyance[1]	0-5%	10	0.8%
	6-10%	4	0.3%
	10-29%	82	5.4%
	30-49%	315	20.9%
	50-69%	590	39.2%
	≥ 70%	142	9.4%
Full inlet closure		161	10.7%
Overflow channel, stable or decreasing water level(≥ 24 hours)		0	0.0%
Device error		199	13.2%

[1]Defined as the ratio of estuary tide range to ocean tide range.

The 161 days when the estuary was closed consisted of 26 separate closure events. Of these, 19 were artificially breached and the remaining 7 were self breaches. Although the low number of self breach events prevents any statistically significant comparisons with river or wave data, it is worth noting that flows over 400 ft^3/s resulted in self breaches within 1-2 days of closure. Including all closures, there was a correlation between Guerneville flow and closure duration, with lower flows leading to longer closure periods.

During the years 1999-2008, there were no instances of overflow conditions during the proposed management period, but there were five relevant events that occurred just outside of the management period. All events had decreasing water levels, reflecting down-cutting of the barrier, although the rate of down-cutting was slow enough to prevent tidal interaction for at least 24 hours. Two of these events occurred during October, one in November, and two in May. Three of the events were associated with closure events and most lasted for less than 48 hours. An exception was a five-day event that occurred 6-11 May 2008. In this case, the inlet was breached artificially, and the Agency immediately noted that the channel had become elongated, beginning near "Haystack Rock", nearly 450 feet north of the jetty, and terminating at the jetty. This is uncommon, as post-breach channels are almost always short and wide (Behrens, 2008). The sudden elongation of the channel is likely associated with onshore bar migration.

During tidal periods, tidal conveyance was less than 10% on only 14 days during the management period from 1999-2008. These states were generally a precursor to closure events – all dates for which tidal conveyance was below 10% resulted in closure and the muted tidal state typically lasted for only one or two days. They were most commonly observed during short periods when an artificial breach failed to keep the inlet open for more than 1 or 2 days, or during periods of low flow when the inlet was narrow and elongated. Note that there is a diminishing propensity for the inlet to be in a muted tidal state when it is close less than 30% of the full tide range. This indicates that being in between fully open or fully closed is not a condition supported by natural processes at this site.

5.2 WAVE AND RIVER CHARACTERISTICS

Wind waves and river outflow characteristics strongly influence the behavior of the inlet. These forcings exhibit seasonal patterns and other trends that correlate with different inlet states. Details of these relationships are presented below.

5.2.1 Seasonal patterns

Wave data were obtained from the CDIP Point Reyes buoy and a transformation matrix accounting for shoaling and refraction (e.g. http://cdip.ucsd.edu/) was used to transfer deepwater conditions to conditions at a location at 10-meter depth near the inlet. This method provides a first-order estimate of nearshore wave conditions that is necessary as there is a significant difference between deepwater/offshore waves and those nearshore. Wave energy is greatest in winter, declining through spring, to a minimum in July-August. However, late spring storms and/or early fall storms can occasionally produce waves exceeding 10 feet in the vicinity of the inlet during the management period. As discussed in Rice (1974) and Behrens et al. (2009), predominant swell waves from the northwest are often the cause of prolonged inlet migration or closure during late spring.

Data on river flow at Guerneville[5] show a rapid decline from a maximum at the beginning of the management period (mid-May) to a minimum in August (Table 2). Flows in July through September are low, between 80 and 225 ft^3/s for the years 1999 to 2008.

5.2.2 Conditions during different inlet states

Wave and flow conditions were compared with specific inlet states, as shown in Table 2.

Marginally tidal inlet: There is a relation between tidal conveyance and nearshore waves (H_s is significant wave height). Marginal tidal conveyance (< 10%) occurs during larger waves (H_s of 2.5 to 3.25 feet), consistent with the idea that these are transitory states associated with inlet closure and one needs waves big enough to overcome tidal (plus river) flows. These wave conditions may be lower during periods of weaker river flow. Further, if this marginally tidal mouth condition persisted, it could do so for any weaker wave conditions (which would not close the mouth).

Closed inlet: Estuary water level increase during closure events was analyzed to understand how close these conditions were to a steady-state overflow scenario. In all cases, water levels rose at rates of 0.1 ft/day or faster (Table 2). However, accounting for estuary area, the slower water level rise suggests that it may be possible to achieve a steady state with limited flow over the berm if river

[5] USGS gaging station located just downstream of Hacienda Bridge, station ID 11467000.

flows are of order 100 ft^3/s or weaker. Flows marginally over 100 ft^3/s may be possible, depending on the limit on overflow rate without eroding the sand barrier.

Overflow inlet: All of the five observed overflow events had flows higher than 100 ft^3/s, but only one persisted for more than a couple of days. Further, all of these events exhibited unusual conditions. The October 1999, November 1999 and first May 2008 event occurred during a sequence in which high waves began to induce closure, but a sudden increase in river flow prevented full closure and eroded the channel down to its original state. It appears that overflow conditions only occurred because the initial transition towards closure allowed estuary water levels to temporarily exceed high tide levels. The event in October 2006 occurred after a self breach of a four-day closure, so the lower flows observed in this case are expected. Finally, the most persistent event in May 2008 was associated with an unusually long channel, which is important in that frictional losses may have encouraged the prolonged high water elevation in the estuary. As noted above, this event was likely due to seasonal onshore bar migration.

Table 2 Comparison of average wave and average river conditions for various ranges of tidal conveyance and water level increase in the estuary. Overflow conditions are analyzed for five events observed outside of the proposed management period.

Inlet state		Guerneville flow, ft^3/s	Nearshore H_s, ft
Open inlet with given tidal conveyance:	<10%	323	3.2
	10-29%	261	2.5
	30-49%	219	2.1
	50-69%	276	2.0
	≥70%	328	1.8
Closed inlet; estuary stage rising at given rates:	0.1-0.29 ft/day	146	2.7
	0.3-0.49 ft/day	175	2.6
	0.5-0.7 ft/day	185	3.4
	≥0.7 ft/day	211	4.1
Overflow channel (outside management period)	Oct 28, 1999	291	15.7
	Nov 4-5, 1999	247	5.9
	Oct 26, 2006	155	2.2
	May 1-2, 2008	323	6.6
	May 6-11, 2008	283	1.3

5.2.3 Analysis of wave runup

The mouth of the estuary is typically closed by waves depositing sediment in the inlet channel during slack high tides, but waves can only do so if wave runup can reach the height of the inlet channel base. Thus, wave runup exceedance curves were generated for each of the management months to assess the likelihood of the (overflow) channel being closed by wave action. De-shoaled deepwater equivalent wave heights were combined with daily higher-high tide water levels to estimate runup height following Stockdon et al. (2006), and assuming a constant beach-face slope.

The height exceeded by 2% of the waves under given monthly wave conditions is shown in Figure 5. Runup is highest in October, with heights of 11ft being exceeded on 1 in 10 days. For May, June and September, runup exceeds 10ft on 1 in 10 days, and this drops to 9ft for July and August. This is consistent with the seasonal cycle of large swell events, due to winter storms in the north Pacific, which may occur in October, and occasional swell events due to storms in the tropical or south Pacific during summer. The locally generated waves due to northerly winds in summer are of shorter period and lower height. These data suggest that wave-induced closure of an overflow channel will be a greater concern at the beginning and end of the May-October management period.

5.3 CHANNEL PLANFORM GEOMETRY

Inlet morphological behavior has been studied by Behrens (2008) for the years 1999-2008 through an analysis of inlet width, length and position estimates derived from photographic records. Data collection methods and error estimates are described in Behrens et al (2009). Inlet planform geometry and closure risk are summarized for different mouth states (Table 3).

Table 3 Inlet planform geometry for overflow conditions and various ranges of tidal muting (May 15 to October 15, 1999-2006). Overflow conditions are analyzed despite the fact that they occurred outside of this timeframe.

Inlet state		**Inlet width[1], ft**	**Inlet length[1], ft**	**Most common configuration**	**Closure risk[2]**
Open inlet with given tidal conveyance:	<10%	25 ± 1.8	530 ± 37.1	≥2 channel bends	81.3%
	10-29%	51 ± 3.6	358 ± 25.1	1-2 channel bends	35.3%
	30-49%	71 ± 5.0	282 ± 19.7	1 channel bend	28.6%
	50-69%	86 ± 6.0	236 ± 16.5	1 channel bend	13.7%
	≥ 70%	92 ± 6.4	221 ± 15.5	Straight	3.5%
Overflow channel (outside management period)	Oct 28, 1999	60 ± 4.2	140 ± 9.8	Straight	--
	Nov 4-5, 1999	20 ± 1.4	360 ± 25.2	Deflected by jetty	--
	Oct 26, 2006	25 ± 1.8	110 ± 7.7	Straight	--
	May 1-2, 2008	65 ± 4.6	100 ± 7.0	Straight	--
	May 6-11, 2008	20 ± 1.4	480 ± 33.6	Deflected by jetty	--

[1] Ranges are based on error estimates from Behrens *et al* (2009).
[2] Defined as the number of observations that were followed by closure within two weeks, divided by the total number of observations.

The data for overflow channel geometry indicate that the limited number of overflow events exhibited a range of shapes. The geometry of the only persistent case (6-11 May 2008) suggests that frictional loss plays an important role in attenuating channel velocity and the resulting downcutting.

However, there is a tradeoff for the frictional losses associated with sinuous channels. For a marginally tidal inlet the channel is long and narrow, with a couple of bends – and there is a very high risk of closure. There is no apparent relation between inlet position (not shown in this table) and tidal conveyance. However, marginally tidal inlets and overflow inlets were observed only at the northern or southern extreme of the inlet's migration range. Inlet width and length are known to vary in concert with river flow during the wetter months of the year and with tidal range during the drier months (Behrens et al., 2009). In general, low-flow conditions (low tides or river flow) appear to encourage inlet elongation and narrowing. Inlet width, length, and the number of channel bends all influence the tidal signal by determining frictional losses in the channel.

5.4 NOTES ON OTHER ESTUARIES

Overflow inlets have been observed in numerous estuaries along the coasts of California, Oregon, Chile and South Africa (and probably other areas with comparable climate and topography) (personal communication, John Largier). These are unpublished observations. Specifically, an overflow inlet is typically observed to persist for 1 to 3 months each year at the mouth of Salmon Creek (10 miles south of the Russian River) and at the mouth of the Gualala River, discussed below. Further, small central coast estuaries exhibit overflow states during spring and summer, e.g., Scott Creek and Waddell Creek. Systems photographed along the Chilean, South African and Oregon coasts are of similar size in terms of river flow and lagoon area. The absence of observations of overflow conditions in larger estuaries, similar to the size of the Russian River, suggests that there is a limit to the flow energy that can be accommodated by flow over a sand barrier of finite width (and thus high slope).

5.4.1 Gualala River

The mouth of the Gualala River is located 31 miles northwest of Jenner. Both its tidal prism and annual river flow are significantly lower than those of the Russian River. Despite this, the sites have several similarities, most notably their similarly sized beaches bordered by headlands. During a typical year, the inlet is closed for the entire summer and is opened by the first major storm of the winter (ECORP, 2005). The inlet requires consistent rainfall to remain open, and it is common for closures to occur within several weeks after each major storm event. As rainfall decreases during the spring, the inlet undergoes repeated cycles involving a closure event, a period of gradual estuary stage increase leading to a natural breach, and finally, several days to several weeks of minimal tidal conveyance and/or overflow conditions culminating in a new closure event. These cycles appear to continue until evaporative and seepage losses counterbalance inflows into the estuary, preventing the stage increase required to cause a natural breach event.

5.4.2 Carmel River

California State Parks adaptively manages the beach berm which creates a lagoon at the mouth of the Carmel River (CA Dept. of Parks and Recreation, 2008). The goal of this management is similar to the goal stated in the Russian River BO (NMFS, 2008): to enhance the freshwater salmonid rearing habitat during summer months. Sometime in April, May, or June, once the Carmel River discharge into the estuary drops below 20-25 ft^3/s, bulldozers are used to increase the height of the beach berm. This elevated berm blocks ocean tides and saline water from entering the estuary, thereby creating a perched lagoon. When forming the elevated beach berm, an outlet channel is also created so that if lagoon water levels exceed 10 feet NGVD, the outlet channel will drain water from the lagoon into the ocean. The outlet channel only conveys water if the discharge to the lagoon does not taper off from 25-20 ft^3/s to 10 ft^3/s as rapidly as expected. Once river discharge falls below approximately 10 ft^3/s, evaporation and seepage export enough water from the lagoon that lagoon water levels no longer increase.

The Carmel Lagoon outlet channel differs from the proposed Russian River outlet channel with respect to several key features, as summarized in Table 4. Overall, the Russian River outlet channel is likely to be more difficult to manage than the Carmel River outlet channel because of its higher required conveyance, longer operational period, and lack of natural grade control.

Table 4 Comparison between Russian River and Carmel River outlet channel features

Outlet channel feature	Russian River	Carmel River
Conveyance capacity	50 ft^3/s	10 ft^3/s
Operational period	5 months (May-Oct)	1 month
Grade control	none	natural rock outcrops

6. CHANNEL CONFIGURATION ANALYSIS

As discussed in the conceptual model for target conditions, the outlet channel geometry must simultaneously meet two key constraints: convey sufficient discharge from the estuary to the ocean to preserve constant water levels in the estuary and preserve channel function by avoiding closure or breaching. Note that these two constraints can be in conflict since both conveyance capacity and the potential for breaching increase with flow rates but closure is more likely for lower flow rates. The technical analyses described in this section inform the range of target channel conditions by quantifying the relationship between outlet channel dimensions, bed scour potential, and hydraulic conditions. The ocean-driven processes associated with closure, the wave runup elevation and planform alignment, are discussed above in Section 5. Preventing breaching, a necessary condition for reducing marine influence on the estuary is the focus of this section.

Since the outlet channel will be located within a bed of unconsolidated beach sand, a key management objective is creating a channel which can sustain its cross section geometry instead of scouring. Breaching can occur if the discharge through the outlet channel is sufficiently forceful to scour the channel bed. To reduce the possibility of scour, threshold design principles (NRCS, 2007) are used to examine channel configurations most likely to avoid scour while meeting the other constraints of the system.

Channel design using a threshold methodology consists of the following steps:

- *Estimate the critical shear stress threshold.* This is a function of the site's bed particle composition, which can be characterized by grain size.
- *Predict hydraulic conditions for the proposed channel.* Use engineering calculations of steady flow and a one-dimensional hydraulic model of time-varying flow to estimate the velocity and shear stress for a proposed set of channel geometry, flow, and bed roughness.
- *Compare threshold and predicted bed shear stress.* The estimates from the two previous steps are compared with a factor of safety to account for variations in hydraulic conditions about the mean and uncertainty in parameter estimation.
- *Sensitivity analysis and uncertainty.* Evaluate the sensitivity of threshold and predicted bed shear stress to input parameters as well as the factors contributing to overall uncertainty.

6.1 CRITICAL SHEAR STRESS

The critical shear stress is defined as the applied bed shear stress at which sediment motion occurs. The critical threshold represents a balance between the force exerted by the flow on the bed and the resisting gravitational force of individual sediment particles. Flows above the critical shear stress will transport sediment while flows below the critical shear stress will result in no motion. The critical shear stress is dependent on characteristics of the sediment such as sediment density and particle size.

Sediment samples at the Russian River mouth were collected in March 2009 to inform the assessment of critical shear stress within the outlet channel. Ten sediment samples taken along the proposed outlet channel alignment were analyzed to determine the characteristic grain size distribution. On average, 78% of the sediment had a grain diameter between 0.6-2.0 mm (coarse sand), 18% was greater than 2.0 mm (granular), and 4% was between 0.2-0.6 mm (medium sand) (EDS, 2009a). Visual observations of grain size by ESA PWA near the mouth indicated a typical diameter between 0.8-1.25 mm (coarse sand).

Based on this assessment of typical beach grain size, ESA PWA estimated the critical shear stress using methods outlined in Soulsby (1997) and Fischenich (2001). For the typical range of observed grain size from 0.8-1.25 mm, a critical shear stress of 0.4-0.7 Pa (0.008-0.015 lb/ft^2) was determined for sand particles in the vicinity of the proposed outlet channel (Attachment A-1).

6.2 PREDICTED HYDRAULIC CONDITIONS

6.2.1 Steady mean flow conditions

ESA PWA conducted a preliminary assessment of outlet channel hydraulics under steady typical summer flow conditions as a screening tool to characterize the range of possible channel geometry parameters (bed elevation, channel slope, width, and length). Simple hydraulic equations for open channel flow were used to estimate the in-channel velocity and bed shear stress.

ESA PWA evaluated different combinations of river discharge, bed roughness, channel slope, and flow depth to evaluate channel performance. For a given discharge the hydraulic equations can be solved to determine the values of slope, width, and depth that satisfy the critical shear stress threshold for sediment motion. Once one of these three parameters is selected, the other two are fixed to meet a given shear stress threshold (NRCS, 2007). Multiple combinations of channel slope and width are capable of conveying the design flow at or below the critical shear stress threshold.

Figure 6 shows an example slope-versus-width stability curve for the outlet channel design. A stability curve is a tool used by designers to evaluate channel stability under a range of feasible slope-width combinations. Any combination of slope and width that falls on the stability curve will be stable for the prescribed discharge. Combinations of width and slope that plot above the stability curve will result in erosion and scour of the channel. Combinations of width and slope that plot on or below the stability curve will be stable (or depositional). For a given width, the depth of flow can be determined from the corresponding depth-width curve (Figure 6). For example, a 100-ft wide channel discharging 70 ft^3/s will be stable for channel slopes less than approximately 0.000125 and will flow at a depth of approximately 11 inches. The stability curve shows that as slope increases, channel width must also increase to keep channel velocities below the critical threshold for transport. Channel width and depth are inversely related for points on the stability curve, resulting in either a narrow channel with relatively deep flow or a wide channel with relatively shallow flow.

6.2.2 Calculation of estuary inflows

ESA PWA developed and calibrated a water balance model based on observed lagoon water levels at Jenner, CA. The purpose of the water balance model is to estimate the reduction in river discharge that occurs over the 21 river miles between Guerneville, a USGS continuous discharge gaging station, and the mouth of the estuary. The losses in discharge are attributed primarily to seepage through the beach berm (Largier and Behrens, 2010), with diversions, interaction with the adjacent aquifer, and groundwater pumping as possible contributing factors. No direct observations of these loss terms is available. The reduction factor serves as the calibration variable for the water balance model. For all cases, predicted estuary water levels during closure periods do not match observations unless lagoon inflows are reduced relative to the Guerneville discharge.

Model Setup

During a closure event, the rate of water level increase is a direct function of the net flows into and out of the lagoon (Goodwin and Cuffe 1993):

$$\frac{\Delta V}{\Delta t} = A\frac{\Delta h}{\Delta t} = \alpha Q_R - A i_{evap} - Q_s$$

where:

	$\triangle V$	=	lagoon inflow during closure (ft^3)
	$\triangle t$	=	duration of closure (days)
	A	=	surface area of the lagoon (ft^2)
	$\triangle h$	=	change in water level in the lagoon (ft)
	Q_R	=	river discharge at Guerneville (ft^3/day)
	α	=	discharge reduction factor for groundwater losses
	i_{evap}	=	rate of evaporation from the lagoon (ft/day)
	Q_S	=	rate of seepage loss through the barrier beach (ft^3/day)

All terms in the water balance equation can be measured or approximated to allow calculation of α, the discharge reduction factor, for each closure event. The components and data sources of the water balance model are described below:

- Estuary water level and inlet state ($\triangle h$) – Jenner water level time series, (SCWA, 2000-2007). The inlet was assumed to be closed (no flow) during the calibration, based on periods when the estuary water levels were non-tidal and increasing estuary water levels.
- Guerneville discharge (Q_R) – USGS gaging station 11467000 (Russian River near Guerneville, CA at Hacienda Bridge) (http://waterdata.usgs.gov).
- Evaporation (i_{evap}) – estimated based on climatological evaporation rates for CIMIS evapo-transpiration reference Zone 1 (California coast) (*www.cimis.water.ca.gov*, Attachment A-3).
- Berm seepage (Q_S) – estimated using Darcy's Law based on water level difference between lagoon and ocean (Attachment A-4).
- Lagoon stage-storage curve (A) – determined from 2009 sidescan survey and LiDAR digital elevation model (EDS 2009b).

The volume of water entering the closed lagoon as a result of waves overtopping the beach berm is not included in the water balance model. Two lines of reasoning provide the basis for this exclusion. First, wave conditions during the May through October management period are generally associated with beach berm building, not with extensive overtopping and berm erosion more prevalent during winter storm events. The wave runup analysis in Section 5.2.3 confirms that runup elevations sufficient to overtop the berm are infrequent. Second, the observed water levels used in the water balance model exhibited nearly constant rates of increase, typically over two days or more. Short periods of rapidly changing water levels indicative of overtopping were not used in the water balance analysis.

Model Calibration

The observed rate of water level increase ($\triangle h/\triangle t$) in the lagoon during 18 closure events was calculated from the Jenner gage data. Rates of water level increase ranged from 0.4 ft/day to 3 ft/day and averaged 1 ft/day. The required inflow ($\triangle V/\triangle t$) to yield the observed rates was calculated based on an assumed lagoon surface area (A) at closure of approximately 400 acres. From the observed average discharge at Guerneville (Q_R) over each closure period, a discharge reduction factor, α, was calculated for estuary inflow during each of the closure events. The percent reduction ranged from 10% to 53% and averaged 37% (Attachment A-5). The largest reductions in discharge typically occurred in summer and were less in the spring and fall.

The reduction factors were averaged over each month from May-October to approximate a seasonal trend. The resulting calibration curve (Attachment A-5) was used to reduce the anticipated Guerneville discharge in the unsteady hydraulic modeling discussed in Section 6.2.3 to predict downstream flow rates into the lagoon based on upstream discharge measurements.

Comparison with Discharge Measurements

A limited set of USGS and Agency discharge measurements provides estimates of river flow at other locations besides the continuous discharge measurements at Guerneville. These discharge measurements, collected at four stations[6] in the 14 miles below Guerneville, typically fall within 10% of the Guerneville average daily discharge. For example, Behrens and Largier (2010) found that the longest record, collected by the Agency in 2009 at Vacation Beach, agreed to within 10 ft^3/s of the discharge measurements made at the permanent USGS Guerneville gage. These relatively low losses suggest that the losses calculated to complete the estuary water balance occur downstream of these discharge measurements, in the lower 6 miles of the river. Since the results of the water balance are used to estimate estuary inflow in the unsteady hydraulic model (see Section 6.2.3 below) and have a significant level of uncertainty, the estuary inflow values in the unsteady hydraulic model may not represent actual estuary inflow. Presently, the existing data are insufficient to fully characterize the losses between the discharge measurements and lagoon water levels. Higher

[6] Data available from USGS National Water Information System (http://waterdata.usgs.gov/nwis), Russian River station names (site number): Duncan Mills (11467210), Monte Rio (382757123003801), Vacation Beach (11467006), and Rio Nido (383012122574501).

rates of seepage through the beach berm are one possible explanation. Largier and Behrens (2010) estimate seepage rates to average 60 ft^3/s for all closure data. Their seepage estimates vary from approximately 30 ft^3/s when the estuary is closed and its water level exceeds the ocean water level by 2-3 ft to more than 70 ft^3/s when the water level difference exceeds 5 ft. Substantial uncertainty about the seepage rate, on the order of ±20 ft^3/s, remains; therefore monitoring to resolve this discrepancy is recommended in Section 7.7. The implications of alternative lagoon inflows are discussed in the model sensitivity analysis and outlet channel management sections of this report.

6.2.3 Hydraulic modeling of unsteady mean flow conditions

Using the calibrated water balance model results described in Section 6.2.2, ESA PWA developed a hydraulic model to evaluate the performance of the outlet channel for various hydrologic scenarios. This modeling is a refinement of the steady mean flow calculations described in Section 6.2.1 because it quantifies estuary discharge, explicit channel geometry, and temporal changes in hydraulic parameters. Sources and sinks accounted for in the model include river discharge, groundwater losses, berm seepage, evaporation, and outlet channel discharge (described in more detail in Section 6.2.2 and Figure 7). Flow in the outlet channel is represented by one-dimensional channel hydraulics as a function of estuarine water levels, channel dimensions, channel slope, and bed roughness. Tidally-varying ocean water levels are included in the model, but since these water levels stay below the channel's bed elevation, they do not influence flow in the channel. Initial channel dimensions were based on the results of the preliminary analysis described in Section 6.2.1. Model channel geometry was revised iteratively based on subsequent hydraulic analyses and discussions with the Agency and NMFS. Channel geometry is fixed throughout the simulation, even though the channel may be subject to scour and its mouth lies in the active transport zone created by ocean waves (Section 4). This assumption has been made because currently available data and models cannot adequately characterize the active transport zone. The management implications of this assumption are discussed in Section 7. The model simulates estuary water levels and outlet channel flow for the period spanning proposed outlet channel operations, from May 15 to October 15.

Discharge Boundary Condition

ESA PWA analyzed historic discharge data at Guerneville to select a "typical" water year for the hydraulic model boundary condition. A time series of monthly discharge was obtained from USGS for the time period from 1970 to 2008 and compared to the median monthly discharge for the duration of record to select a typical water year. For each month, the difference between the month's discharge and the median monthly discharge was computed. The sum of the differences (for May-Oct only) was used to rank each year relative to median conditions. Based on this ranking, the 2000 water year was selected as the most typical year (Attachment A-6).

The year 2000 discharge time series was used to generate a synthetic discharge time series to approximate anticipated reduced instream flow conditions. A measured time series is preferable to using the median daily discharge because it retains some of the short-term variability in the observed flow rates. A synthetic discharge time series for anticipated flow conditions was derived from the typical discharge time series by scaling the Guerneville discharge to an average summertime flow of

120 ft^3/s. This reduction to 67% of observed 2000 discharge is based on the anticipated reduced instream flow requirements (Section 3.1) versus historic instream flows. When flows are adjusted to average 120 ft^3/s from July to October, short-term variability ranges from about 85-150 ft^3/s. The resulting discharge time series at Guerneville is shown in Figure 7a for the simulation period.

The anticipated discharge time series at Guerneville was further reduced using the calibration curve developed in Section 6.2.2 to account for downstream losses between the gaging station and the lagoon. The resulting estuary inflow time series is shown in Figure 7a. Anticipated inflows to the lagoon vary from approximately 45-90 ft^3/s and average approximately 55 ft^3/s during the summer months. Once seepage and evaporation losses are subtracted from the lagoon inflow, modeled baseline flows in the outlet channel are 45-85 ft^3/s and average 50 ft^3/s.

Model Setup

The configuration for the unsteady HEC-RAS hydraulic model is very similar to the water balance model described in Section 6.2.2. The unsteady model includes the lagoon, outlet channel, and beach face, and simulations span the duration of the operational period, from May 15-October 15. The outlet channel was parameterized as a prismatic rectangular channel with a width of 100 ft and length of 300 ft. Bed roughness (Manning's n) was set to 0.02. The channel bed was set at 5 ft NGVD and transitions to a 1V:70H slope on the beach face. The actual beach face slope is believed to be closer to 1V:10H; however, a milder slope was required for model stability. Sensitivity runs with a steeper beach face slope indicated negligible influence on velocities in the upstream portion of the outlet channel. Time-varying seepage and evaporation losses from the lagoon were estimated from Darcy's Law and CIMIS climate statistics for coastal areas, as described in Section 6.2.2. The time series of these losses used as model input are shown in Figure 7b. Because these combined losses are less than 10% of the lagoon inflow, the modeled lagoon outflow through the outlet channel is similar to the lagoon inflow (Figure 7a). A downstream water level boundary condition was prescribed for the ocean; however, since the outlet channel bed elevation is above the limit of tidal influence (approximately 4.5 ft NGVD), there was no impact on outlet channel hydraulics.

Results

Model runs were conducted for the operational period from May 15-October 15 for the proposed outlet channel geometry described above. Time series of lagoon water level, channel velocity, and bed shear stress were extracted to evaluate channel performance. Bed shear stress and lagoon water level results for the hydraulic modeling are shown in Figure 8a and Figure 8b, respectively. The bed shear stress values shown in Figure 8a are mean model predictions times 1.5 to account for transverse variations in bed shear stress not captured by the one-dimensional model (Fischenich, 2001).

The results for the proposed channel geometry and the anticipated reduced instream hydrology are shown as the "Baseline" curve. The expected range of critical shear stress (0.4-0.7 Pa) is shown in Figure 8a for reference. After the initial higher flow period during the spring and early summer, both shear stress and lagoon water level are relatively constant throughout the summer and fall (July-October). Bed shear stresses fluctuate during this period, but are always above the critical shear stress, indicating likely sediment motion and scouring of the channel. Lagoon water levels (Figure 8b) are relatively constant around 5.6 ft NGVD, resulting in a typical flow depth of approximately 0.6 ft in the channel. Channel velocities average 1.1 ft/s and range between 1.0-1.3 ft/s.

6.3 SENSITIVITY ANALYSIS AND UNCERTAINTY

ESA PWA conducted sensitivity and uncertainty model runs for important variables and parameters to assess their impact on channel performance. The testing focused on conditions that may encourage a stable channel by reducing predicted bed shear stress below the critical shear stress. Parameters tested were reduced outlet channel flow and critical shear stress.

Reduced Outlet Channel Flow

Anticipated flows in the outlet channel are somewhat uncertain because the losses between upstream observed discharges and the outlet channel are not well characterized, as described in Section 6.2.2. The baseline simulation presented in Section 6.2.3 used a calibrated seasonally-varying coefficient to reduce flow rates into the lagoon. Once seepage and evaporation losses are subtracted from the lagoon inflow, modeled baseline flows in the outlet channel are 45-85 ft^3/s. To test channel performance under conditions with further flow reductions (due to higher losses, groundwater recharge, diversions, or berm seepage), a sensitivity run was conducted with outlet channel flows reduced to 25-45 ft^3/s, approximately 45% less than baseline conditions.

Critical Shear Stress

Uncertainty in the critical shear stress for beach sand at the Russian River mouth is primarily due to the fact that the beach is comprised of a distribution of particles of varying diameter (see Section 6.1), as opposed to a uniform grain size. Grain size analyses indicate a narrow distribution of approximately 0.8-1.25 mm diameter sand, for which the critical shear stress ranges from 0.4-0.7 Pa. The critical shear stress for the typical grain size of 1 mm is 0.5 Pa.

Results

The results of the reduced outlet channel flow sensitivity model run are shown in Figure 8a for bed shear stress and Figure 8b for lagoon water level. The 45% reduction in outlet channel flow resulted in reduced bed shear stress and water level. Average water levels and channel depth decreased by approximately 0.1 ft relative to the baseline simulation. Average bed shear stress decreased by approximately 30% to an average value of 0.58 Pa for the summer months. The range of critical shear stress, 0.4-0.7 Pa, is shown in Figure 8a as a blue band. While the predicted bed shear stress for baseline conditions almost always exceeds this range, the predicted bed shear stress for reduced outlet channel flow falls within the range of critical shear stress.

The results of the sensitivity simulations suggest that while the baseline conditions are likely to cause scour, variability in outlet channel flow and critical shear stress could result in a marginally stable channel. If necessary, a wider channel could be excavated (or could develop naturally) to reduce bed shear stress below the critical threshold. This model was not used to predict sediment transport and therefore the modeled channel geometry was held fixed. Under target conditions, active transport is expected at the channel mouth (Figure 2). In order for the outlet channel to persist, scour caused by the outlet channel flow accelerating down the beach face at low tides needs to be balanced by sediment deposition generated by wave action at high tides. However, if the active transport zone moves upstream into the outlet channel, the channel is likely to breach and return to tidal conditions, as shown in Figure 4.

7. PROPOSED OUTLET CHANNEL ADAPTIVE MANAGEMENT FOR 2015

This section describes the 2015 recommended channel management practices related to the BO requirements. Existing management practices for public safety, operator safety, operational responsibility, and other practices not related to meeting the BO objectives are not discussed here. These existing practices are documented in the Standard Operational Procedures: Russian River Mouth Opening (SCWA, 2002).

The outlet channel management described in this section is based on the performance criteria, conceptual model and technical analysis described in the preceding sections, as well as extensive discussion between the Agency, the resource management agencies, and ESA PWA. In addition, implementation efforts provided practical experience for adapting the plan. An account of the 2010 implementation is provided in Attachment E and an account of physical conditions is provided for 2011 (Attachment F), 2012 (Attachment G), 2013 (Attachment H), and 2014 (Attachment I). Some uncertainty remains about the exact outlet channel configuration that may best achieve the target performance criteria. This uncertainty arises from the dynamic natural setting for the outlet channel and from the unquantified tradeoffs between channel specifications which may benefit one performance criterion while impairing another criterion. For example, to reduce the likelihood of closure, it may be beneficial to locate the mouth of the channel further north where the coastline's aspect is more sheltered from waves from the north. However, extending the channel's length to the northern location may necessitate narrowing its width to keep excavation within currently-permitted volumes. A narrower channel increases the likelihood of scour-induced breaching. The relative importance of these factors is not known, precluding an exact determination of optimal channel configuration. In addition to these uncertainties, actual conditions at the time of closure, such as beach berm topography, may inform the selected configuration.

The assessment of the outlet channel conducted to date suggests two possible configuration options:

- a wide and short channel that seeks to minimize scour potential; or
- a narrow and long channel aligned to the north that seeks minimize closure potential.

The rationale supporting each of these configurations is described in more detail in Section 7.3 and Attachment D below. The configuration that is selected at the time of closure will be documented to the resource management team in accordance with the communication protocol described in Section 9. Performance of implemented configurations will be monitored and documented to test the conceptual model which guides management and to suggest adaptive changes to future management actions, including some combination of these two configurations.

The strategy for outlet channel management is an adaptive and incremental approach. This strategy favors smaller, more frequent modifications over larger, less frequent, modification with less certain outcome. Once experience is gained from implementing the channel and observing its response, it may be possible to make larger changes during each incremental modification. These larger changes will decrease the duration and frequency of management activity, thereby reducing the disturbance impact over time. Management practices will be incrementally modified over the course of the management period (May 15th to October 15th) in effort to improve performance in meeting the goals of the BO.

The approach may be constrained by an excavation volume limit of 2,000 yd^3 and antecedent beach berm topography prior to implementation. This approach will be implemented to the extent feasible while still staying within the constraints of existing land use permits.

To provide context for the proposed management plan, the first section below describes previous breaching practices for the inlet. Subsequent sections describe the target channel initiation, location, dimensions and supporting operations details. A hypothetical implementation scenario for the outlet channel, based on actual beach berm and ocean conditions observed at the estuary from June 30 to July 6, 2009, is provided in Attachment B.

7.1 PREVIOUS BREACHING PRACTICES

Breaching has historically been performed in accordance with the *Russian River Estuary Study 1992-1993* (PWA, 1993) in effort to minimize flooding of low lying shoreline properties in the Estuary. The beach berm was artificially breached by the Agency when the water surface elevation in the estuary is between 4.5 and 7.0 feet as read at the Jenner gage. Breaching was performed by creating a deep cut in the closed beach berm approximately 100 feet long by 25 feet wide and 6 feet deep by moving up to 1,000 yd^3 of sand. Based on experience and beach topography at the time of the breach, the planform alignment of the breach was selected to maximize the success of the breaches. Breaching activities were typically conducted on outgoing tides to maximize the elevation head difference between the estuary water surface and the ocean. After the last portion of the beach berm was removed, water would begin flowing out the channel at high velocities, scouring and enlarging the channel to widths of 50 to 100 feet. As the channel evolved and meandered, it reached lengths in excess of 400 ft. After breaching, the estuary would be subject to saline water inflow throughout incoming tides.

7.2 INITIATION OF EXCAVATION

Initial channel excavation will be performed when the outlet channel first closes following May 15th, the beginning of the management period. Closure is often preceded by a lengthening and narrowing of the outlet channel, muting of the estuary tide range, and/or an increase in mean tide level within the estuary. The Agency will monitor the estuary for these conditions and initiate planning for a management action when they are observed.

Throughout the management period, the Agency's permits with CSP and the California Coastal Commission dictate that management operations cannot occur on Friday, Saturday, Sunday or a holiday because these days coincide with high public use[7]. The incidental harassment authorization stipulates that management actions cannot occur for more than two consecutive days unless flooding

[7] Exceptions can be made in the event of emergency conditions. See Attachment C for more details.

is threatening. During the marine mammal pupping season (March 15th to June 30th), the initiation of Agency operations is further constrained. Outlet channel management activity must be delayed if a pup less than one week old is on the beach along site access pathways and there must be a week-long break between management actions. More details on timing restrictions are provided in Attachment C.

Should the outlet channel close in the weeks immediately preceding the management period, the Agency, in consultation with NMFS, CDFW, and CSP, may initiate excavation to increase the likelihood of entering the management period with the target channel configuration in place.

The constructed outlet channel may also close during the management season, such as following a large wave event. In such circumstances, it will be necessary to perform maintenance on the outlet channel, to re-connect the channel to the ocean before the lagoon water level rises too high above the new (higher) beach berm elevation.

7.3 CHANNEL LOCATION/PLANFORM ALIGNMENT

Two possible channel configurations within the extent of the existing alignment (Figure 1) may be pursued in 2015 since the location that may best achieve the performance criteria is not certain. Alternative channel alignments may be implemented to test the relationship of mouth location on channel stability.

7.3.1 Wide and short channel alignment

Preference for a wide and short outlet channel assumes that channel failure by scour-induced breaching (Section 4.3) is the controlling failure mode to avoid in selecting the channel's configuration. This assumption is based on the consequences of breaching, which returns the estuary to tidal habitat conditions that will persist until a large wave event occurs to renew the closure. Since these closure events are relatively infrequent during the management period (between 1999 and 2008, there were an average of 2.6 closures per management period), the next opportunity for creating freshwater habitat may be months away. In comparison, if the channel fails by closing, which may be more likely for the wide/short channel because of its mouth's location, another management action can be taken to re-open the outlet channel while preserving the freshwater condition of the lagoon. To reduce the possibility of scour-induced breaching, the hydraulic calculations and modeling in the channel configuration analysis indicates that the excavated channel should be as wide as possible. Under existing permits, the maximum width is 100 ft. The hydraulic modeling indicates that even a width of 100 ft is likely to scour; a narrower channel will further increase bed shear stress and the potential for scour. Once this width is selected, the channel length may need to be constrained to stay within the 2,000 yd^3 limit on excavation volume. The actual dimensions of the wide/short configuration will depend on the beach berm topography at the time of management action.

For a given lagoon water surface elevation, the wide/short configuration will have a higher average bed slope than the longer channel because of the channel's shorter length. The wide/short approach attempts to mitigate this by splitting the outlet channel into two reaches with varying steepness, as shown in Figure 2. Across the beach berm, a flat slope is recommended to reduce the contribution of bed slope to flow velocity, thereby minimizing the potential for scour. The entire drop in elevation between the lagoon water level and ocean water level is initially located at the end of the outlet channel, in the active transport zone. In the active transport zone, scour caused by the outlet channel flow accelerating down the beach face at low tides may be balanced by sediment deposition generated by wave action at high tide. As indicated by modeling (Section 6.2.3), it is likely to be difficult to avoid scour even in the portion of the channel with a flat bed because the lagoon water level will set up to create the water surface slope necessary to convey the discharge that maintains constant lagoon water levels. So even if the bed slope is zero, the total energy slope (the combination of bed slope and water surface slope) is likely to generate scouring flow.

Failure by breaching may not be the controlling mechanism if the actual flows conveyed in the outlet channel are less than anticipated or if the channel develops an armored layer of larger particles. As discussed in Section 6.2.2, direct observations of the flow that the outlet channel must convey are not available and have been inferred from upstream discharge observations and lagoon water levels during closure events. The anticipated outlet channel conveyance rates average 50 ft^3/s and range between 45-85 ft^3/s. If actual flow rates are less due to losses elsewhere (e.g. berm seepage), the outlet channel will be less likely to scour. For example, the sensitivity analysis scenario with reduced flow rates between 25-45 ft^3/s exhibited conditions less likely to scour (Section 6.3). Channel armoring is the process by which the smaller sand particles are eroded, leaving behind larger particles that have a higher critical shear stress for erosion. Because of the uniformity of particle sizes observed on the beach berm (EDS, 2009a), armoring is thought to be unlikely within the range of target elevations for the outlet channel. Larger particles have been observed in the channel, but only when its elevation is lower and within the tidal regime.

The wide/short approach will be to construct the channel in the same general location and alignment as the preexisting channel (i.e., the location just prior to closure). When pursuing this approach, excavation will simply widen and connect the channel in place. As the channel migrates during the management season, the location of new excavation may follow this migration.

7.3.2 Narrow and long channel alignment

The narrow/long approach to channel design assumes that wave-induced closure (Section 4.2) is the controlling failure mode to avoid in selecting the channel's configuration. By excavating a longer channel that stretches to the northwest, the channel's mouth can be situated in an area that may be exposed to less wave energy. Because of its aspect, the area to the north is more sheltered from waves originating from the north. When large waves originate from the south, the channel will be oriented perpendicular to the incident wave direction, which may enhance the channel's capacity to transport sand that is washed into the channel's mouth by waves (Attachment D). Observations of lateral mouth migration in both directions (Behrens et al. 2009) suggest that waves from both north and south directions play a role in mouth dynamics. Additionally, the narrow/long alignment provides flexibility to locate the channel mouth at a location with a flatter beach face slope, which may reduce net scour (Attachment D). The narrow/long approach is supported by observations of outlet channels that form at some other California river mouths (Attachment D). However, many of these other river mouths drain smaller watersheds that have lower flow rates into the lagoon, and therefore are less likely to breach. Also, these lagoons may not be constrained by the risk of flooding to adjacent property. Without a flood risk, lagoon water levels can rise higher and possibly drive more seepage through the beach berm rather than through the outlet channel. Finally, a longer channel will reduce the average bed slope, which is hypothesized to reduce scour. However, as discussed for the wide/short channel, it is the total energy slope (the combination of bed slope and water surface slope), which drives flow through the channel. Hydraulic analysis indicates that even if there is no slope to the outlet channel (i.e. it is flat), the water level in the lagoon will increase to create the water surface slope required to maintain the outlet channel's discharge. For the anticipated discharge, the corresponding bed shear stress is predicted to cause scour (Section 6.2.3).

The narrow/long approach will angle the channel to the northwest with an approximate aspect of 30-40 degrees with respect to the beach. This angled alignment tests possible advantages of site features such as areas of reduced wave energy and rocks imbedded in the beach.

7.4 TARGET CHANNEL DIMENSIONS

Prior to excavation the proposed outlet channel will be designed by Agency survey staff using computer-aided design (CAD) software. This design will then be used either to manually stake target channel dimensions or to automatically guide the excavation equipment via a GPS-based equipment controls. This operation protocol will ensure that the channel is excavated to the intended design.

7.4.1 Excavation Volume

The quantity of sand moved will depend on antecedent beach topography. To stay consistent with current permits, the excavated volume will not exceed 2,000 yd^3. Once either the wide/short or narrow/long planform alignment is selected, the limit on excavation volume will largely set channel dimensions. If a wide channel alignment is selected, the channel length will be limited so the total excavated volume remains below the limit. Similarly, if a long channel alignment is selected, the channel width will be limited so the total excavated volume remains below the limit. The actual dimensions at the time of implementation will depend on the beach berm topography at the time of implementation. Monthly surveys of the outlet channel, supplemented by spot checks at the time of management actions, will provide necessary information about beach berm topography.

Any sand excavated from the channel will be placed on the adjacent beach and graded to depths of approximately 1-2 ft higher than the existing grade. The placed sand will be distributed in such a way as to minimize changes to beach topography. If the time available for excavation is limited by uncontrollable factors such as tides, waves, seal use, or days when operations are forbidden, sand placed on the north side of the channel may be left in piles up to 3 ft high and not blended into the existing beach topography. The piles may need to remain un-graded on the north side because equipment access to this side is more difficult and may slow down operations. Once the outlet channel is in place, the north side is also less accessible, reducing the impact of any remaining sand piles on public use.

7.4.2 Bed Elevation

The bed will be excavated 0.5 to 1 foot below the lagoon water level along its entire length, to achieve target channel depths (discussed below) upon initiation of flow. Channel bed elevations are expected to be in the range of 3 to 7 ft NGVD, with corresponding lagoon water levels of 4 to 8 ft, using a typical flow depth of one foot. At the start of the management season, lagoon water levels and the channel bed may be on the lower of this elevation range, since the system will have recently transitioned from intertidal to closed and the beach berm may not yet have built up. As the management season progresses, sand is expected to move onto the beach berm, raising the viable bed elevation for the outlet channel. As the beach berm builds higher, it will support higher lagoon water levels while maintaining channel depth within the target range. The upper end of the bed elevation is governed by the flood stage elevation (9 ft NGVD) minus the anticipated water depth and a factor of safety to buffer against flooding. Frequent maintenance will likely be required early in the management season to maintain an open outlet channel as the beach berm elevation builds. Eventually, the outlet channel may be above the typical wave runup elevation, the elevation at which waves may induce channel closure, and close less frequently.

The bed elevation is a key determinant of lagoon water levels and influences the stability of the outlet channel. Higher bed elevations have the advantage of better meeting the BO's performance criteria of higher lagoon water levels. Higher lagoon water levels would increase seepage through the beach berm, potentially reducing conveyance requirements and the possibility of scour in the outlet channel. A higher outlet channel is also less likely to be closed by waves. On the other hand, lower bed elevations reduce the potential energy which may cause outlet channel scour, provide a greater buffer before flood stage, and may reduce the release of oxygen-depleting organic matter from inundated upstream marshes. Developing a better feel the optimal bed elevation is one objective of the adaptive management plan.

The Phase 1 performance criteria are to develop an outlet channel that supports a stable, perched lagoon with water surface elevations at approximately 7 ft NGVD for several months (Section 3.1). Stable conditions imply that river inflow into the lagoon would be approximately the same as the sum of outflow through the outlet channel and seepage through the beach berm. Stable conditions also imply that net sand deposition or erosion does not impair the outlet channel's function. However, this goal may not be achievable in 2015 because additional constraints in place during this year call for modified performance criteria.

The bed slope should be nearly flat within the outlet channel to minimize the likelihood of scouring the bed. This may be difficult to maintain. In particular, incision within the "flat" channel bottom may occur.

7.4.3 Depth

The target range of water depths, 0.5-2 ft, is constrained on the upper end by the maximum depth at which the channel is likely to be stable (not scour). Larger depths would be associated with a narrower channel. The lower end of the range is constrained by the width; shallower depths would require impractically large channel widths to provide sufficient cross-sectional area to convey flow. Shallower water depths represent a greater factor of safety with regard to preventing bed scour since bed friction retards flow speed more strongly for shallower depths. Prior to implementation the predicted rate of water elevation rise within the estuary will need to be considered to determine the bed elevation to achieve the flow depths desired at the completion of the channel excavation.

7.4.4 Width

The width of the channel is estimated to vary within 25-100 ft for consistency with the existing management permits. For the wide/short configuration, the channel bottom would be excavated to a width of 100 ft, the permitted maximum, to reduce the potential for scour. For the narrow/long configuration, the channel bottom width will be approximately 30 ft to achieve the desired channel length and slope while still staying within the 2,000 yd^3 excavation volume limit.

7.4.5 Length

The channel length is estimated to vary within 100-800 ft, consistent with historic channel lengths observed within the management period (Behrens, 2008). Length will be a function of the channel's planform alignment while also balancing with other channel dimensions in order to keep excavation volumes less than 2,000 yd^3. The wide/short configuration would result in channel lengths between 100-400 ft while the narrow/long configuration would result in channel lengths approaching the maximum of 800 ft.

7.5 EXCAVATION TIMING RELATIVE TO THE TIDAL CYCLE

Under the proposed management plan, channel modifications will be initiated during low tide so that after several hours of work, the channel will be completed near high tide. As per existing practices, a temporary barrier will be left between the ocean and lagoon during excavation. When the last material is excavated, then the temporary barrier will be removed at or near high tide. This will minimize the difference in water levels between the estuary and ocean, reducing the potential for the re-connected channel to scour into a fully tidal inlet.

7.6 EXCAVATION FREQUENCY

Creating and maintaining the outlet channel will probably employ one or two pieces of heavy machinery (e.g. excavator or bulldozer) to move sand on the beach. At the start of the management period (late spring or early summer), when configuring the outlet channel for the first time that year, conditions may require operating machinery for up to two consecutive days (as allowed under the marine mammal incidental harassment permit). The precise number of excavations would depend on uncontrollable variables such as seasonal ocean wave conditions (e.g. wave heights and lengths), river inflows, and the success of previous excavations (e.g. the success of selected channel widths and meander patterns) in forming an outlet channel that effectively maintains lagoon water surface elevations. As technical staff and maintenance crews gain more experience with implementing the outlet channel and observing its response, maintenance during the remainder of the management season is anticipated to be less frequent.

In consideration of the natural beach environment and public access, effort will be made to minimize the amount and frequency of mechanical intervention. Outlet channel management activities cannot last for more than two consecutive days. During the marine mammal pupping season (March 15th to June 30th), the duration and frequency of Agency operations is constrained by restrictions on incidental harassment. Seven days must pass between management events. More details on duration and frequency restrictions are provided in Attachment C.

7.7 UNCERTAINTY AND LIMITATIONS

The proposed operations are based on the analyses documented in this report, input from resource agency staff, and on our professional judgment. Uncertainties about the actual estuary inflow, berm seepage, and outlet channel performance remain. As described in Section 6.2.2, the two methods for estimating estuary inflow, the water balance model and limited discharge measurements, predict disparate estuary inflows. Estuary inflow will fluctuate over the management period and may be greater than the modeled inflow. The seepage through the beach berm is based only on inferred, not observed, estimates of hydraulic conductivity. The outlet channel, particularly its downstream end, will be located in a highly dynamic environment that is influenced by changing river flow, tidal water levels and waves. Since the outlet channel will not include any hard structures, all of these sources of hydrologic forces can readily alter the channel's configuration, which may make it difficult to achieve and maintain the channel's successful function. Modifications of the proposed plan in response to actual conditions will be discussed with the resource agency management team and documented according to the communication protocol described in Section 9. Any modifications will be consistent with existing permit requirements.

Adaptive management once the channel is implemented will further enhance management practice. Actual feasibility with regards to the full range of dynamic conditions has not been determined. Risks associated with outlet channel failure have not been quantified. In addition to the channel's performance criteria, there are also water quality and ecological performance criteria for the perched lagoon. These additional criteria have not been evaluated as part of the outlet channel management plan.

8. MONITORING AND ADAPTIVE MANAGEMENT

Monitoring of the outlet channel should be implemented to facilitate an understanding of the channel's behavior and guide adaptive changes to this initial management plan. Adaptive management changes may be made over the course of the management season, in response to natural processes, outlet channel conditions, and/or outlet channel response. In addition, a more comprehensive review at the end of the management season will employ the monitoring data to recommend management revisions for the following year.

Because relatively few closure events occur per year and each one experiences different river and ocean conditions, a comprehensive monitoring plan is recommended to support adaptive management. The monitoring would quantify changes in the beach and channel elevation, lengths, and widths, as well as flow velocities and observations of the bed structure (to identify bed forms and depth-dependent grain size distribution indicative of armoring) in the channel. If feasible, the required monthly beach topography surveys should be scheduled just in advance of potential closure situations (neap tides, low discharge, and/or large wave events). Staff safety, staff availability, pinniped constraints, and/or rapidly changing physical conditions may preclude optimal scheduling of beach topographic surveys. Because monitoring requires human presence on beach, potentially disturbing the seal population, the monitoring frequency represents a balance between management of the outlet channel and minimizing disruption of wildlife.

A list of recommended monitoring tasks for 2015 is provided below in Table 5.

Table 5 Monitoring tasks associated with outlet channel management

Task	Description	Field Activities	Frequency
Recommended			
Operations log	Record of outlet channel management actions and ambient conditions.	Operations staff to generate written record of operations (excavation method, extent, and location) and ambient conditions (weather, ocean state, estuary water level)	Daily to monthly (Depends on operational activity)
Outlet channel location and state	An automated video or still camera station to capture the outlet channel's location and state.	Field staff to install and service a camera, power supply, and possibly communication system on hillside adjacent to estuary.	Hourly imaging (automated); Weekly servicing
Outlet channel discharge measurements	Collected within the outlet channel to verify the channel's conveyance.	Field staff to complete cross sectional flow velocity surveys using flow meter attached to a wading rod with electronic data logger.	Monthly
Outlet channel bed structure	Observe the bed for bed forms and depth-dependent grain size distribution indicative of armoring. Sediment sampler used.	Field staff to collect sediment sample from the surface of the channel bed.	Monthly
Outlet channel topography	Collect outlet channel elevation and width	Field staff to survey outlet channel features using a total station and prism mounted on a survey rod.	Monthly
Beach topography	Collect beach elevation	Field staff operating rod and staff on beach.	Monthly
Estuary flow dynamics	Integrate cross sectional velocity data in estuary at various locations from mouth to Duncans Mills.	A boat with field staff, collecting cross sectional data from mouth to Duncans Mills.	Weekly

9. COMMUNICATION PROTOCOL

A communication protocol will provide guidance between the Agency and identified points of contact representing key resource management groups in the estuary for the implementation of the Outlet Channel Management Plan during the management period (May 15 – October 15). Primary and alternative points of contact have been identified for each of the key resource management groups. These parties, which together are hereafter referred to as the “Team”, include: Sonoma County Water Agency, NOAA National Marine Fisheries Service, California Department of Fish and Wildlife, and California State Parks. A list of contacts for these groups is shown in Table 6.

Table 6 Russian River Estuary Management Team

Contact	Level	Organization	Phone Number	E-mail
Jessica Martini Lamb	Primary	Sonoma County Water Agency	707-547-1903 (w) 707-322-8177 (m)	jessica.martini.lamb@scwa.ca.gov
Chris Delaney	Secondary	Sonoma County Water Agency	707-547-1946 (w) 707-975-5606 (m)	cdelaney@scwa.ca.gov
Gary Tourady	Primary	Agency Operator Sonoma County Water Agency	707-547-1065 (w) 707-975-6285 (m)	garywt@scwa.ca.gov
Jon Niehaus	Secondary	Agency Operator Sonoma County Water Agency	707-521-1845 (w) 707-975-3999 (m)	jon@scwa.ca.gov
Robert Coey	Primary	National Marine Fisheries Service	707-575-6090 (w)	Bob.Coey@noaa.gov
John McKeon	Secondary	National Marine Fisheries Service	707-575-6069 (w)	john.mckeon@noaa.gov
Rick Rogers	Secondary	National Marine Fisheries Service	707-578-8552 (w)	rick.rogers@noaa.gov
Tim Dodson	Primary	CA Dept. of Fish and Wildlife	707-944-5513 (w)	timothy.dodson@wildlife.ca.gov
Eric Larson	Secondary	CA Dept. of Fish and Wildlife	707-944-5528 (w)	eric.larson@wildlife.ca.gov
Brendan O'Neil	Primary	California State Parks	707-865-3129 (w)	BONEIL@parks.ca.gov
Damien Jones	Secondary	California State Parks	707-875-3907 (w)	dajone@parks.ca.gov

9.1 IMPLEMENTATION OF OUTLET CHANNEL MANAGEMENT ACTIVITIES

A minimum of 24 hours of notice shall be provided to the Team by the Agency in advance of the excavation and maintenance of the outlet channel. Notice shall be submitted by e-mail (see Attachment B.1 for sample) with a general description of the proposed action to be pursued and will typically include:

- Proposed date and time of implementation;
- Design schematic of proposed channel which shall include:
    - Approximate antecedent beach berm height and width;
    - Proposed location and alignment of outlet channel;
    - Approximate outlet channel dimensions including bed elevation, channel depth, width, length, slope and aspect with respect to beach face
    - Predicted estuary water surface elevation at the time of implementation;
- Current river discharge at USGS Guerneville gage (website: http://waterdata.usgs.gov/nwis/uv?cb_00060=on&cb_00065=on&format=gif_stats&period=21&site_no=11467000)
- Predicted 24 hour precipitation as estimated by the NOAA National Weather Service for Bodega Bay (website: http://forecast.weather.gov/MapClick.php?CityName=Bodega+Bay&state=CA&site=MTR&textField1=38.3333&textField2=-123.047&e=0&FcstType=graphical;
- Predicted deep water swell height, period, and direction at San Francisco as estimated by CDIP (website: http://cdip.ucsd.edu/?nav=recent&sub=forecast&units=metric&tz=UTC&pub=public)
- For maintenance actions a general description of maintenance to be performed;
- Presence of seal pups; and
- Equipment to be used for implementation.

Team members shall provide any comments or suggestions to the approach in writing within 12 hours of the proposed implementation time. If Agency does not receive any comments before this time it is assumed that there are no comments to the proposed action. Comments and recommendations will be recorded for consideration on that management action or future management actions, and the Agency will do its best to respond to comments prior to implementation.

9.2 COMPLETION OF OUTLET CHANNEL MANAGEMENT ACTIVITIES

Within 36 hours of completion of outlet channel excavation or maintenance activities the Agency shall provide the Team a summary of work performed. This summary will be submitted by e-mail and will typically include:

- Date, time and period of implementation;
- Estuary water surface elevation at the time of completion;
- River discharge at USGS Guerneville gage at time of completion
- Deep water swell at CDIP Pt. Reyes buoy at time of completion

- Approximate location of the centerline of the channel mouth in distance along beach berm north of the jetty;
- Approximate orientation of channel along the beach berm;
- Approximate dimensions and orientation of the excavated channel;
- Approximate water depth in the excavated channel;
- For maintenance actions, a general description of maintenance performed;
- Equipment used during implementation;
- Presence of seal pups; and
- Photos documenting work completed.

9.3 OVERRIDING CONDITIONS

Certain conditions such as declines in water quality or imminent flooding to properties and structures in the estuary could drastically change the course of management outlined in this plan and may force the Agency to breach the estuary. The Agency shall stay in close contact with the Team on the development of any conditions which could affect the overall course of management. However, rapidly changing conditions may limit the notification lead time given to the Team in advance of management actions to alleviate flooding or water quality concerns.

9.3.1 Flooding

Based on past management experience in the estuary, the Agency has found that if the estuary is in a closed condition, medium to large storm events can produce very rapid rises in estuary water levels. These storm events are frequently accompanied by large ocean swells which can close the estuary if outflows through the channel are not high enough to counteract the wave forces produced from the large swells. Management to avoid flooding is complicated by safety concerns; the Agency is unable to operate equipment required for channel management activities if ocean swells are too large. In the past the Agency has typically breached the estuary in anticipation of a large storm in order to prevent flooding.

The high water surface elevations pursued under this plan will diminish the storage capacity of the estuary to handle high inflows. Also, based on past management experience, the Agency believes that the outlet channel as described in this plan will be especially susceptible to closure from large swell events. In an effort to avoid flooding of properties in the estuary during the outlet channel management period, the Agency will consult with the Team regarding the possibility of breaching the estuary in anticipation of a large storm event.

9.3.2 Decline in Water Quality

Declines in water quality could have impacts to salmonids rearing in the estuary, other species which reside in the estuary and the public. Potential water quality concerns include, but are not limited to:

- Dissolved oxygen conditions becoming dangerously low to fish and other species;
- Elevated salinity levels in domestic water wells; and
- Elevated bacterial levels.

The Agency will stay in contact with the Team regarding water quality conditions during the management period. Should conditions get to the point that they are potentially dangerous to salmonids, other species, or the public, the Agency shall consult with the Team on potentially changing the course of management. In cases of high bacterial levels, the Agency will additionally consult with North Coast Regional Water Quality Control Board and the Sonoma County Department of Public Health on potential management actions.

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11. LIST OF PREPARERS

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John Largier
Dane Behrens (2009-2012)

12. FIGURES

Source: Sonoma County Orthophotography (April-May, 2000)

figure 1

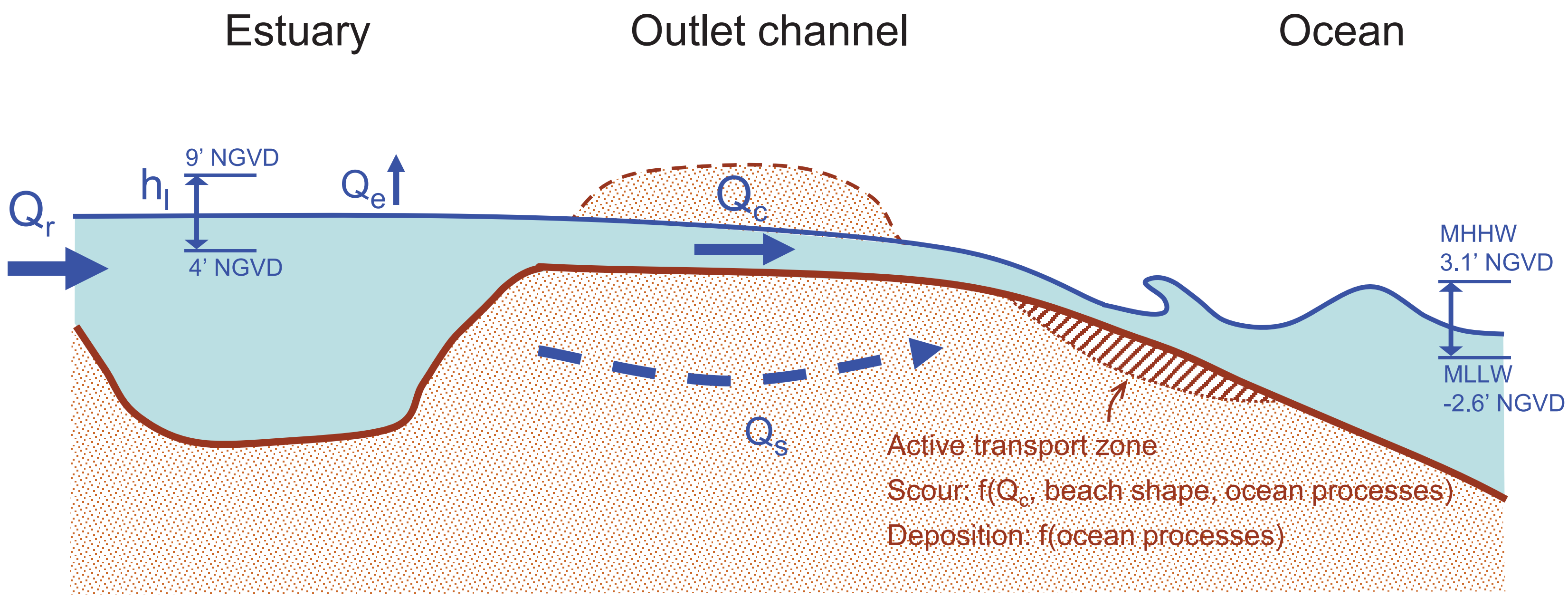
Russian River Estuary Outlet Channel Management Plan

Russian River Estuary Site Location

PWA Ref# - 1958.02

PWA

G:\1958.01_Russian_River\Projects



Parameters

h_l=lagoon water level
Q_r=river discharge
Q_c=outlet channel discharge
Q_s=seepage discharge
Q_e=evaporation from lagoon

Processes

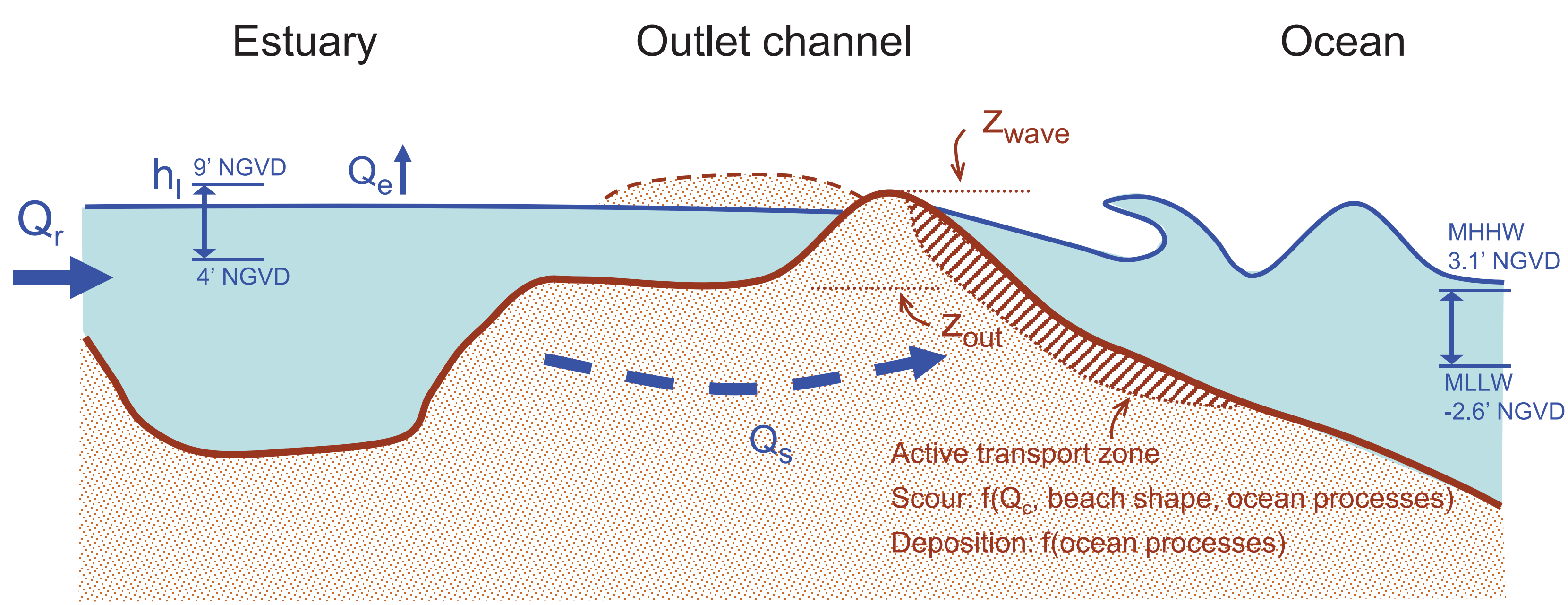
- $Q_r = Q_c + Q_e + Q_s$ (averaged over days)
- No sediment transport within outlet channel
- Active sediment transport outside outlet channel

figure **2**
Russian River Estuary Outlet Channel Management Plan

Conceptual model – Target conditions

PWA Ref# 1958.01

PWA



<u>Parameters</u>

z_{out}=target channel bed elevation

z_{wave}=wave runup elevation; f(wave conditions, ocean water level, channel location)

<u>Processes</u>

- $z_{wave} \geq z_{out}$
- wave-induced sediment transport closes outlet channel
- $Q_c \rightarrow 0$
- h_l increasing

figure **3**

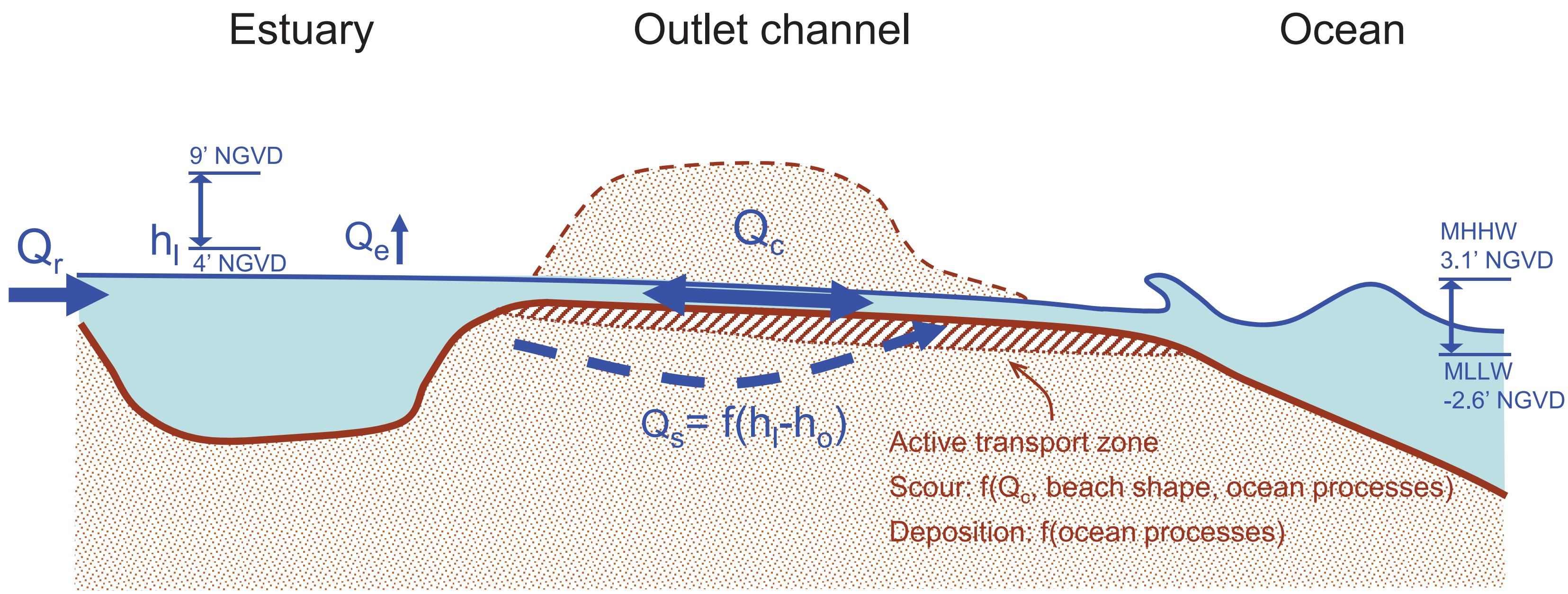
Russian River Estuary Outlet Channel Management Plan

Conceptual model – Closure

PWA Ref# 1958.01

PWA

K:\projects\1958.01RREAMPOutletChannel\Task 8 Year 1 eval & 2011 plan\2011 Mmgt Plan\Draft 2\figs\Figure 2-4 Conceptual model v2.doc



Parameters

u_c= f(channel slope, length, and width; Q_r; ocean water level)
(can be managed to greater or lesser degree)

u_{crit} is f(grain size)

Processes

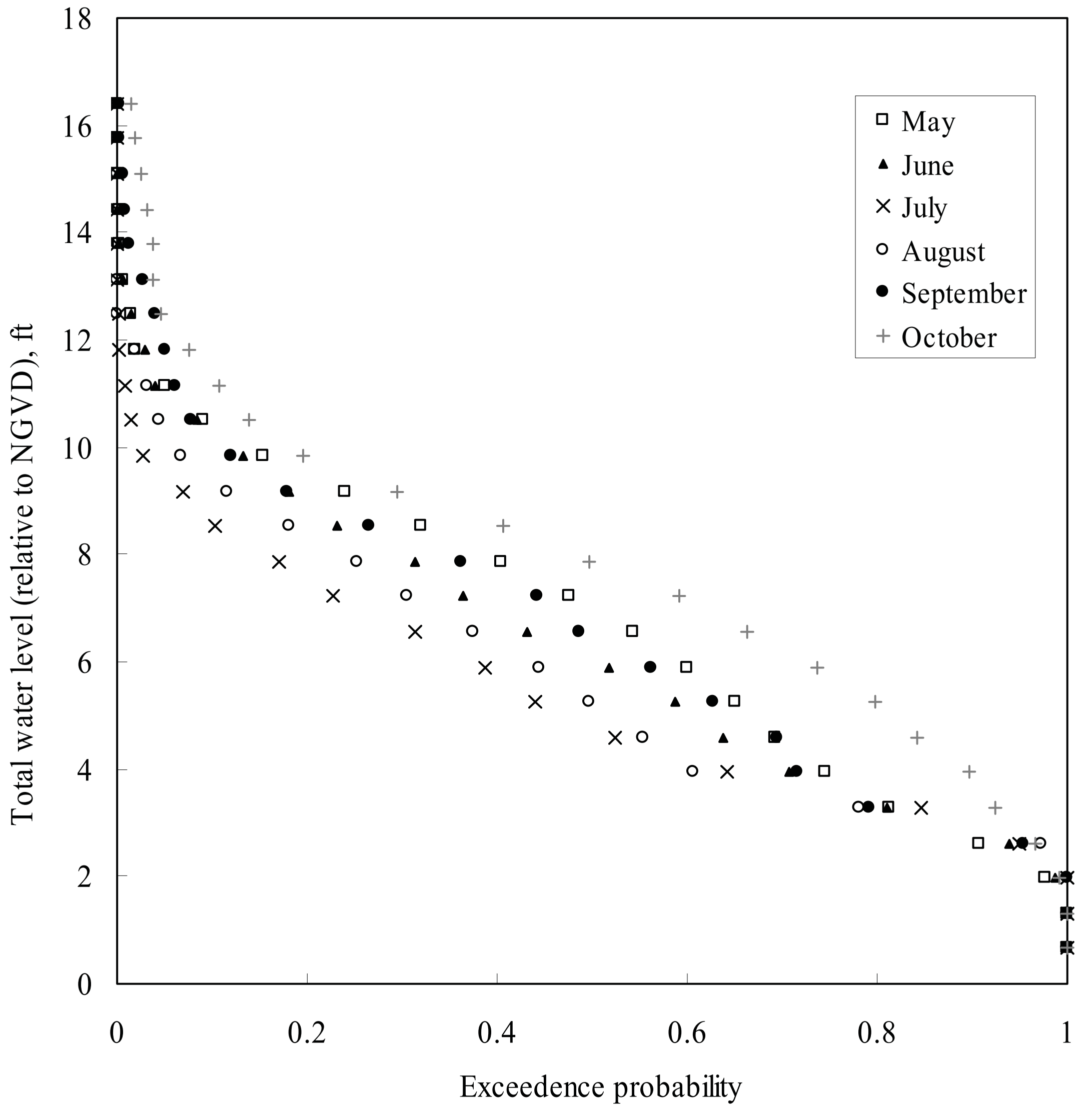
- $u_c > u_{crit}$; high velocities scour channel
- Q_s increases; high seepage creates groundwater piping and erosion
- sediment transport within outlet channel

figure **4**

Russian River Estuary Outlet Channel Management Plan

Conceptual model – Breaching

PWA Ref# 1958.01

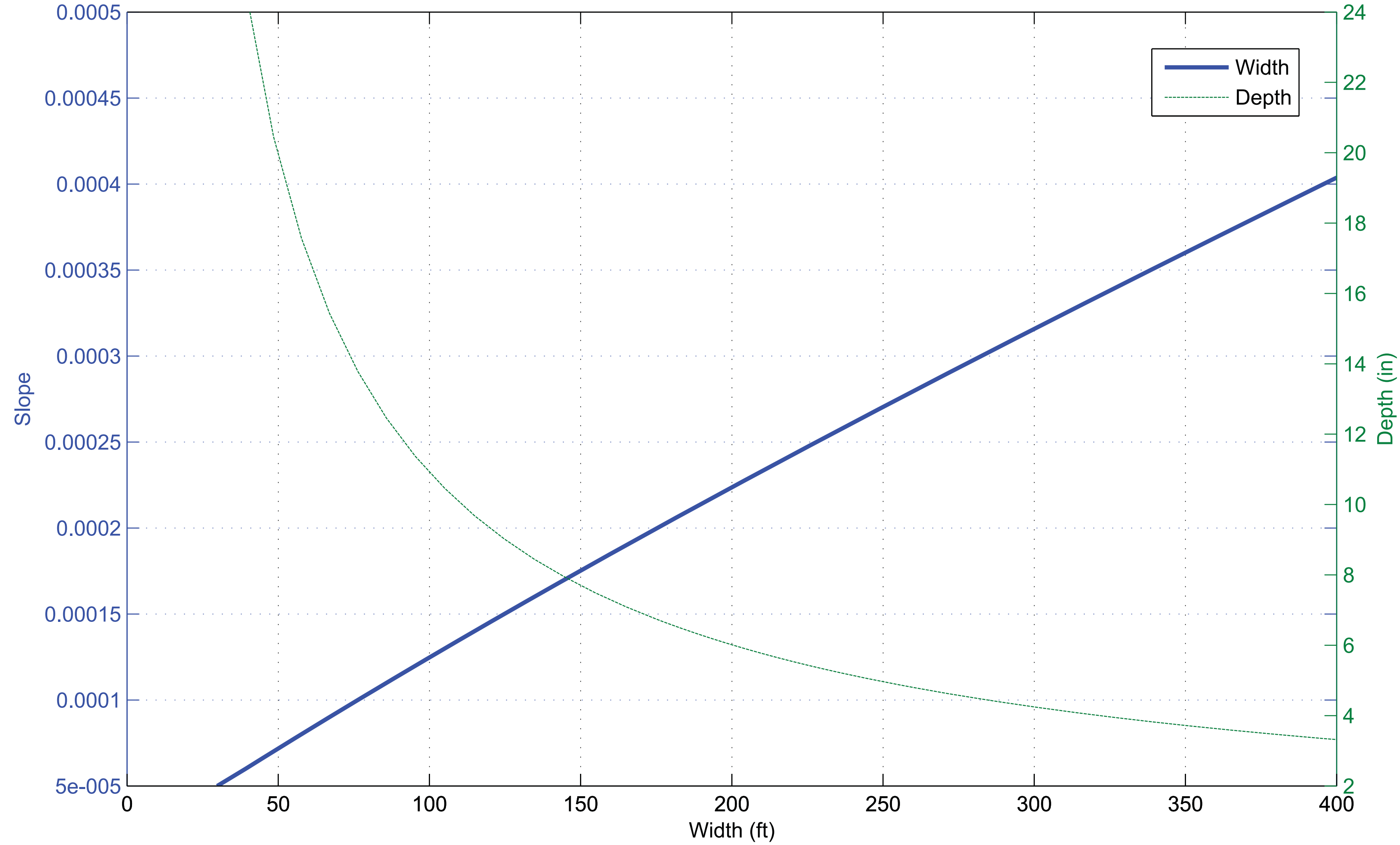


Source: D. Behrens (unpublished). Wave data from CDIP Point Reyes buoy.
Note: Total water level calculated as sum of daily higher high tide and wave runup elevation. Wave runup calculated from Stockdon et al (2006) using estimated de-shoaled deepwater equivalent wave heights.

figure **5**
Russian River Outlet Channel Management Plan

Total Water Level Exceedance, May-Oct

PWA Ref# 1958.01



Source: Stability curve for local bed shear stress of 0.5 Pa, flowrate of 70 cfs, and Manning's roughness of 0.02.

Figure 6

Russian River Estuary Outlet Channel Management Plan

Slope vs. Width Stability Plot

PWA Ref# 1958.01

PWA

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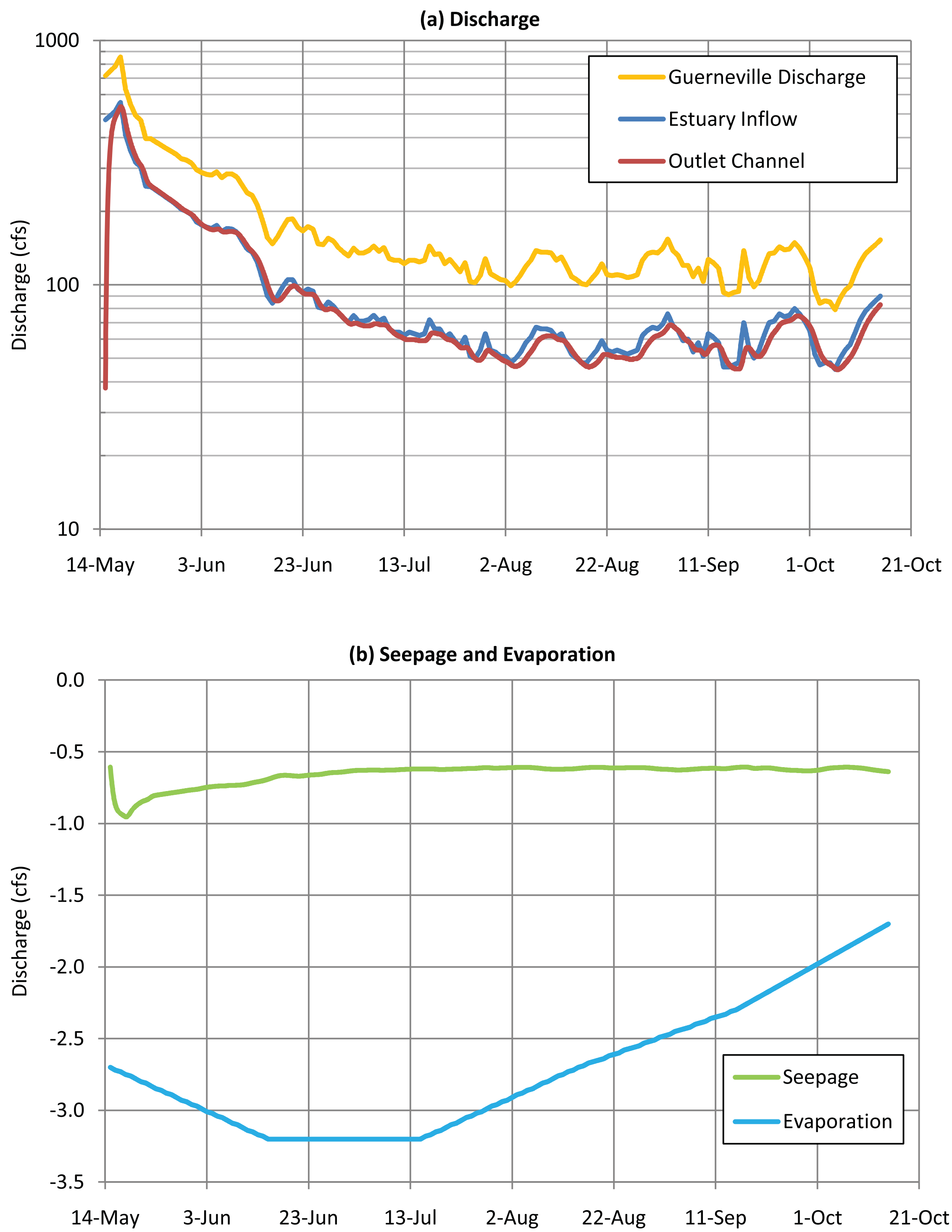


Source: 2010 anticipated discharge at Guerneville and into lagoon calculated by scaling observed 2000 discharge at USGS gage #11467000 (Russian River near Guerneville, CA). Evaporation rates calculated from monthly climatological rates for CIMIS evapotranspiration zone 1 (California coast).

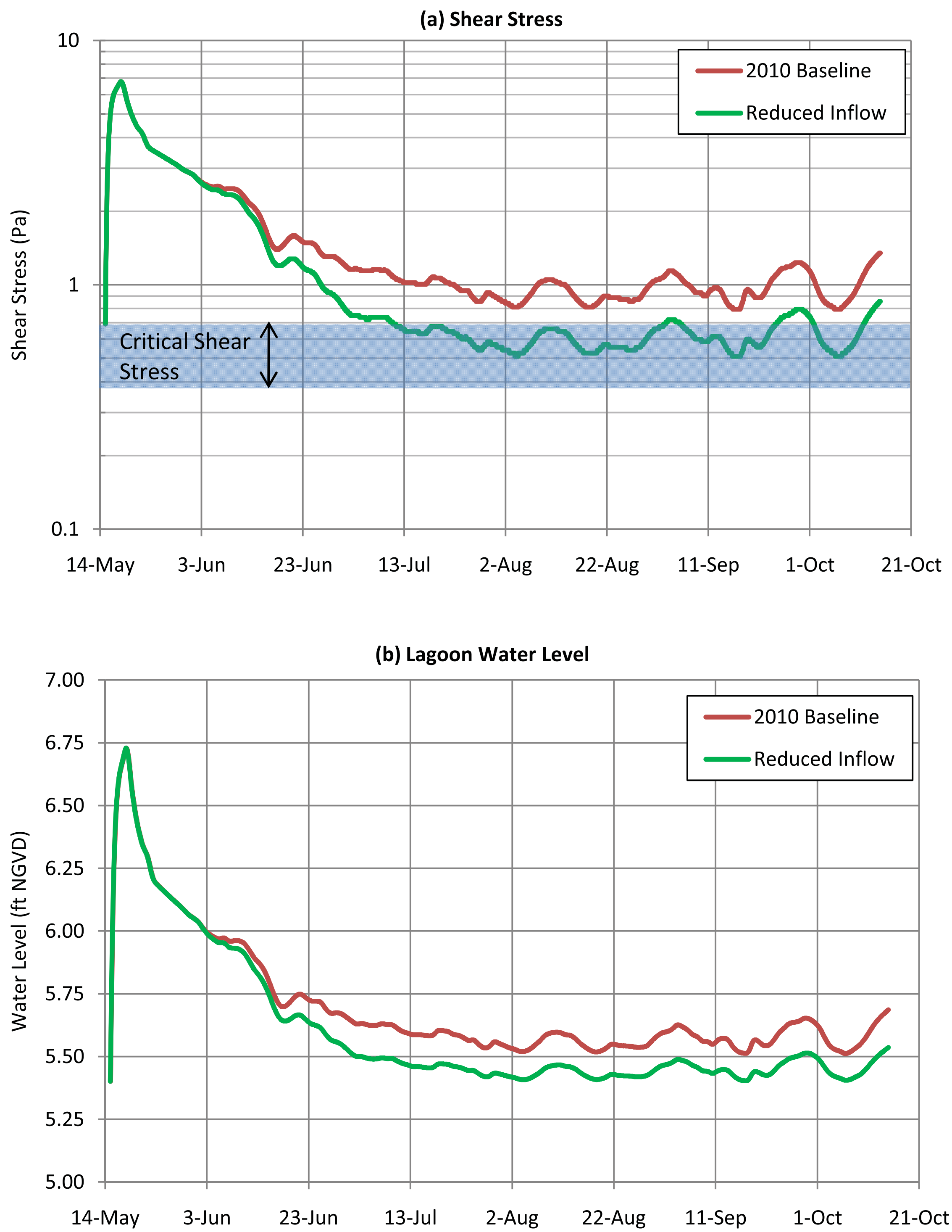
figure **7**

Russian River Estuary Outlet Channel Management Plan

Hydraulic Model Discharge - 2010 Anticipated Hydrology

PWA Ref#: 1958.01

PWA



Notes: Baseline channel geometry: width=100 ft, length=300 ft, bed=5 ft NGVD, n = 0.02.
Source: HEC-RAS hydraulic model results for outlet channel.

figure **8**

Russian River Estuary Outlet Channel Management Plan

Hydraulic Model Results - 2010 Anticipated Hydrology

PWA Ref#: 1958.01

PWA

1958.01_2010_Rev_Anticipated_Operations.xls

ATTACHMENT A: SUPPORTING WORKSHEETS FOR CHANNEL CONFIGURATION ANALYSIS

Worksheets

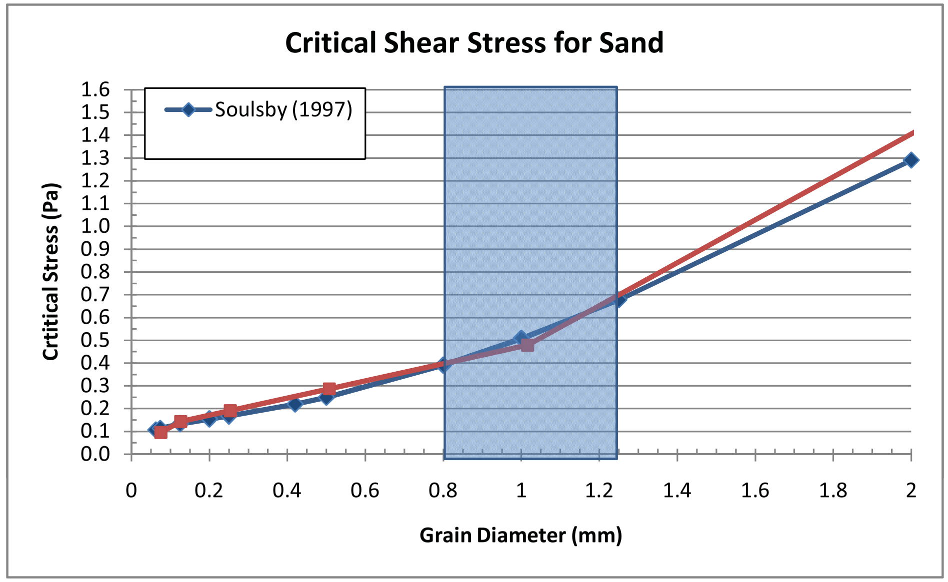
A-1. Critical shear stress for incipient motion of sane particles
A-2. Manning's n
A-3. Evaporation
A-4. Berm seepage
A-5. Mouth closure
A-6. Russian River discharge

A-1. Critical shear stress for incipient motion of sand particles

1958.01 Russian River Estuary Outlet Channel
J. Vandever (PWA)
4/1/2009

Variables		
p	1000	kg/m^3
g	9.81	m/s^2
s	2.65	(quartz)
v	1.0E-06	m^2/s

D (mm)	D*	Theta_crit	tau_crit (Pa)	Grain Size
0.0625	1.58	0.105	0.11	Very Fine Sand
0.074	1.87	0.094	0.11	
0.125	3.16	0.066	0.13	Fine Sand
0.20	5.06	0.048	0.15	
0.25	6.32	0.041	0.17	Medium Sand
0.42	10.62	0.032	0.22	
0.5	12.65	0.031	0.25	Coarse Sand
0.8	20.24	0.030	0.39	
1.0	25.30	0.031	0.51	Very Coarse Sand
1.25	31.62	0.033	0.68	
2.0	50.59	0.040	1.29	Granular



Notes: units Pa = N/m^2, assumes density of freshwater, quartz grained sand
Method based on Soulsby (1997) Dynamics of Marine Sand:

Note: does not account for gravitational effects on sloping bed

$$D_* = \left[\frac{g(s-1)}{\nu^2}\right]^{1/3} D$$

$$\theta_c = \frac{0.3}{1+1.2D_*} + 0.055\left[1-\exp\left(-0.020D_*\right)\right]$$

$$\tau_c = \rho(s-1)gd\theta_c$$

A-2. Manning's n worksheet

1958.01 Russian River Estuary Outlet Channel
J. Vandever (PWA)
4/1/2009

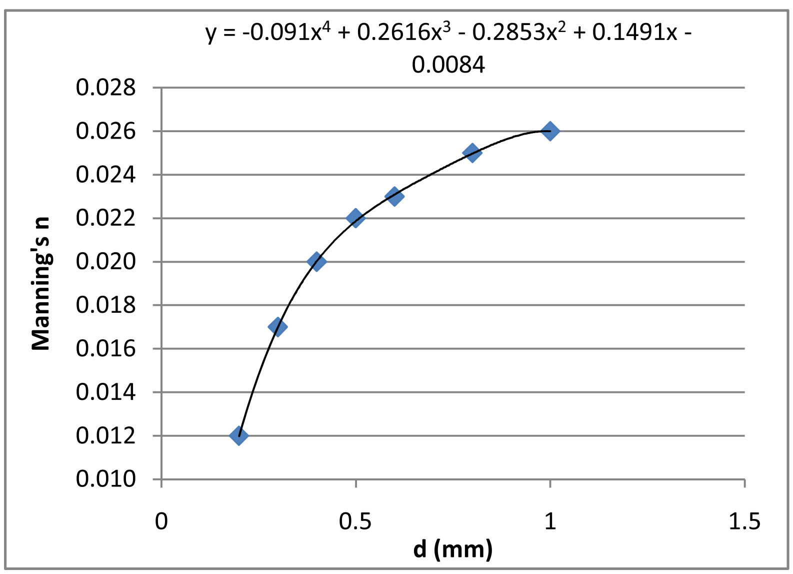
d_{50}	1	mm	0.003281 ft
D	0.84	ft	
Rh	0.83	ft	
S	0.00008	ft/ft	

Equation	n	Notes
Strickler (1923)*	0.018	*valid d range unknown
Limerinos (1970)*	0.021	
Bray (1979)*	0.017	
Bruschin (1985)*	0.018	
Julien (2002)*	0.024	
USGS (WSP2339)	0.026	for 0.2<d<1.0 mm
Average	**0.021**	
Average w/o USGS	**0.020**	

USGS

d (mm)	n
0.2	0.012
0.3	0.017
0.4	0.020
0.5	0.022
0.6	0.023
0.8	0.025
1.0	0.026
2.0	0.035

Polynomial fit to USGS data (d=2.0 mm not included):



A-3. Evaporation Worksheet

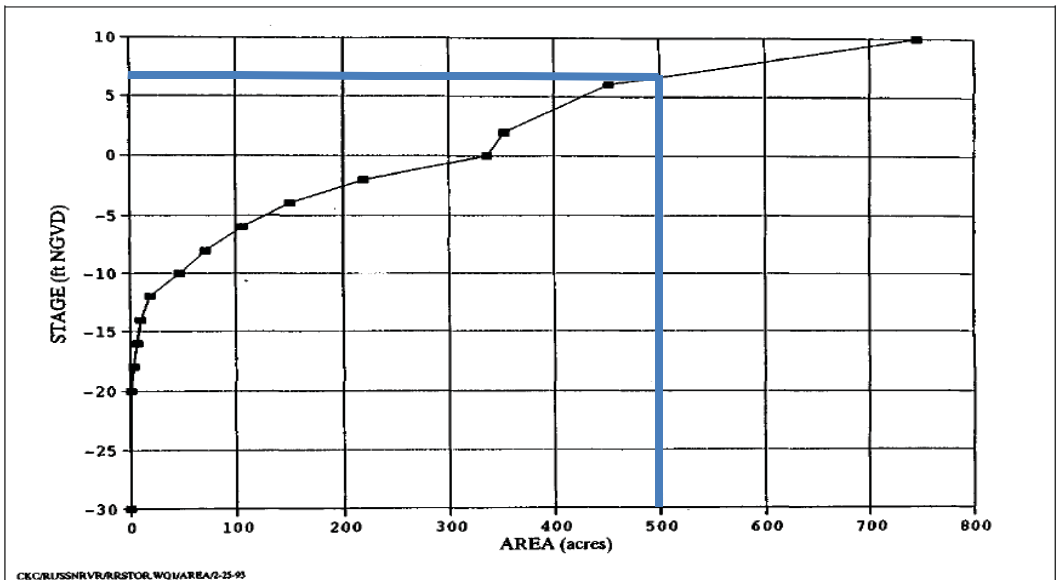
1958.01 Russian River Estuary Outlet Canal
J. Vandever (PWA)
15-Apr-09

CIMIS Reference Evapotranspiration (Eto) Zones
http://www.cimis.water.ca.gov/cimis/images/etomap.jpg

Russian River Estuary is located on California coast in Zone 1
(Coastal plains and heavy fog. Lowest Eto in California, characterized by dense fog)

	in/month	days	in/day	mm/day	cfs
Jan	0.93	31	0.03	0.76	0.6
Feb	1.40	28	0.05	1.27	1.1
Mar	2.48	31	0.08	2.03	1.7
Apr	3.30	30	0.11	2.79	2.3
May	4.03	31	0.13	3.30	2.7
Jun	4.50	30	0.15	3.81	3.2
Jul	4.65	31	0.15	3.81	3.2
Aug	4.03	31	0.13	3.30	2.7
Sep	3.30	30	0.11	2.79	2.3
Oct	2.48	31	0.08	2.03	1.7
Nov	1.20	30	0.04	1.02	0.8
Dec	0.62	31	0.02	0.51	0.4

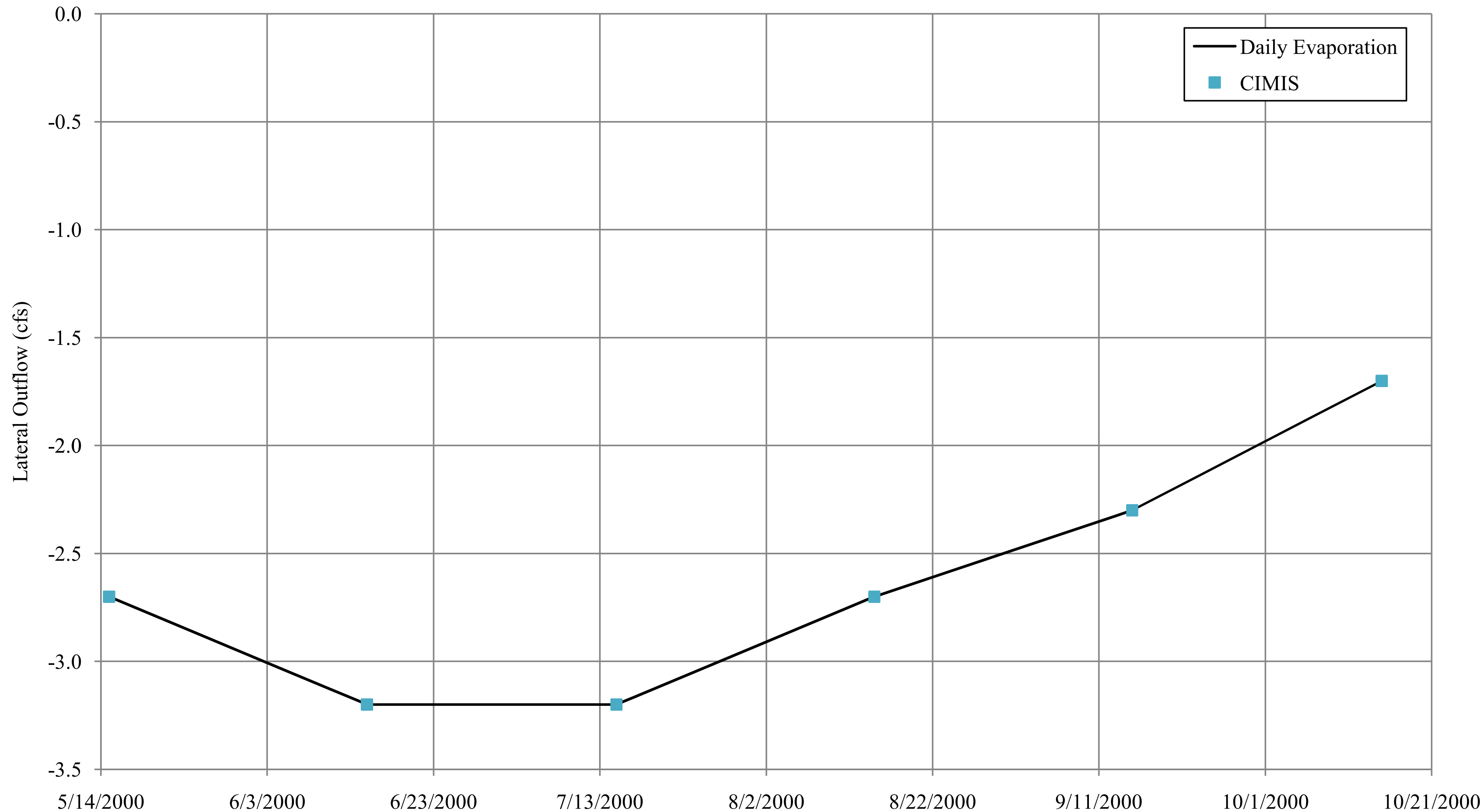
RRE Surface Area	500	acres
	21,780,000	sq ft



Philip Williams & Associates, Ltd.
Consultants in Hydrology

Stage-Area Curve for Russian River Estuary - River Mouth to Monte Rio

Figure 5.6



Notes: Daily evaporation rates for Russian River lagoon interpolated from CIMIS average monthly evapotranspiration statistics for Zone 1 (Coastal plains and heavy fog). Calculations assume lagoon surface area of 500 acres.

Appendix ***A-3***

Russian River Estuary Outlet Channel Management Plan

HEC-RAS model evaporation boundary condition

PWA Ref #: 1958.01

PWA

J:\1958.01RREAMPOutletChannel\Task 5 Hydrologic modeling\Data\Evaporation\1958.01_RRE_Evaporation_Worksheet.xls

A-4. Berm Seepage and Hydraulic Conductivity

1958.01 Russian River Estuary Outlet Canal
J. Vandever (PWA)
16-Apr-09

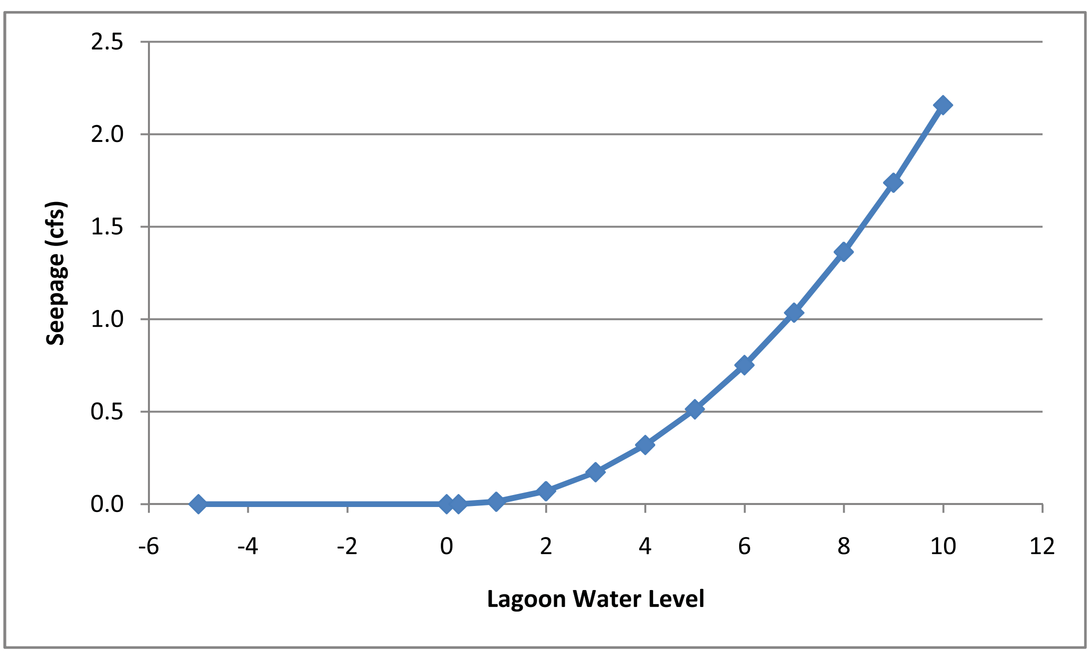
HEC-RAS Diversion Rating Curve

Lagoon WL (ft)	dh (ft)	q (cfs)	
-5	0	0.00	
0	0	0.00	
0.24	0	0.00	(MTL)
1	0.76	0.01	
2	1.76	0.07	
3	2.76	0.17	
4	3.76	0.32	
5	4.76	0.51	
6	5.76	0.75	
7	6.76	1.03	
8	7.76	1.36	
9	8.76	1.74	
10	9.76	2.16	(Flood Stage)
11	10.76	2.62	
12	11.76	3.13	

Darcy's Law

$$q = k\frac{\Delta h}{W}A = k\frac{\Delta h}{W}(\Delta h \cdot L)$$

W	250	ft
L	2500	ft
z_ocean	0.24	ft NGVD (MTL)
k	0.0023	ft/s



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A-4. Berm Seepage and Hydraulic Conductivity

1958.01 Russian River Estuary Outlet Canal
J. Vandever (PWA)
7-Apr-09

Bouwer, H. 1978. Groundwater Hydrology. McGraw-Hill, Inc. 480 p.

	Hydraulic Conductivity (m/day)		Hydraulic Conductivity (cm/s)		
	Low	High	Low	High	Mid
Fine Sand	1	5	0.001	0.006	0.003
Medium Sand	5	20	0.006	0.023	0.014
Coarse Sand	20	100	0.023	0.116	0.069
Gravel	100	1000	0.116	1.157	0.637
Sand and Gravel	5	100	0.006	0.116	0.061

A-5. Mouth Closure Calibration Worksheet

1958.01 Russian River Estuary Outlet Canal
J. Vandever (PWA)
17-Apr-09

Russian River mouth closure calibrations - HEC-RAS model Years Examined: 2000, 2001, 2003, 2004, 2005, 2007

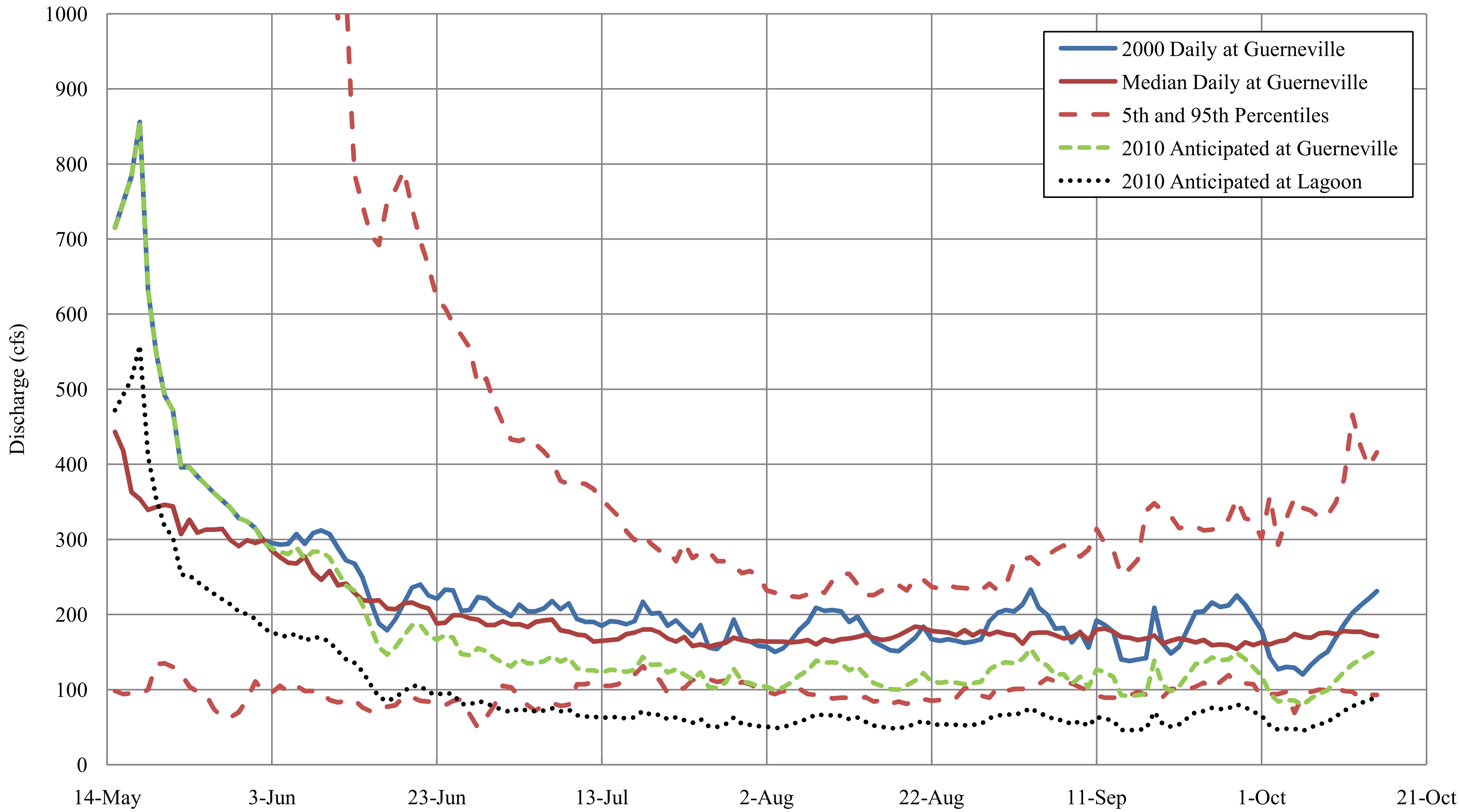
Accounts for losses between Hacienda Bridge (Guerneville, CA) and the lagoon and the interaction with the aquifer adjacent to the estuary.
No detailed information available for the aquifer groundwater elevations or extraction rates by wells. The loss term is a calibrated variable in the model.

Lagoon Surface Area	400	ac
	17,424,000	sq ft
Evaporation and Seepage Losses	4	cfs

Calibration	Date		Water Level (ft NGVD)		dh	dt	dh/dt (ft/day)	dV/dt (cfs)	USGS Discharge (cfs)	% Reduction	alpha
Closure Event ID	Start	End	Start	End							
06May2000	5/6/2000 18:00	5/9/2000 6:00	3.10	8.40	5.30	2.50	2.12	432	580	26%	74%
24May2000	5/24/2000 8:00	5/25/2000 18:00	3.84	5.76	1.92	1.42	1.36	278	385	28%	72%
16June2000	6/16/2000 13:00	6/21/2000 6:00	4.79	6.90	2.11	4.71	0.45	94	200	53%	47%
25Aug2000	8/25/2000 0:00	9/5/2000 8:00	2.56	7.62	5.06	11.33	0.45	94	195	52%	48%
03Oct2000	10/3/2000 0:00	10/11/2000 12:00	2.85	6.53	3.68	8.50	0.43	91	140	35%	65%
15May2001	5/15/2001 23:00	5/21/2001 21:00	2.14	5.51	3.37	5.92	0.57	119	200	41%	59%
07Apr2007	4/7/2007 13:00	4/11/2007 0:00	1.17	7.68	6.51	3.46	1.88	384	480	20%	80%
13Apr2007	4/13/2007 21:30	4/17/2007 14:30	1.97	7.68	5.71	3.71	1.54	315	465	32%	68%
24Apr2007	4/24/2007 17:00	4/26/2007 14:00	1.51	7.57	6.06	1.88	3.23	656	725	10%	90%
13Oct2007	10/13/2007 2:30	10/22/2007 11:30	2.51	9.15	6.64	9.38	0.71	147	255	42%	58%
9June2003	6/9/2003 17:30	6/12/2003 1:00	2.77	6.47	3.70	2.31	1.60	322	475	32%	68%
9Oct2003	10/9/2003 23:11	10/14/2003 20:40	4.00	6.21	2.21	4.90	0.45	91	170	46%	54%
05Nov2004	11/5/2004 11:00	11/12/2004 4:00	2.40	8.93	6.53	6.71	0.97	196	300	35%	65%
26July2004	7/26/2004 15:41	8/5/2004 0:00	2.27	5.90	3.63	9.35	0.39	78	140	44%	56%
2May2004	5/2/2004 15:40	5/6/2004 19:35	3.44	8.39	4.95	4.16	1.19	240	420	43%	57%
16Apr2004	4/16/2004 9:09	4/18/2004 7:40	4.78	7.98	3.20	1.94	1.65	333	570	42%	58%
3Oct2005	10/3/2005 23:00	10/17/2005 6:30	2.40	8.30	5.90	13.31	0.44	89	170	47%	53%
17Sep2005	9/17/2005 2:00	9/21/2005 13:30	3.37	5.69	2.31	4.48	0.52	104	175	40%	60%

Note: Start and end times represent times used for water level calibration and do not correspond to exact timing of closures and breaches.

Month	Month	% Loss	N	HEC-RAS Multiplier
April	4	26%	4	
May	5	34%	4	66%
June	6	42%	2	58%
July	7	44%	1	50%
Aug	8	52%	1	48%
Sep	9	40%	1	50%
Oct	10	43%	4	59%
Nov	11	35%	1	
			18	



Notes: Median daily discharge calculated from 1970-2008.
Source: USGS gage 11467000 (Russian River near Guerneville, CA). 2010 anticipated discharge at Guerneville calculated from 2000 discharge by scaling factor to obtain typical summertime flowrates of 120 cfs. 2010 anticipated lagoon inflow calculated based on calibrated seasonal losses from Guerneville to lagoon.

Appendix A-6

Russian River Estuary Outlet Channel Management Plan

Daily Russian River Discharge

PWA Ref #: 1958.01

PWA

J:\1958.01RREAMPOutletChannel\Task 5 Hydrologic modeling\Data\Streamflow\USGS_11467000_WaterYear_2000.xls

Attachment B. Hypothetical Implementation Scenario

The following hypothetical implementation scenario is presented to demonstrate how the outlet channel management plan may be implemented. The scenario is based on actual beach berm and ocean conditions observed at the estuary from June 30 to July 6, 2009.

This scenario is purely hypothetical and demonstrates how the adaptive management plan may be implemented based on historical conditions observed in 2009. Actual implementation of the plan may vary in terms of channel geometry, channel location and time required for implementation. The beach environment at the project site is highly dynamic so actual implementation of the plan will be evaluated on a case-by-case basis.

Wednesday, June 30th

Agency personnel have been tracking riverine and ocean conditions on a daily basis during the outlet channel management period. Several days ago, they identified a forecasted ocean swell event with the potential to close the estuary. When it arrives, this medium-sized (2-4 ft.) ocean swell, angled from the southwest, pushes sand into the tidal inlet cutting flow from the estuary to the ocean. Stage in the estuary at the time of closure is approximately 3.5 ft NGVD. Based on river discharge and the time of year, Agency personnel estimate that the estuary water level's rate of rise will be 0.5 ft/day.

Thursday, July 1st

Agency personnel visit the site to assess sandbar conditions. The outlet at the time of closure is just south of Haystack Rock, approximately 550 ft northwest of the jetty, with an alignment roughly perpendicular to the beach face. The preexisting channel slope is steep and would, therefore, be susceptible to scour and wave run-up. Agency decides that this is not the preferable alignment for the outlet channel. In effort to create a channel which has shallower gradient and less susceptible to ocean conditions, it is decided that the channel will be more ideally located to the north of Haystack Rock angled to the northwest. Agency staff collects measurements and limited survey data (e.g. elevation at low point of the berm) in the area to develop a design for the outlet channel.

[Note: If closure had occurred during the pupping season (March 15 – June 30), the site assessment would have included a survey for the presence of seal pups.]

Agency staff returns to their offices to develop a plan and design for the implementation of the outlet channel. Changes between the most recent monthly topographic data and current conditions are assessed using the time-lapse photography and today's survey data. If indicated, today's survey data and judgment may be used to revise the topographic data.

Stage in the estuary is now approximately 4.0 ft. NGVD. Observations from the Jenner gage are used to confirm the previously estimated rate of water surface rise of 0.5 ft/day. Based on current stage and this rate of water surface rise, implementation of the outlet channel is scheduled for Monday and Tuesday, July 5th and 6th so that stage in the estuary will be approximately 6.5 ft. NGVD after the outlet channel is completed.

A design is prepared using the best available topographic data. The outlet channel will be approximately 30 ft wide with 4:1 side slopes, 350 ft long to the mean high tide line, a channel bottom elevation at the inlet of approximately 6 ft NGVD, and a channel design flow depth at time implementation of approximately 0.5 ft. Channel will be aligned to the northwest with an approximate aspect of 35° with respect to the beach face. Estimated material to be excavated is approximated and confirmed to be less than 1,000 yd^3.

Agency staff prepares e-mail to management team to notify them of intention and schedule to construct the outlet channel, provide information regarding current conditions, and provide team with a design schematic according to the Communication Protocol procedure documented in Section 7.8.1 of the management plan. Please see Attachments B.1 and B.2 for an example of e-mail transmittal with attached design schematic. Agency biologists coordinate with Stewards of the Coast and Redwoods to schedule volunteers to assist with pre-, day of, and day after outlet channel creation pinniped monitoring.

Friday, July 2nd

Agency staff receives comments from management team on proposed approach. Time allowing, Agency responds, modifies the proposed approach as needed, and decides on the final approach.

Agency staff reviews rate of water surface rise in the lagoon to confirm that flooding is not expected before proposed management action.

Monday and Tuesday, July 5th and 6th

Agency maintenance crews arrive at the Goat Rock State Beach parking lot early in the morning to prepare for implementation. Agency biologist arrives to begin pinniped monitoring at least one hour prior to crews and coordinates with maintenance crew leader. Agency surveyors stake out designed channel and make corrections to alignment and channel geometry to account for potential changes in beach berm topography since last topographic survey. Outlet channel excavation is carried out according to Section 7.5 of the management plan and according to the plan submitted to the management team. Implementation is also conducted in accordance with the Agency's IHA for harbor seals, northern elephant seals and California sea lions which may be present at the site during excavation activities. Photos are taken to document all implementation activities, and following completion of the outlet channel Agency staff collects measurements of completed channel geometry, flow depth and location.

Wednesday, July 7th

Agency staff sends e-mail to management team to provide documentation of the completion of the outlet channel according to the Communication Protocol procedure documented in Section 7.8.2 of the management plan. Please see Attachment B.3 for an example of e-mail transmittal.

After implementation of the channel, the Agency will monitor performance of the outlet channel according to the monitoring program described in Section 7.7 of the management plan.

Attachment B.1: Sample Proposed Outlet Channel Implementation Email

Date: 7/1/10

Hello Outlet Channel Management Team -

The Russian River Estuary closed on 6/30/10. The Sonoma County Water Agency plans to implement an outlet channel beginning at 7 am on July 5th and potentially extending to the afternoon of July 6th. Details of the proposed outlet channel are the following:

- Channel Width: 30 ft.
- Channel Length: 350 ft.
- Channel Bottom Elevation: 6 ft NGVD
- Design Flow Depth: 0.5 ft
- Location of Channel Inlet Centerline: 970 ft northwest of jetty
- Channel Alignment Aspect: 35 deg. with respect to beach face
- Estimated Estuary WSEL at Time of Completion: 6.5 ft
- Existing Beach Berm Crest Elevation: 10 ft NGVD
- Existing Beach Berm Width: 300 ft
- Excavation Equipment: 1 Excavator, 1 Bulldozer

Attached is a design drawing developed using the most recent topographical survey (6/30/10). Due to the highly dynamic nature of conditions at the site, actual topography at the time of implementation may vary. Implementation of the channel may differ from design in order to account for changed topography.

Current and predicted conditions at the site are the following:

- **River and Estuary:**
  - Russian River near Guerneville Flow (USGS 11467000): 120 cfs
  - Predicted 72 hour precipitation: 0 in.
- **Ocean:**
  - Approximate rate of estuary water surface rise: 0.5 ft/day
  - Current Swell Height and Direction: 5.8 ft @ 10 sec. @ 320 deg.
  - 7/5/10 Predicted Mean Swell Height and Direction: 2.5 ft @ 15 sec. @ 200 deg.

No seal pups were observed on the beach.

For updates on conditions please visit the following URL:

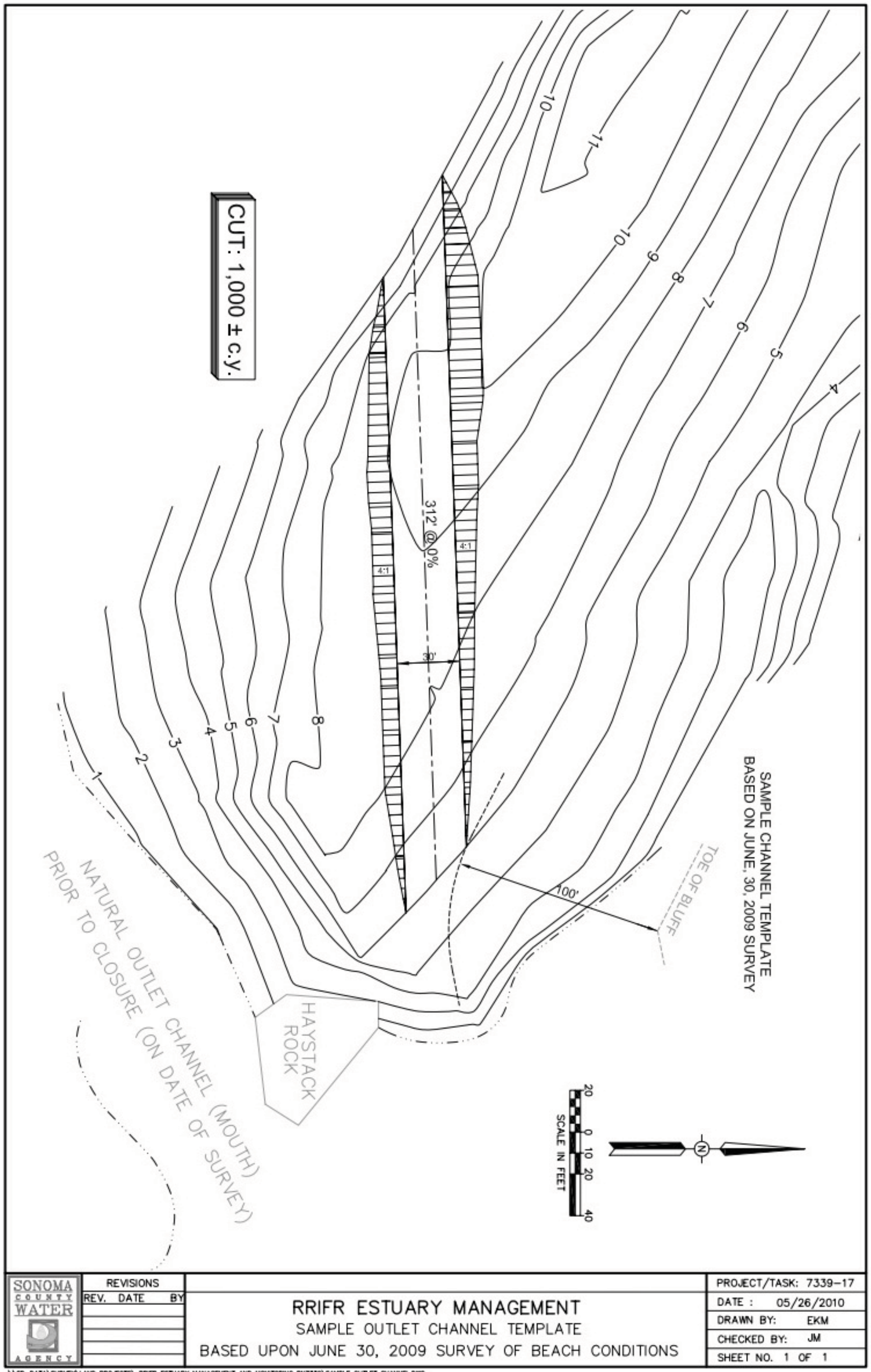
http://www.bml.ucdavis.edu/boon/russianriver

If you have any comments to the proposed implementation plan please provide comments no later than 7/2/10, 5 pm. Should you have any questions or concerns please contact me or Jessica Martini-Lamb at jessicam@scwa.ca.gov, 707-547-1903 (office), 707-322-8177 (mobile).

Sincerely,

Chris Delaney, P.E.
Agency Engineer
Sonoma County Water Agency
707-547-1946 (office)
707-975-5606 (mobile)

Attachment B.2: Sample Proposed Outlet Channel Design Schematic



Attachment B.3: Sample Proposed Outlet Channel Implementation Email

Date: 7/8/10

Hello Outlet Channel Management Team -

The Russian River Estuary closed on 6/30/10. The Sonoma County Water Agency implemented an outlet channel beginning at 7 am on July 5th and extending to the afternoon of July 6th. Details of the implemented outlet channel are the following:

- Channel Width: 30 ft.
- Channel Length: 350 ft.
- Channel Bottom Elevation: 6 ft NGVD
- Flow Depth: 0.7 ft
- Location of Channel Inlet Centerline: 970 ft northwest of jetty
- Channel Alignment Aspect: 35 deg. with respect to beach face
- Estuary WSEL at Time of Completion: 6.7 ft
- Existing Beach Berm Crest Elevation: 10.2 ft NGVD
- Existing Beach Berm Width: 300 ft
- Excavation Equipment: 1 Excavator, 1 Bulldozer

Attached are photographs of the beach before, during, and after the outlet channel implementation.

Current and predicted conditions at the site are the following:

- **River and Estuary:**
  - Russian River near Guerneville Flow (USGS 11467000): 115 cfs
  - Predicted 72 hour precipitation: 0 in.
- **Ocean:**
  - Current Swell Height and Direction: 2.7 ft @ 14 sec. @ 200 deg.
  - 7/10/10 Predicted Mean Swell Height and Direction: 2.4 ft @ 12 sec. @ 200 deg.

No seal pups were observed on the beach.

For updates on conditions please visit the following URL:

http://www.bml.ucdavis.edu/boon/russianriver

If you have any comments on the implemented channel, please provide comments no later than 7/12/10, 5 pm. Should you have any questions or concerns please contact me or Jessica Martini-Lamb at jessicam@scwa.ca.gov, 707-547-1903 (office), 707-322-8177 (mobile).

Sincerely,

Chris Delaney, P.E.
Agency Engineer
Sonoma County Water Agency
707-547-1946 (office)
707-975-5606 (mobile)

Attachment C. Summary of Land Use Permits
(Revised March 23, 2015)

List of Valid Permits and Agreements for the Russian River Estuary Management Project

Page	Agency	Permit No.	Expiration
C-1	California Department of Fish and Wildlife	Lake and Streambed Alteration Agreement (1600-2010-0380-R3)	December 31, 2015
C-6	California Regional Water Quality Control Board, North Coast Region	Section 401 Water Certification (1B10122WNSO)	May 14, 2019
C-11	California Coastal Commission	Coastal Development Permit 2-12-004	August 15, 2016
C-20	US Army Corps of Engineers, San Francisco District	Section 404 & Section 10, Individual Permit (2004- 285610N)	December 31, 2023
C-21	California Environmental Quality Act		None
C-21	California State Lands Commission	General Lease, Public Agency Use (PRC 7918.9)	December 31, 2023
C-24	California Department of Parks and Recreation	Temporary Use Permit	December 31, 2015
C-31	California Department of Parks and Recreation	Collections Permit	February 26, 2015
C-33	US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service	Incidental Harassment Authorization	April 20, 2015

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Fish and Wildlife Lake and Streambed Alteration Agreement (III-1176-96) - November 6, 1996 Agreement Renewal – November 14, 2001 Agreement Extension – October 17, 2002 Agreement Renewal – November 13, 2003 Agreement Renewal – September 30, 2005 Agreement Extension – December 7, 2009 Agreement Amendment – December 13, 2009 Lake and Streambed Alteration Agreement (1600-2010-0380-R3) - September 8, 2011 Expiration - December 31, 2015	**1. Administrative Measures** Permittee shall meet each administrative requirement described below. 1.1 Documentation at Project Site. Permittee shall make the Agreement, any extensions and amendments to the Agreement, and all related notification materials and California Environmental Quality Act (CEQA) documents, readily available at the project site at all times and shall be presented to DFG personnel, or personnel from another state, federal, or local agency upon request. 1.2 Providing Agreement to Persons at Project Site. Permittee shall provide copies of the Agreement and any extensions and amendments to the Agreement to all persons who will be working on the project at the project site on behalf of Permittee, including but not limited to contractors, subcontractors, inspectors, and monitors. 1.3 Notification of Conflicting Provisions. Permittee shall notify DFG if Permittee determines or learns that a provision in the Agreement might conflict with a provision imposed on the project by another local, state, or federal agency. In that event, DFG shall contact Permittee to resolve any conflict. 1.4 Project Site Entry. Permittee agrees that DFG personnel may enter the project site at any time to verify compliance with the Agreement. 1.5 Work Period Extension. If the Permittee needs more time to complete the authorized activity, the work period may be extended on a day-to-day basis by contacting the DFG representative found within the Contact Information section of this Agreement.	May 1: Adaptive Management Annual Report

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Fish and Wildlife (continued)	1.6 To the extent that any provisions of this Agreement provide for activities that require the Permittee to traverse another owner's property, such provisions are agreed to with the understanding that the Permittee possesses the legal right to so traverse. In the absence of such right, any such provision is void. 1.7 If, in the opinion of the DFG, conditions arise, or change, in such a manner as to be considered deleterious to the stream or wildlife, operations shall cease until corrective measures approved by the DFG are taken. **2. Avoidance and Minimization Measures** To avoid or minimize adverse impacts to fish and wildlife resources identified above, Permittee shall implement each measure listed below. 2.1 In each year that this Agreement is in effect, the Permittee shall provide DFG with an annual lagoon outlet channel adaptive management plan by April 15. 2.2 No excavation of the lagoon outlet channel may occur until DFG has reviewed and approved the annual lagoon outlet channel adaptive management plan. DFG shall provide written comments or approval by May 15 of each year this agreement is in effect. 2.3 The project site has been identified as an area that is potentially inhabited by steelhead trout (Federal Threatened), chinook salmon (Federal Threatened), coho salmon (Federal and State Endangered) and green sturgeon (Federal Threatened). This agreement does not authorize the take, or incidental take of any State or Federal listed threatened or endangered listed species. The Permittee is required, as prescribed in the state or federal endangered species acts, to consult with the appropriate agency prior to commencement of the project. Any unauthorized take of such listed species may result in prosecution. 2.4 To avoid impacts on aquatic and terrestrial species within the immediate work area, prior to implementation of an outlet channel, a qualified biologist will conduct a preconstruction survey to ensure no special-status species are occupying the site. If special-status species are observed within the project site or immediate surroundings, these areas will be avoided until the animal(s) has (have) vacated the area, and/or the animal(s) have been relocated out of the project area by a qualified biologist, upon approval by the regulatory agencies. In addition, the site will be surveyed	

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Fish and Wildlife (continued)	periodically during construction to ensure that no special-status species are being impacted by construction activities. 2.5 The project biologist will conduct a preconstruction training session for construction crew members. The training will include a discussion of sensitive biological resources within the project area and the potential presence of special-status species, special-status species' habitats, protection measures to ensure species are not impacted by project activities and project boundaries. 2.6 Any material, which could be hazardous to aquatic life and enters a stream or lake (i.e., a piece of equipment tipping-over in a stream and dumping oil, fuel or hydraulic fluid), shall be removed immediately and the DFG shall be notified within 24 hours. 2.7 Any hazardous or toxic materials that could be deleterious to aquatic life that could be washed into State waters or its tributaries shall be contained in water tight container or removed from the project site. 2.8 The Permittee/contractor shall not dump any litter or construction debris within the riparian/stream zone. All such debris and waste shall be picked up daily and disposed of at an appropriate site. 2.9 Refueling of construction equipment and vehicles may not occur within 300 feet of any water body, or anywhere that spilled fuel could drain to a water body. Tarps or a similar material shall be placed underneath the construction equipment and vehicles, when refueling, to capture incidental spillage of fuels. 2.10 Any equipment or vehicles driven and/or operated within or adjacent to the stream/lake shall be checked and maintained daily to prevent leaks of materials that if introduced to water could be deleterious to aquatic life, wildlife, or riparian habitat. 2.11 Any equipment or vehicles driven and/or operated within or adjacent to the stream/lake shall be cleaned of all external oil, grease, and materials that, if introduced to water, could be deleterious to aquatic life, wildlife or riparian habitat.	

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Fish and Wildlife (continued)	**3. Reporting Measures** Permittee shall meet each reporting requirement described below. 3.1 The Permittee shall notify DFG a minimum of 24 hours in advance of implementing the outlet channel management plan during the lagoon management period (May 15 to October 15). All communications shall be made in the method prescribed within the communication protocol section of the DFG approved annual lagoon outlet channel adaptive management plan. 3.2 The Permittee shall submit an annual report detailing that year's outlet channel management activities. This report may be submitted as a section of the annual lagoon outlet channel adaptive management plan required by May 1 of each year this agreement is in effect.	

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Regional Water Quality Control Board, North Coast Region Section 401 Water Certification (1B04001WNSO) - May 6, 2004 Amendment Extension – October 14, 2009 Amendment Extension – January 20, 2011 Amendment Extension – January 5, 2012 Amendment Extension – December 11, 2012 Amendment Extension – December 16, 2013 Expiration - December 31, 2014 Section 401 Water Certification (WDID 1B10122WNSO) - May 14, 2014 Expiration – May 14, 2019	**All conditions of this order apply to the applicant (and all their employees) and all contractors (and their employees), sub-contractors (and their employees), and any other entity or agency that performs activities or work on the project as related to this water quality certification.** 1. If monitoring results identify potentially dangerous water quality conditions, the applicant will promptly consult with Regional Water Board staff in addition to staff from other agencies identified in the application, including the National Marine Fisheries Service, the California Department of Fish and Wildlife, and California State Parks, with the intent of examining possible resolution through management action. Potentially dangerous conditions may include, but are not limited to, high bacterial levels, the presence of cyanobacteria, or other conditions that could affect human health. 2. The mitigation measures detailed in the Environmental Impact Report (SCH 2010052024) are hereby incorporated by reference and are conditions of approval of this certification. Notwithstanding any more specific conditions in this certification, the applicant shall comply with all mitigation measures identified in the Environmental Impact Report that are within the Regional Water Board's jurisdiction. 3. The annual fee amount for this Clean Water Act Section 401 Water Quality Certification shall be in accordance with the current dredge and fill fee schedule, per Division 3, Chapter 9, Article 1, section 2200(a)(3) of title 23 of the California Code of Regulations, based on the maximum dredge amount of 49,000 cubic yards proposed for the first year, and each year following. This fee shall be submitted prior to authorization of that year's management period and shall be approved by amendment to this Order by signature of the Executive Officer. The fee payment shall indicate the WDID number, and which season it is for. If the entire proposed beach dredging work for that year is not completed during that management season, the fee for the remaining amount of beach dredging for that year shall be applicable to the remaining management season(s), until the remaining amount of the fee is exhausted. In the case the remaining amount of the fee is exhausted within the five year term of this Order, the appropriate fee amount shall be paid at that point to be based on the actual volume of beach dredging performed, and/or proposed to be performed. There shall be no fee refunded to the Applicant if at the expiration of this Order there is any unapplied fee. 4. A draft water quality monitoring plan was submitted on December 23, 2013, which includes datasonde deployment, nutrient/bacterial/algal sampling, and sediment chemistry and benthic community indices. Regional Water Board staff issued a letter to SCWA on April 1, 2014, detailing the Regional Water Board's requirements for a water quality monitoring plan. A final water quality monitoring and reporting plan (WQMRP) must be submitted to the Regional Water Board by July 15, 2014, for approval by the Executive Officer. The WQMRP must include the following: a. Datasonde deployment – Since the size of estuary pool will increase at times under the new estuary management, it is expected that there will be an increase in shallow over-bank habitat along the new shoreline. Diel water temperature, dissolved oxygen, and pH levels in these expanded littoral regions should be evaluated for impacts to the COLD beneficial use during target water surface elevations. Sampling will	March 31: Draft Annual Adaptive Management Plan

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Regional Water Quality Control Board, North Coast Region (continued)	consist of vertical profiles in shallow water areas to characterize lagoon backwater areas. b. Stage measurements – The river reach near Monte Rio is expected to be affected by the backwater effects under the new estuary management. An additional water level measurement station should be placed in this river reach to evaluate when backwater effect on water quality conditions at stations sampled in the reach. c. Bacteria Sampling i. Duncans Mills and Bridgehaven stations should be replaced with public beach access locations at Patterson Point Preserve and Vacation Beach. ii. The monitoring plan should specify that the USEPA (2012) Beach Action Value for *E .coli* bacteria concentration (i.e., 235 MPN/100mL) will be used to determine if sampling should proceed the next day. iii. Water samples should be diluted when higher concentrations of bacteria are expected so that the results are not censored. iv. Assessment of the human-host *Bacteroides* bacteria levels should also be conducted to determine if the new estuary management increases a threat to public health from human sources. Quantifiable levels of human-host *Bacteroides* bacteria indicate recently deposited human waste. The assessment should be conducted at the public recreation beaches (i.e., Monte Rio, Patterson Point Preserve, and Vacation Beach) during the lagoon management period when the estuary is closed and the beaches are inundated. The Sonoma County Public Health Laboratory (as well as other labs) has the capability to quantify human-host *Bacteroides* bacteria that indicate recently deposited human waste. d. Algal sampling – Since the size of estuary pool will increase at times under the new estuary management, it is expected that there will be an increase in shallow over-bank habitat along the new shoreline. The larger areas of shallow habitat will provide additional habitat substrate for periphytic algal mats. The spatial extent of these algal mats and the resulting impact under the new estuary management should be evaluated. In addition, an evaluation of possible cyanobacteria within the periphytic algal mats should be conducted, and if found, the possibility of cyanotoxins should be evaluated. e. A Quality Assurance Project Plan (QAPP) needs to be submitted with the final WQMRP (i.e., EPA/240/B-01/003). 5. This certification action is subject to modification or revocation upon administrative or judicial review, including review and amendment pursuant to Water Code section 13330 and title 23, California Code of Regulations, section 3867. 6. This certification action is not intended and shall not be construed to apply to any discharge from any activity involving a hydroelectric facility requiring a Federal Energy Regulatory Commission (FERC) license or an amendment to a FERC license unless the pertinent certification application was filed pursuant to title 23, California Code of Regulations, section 3855, subdivision (b) and the application specifically identified that a FERC license or amendment to a FERC license for a hydroelectric facility was being sought.	

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Regional Water Quality Control Board, North Coast Region (continued)	7. The validity of this certification is conditioned upon total payment of any fee required under title 23, California Code of Regulations, section 3833, and owed by the applicant. 8. Regional Water Board staff shall be notified in writing at least five working days, when conditions allow, prior to the commencement of ground disturbing activities, or as soon as possible prior to or upon initiating ground disturbing activities, with details regarding the construction schedule, in order to allow staff to be present onsite during construction, and to answer any public inquiries that may arise regarding the project. 9. No debris, soil, silt, sand, bar, slash, sawdust, cement or concrete washings, oil or petroleum products, or other organic or earthen material from any construction or associated activity of whatever nature, other than that authorized by this Order, shall be allowed to enter into or be placed where it may be washed by rainfall into waters of the state. When operations are completed, any excess material or debris shall be removed from the work area. 10. All activities and best management practices (BMPs) shall be implemented according to the submitted application and the conditions in this certification. BMPs for erosion, sediment, and turbidity control shall be implemented and in place at commencement of, during, and after any ground clearing activities or any other project activities that could result in erosion or sediment discharges to surface water. 11. In accordance with state and federal laws and regulations, the applicant is liable and responsible for the proper disposal for project-generated waste. When handling, transporting, and disposing of project-generated waste, the applicant and their contractors shall comply with all applicable state and federal laws and regulations. When disposing of project-generated waste offsite, the applicant and its contractors shall: a. Make appropriate arrangements to dispose of the material, including, but not limited to, property owner agreements, permits, licenses, and environmental clearances; b. Obtain satisfactory evidence that the work in 11.a has been completed; and c. Obtain a dated, signed manifest from the disposal site owner, or authorized representative, that identifies the type and quantity of disposed waste. 12. The applicant shall prioritize the use of wildlife-friendly, biodegradable (not photo- degradable) erosion control products wherever feasible. The applicant shall not use or allow the use of erosion control products that contain synthetic materials within waters of the United States or waters of the state at any time. The applicant shall not use or allow the use of erosion control products that contain synthetic netting for permanent erosion control (i.e. erosion control materials to be left in place for two years or more after the completion date of the project). If the applicant finds that erosion control netting or products	

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Regional Water Quality Control Board, North Coast Region (continued)	have entrapped or harmed wildlife, personnel shall remove the netting or product and replace it with wildlife-friendly biodegradable products. The applicant shall request approval from the Regional Water Board if an exception from this requirement is needed for a specific location. 13. Disturbance or removal of existing vegetation shall not exceed the minimum necessary to complete the project. 14. If, at any time, an unauthorized discharge to surface water (including wetlands, lakes, rivers, or streams) occurs, or any water quality problem arises, the associated project activities shall cease immediately until adequate BMPs are implemented including stopping work. The Regional Water Board shall be notified promptly and in no case more than 24 hours after the unauthorized discharge or water quality problem arises. 15. Fueling, lubrication, maintenance, storage, and staging of vehicles and equipment shall not result in a discharge or threatened discharge to any waters of the state including dry portions of the shoreline. At no time shall the applicant or its contractors allow use of any vehicle or equipment that leaks any substance that may impact water quality. 16. Prior to implementing any change to the project that may have a significant or material effect on the findings, conclusions, or conditions of this Order, the applicant shall obtain the written approval of the Regional Water Board executive officer. If the Regional Water Board is not notified of a significant alteration to the project, it will be considered a violation of this Order, and the applicant may be subject to Regional Water Board enforcement actions. 17. The Regional Water Board may add to or modify the conditions of this Order, as appropriate, to implement any new or revised water quality standards and implementation plans adopted and approved pursuant to the Porter-Cologne Water Quality Control Act or section 303 of the Clean Water Act. 18. The applicant shall provide Regional Water Board staff access to the project site to document compliance with this certification. 19. In the event of any violation or threatened violation of the conditions of this Order, the violation or threatened violation shall be subject to any remedies, penalties, process or sanctions as provided for under applicable state or federal law. For the purposes of section 401 (d) of the Clean Water Act, the applicability of any state law authorizing remedies, penalties, process or sanctions for the violation or threatened violation constitutes a limitation necessary to assure compliance with the water quality standards and other pertinent requirements incorporated into this Order. In response to a suspected violation of any condition of this certification, the State Water Board may require the holder of any federal permit or license subject to this Order to furnish, under penalty of perjury, any technical or monitoring reports the State Water Board deems appropriate, provided that the burden, including costs, of the reports shall bear a reasonable relationship to the need for the reports and the benefits to be obtained from the reports. In response to any violation of the conditions of this Order, the Regional Water	

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Regional Water Quality Control Board, North Coast Region (continued)	Board may add to or modify the conditions of this Order as appropriate to ensure compliance. 20. The applicant shall provide a copy of this Order and State Water Board Order 2003- 0017-DWQ to any contractor(s), subcontractor(s), and utility company(ies) conducting work on the project, and shall require that copies remain in their possession at the work site. The applicant shall be responsible for ensuring that all work conducted by its contractor(s), subcontractor(s), and utility companies is performed in accordance with the information provided by the applicant to the Regional Water Board. 21. In the event of any change in control of ownership of land presently owned or controlled by the Applicant, the Applicant shall notify the successor-in-interest of the existence of this Order by letter and shall forward a copy of the letter to the Regional Water Board at the above address. To discharge dredged or fill material under this Order, the successor-in-interest must send to the Regional Water Board Executive Officer a written request for transfer of the Order. The request must contain the requesting entity's full legal name, the state of incorporation if a corporation, and the address and telephone number of the person(s) responsible for contact with the Regional Water Board. The request must also describe any changes to the Project proposed by the successor- in-interest or confirm that the successor-in-interest intends to implement the Project as described in this Order. Except as may be modified by any preceding conditions, all certification actions are contingent on: a) the discharge being limited to and all proposed mitigation being completed in strict compliance with the Applicant's Project description, and b) compliance with all applicable requirements of the Water Quality Control Plan for the North Coast Region (Basin Plan). 22. Except as may be modified by any preceding conditions, all certification actions are contingent on a) the discharge being limited to and all proposed mitigation being completed in strict compliance with the applicant's project description, and b) compliance with all applicable requirements of the Water Quality Control Plan for the North Coast Region (Basin Plan). 23. The authorization of this certification for any dredge and fill activities expires on May 14, 2019. Conditions and monitoring requirements outlined in this Order are not subject to the expiration date outlined above, and remain in full effect and are enforceable.	

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Coastal Commission Coastal Development Permit (CDP 2-01-033) – May 15, 2002 Amend. Extension (2-01-033-1A) – June 14, 2010 Monthly Extensions (January - June 2011) Emergency CDP (2-12-002-G) –January 9, 2012 New CDP Application Submitted – January 23, 2012 Application deemed complete – July 9, 2012 Emergency CDP (2-13-005-G) –February 21, 2013 Emergency CDP (2-13-005-G) –February 21, 2013 Emergency CDP (G-2-13-0221) –October 15, 2013 CDP (2-12-004) February 26, 2014 Expiration-August 15, 2016	**SPECIAL CONDITIONS:** This permit is granted subject to the following special conditions: 1. **Approved Project.** Subject to these standard and special conditions (including modifications to the project, mitigation measures, and/or the project plans required by them), this CDP authorizes implementation of the Russian River Estuary Management Project and related jetty study, including 1) a new program that would implement a lagoon outlet channel during the lagoon management season, from May 15th to October 15th, 2) sand bar breaching from October 16th to May 14th and necessary from May 15th to October 15th to minimize flooding, and 3) a geotechnical evaluation of a relic jetty at the river mouth, all as more specifically described in the proposed project materials (see Appendices A and B and Exhibits 2, 3, and 7). 2. **Construction Plan.** PRIOR TO ISSUANCE OF THE COASTAL DEVELOPMENT PERMIT, the Permittee shall submit two copies of a Construction Plan (the Plan) to the Executive Director for review and written approval. The Plan shall, at a minimum, include the following: a. **Construction Areas.** The Construction Plan shall identify the specific location of all construction areas, all staging areas, and all construction access corridors in site plan view. All such areas within which construction activities and/or staging are to take place shall be	August 15: Annual Report for CDP (2-12-004)

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California Coastal Commission (continued)	minimized to the maximum extent feasible in order to have the least impact on public access and adjacent biological resources as well as to maintain best management practices (BMPs) to protect coastal dune and marine resources on-site and in the surrounding area, including by using offsite areas for staging and storing construction equipment and materials, as feasible. In addition, all construction areas shall avoid sensitive dune plant species, including Tidestrom's lupine, as required in subsection (c), below. The placement of the piezometers shall occur no closer than fifty feet from the sensitive dune plant habitat (as outlined in Exhibit 3 – Jetty Study Location, Detail, and Photos). Construction (including but not limited to construction activities, and materials and/or equipment storage) is prohibited outside of the defined construction, staging, and storage areas. **b. Construction Methods and Timing.** The plan shall specify the construction methods to be used, including all methods to be used to keep the construction areas separated from sensitive coastal dune and marine resources and public recreational use areas (including using unobtrusive fencing (or equivalent measures) to delineate construction areas). All work shall take place during daylight hours and all lighting of the beach, river, and dune habitat is prohibited. **c. Dune Plants Avoidance.** The plan shall include methods to avoid impacts to sensitive dune plant species, including Tidestrom's lupine. All sensitive species shall be avoided during construction, including through locating the defined construction areas required in subsection (a) away from such species (as generally depicted on Exhibit 3 – Jetty Study Location, Detail, and Photos). Furthermore, the sensitive dune plant habitat shall be fenced off during the two weeks wherein the instruments are being placed and the seismic work is occurring. For the duration of the project, markers identifying the boundaries of the sensitive dune plant habitat shall remain in place. A monitor shall be on site during instrument placement, testing, and removal to ensure that project activities occur within the defined construction, staging, and storage areas and outside of the sensitive dune plant habitat. **d. Best Management Practices.** The plan shall clearly identify all BMPs to be implemented during construction and their location. Contractors shall ensure that work crews are carefully briefed on the importance of observing the appropriate precautions and reporting and cleanup of accidental spills. Construction contracts shall contain appropriate penalty provisions, sufficient to offset the cost of retrieving or cleaning up improperly contained foreign materials. **e. Construction and Instrument Noise Level Restrictions.** Noise generated by any instrument driving or hammer strike activities shall be minimized to the maximum extent practicable. Underwater noise shall not exceed an accumulated 187 dB SEL as measured 10 meters from the source. At no time shall peak dB SEL rise above 206 at 10 meters from the source. Furthermore, the Applicants shall limit activities at the site that involve the use of heavy equipment to between local sunrise to local sunset. **f. Construction Site Documents.** The plan shall provide that copies of the signed CDP and the approved Construction Plan be maintained in a conspicuous location at the construction job site	

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California Coastal Commission (continued)	at all times, and that such copies are available for public review on request. All persons involved with the construction shall be briefed on the content and meaning of the coastal development permit and the approved Construction Plan, and the public review requirements applicable to them, prior to commencement of construction. **g. Construction Coordinator.** The plan shall provide that a construction coordinator be designated to be contacted during construction should questions arise regarding the construction (in case of both regular inquiries and emergencies), and that their contact information (i.e., address, phone numbers, etc.) including, at a minimum, a telephone number that will be made available 24 hours a day for the duration of construction, is conspicuously posted at the job site where such contact information is readily visible from public viewing areas, along with indication that the construction coordinator should be contacted in the case of questions regarding the construction (in case of both regular inquiries and emergencies). The construction coordinator shall record the name, phone number, and nature of all complaints received regarding the construction, and shall investigate complaints and take remedial action, if necessary, within 24 hours of receipt of the complaint or inquiry. In addition, all construction personnel shall be trained in proper material handling, cleanup, and disposal procedures. **h. Notification.** The Permittee shall notify planning staff of the Coastal Commission's North Central Coast District Office at least three working days in advance of commencement of construction, and immediately upon completion of construction. **i. Property Owner Consent.** The plan shall be submitted with evidence indicating that the owners of any properties on which construction activities are to take place, including properties to be crossed in accessing the site, consent to such use of their properties. Minor adjustments to the above construction requirements may be allowed by the Executive Director in the approved Construction Plan if such adjustments: (1) are deemed reasonable and necessary; and (2) do not adversely impact coastal resources. All requirements above and all requirements of the approved Construction Plan shall be enforceable components of this CDP. The Permittee shall undertake construction in accordance with the approved Construction Plan. **3. Mitigation Monitoring Plan.** The project shall be conducted in compliance with the requirements of the Mitigation Monitoring Plan, dated August 17, 2011 (see Appendix B), except where the terms and conditions of this CDP require actions more protective of coastal resources. **4. Marin e Mammal Avoidance and Monitoring.** To the maximum extent feasible, all work shall avoid the river mouth area where seal haul out is typically located (see Exhibit 4 – Pinniped Haul Outs). In addition, all work shall be conducted consistent with the NMFS and NOAA-approved seal haul out plan described in the Incidental Harassment Authorization (April 2013) (IHA) and any updates to this IHA. Project activities shall comply with all mitigation, monitoring and reporting requirements contained in the IHA, including the following requirements as outlined in the IHA:	

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California Coastal Commission (continued)	**a. Avoid Sudden Flushes.** Permittee crews shall cautiously approach the haul-out ahead of heavy equipment to minimize the potential for sudden flushes, which may result in a stampede. Crews on foot shall make an effort to be seen by seals from a distance, if possible, rather than appearing suddenly at the top of the sand bar, again preventing sudden flushes. Boats operating near river haul-outs during monitoring shall be kept within posted speed limits and driven as far from the haul-outs as safely possible to minimize flushing seals. **b. Avoid Haul-Out.** Permittee crews shall avoid walking or driving equipment through the seal haul-out. Physical and biological monitoring at the haul-out location shall not be occur if a pup less than one-week old is present at the monitoring site or on a path to the site. **c. Monitoring From Bluff.** During breaching events, all monitoring shall be conducted from the overlook on the bluff along Highway 1 adjacent to the haul-out in order to minimize potential for harassment. **d. Disturbance Recovery.** The Permittee shall maintain a one-week no-work period between water level management events (unless flooding is an immediate threat) to allow for an adequate disturbance recovery period. During the no-work period, equipment must be removed from the beach. **e. Equipment BMPs.** All equipment shall be driven slowly on the beach and care shall be taken to minimize the number of shutdowns and start-ups when equipment is on the beach. All work shall be completed as efficiently as possible, with the smallest amount of heavy equipment possible, to minimize disturbance of seals at the haul-out. **f. Haul-out Maintained.** The Permittee shall conduct seal counts at the Jenner seal haul-out and at nearby coastal and river haul-outs in accordance with methods described in the Russian River Management Activities Pinniped Monitoring Plan (Pinniped Monitoring Plan), dated September 9, 2009, or as updated by requirements of NMFS under the Marine Mammal Protection Act (MMPA). If monitoring during the lagoon management period indicates decreases in overall use at the Jenner haul-out are correlated with increases in use at the three closest haul-outs, then the Permittee shall consult with the Executive Director, NMFS and CDFW to modify the Estuary Management Plan activities such that the haul-out site is maintained. Proposed alterations to the approved Estuary Management Plan shall be reported to the Executive Director. No alterations to the approved Estuary Management Plan shall occur without an approved amendment to this CDP, unless the Executive Director determines that no amendment is legally required. **5. Public Acc ess Management Plan.** PRIOR TO ISSUANCE OF THE COASTAL DEVELOPMENT PERMIT, the Permittee shall submit two copies of a public access management plan (Public Access Plan) to the Executive Director for review and approval. The Public Access Plan shall clearly describe the manner in which public access at the project site is to be protected, with the objective of avoiding any adverse impacts to public access at Goat Rock, Sonoma Coast State Beach. The Public Access Plan shall be consistent with all other terms and conditions of this CDP, and shall at a minimum include the following:	

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California Coastal Commission (continued)	**a. No Disruption of Public Access.** Development under this CDP that blocks access to the beach at the project site shall be prohibited. Temporary signs shall warn the public of construction while construction activities are underway. Signs shall direct the public to safe access routes during construction activities. Signs shall not discourage public access. Signs shall notify beach users of channel conditions, potential for safety hazards from beach erosion or hydrologic action, and emergency contact information. Signs shall be posted and maintained at key locations, such as the parking lot at Goat Rock State Beach Parking lot, the unofficial beach access trail located on the north side of the beach off Highway 1, and 100 feet on either side of the outlet channel. **b. Peak Public Access Times Avoided.** Project activities shall occur Monday through Thursday only, to avoid impacts to park visitors during peak visitation times (Friday through Sunday). All requirements above and all requirements of the approved Public Access Plan shall be enforceable components of this CDP. The Permittee shall undertake development in accordance with the approved Public Access Plan, which shall govern all general public access to the site pursuant to this CDP. **6. Monitoring Plan.** PRIOR TO ISSUANCE OF THE COASTAL DEVELOPMENT PERMIT, the Permittee shall submit two copies of a Flood Analysis, Habitat and Water Quality Monitoring Plan (Monitoring Plan) to the Executive Director for review and approval. The Flood Analysis portion of the Monitoring Plan shall identify avoidance and mitigation measures as detailed in Special Condition 6(a). The Habitat Monitoring portion of the Monitoring Plan shall cover all approved project activities, and shall evaluate project effectiveness and alternatives as detailed in Special Condition 6(b). The Water Quality Monitoring portion of the Monitoring Plan shall direct management actions in response to water quality conditions and as detailed in Special Condition 6(c). The primary objective of the Monitoring Plan shall be to ensure that approved project activities protect and enhance project area habitats while also protecting development from flooding and enhancing water quality, and shall be measured against a clearly defined project baseline, which shall be provided in the Monitoring Plan. The Monitoring Plan shall be based upon an adaptation framework where lessons learned from approved project activities and monitoring are applied through adaptive changes designed to better achieve the primary objective over the course of this authorization. The Monitoring Plan shall include all monitoring components of the BO and the FEIR for the project, and shall include, at minimum, the following: **a. Flood Analysis.** The Permittee shall continue to coordinate with NMFS and work with property owners affected by flooding to identify measures that would, if necessary, substantially minimize or avoid any damages to existing structures that would occur as a result of increasing water elevations in the lagoon pursuant to the approved project. As appropriate and indicated in the BO, the Permittee shall continue to survey properties within the estuary's maximum water elevation in greater detail to more accurately and precisely determine the elevation of the structures potentially at risk; this information shall be kept on record by the Permittee and a copy shall be provided to each of the property owners. A detailed account of individual properties and development of these properties for each foot of estuary water surface elevations shall be	

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Agency / Permit / Expiration	Special Conditions	Report Due Date
California Coastal Commission (continued)	provided. The range of options available to protect affected developments, other than breaching or controlling water levels in the estuary, including relocating, elevating, or reinforcing structures, shall be provided. At a minimum, and evaluation of the effects of flood levels at 4.5, 7, and 9 feet shall be so evaluated. **b. Habitat Monitoring.** Monitoring shall be conducted consistent with the BO to provide information on (1) the ways in which the project results in benefits to juvenile steelhead and/or adverse impacts to other salmonids, (2) whether a controlled outlet program can achieve optimal lagoon elevations, and (3) whether habitat improvements would result if no breaching occurred, water levels were allowed to be higher than current management, a larger estuary was formed, and low-lying development within the historic estuary footprint were flooded. A geotechnical study shall be conducted prior to December 31, 2014 to contribute to a determination as to what modifications to/removal of the jetty infrastructure would optimize seepage through the sand barrier and allow estuary levels to rise to a maximum elevation without the sand bar manipulation. An evaluation of the need for additional monitoring wells and frequency of water level data needed to adequately characterize seepage through the sand bar and jetty shall be conducted at the commencement of the geotechnical work so that reliable information is assured to be included in the study. **c. Water Quality Monitoring.** The water quality monitoring data collected for the 2008 BO, the Temporary Urgency Change Petition's surface water sampling program, and the Stipulated Judgment's sediment sampling requirement shall be integrated under the direction of an independent water quality professional. These data collection programs shall be linked and coordinated so that they provide a cohesive and useful data set that can be used to evaluate the low velocity lagoon outlet channel and whether or not it is successful in sustaining raised water elevations and improved water quality conditions in the estuary. At a minimum, the Plan shall specify the water quality analyses, sampling locations, sampling frequency, quality control and data reporting that will be used to assess water quality impacts of implementing the Russian River Estuary Management Program Adaptive Management Plan. In addition, the Water Quality Monitoring Plan shall include sampling for the following constituents, at a minimum, temperature, salinity, pH, nutrients, chlorophyll, and bacteria indicators used to assess human health impacts consistent with the most up-to date methods and standards required by the North Coast Regional Water Quality Control Board (NCRWQCB). Monitoring shall occur weekly during the Lagoon Management Period at the locations that are currently included in the Russian River Water Quality Summary for the Sonoma County Water Agency 2012 Temporary Urgency Change. Finally, the Plan shall include a contingency to increase sampling frequency to daily if the bacteria indicators exceed the operative standards required by the NCRWQCB and monitoring shall continue daily until measurements are below the operative standards. If the operative standards are exceeded, the Permittee will immediately inform the NCRWQCB and Sonoma County Public Health and seek direction on whether warning signs should be posted at the affected beaches regarding a potential health threat and consult with NCRWQCB and Sonoma County Public Health to determine if mechanical breaching is a recommended action to reduce the threat to public health.	

Expiration		Report Due Date
California Coastal Commission (continued)	d. **Monitoring Reports.** The Monitoring Plan shall provide for submission of annual reports of monitoring results to the Executive Director for review and approval for as long as activities are authorized by this CDP, with the first annual monitoring report due on August 15, 2014, and subsequent reports due on August 15th of each year thereafter. Each monitoring report shall be cumulative and shall summarize all previous results. Each report shall clearly document conditions in the project area related to project implementation, including in narrative (with supporting monitoring data) and through photographs taken from the same fixed points in the same directions each year, all commencing from the project baseline. Each report shall include a performance evaluation section where information and results from the monitoring program are used to evaluate the effect of project implementation with respect to flooding, habitat, and water quality impacts, both beneficial and detrimental. To allow for an adaptive approach, each report shall also include a recommendations section to address changes that may be necessary in light of monitoring results and/or other information, including with respect to more current data and/or species information related to the habitat areas in question, if any. Actions necessary to implement the recommendations shall be implemented within 30 days of Executive Director approval of each Monitoring Report, unless the Executive Director identifies a different time frame for implementation. Minor adjustments to the above monitoring requirements may be allowed by the Executive Director in the approved Monitoring Plan if such adjustments: (1) are deemed reasonable and necessary; and (2) do not adversely impact coastal resources. All requirements above and all requirements of the approved Monitoring Plan shall be enforceable components of this CDP. The Permittee shall undertake development in accordance with the approved Monitoring Plan. 7. **Assumption of Risk.** By acceptance of this CDP, the Permittee acknowledges and agrees, on behalf of itself and all successors and assigns: a. **Coastal Hazards.** That the site is subject to coastal hazards including but not limited to episodic and long-term shoreline retreat and coastal erosion, high seas, ocean waves, storms, tsunami, tidal scour, coastal flooding, and the interaction of same; b. **Assume Risks.** To assume the risks to the Permittee and the property that is the subject of this permit of injury and damage from the above-identified coastal hazards in connection with this permitted development; c. **Waive Liability.** To unconditionally waive any claim of damage or liability against the Commission, its officers, agents, and employees for injury or damage from the above-identified hazards; d. **Indemnification.** To indemnify and hold harmless the Coastal Commission, its officers, agents, and employees with respect to the Commission's approval of the project against any and all liability, claims, demands, damages, costs (including costs and fees incurred in defense of such	

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California Coastal Commission (continued)	claims), expenses, and amounts paid in settlement arising from any injury or damage due to the above-identified coastal hazards. **8. Sand Bar Breaching L imitation.** Except under conditions requiring immediate action to prevent or mitigate loss or damage to life, health, property, or essential public services, the sand bar breaching activities authorized by the CDP shall not be initiated on or within 36 hours prior to any weekend or State holiday. **9. CD P Term.** Development authorized by this CDP is valid for three (3) years from the date of Commission approval (until August 15, 2016). One request for an additional three-year period of development authorization may be accepted, reviewed and approved by the Executive Director for a maximum total of six (6) years of development authorization, provided the request would not alter the project description and/or require modifications of conditions due to new information or other changed circumstances. The request for an additional three-year period of development authorization shall be made at least 120 days prior to August 15, 2016. If the request for an additional three-year authorization period would alter the project description and/or require modifications of conditions due to new information or other changed circumstances, an amendment to this CDP shall be necessary to authorize development beyond August 15, 2016. If the Permittee submits a request/application to continue estuary management (including breaching and other activities intended to control water elevations) beyond August 15, 2016, such request/application shall be accompanied by a project alternatives analysis that, at minimum, provides a survey of potential flooding risks to properties within the estuary up to a water elevation of 14 feet, or the maximum water elevation known to occur, whichever is higher, to precisely determine the elevation of the structures potentially at risk. In addition, the analysis shall include an evaluation of the range of options available to protect against identified flooding risks, other than breaching or controlling water levels in the estuary, including relocating, elevating, or reinforcing structures. Such analysis shall also include an evaluation of the range of options available to modify or remove the jetty to reduce or eliminate the need for breaching. **10. Other Agency Approval.** PRIOR TO ISSUANCE OF THE COASTAL DEVELOPMENT PERMIT, the Permittee shall submit to the Executive Director written evidence that all necessary permits, permissions, approvals, and/or authorizations for the approved project have been granted by Sonoma County, the North Coast Regional Water Quality Control Board, California State Lands Commission, California Department of Parks and Recreation, California Department of Fish and Wildlife, National Marine Fisheries Service, U.S. Army Corps of Engineers, and the U.S. Fish and Wildlife Service or that no such permits or approvals are necessary. Any changes to the approved project required by these agencies shall be reported to the Executive Director. No changes to the approved project shall occur without a Commission amendment to this CDP unless the Executive Director determines that no amendment is necessary. **11. Liability for Costs and Attorneys' Fees.** By acceptance of this CDP, the Applicant/Permittee agrees to reimburse the Coastal Commission in full for all Coastal Commission costs and attorneys'	

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California Coastal Commission (continued)	fees (including (1) those charged by the Office of the Attorney General, and (2) any court costs and attorneys' fees that the Coastal Commission may be required by a court to pay) that the Coastal Commission incurs in connection with the defense of any action brought by a party other than the Applicant/Permittee against the Coastal Commission, its officers, employees, agents, successors and assigns challenging the approval or issuance of this CDP. The Coastal Commission retains complete authority to conduct and direct the defense of any such action against the Coastal Commission.	

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US Army Corps of Engineers, San Francisco District Section 404 & Section 10, Individual Permit (285610N) - July 22, 2005 Permit Modification - October 5, 2009 Time Extension January 5, 2011 Time Extension December 8, 2011 Time Extension December 10, 2012 Time Extension December 10, 2013 Section 404 & Section 10, Individual Permit (2004- 285610N) – April 1, 2014 Expiration - December 31, 2023	SPECIAL CONDITIONS: 12. To remain exempt from the prohibitions of Section 9 of the Endangered Species Act, the non-discretionary Terms and Conditions for incidental take of federally-listed Species shall be fully implemented as stipulated in the Biological Opinion entitled, *"Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Conh·ol and Water Conservation Improvement District in the Russian River Watershed,"* also known as the Russian River Biological Opinion, (NMFS File No. 151422SWR2000SRl50) dated September 24, 2008. Project authorization under this permit is conditional upon compliance with the mandatory terms and conditions associated with incidental take. Failure to comply with the terms and conditions for incidental take, where a take of a federally-listed species occurs, would constitute an unauthorized take and non-compliance with the authorization for your project. The NMFS is, however, the authoritative federal agency for determining compliance with the incidental take statement and for initiating appropriate enforcement actions or penalties under the Endangered Species Act. 13. SCWA shall provide USACE a copy of the approved Estuary Monitoring Plan and all subsequent Annual Monitoring Reports required by the Biological Opinion. 14. Unless otherwise approved, authorized discharges of dredged material on the sandbar below the high tide line shall consist only of the native sand excavated from the pilot channel. 15. SCWA shall provide USACE a Breaching Activities Report by 31 March for each year of the ten-year permit authorization period. Each Breaching Activities Report shall present a tabulation of the breaching events that occurred during the preceding year, including the approximate estuary closure date, the approximate number of estuary closure days occurring before the breach event, the breaching event date, and the recorded estuary water level of the breaching event date. 5. The current Coastal Development Permit (CDP 2-12-004) issued by the California Coastal Commission expires on 15 August 2016. The current Section 401 water quality certification (WDID No. IB04001WNSO) issued by the Regional Water Quality Control Board expires on 31 December 2015. SCWA shall obtain requisite time extensions for the Coastal Development Permit and water quality certification prior to the commencement of any work to be performed during the remainder of the ten-year Department of the Army permit authorization period. SCWA shall provide USACE a copy of all requisite time extensions to ensure continuing project conformance with State coastal zone and water quality standards.	March 31: Annual Breaching Report

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California Environmental Quality Act Environmental Impact Report (EIR) Notice of Preparation – May 10, 2010 Notice of Completion – December 15, 2010 Notice of Determination – August 16, 2011	See EIR for Mitigation Measures.	None
California State Lands Commission General Lease, Public Agency Use (PRC 7918.1 R 08103) – June 29, 2004 Lagoon Outlet Channel Authorization – October 13, 2009 (Expiration - December 31, 2010) Monthly Extensions - January 1 to December 31, 2011 General Lease, Public Agency Use (PRC 7918.9) – January 1, 2012	**SECTION 2** **SPECIAL PROVISIONS** **BEFORE THE EXECUTION OF THIS LEASE, ITS PROVISIONS ARE AMENDED, REVISED OR SUPPLEMENTED AS FOLLOWS:** 1. Lessee agrees to be bound by and fully carry out, implement, and comply with all mitigation measures and reporting obligations identified as Lessee's, or Responsible Party's responsibility as set forth in the Mitigation Monitoring Program (MMP) attached hereto as Exhibit C and by this reference made a part of this Lease, or as modified by Lessor as permitted by law. 2. Lessee acknowledges that the land described in Exhibit A of this Lease is subject to the Public Trust and is presently available to members of the public for recreation, waterborne commerce, navigation, fisheries, open space, or other recognized Public Trust uses and that Lessee's proposed construction activities and use of the Lease Premises shall not interfere or limit the Public Trust rights of the public. At least 24 hours prior to and during the breaching activities, Lessee will contact the California Department of Parks and Recreation lifeguards and post signs and barriers to minimize potential hazards to the public. 3. Prior to the start of the initial freshwater lagoon construction on the Lease Premises, Lessee shall submit to Lessor copies of all permits and authorizations from agencies having jurisdiction over the construction of the authorized activities on the Lease Premises. Lessee shall maintain all regulatory permits and authorization required during the term of the lease.	No Date: Annual Water Quality Data Summary Reports; Annual Report for Russian River Estuary Management Activities Monitoring Plan

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California State Lands Commission (continued) Renewed General Lease, Public Agency Use (PRC 7918.9) – Approved by Commission on February 20, 2015 Expiration – December 31, 2023	4. All breaching activities shall be carried out in accordance with all applicable safety regulations, permits, and conditions of all other agencies. 5. During the term of the lease, Lessee shall provide Lessor with an annual report on frequency and timing of outlet channel construction and maintenance and breaching occurrences completed each calendar year, including number of days of closure of Goat Rock State Beach. The report should include narrative descriptions and evaluations of outlet channel and breaching events, including any adaptive management changes implemented. 6. Lessee shall submit to Lessor copies of the following: a. Adaptive estuarine water level and barrier beach management plans (as described in 2.1.1 of the Russian River Biological Opinion) after approval by the National Marine Fisheries (NMFS), the California Department of Fish and Wildlife, and the U.S. Army Corps of Engineers. b. Annual water quality data summary reports (as described in 2.2, Monitoring Estuarine Water Quality: Reporting and Review, of the Biological Opinion). c. Annual report, as specified in the "Russian River Estuary Management Activities Pinniped Monitoring Plan" and distributed to NMFS, the California Department of Parks and Recreation, and the Stewards of the Coasts and Redwoods, on pinnipeds' reaction to the proposed activities authorized in this Lease. 7. All personal property, tools, or equipment taken onto or placed upon the Lease Premises shall remain the property of the Lessee or its contractors. Such personal property shall be promptly removed by the Lessee, at its sole risk and expense upon the completion of the project. Lessor does not accept any responsibility for any damage, including damages to any personal property, including any equipment, tools, or machinery on the Lease Premises	

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California State Lands Commission (continued)	8. No refueling, repairs, or maintenance of vehicles or equipment will take place on the Lease Premises. 9. Lessee shall maintain a logbook on all work vessels during work within the Lease Premises utilized in operations conducted under this Lease to keep track of all debris created by objects of any kind that may fall into the water. The logbook should include the type of debris, date, time and location to facilitate identification and location of debris for recovery and site clearance verification. All debris shall be promptly removed from the Lease Premises. 10. Any equipment to be used on the Lease Premises is limited to that which is directly required to perform the authorized use and does not include any equipment that may cause damage to the Lease Premises. 11. Lessee acknowledges and agrees: a. The site may be subject to hazards from natural geophysical phenomena including, but not limited to waves, storm waves, tsunamis, earthquakes, flooding and erosion. b. To assume the risks to the Lessee and to the property that is the subject of any Coastal Development Permit (CDP) that is issued to Lessee for development on the leased property, of injury and damage from such hazards in connection with the permitted development and use. c. To unconditionally waive any claim or damage or liability against the State of California, its agencies, officers, agents, and employees for injury or damage from such hazards. d. To indemnify, hold harmless and, at the option of Lessor, defend the State of California, its agencies, officers, agents, and employees, against and for any and all liability, claims, demands, damages, injuries, or costs of any kind and from any cause (including costs and fees incurred in defense of such claims), expenses, and amounts paid in settlement arising from any alleged or actual injury, damage or claim due to site hazards or connected in any way with respect to the approval of any CDP that is issued to Lessee involving this property or issuance of this Lease, any new lease, renewal, amendment, or assignment by Lessor. 12. Lessor shall have the right to enter upon the property at reasonable times in order to monitor Lessee's compliance with and otherwise enforce the terms of the Lease. 13. Paragraph 10, Surety Bond, contained within Section 3 is hereby deleted from this Lease.	

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California Department of Parks and Recreation Temporary Use Permit – December 30, 2003 Permit Extension – September 14, 2009 Permit Extension – December 28, 2009 Expiration – June 30, 2010 Temporary Use Permit – May 15, 2011 Time Extension – February 20, 2013 Time Extension – December 18, 2013 Time Extension – February 2, 2015	**Now therefore**, the State by this Permit hereby grants to the Permittee permission to enter upon State's property, conditioned upon the agreement of the Parties that this Permit does not create or vest in Permittee any interest in the real property herein described or depicted, that the Permit is revocable and non-transferable, and that the Permit is further subject to the following terms and conditions: 1. **Project Description:** By this Permit, the State hereby grants to the Permittee permission to enter onto those lands depicted and described on Exhibit "A", Russian River Estuary Management Activities, and Exhibit "B", Russian River Estuary Outlet Channel: Excavation Cut and Fill Locations, attached hereto and herein incorporated by this reference, solely for the purpose of flood control and environmental monitoring. 2. **Permit Subject to Laws and Regulatory Agency Permits:** This Permit is expressly conditioned upon Permittee's obtaining any and all regulatory permits or approvals required by the relevant regulatory agencies for the Project and Permittee's use of the Property, and upon Permittee's compliance with all applicable municipal, state and federal laws, rules and regulations, including all State Park regulations. Prior to commencement of any work, Permittee shall obtain all such legally required permits or approvals and submit to the State full and complete copies of all permits and approvals, including documentation related to or referenced in such permits and approvals, along with the corresponding agency contact and telephone numbers, and related California Environmental Quality Act (CEQA) and/or National Environmental Policy Act (NEPA) documentation as applicable. 3. **Term of Permit:** This Permit shall only be for the period beginning on 11/15/2011, and ending on 12/31/2012, or as may be reasonably extended by written mutual agreement of the Parties. 4. **Consideration:** Permittee agrees to pay State the sum of One thousand five hundred and No/100 Dollars ($1,500.00) as consideration for the rights granted by this Permit. Payment is due upon execution of this Permit. 5. **Permit Subject to Existing Claims:** This Permit is subject to existing contracts, permits, licenses, encumbrances and claims which may affect the Property.	No Reporting Required for TUP

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Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Parks and Recreation (continued) Expiration – December 31, 2015	6. **Waiver of Claims and Indemnity:** Permittee waives all claims against State, its officers, ag and/or employees, for loss, injury, death or damage caused by, arising out of, or in any way connected with the condition or use of the Property, the issuance, exercise, use or implemen of this Permit, and/or the rights herein granted. Permittee further agrees to protect, save, hol harmless, indemnify and defend State, its officers, agents and/or employees from any and a damage, claims, demands, costs and liability which may be suffered or incurred by State, its agents and/or employees from any cause whatsoever, arising out of, or in any way connecte this Permit, exercise by Permittee of the rights herein granted, Permittee's use of the Propert and/or the Project for which this Permit is granted, except those arising out of the sole active negligence or willful misconduct of State. Permittee will further cause such indemnification a waiver of claims in favor of State to be inserted in each contract that Permittee executes for t provision of services in connection with the Project for which this Permit is granted. 7. **Contractors:** Permittee shall incorporate the terms, conditions and requirements contained when contracting out all or any portion of the work permitted hereunder. Permittee shall be responsible for ensuring contractor/subcontractor compliance with the terms and conditions contained herein. Failure of Permittee's contractors to abide by State's terms and conditions constitute default by Permittee (see Paragraph 20) allowing State to terminate this Permit an all legal remedies. 8. **Insurance Requirements:** As a condition of this Permit and in connection with Permittee's indemnification and waiver of claims contained herein, Permittee shall maintain, and cause it contractors to maintain, a policy or policies of insurance as follows: Permittee shall maintain motor vehicle liability with limits of not less than $1,000,000 per a Such insurance shall cover liability arising out of a motor vehicle, including all owned, hire non-owned motor vehicles. Permittee shall maintain statutory Workers' Compensation and employer's liability insuran coverage in the amount of $1,000,000/employee/disease/each accident, for all its employ will be engaged in the performance of work on the Property, including special extensions applicable. Said policy shall include a waiver of subrogation in favor of State. If the Perm an individual or sole proprietor who is not required by law to have Workers' Compensatio insurance, Permittee shall provide State with a written confirmation that Permittee is not r to be, and has elected not to be, covered by Workers' Compensation. Permittee shall procure commercial general liability insurance at least as broad as the mo commonly available ISO policy form CG 0001 premises operations, products/completed operations, personal/advertising injury and contractual liability with limits not less than $1, per occurrence and $2,000,000 general aggregate. Said policy shall apply separately to insured against whom any claim is made or suit is brought subject to the Permittee limits liability.	

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Parks and Recreation (continued)	Each policy of insurance required by this provision shall: (a) be in a form, and written by an insurer, reasonably acceptable to State; (b) be maintained at Permittee's sole expense; and (c) require at least thirty (30) days written notice to State prior to any cancellation, non-renewal or material modification of insurance coverage. Insurance companies issuing such policies shall have a rating classification of "A-" or better and financial size category ratings of "VII" or better according to the latest edition of the A.M. Best Key Rating Guide. All Insurance companies issuing such policies shall be licensed to do business in the State of California. Such policies shall contain an endorsement naming the CALIFORNIA DEPARTMENT OF PARKS AND RECREATION as an additional insured at no cost to State. Permittee shall provide to State evidence that the insurance required to be carried by this Permit, including any endorsement affecting the additional insured status, is in full force and effect and that premiums therefore have been paid. Such evidence shall, at State's discretion, be in either the form of an ACORD Form (Certificate of Insurance) or DPR Form 169A (Certificate of Insurance for Concession Contracts/Special Events), or a certified copy of the original policy, including all endorsements. Permittee is responsible for any deductible or self-insured retention contained within the insurance program. Should Permittee fail to keep the specified insurance in effect at all times, Permittee shall be considered to be in default of this Permit, and State may, in addition to any other remedies it has, terminate this Permit.	

Sonoma County Water Agency
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Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Parks and Recreation (continued)	Permittee shall require and ensure that all contractors and subcontractors have adequate insurance meeting the coverage requirements in this provision. Any insurance required to be carried shall be primary and not excess to any other insurance carried by State. Coverage shall be in force for the complete term of this Permit, including any extension thereof, and for all work being done for which this Permit is required. **9. Reservation of Rights:** State reserves the right to use the Property in any manner, provided such use does not unreasonably interfere with Permittee's rights herein. **10. Access Limits and Conditions:** Access to the Property shall be limited to the access designated by State and is illustrated in Figure 2 of Exhibit "A" and as described below. The barrier beach would be accessed from the paved parking lot at Goat Rock State Beach, located at the end of Goat Rock Road off of Highway 1. Equipment would be off-loaded in the parking lot and driven north onto the beach via an existing access point within the parking lot. Additional detail is provided in the attached Russian River Estuary Management Activities. **11. Notice of Work:** Any required notices to State shall be sent to the State authorities in charge of Sonoma Coast State Park named below. At least 24 hours prior to any entry upon the Property for any of the purposes hereinabove set forth, Permittee shall provide the State contact[s] named below with written notice of Permittee's intent to enter the Property. **STATE:** Contact: Brendan O'Neil Address: 25381 Steelhead Blvd. Duncans Mills, CA 95430 Tel: 707/865-2391 Fax: 707/865-2046 **PERMITTEE:** Contact: Jessica Martini-Lamb Address: 404 Aviation Blvd. Santa Rosa, CA 95403 Tel: 707/547-1903 Fax: 707/524-3782 **12. Limits of Work:** In no event shall this Permit authorize work in excess or contrary to the terms and conditions of any regulatory agency permit or approval. Under no circumstances, whether or not authorized by any regulatory agency, other permit or any person or entity other than State, shall work exceed that which is authorized by this Permit as described in the Exhibit B, Russian River Estuary Management Activities. **13. Public Safety:** Permittee is responsible for public safety during and after the breaching operation until such time that water velocities and standing waves recede, the sandbar banks stabilize and cease to erode, cave and wash away and heavy equipment has been removed from State Park property. In the interest of public and Park visitor safety STATE reserves the right to require PERMITTEE to provide Peace Officers and/or Lifeguards, at no cost to STATE, to monitor and close the beach to the public for a distance of 750' on each side of the breach as recommended in the Russian River Estuary Study. In the interest of public safety, the preferred days for sandbar breaching are from Monday to Thursday (excluding holidays) when Park visitation is usually at a minimum. In the event of emergency situations, breaching may proceed immediately after notifying the State Park District Superintendent or their designee. **14. Compliance with Monitoring and Mitigation Measures:** Resource monitoring and mitigation measures identified within the Russian River Estuary Management Project Final Environmental Impact Report, NMFS Biological Opinion, DFG Lake and Streambed Alteration Agreement, Regional Water Quality Control Board Section 401 Water Certification, California Coastal Commission Coastal Development Permit, US Army Corps of Engineers Section 404 and Section 10 Permit, and State Lands Commission General Lease shall be completed in accordance with and to the satisfaction of the District Superintendent or designee. Permittee's activities conducted under this Permit shall comply with all State and Federal environmental laws, including, but not limited to, the Endangered Species Act, CEQA, and Section 5024 of the Public Resources Code. Any of Permittee's archaeological consultants working within the boundaries of the Property shall obtain a permit from the California State Parks Archaeology, History & Museums Division prior to commencing any archaeological or cultural investigations of the Property.	

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Parks and Recreation (continued)	Permittee shall immediately advise State's contact person if any new site conditions are found during the course of permitted work. State will advise Permittee if any new historical resources (including archaeological sites), special status species, threatened/endangered species protocols, or other resource issues are identified within the Project site. Permittee shall abide by District Superintendent or designee's instructions to protect the resource(s) during the permitted work or risk revocation of the Permit. Permittee shall make all excavation activities on the Property available to the State Archaeologist for observation and monitoring. During excavation, the State archaeological monitor may observe and report to the State on all excavation activities. State archaeological monitor shall be empowered to stop any construction activities as necessary to protect significant cultural resources from being disturbed. In the event that previously unknown cultural resources, including, but not limited to, dark soil containing shell, bone, flaked stone, groundstone, or deposits of historic trash are encountered during Project construction by anyone, work will be suspended at that specific location, and the Permittee's work will be redirected to other tasks, until after a State-qualified archaeologist has evaluated the find and implemented appropriate treatment measures and disposition of artifacts, as appropriate, in compliance with all applicable laws and department resource directives. If human remains are discovered during the Project, work will be immediately suspended at that specific location and the District Superintendent or designee shall be notified by Permittee. The specific protocol, guidelines and channels of communication outlined by the California Native American Heritage Commission (NAHC), and/or contained in Health and Safety Code Section 7050.5 and Public Resources Code Sections 5097.9 et seq., will be followed. Those statutes will guide the potential Native American involvement in the event of discovery of human remains. Permittee shall provide a written work schedule to State so that the State archaeological monitor can arrange to be on site on the necessary days. Permittee shall provide reasonable advance notice of and invite the District Superintendent or designee to any preconstruction meetings with the prime contractor or subcontractors. **15. Restoration of Property:** Permittee shall complete the restoration, repair, and revegetation of the Property in consultation with, and to the satisfaction of the State Environmental Scientist should any damage result from permitted activities. Restoration, repair and/or revegetation is required within 30 days after damage or as determined by the State Environmental Scientist. This obligation shall survive the expiration or termination of this Permit. **16. Right to Halt Work:** The State reserves the right to halt work and demand mitigation measures at any time, with or without prior notice to Permittee, in the event the State determines that any provision contained herein has been violated, or in the event that cessation of work is necessary to prevent, avoid, mitigate or remediate any threat to the health and safety of the public or state park personnel, or to the natural or cultural resources of the state park. **17. Use Restrictions:** The use of the Property by Permittee, including its guests, invitees, employees, contractors and agents, shall be restricted to the daytime hours between sunrise and sunset on a day-by-day basis, unless otherwise approved in advance in writing by State. No person shall use or occupy the Property overnight. Activities on the Property shall be conducted only in a manner which will not interfere with the orderly operation of the state park. Permittee shall not engage in any disorderly conduct and shall not maintain, possess, store or allow any contraband on the Property. Contraband includes, but is not limited to: any illegal alcoholic beverages, drugs, firearms, explosives and weapons. Permittee shall not use or allow the Property to be used, either in whole or in part, for any purpose other than as set forth in this Permit, without the prior written consent of the State. **18. State's Right to Enter:** At all times during the term of this Permit and any extension thereof, there shall be and is hereby expressly reserved to State and to any of its agencies, contractors, agents, employees, representatives, invitees or licensees, the right at any and all times, and any and all places, to temporarily enter upon said Property to survey, inspect, or perform any other lawful State purposes. Permittee shall not interfere with State's right to enter. **19. Protection of Property:** Permittee shall protect the Property, including all improvements and all natural and cultural features thereon, including cultural and natural resources, at all times at Permittee's sole cost and expense, and Permittee shall strictly adhere to the following restrictions:	

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Parks and Recreation (continued)	(a) Permittee shall not place or dump garbage, trash or refuse anywhere upon or within the Property, except in self-contained trash receptacles that are maintained to State's satisfaction by Permittee. (b) Permittee shall not commit or create, or suffer to be committed or created, any waste, hazardous condition or nuisance in, on, under, above or adjacent to the Property. (c) Permittee shall not cut, prune or remove any vegetation upon the Property, except as identified in the Project description and herein permitted or subsequently approved in writing by the District Superintendent. (d) Permittee shall not disturb, move or remove any rocks or boulders upon the Property, except as identified in the Project description and herein permitted or subsequently approved in writing by the District Superintendent. (e) Permittee shall not grade or regrade, or alter in any way, the ground surface of the Property, except as herein permitted, or subsequently approved in writing by the District Superintendent. (f) Permittee shall not bait, poison, trap, hunt, pursue, catch, kill or engage in any other activity which results in the taking, maiming or injury of wildlife upon the Property, except as identified in the Project description and herein permitted or subsequently approved in writing by the District Superintendent. (g) Permittee shall not use, create, store, possess or dispose of hazardous substances (as defined in the California Hazardous Substances Act) on the Property except as herein permitted, or subsequently approved in writing by the District Superintendent. (h) Permittee shall exercise due diligence to protect the Property against damage or destruction by fire, vandalism and any other causes. **20. Default:** In the event of a default or breach by Permittee of any of the terms or conditions set forth in this Permit, State may at any time thereafter, without limiting State in the exercise of any right of remedy at law or in equity which State may have by reason of such default or breach: (a) Maintain this Permit in full force and effect and recover the consideration, if any, and other monetary charges as they become due, without terminating Permittee's right to use of the Property, regardless of whether Permittee has abandoned the Property; or (b) Immediately terminate this Permit upon giving written notice to Permittee, whereupon Permittee shall immediately surrender possession of the Property to State and remove all of Permittee's equipment and other personal property from the Property. In such event, State shall be entitled to recover from Permittee all damages incurred or suffered by State by reason of Permittee's default, including, but not limited to, the following: (i) any amount necessary to compensate State for all the detriment proximately caused by Permittee's failure to perform its obligations under this Permit, including, but not limited to, compensation for the cost of restoration, repair and revegetation of the Property, which shall be done at State's sole discretion and compensation for the detriment which in the ordinary course of events would be likely to result from the default; plus (ii) at State's election, such other amounts in addition to or in lieu of the foregoing as may be permitted from time to time by applicable law. **21. State's Right to Cure Permittee's Default:** At any time after Permittee is in default or in material breach of this Permit, State may, but shall not be required to, cure such default or breach at Permittee's cost. If State at any time, by reason of such default or breach, pays any sum or does any act that requires the payment of any sum, the sum paid by State shall be due immediately from Permittee to State at the time the sum is paid. The sum due from Permittee to State shall bear the maximum interest allowed by California law from the date the sum was paid by State until the date on which Permittee reimburses State. **22. Revocation of Permit:** The State shall have the absolute right to revoke this Permit for any reason upon ten (10) days written notice to Permittee. Written notice to Permittee may be accomplished by electronic or facsimile transmission, and the notice period set forth in this paragraph shall begin on the date of the electronic or facsimile transmission, or, if sent by mail, on the date of delivery. If Permittee is in breach of the Permit or owes money to the State pursuant to this Permit, any prepaid monies paid by Permittee to State shall be held and applied by the State as an offset toward	

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Parks and Recreation (continued)	damages and/or amounts owed. Nothing stated herein shall limit the State's exercise of its legal and equitable remedies. 23. **Recovery of Legal Fees:** In any action brought to enforce or interpret any provisions of this Permit or to restrain the breach of any agreement contained herein, or for the recovery of possession of the Property, or to protect any rights given to the State against Permittee, and in any actions or proceedings under Title 11 of the United States Code, if the State shall prevail in such action on trial or appeal, the Permittee shall pay to the State such amount in attorney's fees in said action as the court shall determine to be reasonable, which shall be fixed by the court as part of the costs of said action. 24. **Voluntary Execution and Independence of Counsel:** By their respective signatures below, each Party hereto affirms that they have read and understood this Permit and have received independent counsel and advice from their attorneys with respect to the advisability of executing this Permit. 25. **Reliance on Investigations:** Permittee declares that it has made such investigation of the facts pertaining to this Permit, the Property and all the matters pertaining thereto as it deems necessary, and on that basis accepts the terms and conditions contained in this Permit. Permittee acknowledges that State has made, and makes, no representations or warranties as to the condition of the Property, and Permittee expressly agrees to accept the Property in its as-is condition for use as herein permitted. 26. **Entire Agreement:** The Parties further declare and represent that no inducement, promise or agreement not herein expressed has been made to them and this Permit contains the entire agreement of the Parties, and that the terms of this agreement are contractual and not a mere recital. 27. **Warranty of Authority:** The undersigned represents that they have the authority to, and do, bind the person or entity on whose behalf and for whom they are signing this Permit and the attendant documents provided for herein, and this Permit and said additional documents are, accordingly, binding on said person or entity. 28. **Assignment:** This Permit shall not be assigned, mortgaged, hypothecated, or transferred by Permittee, whether voluntarily or involuntarily or by operation of law, nor shall Permittee let, sublet or grant any license or permit with respect to the use and occupancy of the Property or any portion thereof, without the prior written consent of State. 29. **Choice of Law:** This Permit will be governed and construed by the laws of the State of California.	

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California Department of Parks and Recreation (continued) Collections Permit – September 1, 2012 Collections Permit renewal – February 26, 2014 Expiration – February 26, 2015	**PERMIT CONDITIONS:** COORDINATE STUDY WITH STATE PARK STAFF. CONTACT ONE WEEK PRIOR TO IMPLEMENTATION. SONOMA COAST LIFEGAURD SUPERVISOR; TIM MURPHY (TIM.MURPHY@PARKS.CA.GOV) SONOMA COAST RANGER SUPERVISOR; DAMIEN JONES (DAMIEN.JONES@PARKS.CA.GOV) RUSSIAN RIVER SR. ENV. SCIENTIST; BRENDAN O'NEIL (BRENDAN.O'NEIL@PARKS.CA.GOV)	No Reporting Required for Collectors Permit

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service Incidental Harassment Authorization (IHA) - April 21, 2011 IHA (renewal) - April 21, 2012 IHA (renewal) - April 21, 2013 IHA (renewal) - April 21, 2014 Expiration – April 20, 2015	1. This Incidental Harassment Authorization (IHA) is valid from April 21 , 2014 through April20, 2015. 2. This IHA is valid only for activities associated with estuary management activities in the Russian River, Sonoma County, California, including: (a) Lagoon outlet channel management; (b) Artificial breaching of barrier beach; (c) Geophysical surveys and other work associated with a jetty study; and (d) Physical and biological monitoring of the beach and estuary as required. 3. General Conditions (a) A copy of this IHA must be in the possession of SCW A, its designees, and work crew personnel operating under the authority of this IHA. (b) SCWA is hereby authorized to incidentally take, by Level B harassment only, 3,880 harbor seals *(Phoca vitulina richardii),* 42 California sea lions *(Zalophus californianus californianus),* and 42 northern elephant seals *(Mirounga angustirostris).* (c) The taking by injury (Level A harassment), serious injury, or death of any of the species listed in condition 3(b) of the IHA or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA. (d) If SCWA observes a pup that may be abandoned, it shall contact the National Marine Fisheries Service (NMFS) West Coast Regional Stranding Coordinator immediately (562-980-3230; Justin.Viezbicke@noaa.gov) and also report the incident to NMFS Office of Protected Resources (301-427-8425; Benjamin.Laws@noaa.gov) within 48 hours. Observers shall not approach or move the pup. 4. Mitigation Measures In order to ensure the least practicable impact on the species listed in condition 3(b), the holder of this IHA is required to implement the following mitigation measures:	January 20, 2015: Marine Mammal Monitoring Results Report

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Expiration		Report Due Date
US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (continued)	(a) SCWA crews shall cautiously approach the haul-out ahead of heavy equipment to minimize the potential for sudden flushes, which may result in a stampede – a particular concern during pupping season. (b) SCWA staff shall avoid walking or driving equipment through the seal haul-out. (c) Crews on foot shall make an effort to be seen by seals from a distance, if possible, rather than appearing suddenly at the top of the sandbar, again preventing sudden flushes. (d) During breaching events, all monitoring shall be conducted from the overlook on the bluff along Highway 1 adjacent to the haul-out in order to minimize potential for harassment. (e) A water level management event may not occur for more than two consecutive days unless flooding threats cannot be controlled. (f) Equipment shall be driven slowly on the beach and care will be taken to minimize the number of shut-downs and start-ups when the equipment is on the beach. (g) All work shall be completed as efficiently as possible, with the smallest amount of heavy equipment possible, to minimize disturbance of seals at the haul-out. (h) Boats operating near river haul-outs during monitoring shall be kept within posted speed limits and driven as far from the haul-outs as safely possible to minimize flushing seals. In addition, SCWA shall implement the following mitigation measures during pupping season (March 15-June 30): (i) SCWA shall maintain a one week no-work period between water level management events (unless flooding is an immediate threat) to allow for an adequate disturbance recovery period. During the no-work period, equipment must be removed from the beach. G) If a pup less than one week old is on the beach where heavy machinery will be used or on the path used to access the work location, the management action shall be delayed until the pup has left the site or the latest day possible to prevent flooding while still maintaining suitable fish rearing habitat. In the event that a pup remains present on the beach in the presence of flood risk, SCWA shall consult with NMFS and CDFG to determine the appropriate course of action. SCWA shall coordinate with the locally established seal monitoring program (Stewards of the Coast and Redwoods) to determine if pups less than one week old are on the beach prior to a breaching event. (k) Physical and biological monitoring shall not be conducted if a pup less than one week old is present at the monitoring site or on a path to the site. (1) No jetty study activities shall occur in the vicinity of the harbor seal haul-out during the pupping season.	

Agency / Permit / Expiration	Special Conditions	Report Due Date
	5. Monitoring The holder of this IHA is required to conduct baseline monitoring and shall conduct additional monitoring as required during estuary management activities. Monitoring and reporting shall be conducted in accordance with the approved Pinniped Monitoring Plan. (a) Baseline monitoring shall be conducted twice-monthly for the term of the IHA. These censuses shall begin at dawn and continue for eight hours, weather permitting; the census days shall be chosen to ensure that monitoring encompasses a low and high tide each in the morning and afternoon. All seals hauled out on the beach shall be counted every 30 minutes from the overlook on the bluff along Highway 1 adjacent to the haul-out using high-powered spotting scopes. Observers shall indicate where groups of seals are hauled out on the sandbar and provide a total count for each group. If possible, adults and pups shall be counted separately. (b) In addition, peripheral haul-outs shall be visited for 1 0-rninute counts twice during each baseline monitoring day. (c) During estuary management events, monitoring shall occur on all days that activity is occurring using the same protocols as described for baseline monitoring, with the difference that monitoring shall begin at least one hour prior to the crew and equipment accessing the beach work area and continue through the duration of the event, until at least one hour after the crew and equipment leave the beach. In addition, a one-day pre-event survey of the area shall be made within one to three days of the event and a one-day post-event survey shall be made after the event, weather permitting. (d) Monitoring of peripheral haul-outs shall occur concurrently with event monitoring, when possible. (e) For all monitoring, the following information shall be recorded in 30-minute intervals: i. Pinniped counts by species; ii. Behavior; iii. Time, source and duration of any disturbance, with takes incidental to SCWA actions recorded only for responses involving movement away from the disturbance or responses of greater intensity (e.g., not for alerts); iv. Estimated distances between source of disturbance and pinnipeds; v. Weather conditions (e.g., temperature, percent cloud cover, and wind speed); and vi. Tide levels and estuary water surface elevation. (f) All monitoring during pupping season shall include records of any neonate pup observations. SCWA shall coordinate with the Stewards' monitoring program to determine if pups less than one week old are on the beach prior to a water level management event.	

Agency / Permit / Expiration	Special Conditions	Report Due Date
	6. Reporting The holder of this IHA is required to: (a) Submit a report on all activities and marine mammal monitoring results to the Office of Protected Resources, NMFS, and the West Coast Regional Administrator, NMFS, 90 days prior to the expiration of the IHA if a renewal is sought, or within 90 days of the expiration of the permit otherwise. This report must contain the following information: i. The number of seals taken, by species and age class (if possible); ii. Behavior prior to and during water level management events; iii. Start and end time of activity; iv. Estimated distances between source and seals when disturbance occurs; v. Weather conditions (e.g., temperature, wind, etc.); vi. Haul-out reoccupation time of any seals based on post-activity monitoring; vii. Tide levels and estuary water surface elevation; viii. Seal census from bi-monthly and nearby haul-out monitoring; and ix. Specific conclusions that may be drawn from the data in relation to the four questions of interest in SCWA's Pinniped Monitoring Plan, if possible. (b) Reporting injured or dead marine mammals: i. In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by this IHA, such as an injury (Level A harassment), serious injury, or mortality, SCWA shall immediately cease the specified activities and report the incident to the Office of Protected Resources, NMFS, and the West Coast Regional Stranding Coordinator, NMFS. The report must include the following information: A. Time and date of the incident; B. Description of the incident; C. Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility); D. Description of all marine mammal observations in the 24 hours preceding the incident; E. Species identification or description of the animal(s) involved; F. Fate of the animal(s); and G. Photographs or video footage of the animal(s).	

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	Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS will work with SCW A to determine what measures are necessary to minimize the likelihood of further prohibited take and ensure MMP A compliance. SCWA may not resume their activities until notified by NMFS. ii. In the event that SCWA discovers an injured or dead marine mammal, and the lead observer determines that the cause of the injury or death is unknown and the death is relatively recent (e.g., in less than a moderate state of decomposition), SCWA shall immediately report the incident to the Office of Protected Resources, NMFS, and the West Coast Regional Stranding Coordinator, NMFS. The report must include the same information identified in 6(b)(i) of this IHA. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with SCWA to determine whether additional mitigation measures or modifications to the activities are appropriate. iii. In the event that SCWA discovers an injured or dead marine mammal, and the lead observer determines that the injury or death is not associated with or related to the activities authorized in the IHA (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), SCW A shall report the incident to the Office of Protected Resources, NMFS, and the West Coast Regional Stranding Coordinator, NMFS, within 24 hours of the discovery. SCWA shall provide photographs or video footage or other documentation of the stranded animal sighting to NMFS. IV. Pursuant to sections 6(b)(ii-iii), SCWA may use discretion in determining what injuries (i.e., nature and severity) are appropriate for reporting. At minimum, SCWA must report those injuries considered to be serious (i.e., will likely result in death) or that are likely caused by human interaction (e.g., entanglement, gunshot). Also pursuant to sections 6(b)(ii-iii), SCWA may use discretion in determining the appropriate vantage point for obtaining photographs of injured/dead marine mammals. 7. Validity of this IHA is contingent upon compliance with all applicable statutes and permits, including NMFS' 2008 Biological Opinion for water management in the Russian River watershed. This IHA may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if the authorized taking is having a more than a negligible impact on the species or stock of affected marine mammals.	

Attachment D. Russian River Barrier Beach and Estuary Water Surface Level Adaptive Management in Concert with Physical Processes

(from National Marine Fisheries Service)

Russian River Barrier Beach and Estuary Water Surface Level Adaptive Management in Concert with Physical Processes

John McKeon, National Marine Fisheries Service

To comply with NMFS' BO for adaptive management of the RR estuary, i.e., to manage the beach with the goal of conserving beach sand to allow formation of a stable low-flow season elevated outlet-channel and creating a brackish /freshwater lagoon with marine influence minimized, the Sonoma County Water Agency (SCWA) will need to balance multiple natural physical processes when carrying out flood control activities. The two primary processes to balance are: wave and longshore transport of sand into the channel, dependent on wave direction, height and steepness; and outlet channel river-flow scour determined by slope, depth and roughness. The amount of sand transported by either force is dependent on sand supply. As the channel is likely to be of sand only, the vertical elevation-controls of the outlet channel will be the sum of sand transport out of the channel at low tide by the river outflow, versus transport of sand into the channel on the incoming high tide by wave action and longshore current. As the tide lowers and rises, one of these two physical forces will predominate. Balancing the two transport mechanism rates over a 24 hr tidal cycle will be key to maintaining an over-all stable vertical outlet channel elevation and stable estuary water levels minimally influenced by tidal fluctuation. The wave-face between the low tide line and the top of the wave-face crest (height determined by wave height at high tide) will be the key area of scour and accretion during the cycle.

Calculation of scour in open flume channels is a well studied subject, with critical shear stress of when sediments are mobilized on the channel bottom a function of grain size, water velocity and depth. Velocity is determined by roughness and slope. Channel dimension, slope and roughness can be calculated for predicted flow ranges to minimize sheer stress, bed mobilization, scour, and incision of the channel. However, slope across the wave face will be determined by the beach profile where the river outflow meets the ocean. This is the likely point at which channel headcutting would begin, resulting in significant lowering of the outlet channel elevation and estuary water surface elevation (WSE). Because SCWA cannot influence the slope of the wave face beach profile, strategies to minimize scour potential are limited to: 1) choose a river channel outlet location across the wave face where the beach profile has the least slope between the low tide line and wave-face crest height, and 2) minimize depth with increased channel width across the crest of the wave face. This will both limit scour on the outgoing tide, and increase wave transport of sand into the mouth with a greater length of wave break pushing sand into the channel on high tides. Also, to limit propagation of any headcutting precipitated at low tide, the velocity in the channel above the wave face can be decreased with increased roughness and length, or the depth (and scour potential) decreased by increasing the outlet channel width. The beach size and configuration at the time of closure, and the jetty, will constrain, and in part determine, these three channel characteristics.

However, if flood threats and subsequent breaching actions are to be avoided, minimization of scour in the channel and across the wave face needs to be balanced against the ability of channel outflow to remove the predictable transport of sand into the channel by wave and longshore transport, both of which significantly increase during a beach building event and result in a channel closure event.

Transport of sand by waves on to a beach (and into the outlet channel) occurs when wave height compared to wave length reaches a critical point, which is called critical steepness, expressed as Critical H/L. JW Johnson determined critical steepness in the laboratory as = 0.03; waves with a lower H/L value moved sand offshore, those with a higher value moved sand onshore[2]. Wave length is directly proportional to wave period. Using the acceleration rate of gravity, 32/ft/sec/sec= g; and pi for rough approximation of wave form as sinusoidal, $L = g/2pi^* T^2$ or $5.12T^2$ (*e.g.,* 13 ft waves, 9 second period; 9 squared*5.12= 414.72; 13/414.72= 0.0314, steep enough to accrete, or 9 ft waves, 7 second period; 7 squared*5.12= 250.88; 9/250.88= 0.0359).

Because of the coastal aspect of the RR beach and the presence of headlands to the north and south, wave direction is important in determining the height of waves which reach the beach. Wave direction and size also determine the strength of the longshore current, and thus the rate of channel infilling on an incoming tide. The larger the waves, and greater the angle of wave incidence away from perpendicular to the beach, the stronger the longshore current and amount of sand transport.

The incidence of the outlet channel to the wave-face crest will be critical in limiting channel infilling by wave action during a beach building event. When a beach building/closure event is occurring, at high tide waves will be delivering and depositing sand up and over the wave face crest into the mouth of the channel at a rate much greater than the ability of the relatively low flow of the channel to transport sand in opposition to the direction of wave transport. However, a channel behind the wave-face crest and close to perpendicular to the wave direction will be more capable of transporting the sand washed into it by wave action, as flow from the wave will be entrained in the flow of the outlet channel, with the added flow increasing the transport power of the outlet channel. Thus, by orienting the outlet channel near to perpendicular to wave run-up direction, the out-flow channel will be better at limiting or preventing accretion of sand in the channel mouth by successive waves than if the channel is parallel to the wave run-up direction. Strategies for minimizing accretion of sand in the lagoon outlet channel mouth during a beach building event, and limiting likelihood of outlet channel closure events will be: 1) choose a river channel outlet location where the beach profile has the least slope between the low tide line and wave-face crest height, as less slope will mean a greater distance for waves to expend their energy before topping the wave crest, and/or the lower wave-face crest would signify an area of reduced wave size and transport capacity; 2) align the channel from the lagoon outlet, and behind the wave-face crest, to be as near to perpendicular as possible to wave run-up direction in order to minimize sand accretion at the channel mouth during high tide.; 3) insure there is sufficient slope from the lagoon WSE to the point the channel crosses the wave-face crest sufficient to maintain flow across the wave-face crest when waves push the crest above the high tide line (~ 3.3 ft NGVD with a 6 foot high tide). This means planning for the outlet channel invert to be above the lowest point of the wave-face crest height.

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[2] Willard Bascom. 1980. *Waves and Beaches.* Anchor Books Edition. ISBN: 0-385-14844-5

Channel Planform and Slope

In addition to the above described means to balance scour and accretion in the channel mouth and across the wave face, the channel planform will be dictated by beach topography. The entire beach topography above the tide lines is determined by waves and longshore current that will continue to sculpt the beach once the outlet channel has been established. To avoid repetitive heavy equipment excursions on to the beach to reform the outlet channel, the beach topography should dictate both the channel planform and slope of the outlet channel. To determine the most natural channel planform and slope, *i.e.*, the planform location and slope that will most likely be maintained by wave and tidal action subsequent to formation of an outlet channel by SCWA, a detailed topographic survey of the beach will need to be prepared post lagoon-closure, and prior to beach and estuary WSE management actions.

Natural Analogues

When waves reach critical steepness and sand accretion occurs on the beach, the underwater sand bar just outside the wave break is moved onshore with the incoming tide. The beach increases in both width and height, which results in a lengthening of the outlet channel as it has a greater width of beach to cross, and behind the wave-face crest, flows longitudinally along the beach to the lowest point of the crest. The increased length of the channel results in more resiliency to scour and incision during low tide and allows for stabilized lagoon WSE, with tidal influence becoming muted. Lacking subsequent beach building events, the channels may scour back down below the high tide level within weeks, reintroducing tidal influence to the lagoon WSE. However, with continued or subsequent beach building events, the channel continues to elevate and lengthen, and with river inflows declining in spring/summer, the channel loses its ability to incise, and a closed of perched lagoon WSE eventually results.

A short duration event of critically steep waves and beach building occurred along the California Coast the week of May 27th to June 3, 2010. Attached are photos of these river mouth beaches and the channels that resulted from that short duration beach building event. A WSE stage monitor in the Carmel lagoon recorded the effect on lagoon WSE, in which subsequent to the event and the lengthening of the channel, the WSE of the lagoon was maintained above the high tide level and tidal influence became muted. Photos included are of Carmel, San Lorenzo, Scott, Waddell, Pamponio and Navarro river beaches. A plot of the Carmel lagoon WSE for June 2010 can be viewed at http://www.mpwmd.dst.ca.us/wrd/lagoon/webplots/2010/2010webplots.htm

CARMEL, 6/9/2010

San Lorenzo, 6/10/2010

Scott Creek, 6/10/2010

Waddell, 6/10/2010

Pamponio, 6/10/2010

Navarro, 6/6/2010

Navarro, 6/6/2010

Navarro, 6/6/2010 (high tide-/Lagoon WSE ~ 6-7 feet NGVD estimated)

Navarro, 6/6/2010

Attachment E. Implementation of the 2010 Outlet Channel Adaptive Management Plan!

!

At the direction of NMFS, Sonoma Count/ !Water Agency (the Agency3 has been tasked with creating an outlet cˆannel intended to)&prove salmonid habitat in the Russian River Estuary while &aintaining the current level of flood protection for properties adjacent to the estuary! (NMFS, 2008). The adaptive &˙˝˙ gement plan, described in the!&ain bo(/ of this report, was developed by the Agency with assistance fro&!ESA PWA and the resource agency management team in 2009 ˙nd revised in 2010. Because of permit constraints, the Agency!5 as onl/ able to)&plement the plan beginning in %° °˛!!This att˙ ˆ ment documents the &anagement actions)˝! response to inlet closures that occurred during the 201°!lagoo˝!&anagement period.!

!

During the management period, Ma/ ! 5th to October 15th, Agency staff regularly!&onitored current and forecast estuar/ water levels, inlet state, river discharge, tides, and wave conditions to anticipate inlet closure. For the first mo˝th and a half, river ( )scharge was somewhat larger than historic dail/ !&edian conditions due to a wetter8than-average spring, but then receded to nearly replicate historic median flow rates. Average monthly wave ener1/ !)n 2010 was si&)˘˙r to historic averages for most of the m˙nagement period a˝(!ˆ)1 ˆer for!9une and October. Two periods of inlet closure occurred (Figure 1), leading the Agency to begin planning for management action to create an outlet channel, in accordance with the p˘˙˝: s communication protocol: !

!

- Starting in late June 2010,!pˆ/ sical conditions at the &outh of the Russian River Estuary! naturally established an outlet channel that persisted for a week!4efore wave action co&pletely closed the lagoon. In response to this closure, the Agency attempted to create an outlet channel for the first time. This m˙nagement action briefly re&established outlet channel conditions, but within a!ˆ˙ ˘*!(˙/.!5 ave a tion re&closed the outlet cˆanne˘˛!! Before the next scheduled management action could t˙ e place, the lagoon breached, returning the estuary to ti(al conditions.!!!
- The estuary closed twice more in the management period, during the third week of September and again at the start of October. Although action to create an outlet channel was initially!considered after the Septem4er closure, an extended period of large waves ˘)&ited beach access due to safety concerns. As a result, water levels continued to rise, heightening flood risk. Therefore, in consultation with the resource agency!&anagement team, the Agency decided to implement full breaching. Two attempts were required for each closure before the lagoon was successfully breached.

!

The next section of this attach&ent reviews the process for leading up to!˙˝(!(uring the Jul/ ! outlet channe˘!)&plementation. In the following section, the September and October closures are assessed. Although the September and October closures did not result in creation of an outlet channel, the planning process and physical processes are relevant to adaptive management. The last section summarizes lessons learned!from the 2010 m˙˝˙1 ement period to consider in subsequent years.

!

JUNE-JULY 2010 OUTLET CHANNEL EVOLUTION

!

In the second half of June, an outlet channel and perched lagoon were naturally established at the &outh of the Russian River. For about one week, this cˆ˙ nnel conveyed e˝ oug ˆ !5 ˙ ter to the ocean to sustain 4.5 to 5 ft!+@A7!water levels in the lagoon. Once waves closed the outlet channel and lagoon water levels began to rise, the Agency!)&plemented!˙!&˙ nagement action to create an outlet channel. In the face of strong waves, this outlet qui ly closed. Several days later, the lagoon was breached and tidal con()tions returned until September¸!!7etails of this channel evolutio˝!˙ re provided belo5¸!

NATURALLY ESTABLI- HED OUTLET CHAN+ EC!

!

Outlet channel conditions (defined as a nearly steady lagoon water levels above ocean water levels a˝(!& ˙ intained b/! u˝)&directional outflow in!˙ ! ˆ ˙ nnel passing through the beach berm3! naturally established over a week-long period in late June. The ph/ s) ˙˘! onditions associated with this evolution are described below.!

Water level !

Water levels in the lagoon, as observed at!the Jenner g˙ ge, exhibited a muted tide range, indicative of partial c˘osure, starting on June 20th as shown in Figure 2a. The tide range gradually! decreased from!about 1.5 ft until ti(˙˘!#˙ riations ceased early on the morning of June 27th¸!! Lagoon water levels then increased over the next!(˙ / !to just over 4 ft NGVD. Water levels were then fairly constant at about ?!ft NGVD for three d˙/ s¸ On June 3°th, the water levels started to decline, probably due to the drop in upstream!riverine discharge as co&pared to higher outlet channel d)scharge. Water levels declined to!˙!&)˝)&um o*!'!ft NGVD before the channel closed on Jul/ !?th¸!

Ocean waves and tides!

Significant w˙ ve height at CDIP's Point Reyes buo/!)ncreased above!%!&starting on June 24th as shown in Figure 2b. About the time that tidal influence disappeared from!lagoon water levels on June 27th, the significant wave height exceeded 3 m!and sta/ e(!˙ bove 3 m until Jul/ ! st. Peak! wave period during this ti&e period was approxim˙ tely 8 seconds and the peak direction was from!the northwest. Figure 3 illustrates the wave direction, perio(.!˙˝(!& agnitude fro&!June 16th! throug ˆ!9ul/! ? th. Astronomic tides were declining fro& pe˙ spring levels, with the hig ˆ er h)1ˆ! water on June 2Eth of just over 3 ft NGVD as shown in Figure 2c.

Riverine discharge!

Riverine discharge in late June was higher than to median conditions because o*!late season precipitation and full reservoirs. Figure 2d illustrates how flow dropped rapid˘y from 325 ft'/s on June 2Eth to 225 ft'/s on!9une 30th¸!!,˘ow then continued to drop!&ore slowly ˙ t a!rate of less than 5 ft'/s per day for the next two weeks.

Planform!˙˜)1nment!

At the time of closure, the channel exited the northwest corner of the lagoon and ran along the foot of the bluff, landward of the berm crest, for approxim˙tely 550 ft. The channel then crossed the berm!˙nd exiting to the ocean. This alignment was similar to the alignment observed during 1998, an El Nino / ear (personal communication, C. Delaney). Several days be*ore the closure, the cˆannel was observed further south than its a˜)1˝&ent a˜ong the bluff once tˆe outlet cˆannel established. Unfortunately, the Agenc/ :s autom˙te(! camera d)(!˝ ot collect pictures between 9une 23-29 due to!a power failure, precluding!˙!&ore detailed analysis of the channel's planform! evolution in the days preceding the establishment of the outlet cˆannel. !

Beach a˝(! hannel topograph/ !

The beach berm north of the outlet channel and the downstre˙& !end of the channel was surveyed 4/ Agenc/ staff o˝ Ju˜/ ! st (Figure 4). The presence of seals on the beach to the south o*the channel prevented additional survey data from being collected. On both sides of the channel's &outh, sand had deposited!such the intertidal beach protruded approxim˙tely 5°!feet into the ocean as compared to the beach align&ent further south (Figure 4 and Figure 5a). Just north of the outlet channel, the beach face that had been covered b/ !wave runup during the previous hi1ˆ! tide extended up to 8 ft N@A7¸!!˜hen the beach profile stepped up to a bench with elevations above 10 ft NGVD. South of the channe˜.!the berm crest elevation was esti&ated to approxim˙tel/ !Eft NGVD, but was not measured d)rectly. The outlet channel was approximately! 60 ft wide, with its bed elevation at 0-1 ft NGVD for last one hundred feet before it entered the ocean. The channel flowed around numerous large boulders along!&uch of its length. These boulders m˙/ have served as natural grade control inhibiting erosion.!

Channel discharge!

On June 30th.!the A1ency collected water depths a˝(! point #elocities in the outlet cˆannel.!5ˆ) ˆ! was approximately 60 ft wide. Water in the outlet channel flowed at depths up to 2.7 ft and velocities of at least 5.4 ft%/s. These velocities are in excess of per&issible scour criteria for beach sands, but not sufficient to scour the larger boulders found in the outlet cˆannel (Fischenich, 2001). Integrated water depth and point velocity measurements yielded an estimate the channel's discharge of 297 ft' /s (SCWA unpublished observations). As shown in Figure 2d, this (ischarge magnitude was observed upstream!at Guerneville approxim˙tely two days earlier and was larger than the concurrent Guerneville discharge. This is consistent with the dropping water levels in the lagoon (Figure 2a) and tributar/ !)˝*˜ows downstream!of Guerneville.

!

WAVE-INDUCED OUTLET CHANNEL CLOSURE

!

After the week of sustained outlet channel conditions, the wave energy briefly relaxed on July 2˝(.! and then returned to significant wave heights from the northwest exceeding 3.5 m!starting on July ' rd (Figure 2b). This increase in wave height was acco&panied by!˙˝ increase in northwest swell wave period to approximately!10 seconds. This increase in wave energy provided enough landward sand transport to close the outlet ch˙nnel. Riverine discharge had recently declined, reducing the hannel's a4)˜ity to clear s˙˝(!˙ nd remain ope˝˛!!This losure occurred during!˙!˝eap tide, when higher h)gh water levels just b˙rely exceeded 2 ft NGVD. !

!

Changes to the wave cli&ate continued for the next several d˙/ s, with the peak!(irection shifting to the south and the wave period lengthening to nearly 14 seconds!2Figure 3). Significant wave height dropped to less than 1.5 m. This long-period, ˜ow-steepness swell is likely to have built the beach berm!with onshore sand transport. This likely onshore transport changed the beach topography! hanged in two!5˙/ s. The protruding s˙nd deposits at!the channel's!&outh noticeably ()&inished in size between Ju˜/ !?th!˙˝(!9 uly 5th.!˙˝(!5 ere essentially gone by Jul/ !Fth. In addit)on, the onshore transport proba4˜/ !4uilt the berm crest elevation from the estimated berm crest elevation of 7 ft NGVD on Ju˜/! st (C. Delaney3!˙˝d July!?th (J. Largier) to an elevation of 8.5 ft NGVD as surveyed on Jul/ !8th˛!!

!

Once the outlet channel closed, lagoon water levels began to rise at a rate of approxim˙tely 0.5 ft/day. The channel closure and rising water levels initiated the Agency's outlet channel management plan. !

!

MANAGEMENT ACTIO+!

!

Management action to create an outlet channel was scheduled for Jul/ !8th in consultation with the resource management team. Tˆe action was scheduled for Ju˜/ 8th because it was a Thursday, the last day that action could be taken before the State Parks permit restrictions on Friday8-unda/! operations went into effect. Given the observed rate of lagoon water level rise o*!°˛5 ft/da/ .! waiting until the following Monda/!5 as deemed to be too risky in ter&s of flood hazard a˝(! channel scour. To provide operational flexibilit/ !)n response to site conditions, two different management options were proposed during planning. Figure 4 shows the alignment of these options, botˆ!'°! ft wide, as laid on the topographic sur*ace collected on Jul/! st. This schemati ! design was used to discuss management plans with the resource agencies, to esti&ate volu&es o*! excavated &aterial, and to guide operations staff. Option A, the preferred option, followed the northwest alignment of the natural outlet channel prior closure. In the event that beach surveys indicated a low point in the!4er&!further south or if access to the Option A location was restricted 4/ waves, Option B was proposed just north of Ha/ st˙ Rock˛!!

!

Based an assessment of site conditions early on the morning of Jul/ !8th, Option A was selected for)&plementation. Excavation be1˙n at approxim˙tely E˙& on Jul/! 8th with a bulldozer a˝(! 4˙ hoe excavator. The lagoon water level at the time work began was 5.9 ft NGVD.

!

The excavated portion of the managed channel follo5 ed the alignment of the southern half of the naturally established outlet channel, as shown in Figure 5b. This alignment allowed the excavation equipment to ˙void roc s embedded in the berm. The backhoe remo#ed sand from!the landward portion of the berm.!adjacent to a large rock. The bulldozer pushed sand towards the ocean to form the lower portion of the channel. A s&˙˜˜!4erm!was preserved between the two pieces of equipment to prevent lagoon outflow before the channel was co&plete. After

approxim˙tely two hours of work, wave runup associated with the rising tide started to enter the channel's mouth. Therefore, the middle ber&!5˙ s removed with the excavator at approxim˙te˘/ ! 9:30am.! ompleting the cˆ ˙nnel. !
!
At the time of completion, the outlet channel was approxim˙tely!' °!ft wide and had an invert o*! approxim˙tely 4.5 ft NGVD. Water flowed in the channel at a depth of approximately 0.5 ft. Flow was t/ p) ˙˘˘/ uniformly seaward in the upstream portion of the newly ex ˙vated channel. However, in the downstream portion, wave runup periodically over5 helmed the outflow, c˙using the flow to switch direction to landward. The transition between the existing channel and the newly excavated portion created a h/ (raulic control across which water transitioned from! subcritical to supercritical, thereby explaining the channel's lower water level as compared to the lagoon. Bed erosion was observed starting from!this transition region and into the new portion. !
!
During the period when the outlet ˆ ˙˝˝ e˘!5as ope˝.!5 ater levels in the lagoo˝!continued to increase at a s)&ilar rate to the rate before the &anagement action. This constant rate of water level increase indicates that flow in the outlet channel was relatively sm˙˘˘ co&pared to riverine inflow to the lagoon. !!
!

OUTLET CHANNEL CLOSURE!

!
As ocean tides increased water levels throughout Jul/ 8th, the w˙ve runup fro&!the south swell advanced up and over the beach face, as evidence(!4y the absence of equipment tracks on the beach in Ju˘/ 9th photo1raphs˛!!6y the e#ening of Jul/! 8th, this a(#˙˝)˝1!5 ave runup transporte(! enough s˙˝(!)˝to the outlet channel that the channel once a1˙)˝! losed. Higher hi1ˆ!5 ater on the evening of Ju˘y 8th was above 3 ft NGVD, as tidal conditions were building towards large spring tides.
!
After reviewing lagoon a˝d be˙ ˆ! onditions on Ju˘/! 9th, the A1ency scheduled follow&up management for Monda/.! 9uly 12th, the first d˙/ !5ˆ) h the/ were allowed to operate on the beach under their St˙te Parks permit.

BREACD;+ G TO TIDAL!˘ ONDITIO+ -!

!
Lagoon water levels continued to rise at a rate of!˙pproxim˙tely 0.5 ft/da/ in the days followin1! closure. On the evening of!9ul/! th, the!lagoon breached in the vicinit/ !of Ha/ st˙ Rock. The lagoon water level at the time of the breach was 7!*t NGVD, which is approxim˙tely! ˛5 ft below the berm crest elevation surveyed on July 8th˛!!˜his difference suggests that the breach may!ˆ˙#e been caused 4/ !seepage through the ber&. Just before the breach, the water's edge extending towards the breach site, indicating that breach occurred at the low point in the beach berm:s crest elevation.
!
Because the estuary returned to ti(al conditions on Jul/! th, the m˙nagement action planned for! July 12th was cancelled. Tidal conditions persisted in the estuary until September.

!

SEPTEMBER-OCTOBER 2010 CLOSURES AND MANAGEMENT

!

In the end of August, coincident with ne˙p tides and increased wave heights, the estuary water levels became muted, diminishing to a ti(e range of less than one foot (Figure 6a). Shortl/! afterwards, starting o˝ Septem4er 4th.!5˙ve energy increased considerably fro&!the northwest (Figure 7b) to sustained wave heights exceed)˝1!'!& and peaking above 4 m!2Figure 6b). This! co&4ination of muted tides followed by large waves, would seem!to have been ideal conditions to prompt closure. However, the inlet stayed open throughout this high wave period. Several factors probabl/! ontributed to the inlet's persistent ope˝)˝1˛!Although lar1e in height, the w˙ves' period was relatively short (below 12 seconds) and fro&!the northwest. Because of the beach faces the! southwest, it may!4e partially sheltered from!waves out of the northwest. The tides were transitioning from neap to spring, so the increasing tidal prism!would have contributed to scouring the inlet's channel˛!0˙# e overtoppin1 also &˙/!ˆ˙ ve contributed to!maintaining in˘et b/! adding water to the estuary that then flowed out the inlet, s our)˝1!the cˆannel. !!

!

After the &uted tides in early Septem4er,!full tide range returned to the lagoon, probabl/ assisted 4/ the arrival of larger spring tides. Around Septem4er 18th, during the month's!second neap tide, another wave event was observed with significant wave height less than 2 m, nearly half the magnitude of tˆe early Septe&4er event (Figure 6b). However, the wave period was longer, 16-18 seconds instead of 8-10 seconds, and waves were from!the south instead of the northwest. These conditions closed the estuary on September 21st˛!!!

!

After the inlet closed on Septem4er 21st, planning to establish an outlet channel began. Based on the most recent beach topography, tˆe projected rate of lagoon water level increase, ti(es, and wave forecasts, Septem4er 28th, was selected for an attempt at creati˝1!˙˝ outlet channel. Two options for the channel were proposed, o˝e extending to the nortˆwest fro&!the edge of the lagoon, and one just south of Haystack Rock where the inlet had been just before closure. Lagoon water levels were above 6 ft NGVD b/ the 28th, as anticipated, in part due to wave overwash. Although water levels were rising, runup fro& large waves &˙(e beach access unsafe and operations were postponed to September 29th. Unsafe wave conditions persisted on the 29th.!˙1˙)˝! preventing beach access. Si˝ce wave forecasts predicted o˝˘/ a brief lull on the next da/ before large waves returned and weekend access restrictions loomed, the Agency, in consultation witˆ! the resource agency management team, decided on tˆe evening of!0 ednesday, September 29th, to switch fro& attempting to create an outlet channel to attempting a full breach.

!

Wave and tide conditions on the &orning of September 30th allowed for beach access an(!˙!*u˘˘! breach was i&p˘emented. However, waves carried o˝!the rising tide re-closed the inlet that afternoon and lagoon water levels continued to rise. A second attempt at breaching the afternoon of the 30th was cancelled because of unsafe wave conditions on the beach. Because of the)&pending flood risk!29 ft water levels were projected by Sunday, October 3rd), the Agency! sought and received permission from State Parks to access the beach Frida/ , October 1st. The

breach on October 1st was successful, helped b/ !extensive scour coinciding with tides dropping to lower low water during the night. Estuary water levels dropped to 1 ft NGVD on October 2˝˙(˛!!
!
After a brief lull, wave conditions once again intensified and the)˝˘et closed again on October 4th˛! Although still within the management period, the proximity to the end of the m˙˝ agement season, as well as continuing forecasts for high waves, led the Agency to propose and receive permission from!the resource agency management team for a full breach. Breaching was attempted on October 1 th, when lagoon water levels had exceeded E!*t NGVD. This attempt failed as waves pushed sand into the breach before it could enlarge and lower lagoon water levels. A seco˝(! breach attempt was &˙de on the afternoon o* October 12th, successfully creating a sustained breach that lowered estuary water levels to tidal conditions. A third closure occurred o˝ October % st and self breached on October 24th, p˙rtly!)n response to high r)#er discharge. Although this third event was outside the outlet channel &˙nagement period, it was indicative of the extended period of large!5aves during Septem4er and October 2010˛!
!

LESSONS LEARNED AND RECOMMENDATIONS

!
Based on observations of the estuary, associated physical processes, and the July 8th outlet channel m˙nagement action, we note the following lessons about i&plementing the outlet cˆannel management plan.!

CONCEPTBAL MODEL!

- All four closures discussed above occurred coincident with noticeable wave ener1/ ! associated with periods greater than 12 seconds. In fact, a long period, but relatively!˘o5! wave height (less than 2&) event closed the inlet in the third week of Septem4er even though a larger wave heigˆt, but shorter!period wave event two weeks earlier did not close the inlet. In all but!one case, the long period waves which caused closure originated from!the south or west.
- When wave runup started to progress into the outlet channel and force operations to end, it was decided to favor a deeper outlet channel o#er a wider outlet channel. Channel depth was sought to facilitate!&ore discharge from!the lagoon to counter incom)˝1! waves. We recommend continuing to observe channel/ocean dynamics in subsequent outlet cˆannels to inform!tradeoff decisions of this nature.!

!
FEASIBILIT"!

- ;˝!ˆ)˝ (sight, a better opportunit/ !*or establisˆ)˝1!˙ ˝ !outlet cˆannel!)˝!9ul/!!&ay have been Jul/! ° th or the morning of Jul/! th.!5ˆ en!the lon1!perio(!south!swell ˆ˙(!su4sided! but before the breach occurred. However, based on available information (wave forecasts and no nowledge of the breach) tˆe &˙nage&ent action was enacted earlier, on July 8th.! because the following days were Friday through Sunday when State Parks restricts beach access. Future outlet channel management opportunities are likely!to face si&)˘˙rly! constrained time windows: too soon after closure, the wave conditions which caused closure &˙/ !prevent safe beach access ˙˝(! lagoon water levels wi˘˘!4e less than the BO targets; too late after closure and water levels &˙/ cause flooding or overtopping the beach ber&. In addition to the State Parks weekend access constraints, operations are constrained b/ IHA rules, particularly!4efore June 15th when pupping season ends.

- If the rocks em4edded in the beach are essential for stabilizing against failure by scour, then the elevation of the roc s will largely determine the outlet channel bed elevation and lagoon water level. During the naturall/! established outlet channel which occurred from! June 27th through July 3rd, the channel's bed elevation just before the beach face was 0-1 ft NGVD (9uly 1st Agency survey) and the lagoon water level was between 4.5 and 5 ft! NGVD. Under these conditions, the outlet channel was able to convey approxim˙tely! 300 ft'/s.
- If an outlet channel had been in p˘ace at the start o*the September-O tober large wave period, it quite likely woul(have closed since waves frequentl/ overtopped the beach berm and even some full breaches were quick˘/ closed. If the lagoon water level was close to or at the BO target!Eft NGVD 5ˆ en the closure occurred an(!4each access was ˘)&ited by wave conditions for multiple days, e.g. the five day period from Septem4er %Fth to Septem4er 3°th, the lagoon woul(!˘) el/ !have reached flood stage.
- Management actions attempting full bre˙ ˆ)˝1.!5ˆ) ˆ!˙)& !to convert the inlet between two of its stable modes (breached and closed)!˙˝(!5ˆ ich are informed b/ decades o*! management experience, st)˘˘!*˙)˘quite regularly. For e<˙&ple, in 2010, two of four breach attempts were unsuccessful and historically, one out of every three attempts have been unsuccessful (Behrens et al., in prep). We anticipate that the failure rate of efforts to create an outlet channel, a less common and less stable transitional state, to be at least as frequent, if not more frequent, than the failure rate for full breaches.

!

COMMUNICATION

- Continue the practice of developing!˙˝(! communicating a!4˙ up p˘an for the outlet channel management action in the event that surf conditions were unsafe at the preferred channel location. Communicating this b˙ up plan ahead of time allowed time for discussion a&ong the resource m˙nagement team. reducing the potential for last minute disagreement if this opt)on had to be e˝˙ cted.
- Agency, NMFS, and ESA PWA staff consulted as to the specifics of the outlet channel)&plementation immediately before and during the excavation. This discussion was necessary!because of uncertaint/ about the actual beach topography, the excavation progress relative to the tides.!and the overall development of outlet cˆ˙nnel strategy for this initial implementation. It enabled real-t)&e adaptation to on-site constraints. For instance, the excavation's location was shifted slightly south of the prior cˆannel:s location to avoid large rocks known to be!ˆ)dden within the berm. After following this alignment beyond the rocks, the excavation was guided nortˆward so that the mouth of the outlet channel would be as close as possible to the prior location. !
- After each &anagement action, we suggest ask)ng State Parks staff if operations had gone)˝!˙ccordance with their e<pectations with regard to park)˝1!˘ot use, public safety, s˙˝(! placement, etc.

!

STAFFING!

- The A1ency's engineer on site had broad k˝owledge of the project objectives a˝(! operational constraints, e˝˙ 4˘)˝1!ˆ)& !to engage in dis ussion with the other on-site personnel (particularly the NMFS representative), observe physical conditions, and m˙ e real-time decisions about the outlet channel configurat)on. This presence and decision-&˙ ing authority was essential since the management action was onl/ defined ahead of time as a strate1/ .!˝ot construction-grade drawings.
- Develop capacity of other Agency staff to m˙ ˝˙1 e outlet channel operation so availability! of informed decision-m˙ ers does not hinder m˙nagement operations.!
- Although equipment operators were new to the site, they adeptly executed outlet channel design as directed by Agency staff. Encourage the contractor to provide staff familiar with the project whenever possible.
  !

EQUIPMENT AND OPERATIONS!

- The backhoe excavator was &ore adept at operations adjacent to rock, the bulldozer was faster for areas with open sand. Particularly!)f operations occur o#er two d˙/ s, consider choice of equipment. For e<˙&ple, on the first da/. ! hoose two bulldozers for speed in excavating a larger channel and replace one bulldozer with an excavator on the seco˝(! (˙/ !for more precise operat)ons.!
- Tides, day˘)ght, and permits all restrict the time available for operations. To m˙<)&ize time available for implementing m˙ ˝˙1 e&ent actions.! onsider the following procedures:!
    - When possible, have key resource &˙ ˝˙1 e&ent team mem4ers discuss the operations pl˙n ahead of time, ideally on-site the day before, or by phone if on-site is not practical.
    - Clarify staging procedure between equipment operators and engineering staff to reduce waitin1!!
    - Consider the use of lights to enable equipment to oper˙te under low8light conditions.
- Because rocks limit the outlet channel's alignment; having survey staff on-hand to stake locations of rocks covered b/ !the sand was useful. Agency surve/ s should continue to &onitor rock locations duri˝1!&onthly surve/ s. !
- Equipment operators demonstrated good coordi˝˙ tion between the pieces of equipment, with neither piece idle for an extended period. The two pieces smoothl/ switched the two primary!tasks o*! ˆannel excavation an(!*eathering excavated &aterial o˝ to the beach face.!
- Sand cleared from!the outlet channel was left as a temporar/ !berm!˙t the &outh of the outlet cˆannel to impede wave runup into the outlet ˆannel. This berm was re-shaped just before finishing to open the outlet channel while still providing some protection from! south swell.

!

MONITOR;+@!

- Because the IHA li&its the d˙/ s available to p˘ace people on the beach to collect data, use the full two days allotted for outlet ˆ˙ nnel creation to collect additional dat˙. For instance, consider having the survey team return at 12-hr intervals to take photographs and surve/ channel b˙thy&etry!˙˝(!( )scharge.
- Consider an alternate automated ˙& era placement to capture!the northern portion of the beach.

!

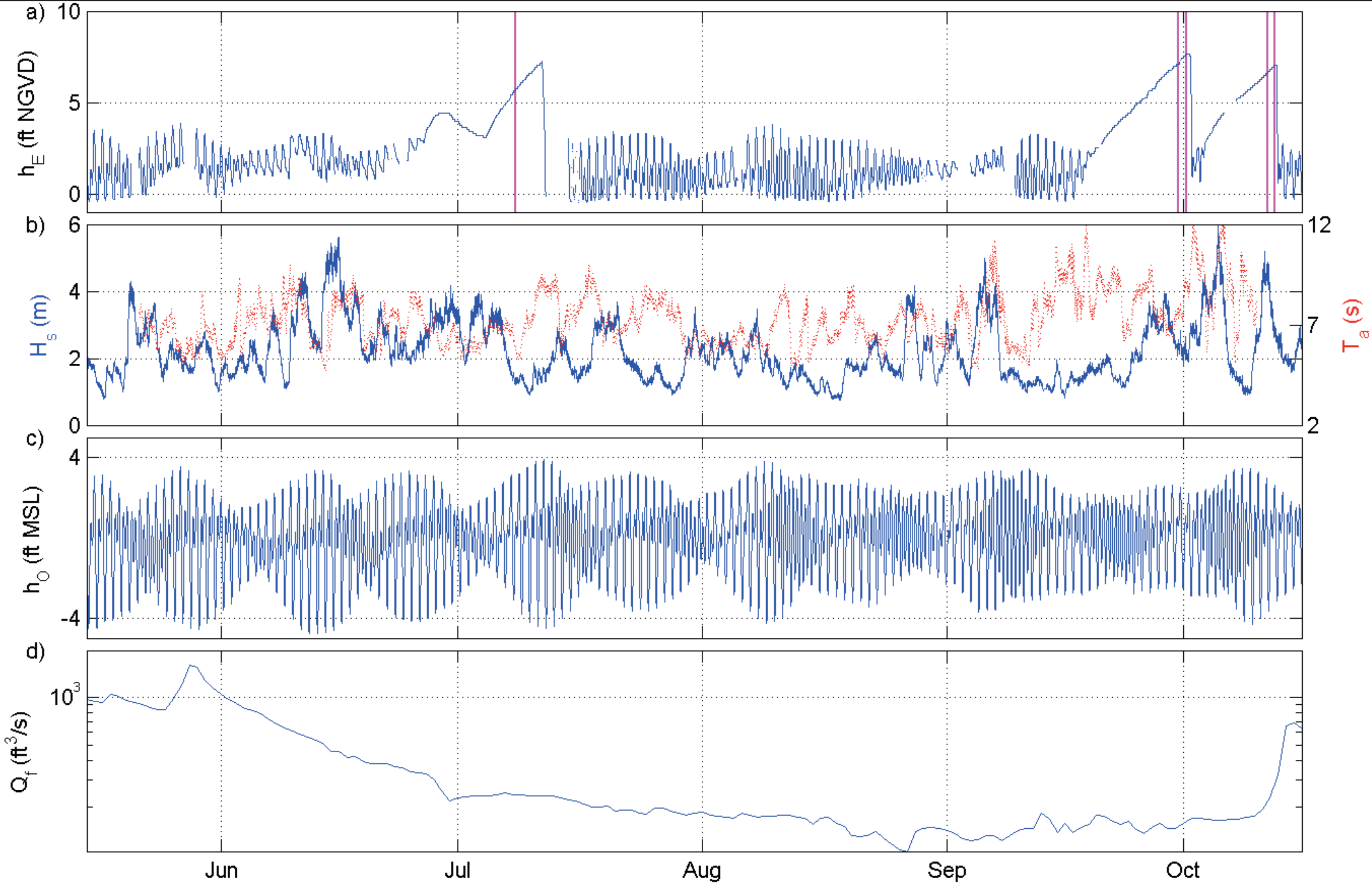
!

REFERENCES

!

Behrens, D.K., F. A. Bombardelli, J. L. Largier, and E. Twohy. in preparation. Natural and human influences on tidal inlet closure in small bar8built estuaries

Fischenich, C. 2001. Stability thresholds for stream restoration m˙terials. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-29). U.S. Arm/ Engineer Research and Develop&ent Center, Vicksburg, MS.



Sources:
a) h_E=estuary water level (SCWA); pink bar = mmgt action
b) H_s=sig. wave height; T_a=avg. wave period (CDIP, Pt. Reyes, #029)
c) h_O=ocean water level (NOAA, Pt. Reyes #9415020)
d) Q_f=river discharge (USGS, Guerneville #11467000)

Figure 1
Russian River Estuary Outlet Channel Management Plan

Estuary and Ocean Conditions, May 15 - October 15 2010

PWA Ref# 1958.01

ESA PWA

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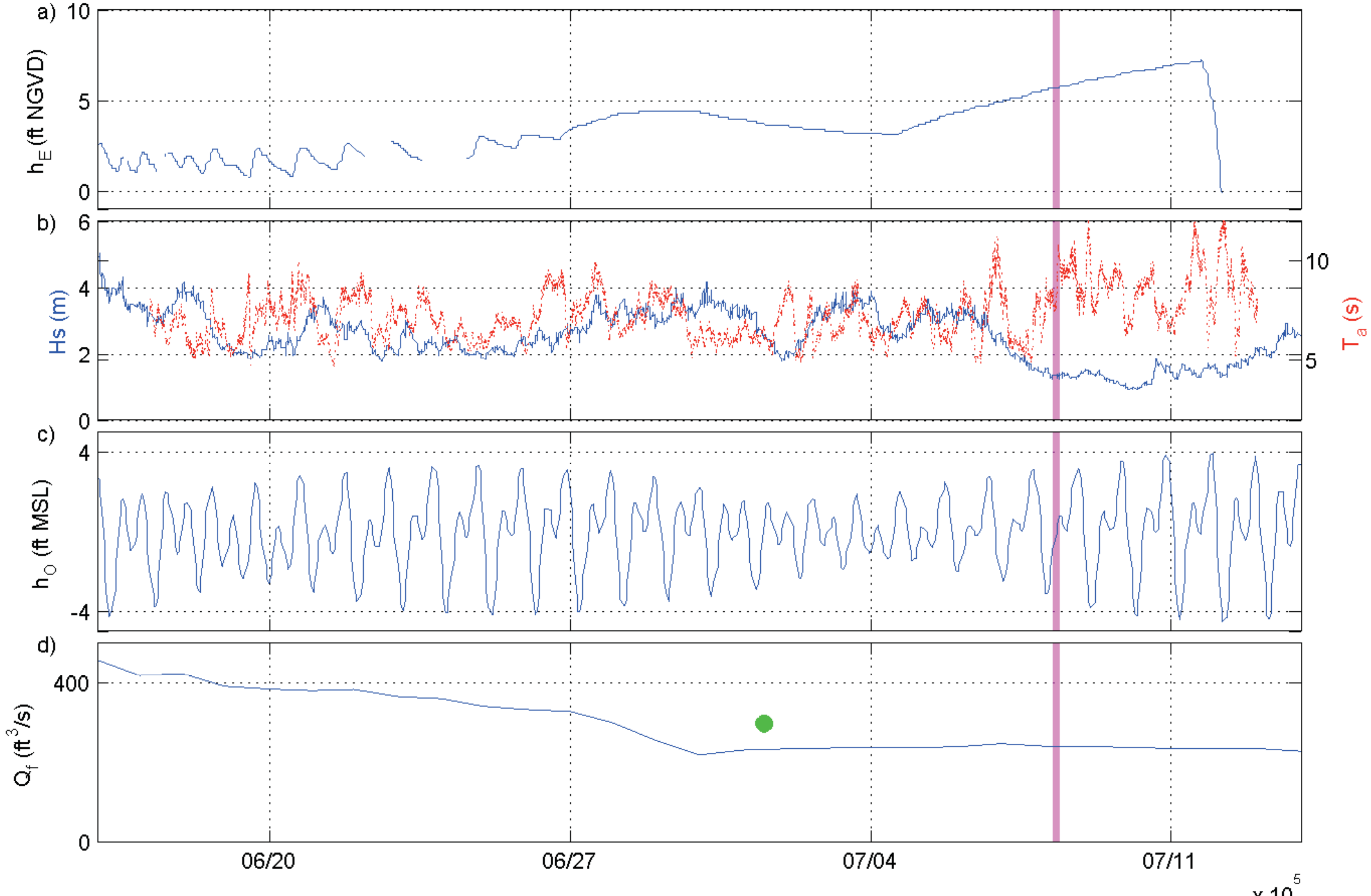

Sources:

a) h_E=estuary water level (SCWA); pink bar = mmgt action

b) H_s=sig. wave height; T_a =avg. wave period (CDIP, Pt. Reyes, #029)

c) h_O=ocean water level (NOAA, Pt. Reyes #9415020)

d) Q_f=river discharge (USGS, Guerneville #11467000)

Figure 2

Russian River Estuary Outlet Channel Management Plan

Estuary and Ocean Conditions, June - July 2010

PWA Ref# 1958.01

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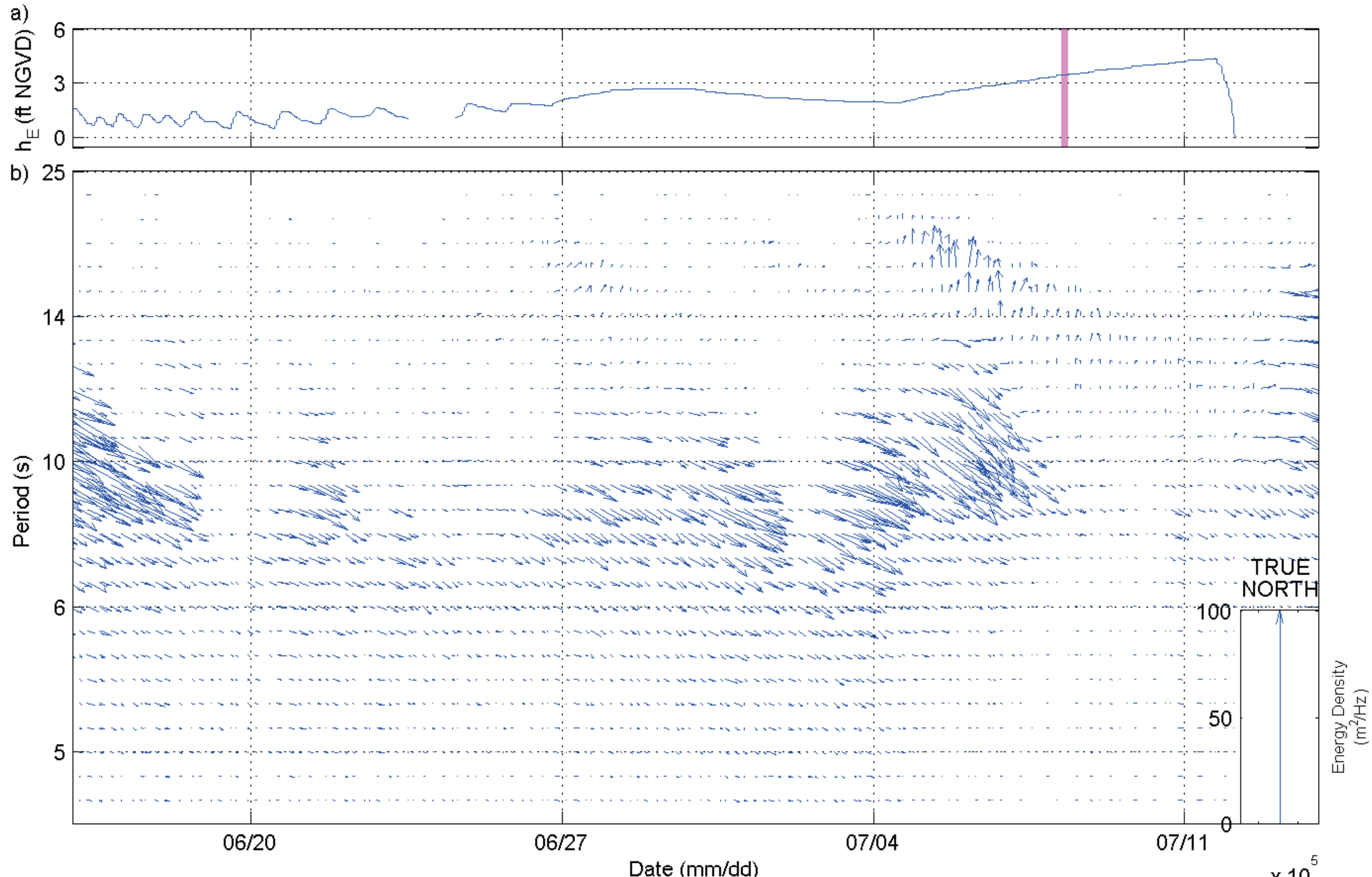


Sources:
a) h_E=estuary water level (SCWA); pink bar = mmgt action
b) Wave magnitude and direction (CDIP, Pt. Reyes, #029)

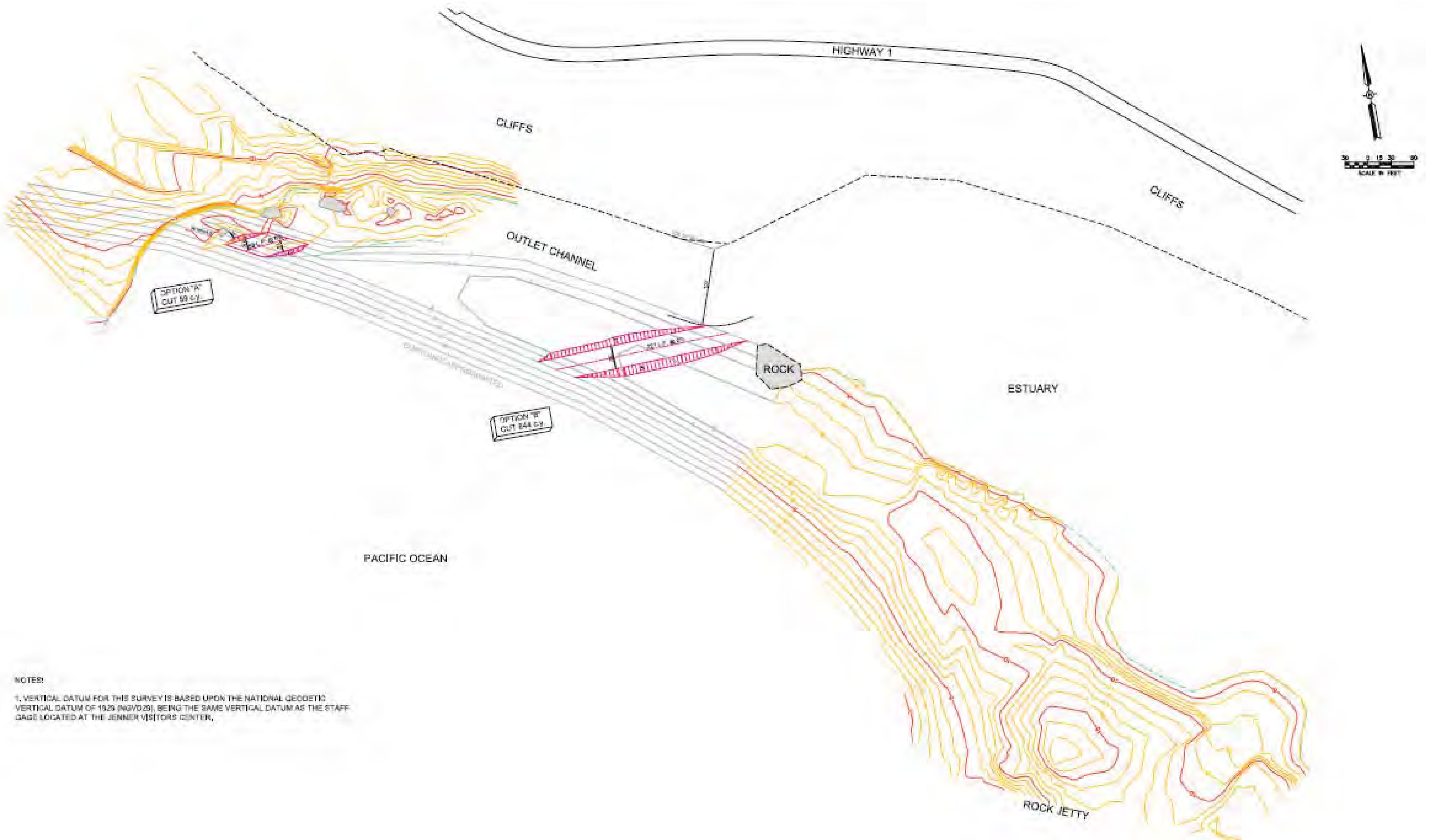
Figure 3
Russian River Estuary Outlet Channel Management Plan

Estuary Water Level and Wave Energy/Direction Spectrum
JUNE-JULY 2010

PWA Ref# 1958.01

ESA PWA

K:\projects\1958.01RREAMPOutletChannel\Task 8 Year 1 eval & 2011 plan\Year 1 eval memo\mfiles\featherfigure.m



NOTES:

1. VERTICAL DATUM FOR THIS SURVEY IS BASED UPON THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29), BEING THE SAME VERTICAL DATUM AS THE STAFF GAGE LOCATED AT THE JENNER VISITORS CENTER.

Source: SCWA

figure **4**

Russian River Outlet Channel Adaptive Management Plan

Beach Topography and Management Options, June 2010

PWA Ref# 1958.01

a)

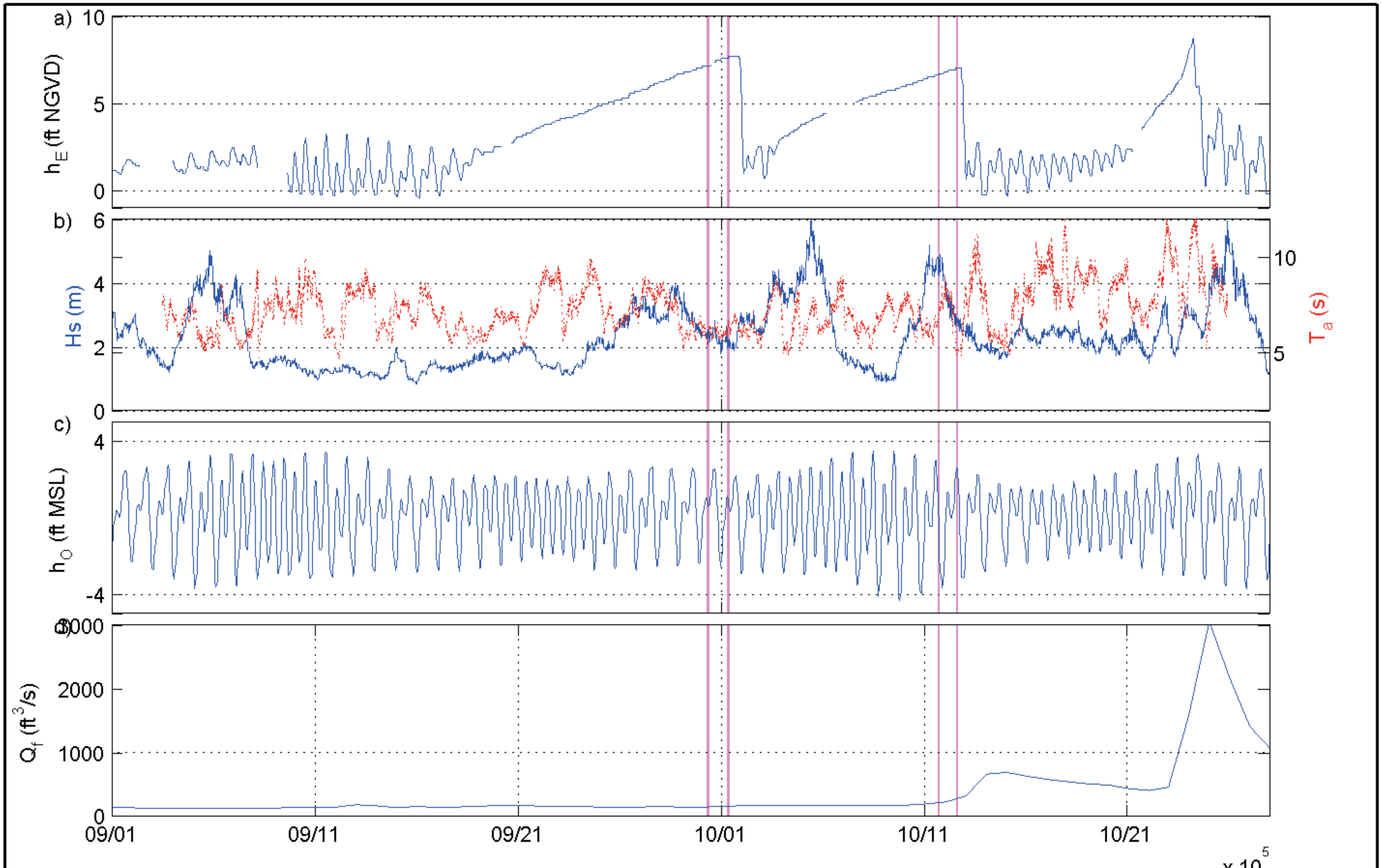
b)

Source: C. Delaney, SCWA

figure 5
Russian River Outlet Channel Adaptive Management Plan

Natural and Managed Outlet Channels

PWA Ref# 1958.01



Sources:

a) h_E=estuary water level (SCWA); pink bar = mmgt action

b) H_s=sig. wave height; T_a =avg. wave period (CDIP, Pt. Reyes, #029)

c) h_O=ocean water level (NOAA, Pt. Reyes #9415020)

d) Q_f=river discharge (USGS, Guerneville #11467000)

Figure 6

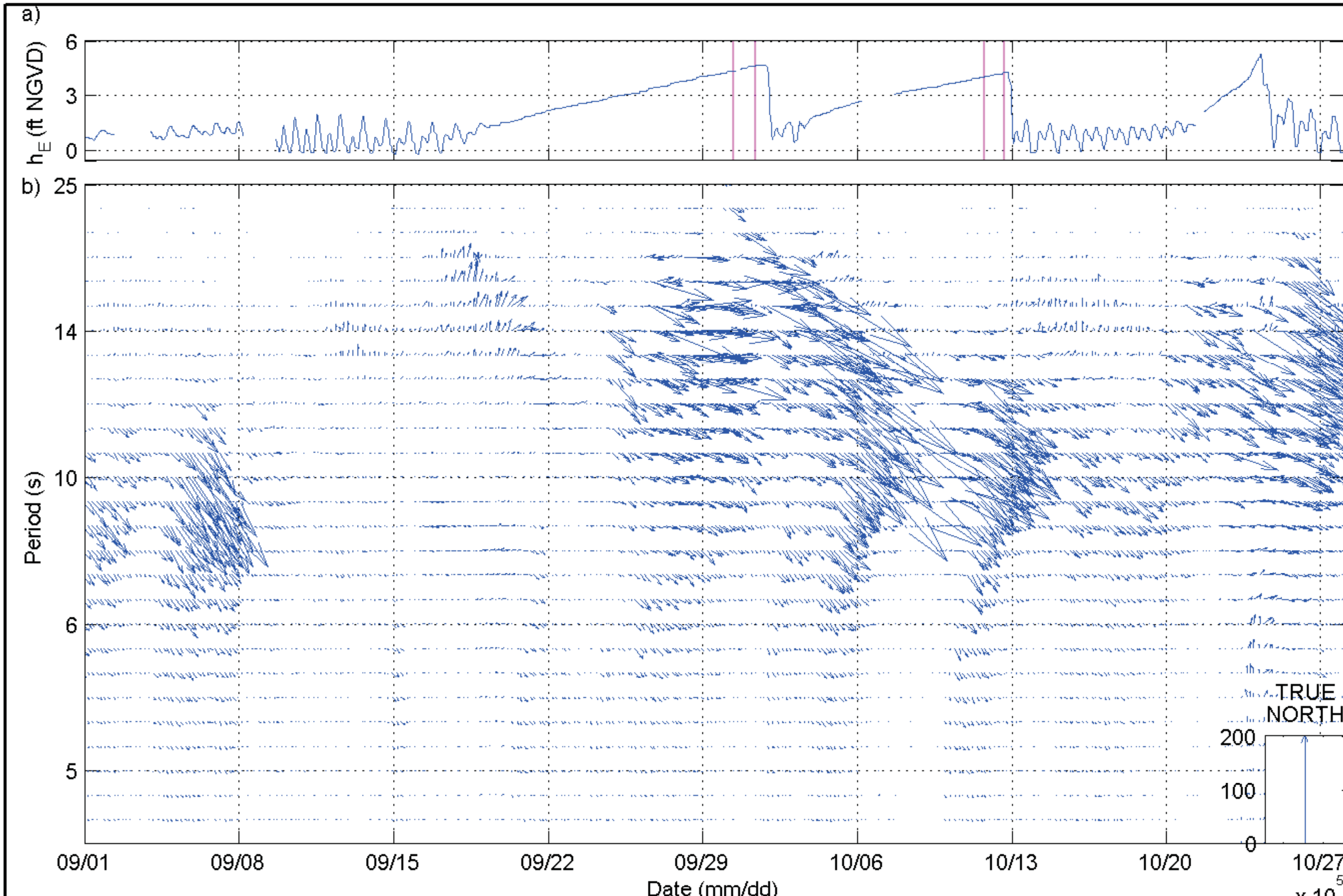
Russian River Estuary Outlet Channel Management Plan

Estuary and Ocean Conditions, September - October 2010

PWA Ref# 1958.01

ESA PWA

K:\projects\1958.01RREAMPOutletChannel\Task 8 Year 1 eval & 2011 plan\Year 1 eval memo\mfiles\plot_rre.m



Sources:
a) h_E=estuary water level (SCWA); pink bar = mmgt action
b) Wave magnitude and direction (CDIP, Pt. Reyes, #029)

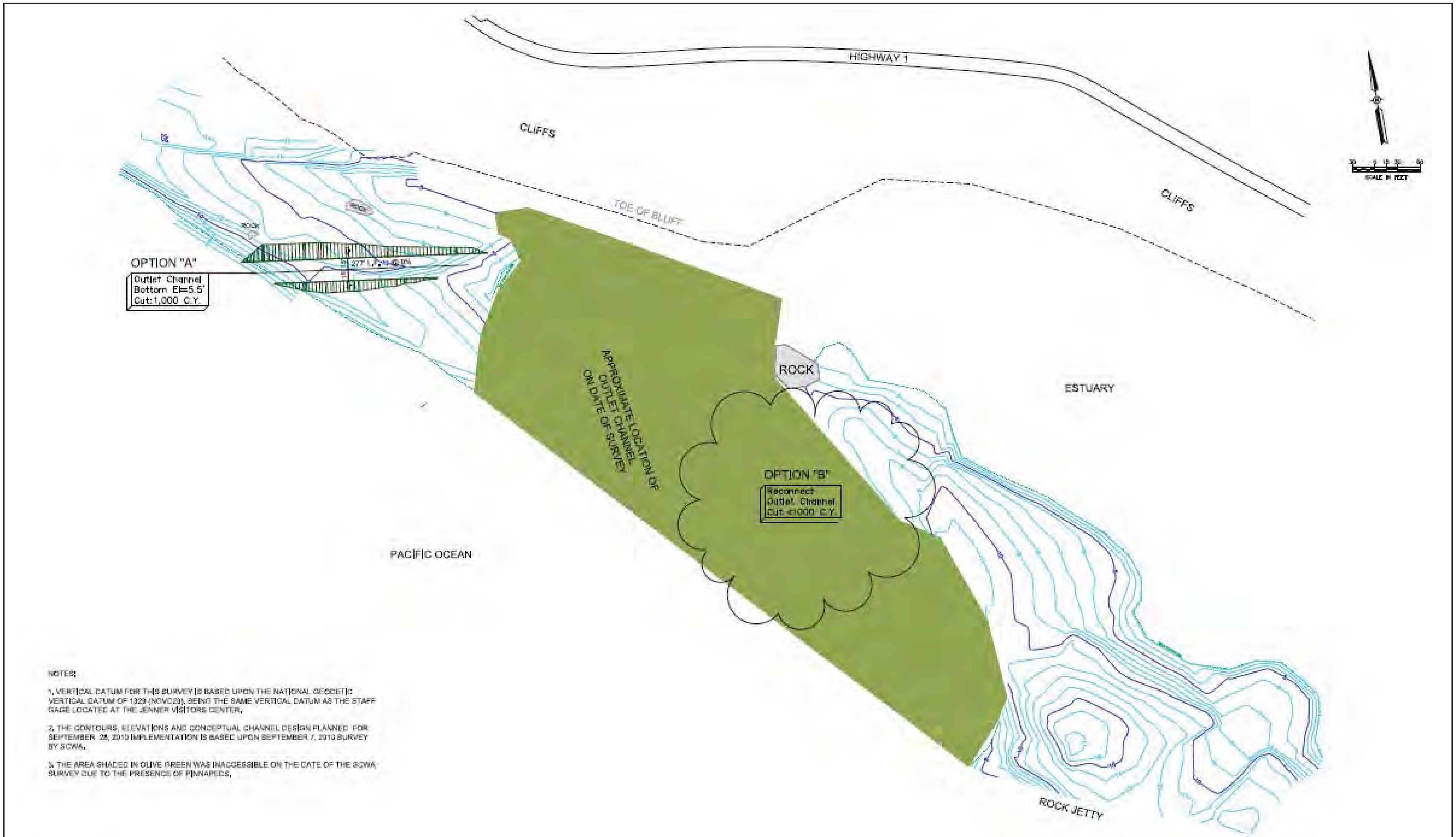
Figure 7
Russian River Estuary Outlet Channel Management Plan

Estuary Water Level and Wave Energy/Direction Spectrum
September-October 2010

PWA Ref# 1958.01

ESA PWA

K:\projects\1958.01RREAMPOutletChannel\Task 8 Year 1 eval & 2011 plan\Year 1 eval memo\mfiles\featherfigure.m



Source: SCWA

figure 8

Russian River Outlet Channel Adaptive Management Plan

Beach Topography and Management Options, September 2010

PWA Ref# 1958.01

ESA PWA

Attachment F. Physical Processes During the 2011 Management Period!

!

As required by the Russian River Biological Opinion, - onoma County Water Agency (0 ater Agency) has been tasked with managing a summer lagoon i˝ tended to improve s˙˘&onid habitat in the Russian River Estuary!4/ !creating an outlet channel while maintaining the current level of flood protection for properties adjacent to the estuary!2NMFS, 2008). The adaptive &˙nagement plan, described in the main body of this report, was developed by the Water Agen /   with assistance fro&!ESA PWA and the resource agency management team in 2009 and revised in %° °!˙˝(!%011. Because of permit constraints, the Water Agency was onl/ able to implement the plan begin˝)˝ 1!)˝!%° ¸!ˆˆ e revised plan was in effect for 20 .! but no opportunities for management action occurred during the management period.!!

!

During the 2°   !& ˙nagement period, May 15th to October 15th, Water Agency staff regularly &onitored current and forecasted estuary water levels, inlet state, river discharge, tides, and wave conditions to anticipate changes to the inlet's state. High river discharge in the first two &onths of the m˙nagement period followe(!4/ !the typical low wave energy!conditions during the summer contributed to!the inlet staying open for the first four!&onths of the management period. Starti˝1! in late Septem4er, the inlet went through a successio˝ of perche(!˘agoon   onditions and self breaches, during which the Water Agency closely!&onitored estuary conditions and considered management options. The perched episodes were short-lived, lasting no more than a week.!˙˝(! included a small outlet channel flowing along and sometimes through gaps in tˆ e jetty. The perched episodes ended when lagoon water levels increased, overtopped the beach berm.!˙˝(! scoured a new tidal channel. Since the perched lagoon episodes did not evolve to the point tˆ at management action was warranted, the Water Agency did not take!˙˝/!& ˙˝ agement actions to encourage formation of!˙˝! outlet channe˘¸!!

!

Even though no management a tions were!)&plemented to inform!the a(aptive m˙nagement process, the ph/ sical conditions and inlet response during the m˙˝˙1 ement period are reviewed in this attachment to contribute to site understandi˝1!˙ ˝(to inform!future management a tions.!

!

METHODOLOGY

This review of the 2011 outlet channel management period ex˙&ined water levels, ocean wave conditions, ocean water levels, riverine discharge, beach topography, as well as inlet size and location. The sources for these parameters are listed in Table 1. These data were supplemented with personal observations and discussion with staff from the Water Agency, NMFS, DFG, and the Bodega Marine Laboratory.!!

!!

Table 1. Data Sources

Parameter	Source
Estuary water level (h_E3!	Water Agency Jenner g˙ge[J]!
Wave height (D_s), period (T·3.!˙nd direction !	ˇ DIP Point Reyes buo/!K°%9!
Ocean water level (h_O3!!	NOAA Point Reyes #9415020
Russian River discharge (Q*3!	USGS Guerneville # ?FE°°°!
Beach topography, ft NGVD	Water Agency monthly surveys!
Inlet size and location	Water Agency and Bodega Marine Laboratory! autonomous c˙&eras

[J]Gage faile(!˝ ear the end of Juˇ/ .!˙˝ d was replaced 4/ early Septem4er.!

!

INLET STABILITY PARAMETER AND CLOSBRE RISK PROBABILIT" !

In addition to considering individual parameters, researchers at the 6 odega Marine Laboratory have developed a co&4ined parameter to evaluate the stability of the inlet's state, with the aim!of predicting closure risk. (Note that the inlet stability parameter does not differentiate between full closure and the perched conditions with a small outlet channel that formed in fall 2010. When discussing this parameter, both states are referre(! to as a 'closure'.) The inlet stability!parameter presented by Behrens et al. (in pu4lication) quantifies the risk of inlet closure based on a sediment balance in the inlet. It considers the daily balance between wave-dri#en sediment import to the inlet and sediment export dr)#en b/ !tidal fluctuations. The former is estimated from!wave measurements and the latter is esti&ated fro&!tide g˙1 e data within the estuary and a stage-storage relation derived from the available batˆ/ &etry. Using daily-average values of the stabilit/ ! parameter witˆ in the period 1999-2008, Behrens et al.!(in publication) showed that high-percentile values of the parameter are closely!ˇ)˝ ed to the risk of the inlet closing within five (˙/ s. As the percentile of the stability parameter increases, the risk of inlet closure witˆ in five (˙/ s increases exponentially, from!risks of roughl/ !*)ve percent when the parameter is at the 50th percentile to a risk of 80 percent when it is measured at the 99th percentile.!!

!

FALL PERCHED EPISODES AND SELF BREACHES

!

ˇ) &e series of estuary water levels, as well as the key forcing factors (waves, ti(es, and riverine discharge), are shown in Figure 1 for the entire &˙˝˙1 e&ent period. Prior to Septe&4er, no inlet closures occurred, so lagoon water levels fluctuated in concert with ocean tides 2Figure 1a). As shown in Figure 1d, discharge remained high for the first two months of the m˙˝ agement period as a result of a wet spring, including pre ipitation in the start of June. River discharge did not drop beˇo5!? 00 ft'/s until after June 15th and below 200 ft'/s until after July 15th. This elevated discharge probably reduced the l) elihood of inlet closure during tˆ e first two months of the management season even though so&e sizeable wave events occurred during these &onths (Figure 1b). In late July and particularly in August, wave energy was at the annual &)˝) &u&.!so tidal exchange was sufficient to m˙intain an open inlet. As typically occurs on the California coast, wave energy!increased starting in September,!5 hich eventually caused the estuary to perch! six times, starting in late September and into Novem4er.

!

All six inlet perched lagoon episodes in fall 2011 lasted a week or less, ending when the estuary! water levels reached 4-5 ft NGVD, overtopped the beach berm. and scoured a new tidal channel. Conditions during the perched lagoon episodes (Septem4er 22-29, October 3-8, October 10-14, Novem4er 3-8, Novem4er °8 %.!˙˝(!+ ovem4er 17-20) are shown in Figure 2. Although the management period ends on October 15th, conditions up through the end of Novem4er were reviewed since they were consistent with the inlet beˆavior that started in late Septem4er. Six instances of perched lagoon conditions are slightly!ˆ)gher than the average nu&ber of closures, ?¸F.!)n Septem4er through Nove&4er (ESA, 2011). However, a series of repeated perched episodes and self breaching is not com&on; since 1996, this pattern has onl/ !been observed onl/! one other time, in 20°F¸!

!

Consistent with the existin1! onceptual &odel described in Section 4 of!the Management Plan, perched lagoon conditions t/ p) ˙˜˜/ occurred when both wave energy increased and tidal exchange decreased. All perched episodes occurred when the mean wave period was greater tˆ˙˝! 10 seconds and five perched episodes occurred when significant wave heights were greater th˙˝! 12 ft. Tˆ e O tober 10th episode coincided with wave heights of only 8 ft, but since these waves had long, 1F8second periods and originated from!the southwest, they still conveyed significant wave energy to the beach. Five of the 2011 episodes occurred during neap tides when the tide range was reduced to less than 5 ft (Figure 2c). When the tide range is less, tidal scour in the inlet is also less, &˙ ing the inlet more susceptible to infill with sand. Onl/ !the Nove&4er 10-12 episode occurred when the oceanic tide range was greater than 6 ft. All but the first episode occurred with riverine discharge elevated above 250 ft' /s and the three Novem4er episodes occurred when riverine dis ˆ˙ rge was approxim˙tely 400 ft' /s.

!

PERCHED LAGOON A+ D NATURAC BREACH 7"+ AMICS!!

As an ex˙&ple of a perched lagoon-breach cycle, Figure 3 shows a sequence of photos of the inlet before, during, and after the October 3-8 episode. As was the case for almost ˙ll of the management period, the i˝˘et was located next to!the jetty. Shortl/! before the episode, on September 30 (Figure 3a), the inlet had narrowed in width to approxim˙tely!"°!*eet.

!

The estuarine water level became &uted starting o˝ October 3 with the arrival of so&e larger, longer-period waves (Figure 2a and b). B/ October 5, a tidal signal was absent from!the estuary and water levels began to rise. The inlet transformed into a small outlet channel running)&&ediately adjacent to and among the rocks at the toe of the jett/ (Figure 3b; Figure 4a). The! outlet channel was narrow, with a width of approxi&˙tely ten feet. When the channel reached the portion of the jetty wˆ) ˆ!ˆ ad been damaged, the cˆ ˙˝ nel turned south a˝(!*˘owed through the gap in the jetty (Figure 4b).

!

The jetty and rocks which had been a part of the jetty!&˙/ have stabilized the outlet channel, both in sheltering the outlet cˆannel from!5aves a˝(!4 y providin1!4˙˝ !˙nd bed stabil)zation that &)˝)&ized ch˙nnel scour. Sheltering by the jett/ probably reduced 4erm build-up at the inlet's

location, leaving a low point in the beach berm that was the site for subsequent overtopping and self breaching. This sm˙˘˘!outlet channel, present from the start of the episode, contrasts with other historic closures that were &ore extensive. For these extensive closures, al&ost the entire inlet was filled with sand, 5 ith onl/ a small indentation on the!4˙ side of the berm providing ˙˝/ !indication of the inlet's prior location, and no outlet channel was present. All the 2011 episodes were less extensi#e, which left the beach berm!more susceptible to self breaching.
!
Self breaching probabl/ occurred when the estuary water level had risen sufficiently high that it overtopped the beach berm!)n the vicinit/ of the outlet channel. This overtopping increased the flow rate through the outlet channe˘!˙˝(.!)n spite of a˝/!4˙ ˝ sta4)˘)zation provi(e(!4y the jett/ ! and associated rocks, the increased flow rate scoured sand from!the channel bed and ba˝ s. The enlarged channel was then su**))ently deep to allow tides and salt water to return to the estuary.!
Shortly!after self breaching, the tidal channel was approxim˙tely 50 feet wide (Figure 3c), wider than it had been in the da/ s preceding the episode. This channel enlargement is consistent with the self breaching mechanis& as the higher flow, induced by the elevated estuar/ water levels during episode, scoured the channel.
!
CLOSURE R;SK PROBABILITY !
!
The 5-da/ closure risk probability.!˙!(erivative of the inlet stability!parameter described above, was hindcast *or 2011 according to the method described in Behrens et al. (in publication). Tˆ is hindcast provides an indication of the utilit/ of the stabilit/ parameter as a prediction tool for &onitoring inlet conditions and pla˝˝) ng management action. This parameter integrates wave an(! ocean forcing conditions, as well as estuary water levels, to provide greater pred)ctive skill than just waves or ocean tides on their own. The stability parameter co&4ines these factors, and the corresponding five-da/ closure risk time series exceeded 50 percent before each 2011 event (Figure 2a). - ome 2011 episodes occurred quick˘/ , tra˝sitioning from fully tidal to perched lagoon withi˝ !˙!(˙/ , so the risk time series did not provide much forewarning in these cases. However the risk was elevated &ore than two d˙/ s be*ore the episodes on Septem4er 22, Novem4er 3, and Novem4er 17.!
!
TOPOGRAPD;˘!˘D ANGE
The Water Agency has conducted monthl/ !surve/ s o* Goat Rock State Beach that cover a region starting from!the jetty a˝(! extending approxim˙tely! ,500 feet to tˆ e north. Typically, the sur#eys do not include bathy&etry within the inlet because flow conditions in the inlet prevent safe access. Also, the survey extent is often li&ited by the Water Agency's comp˘)˙˝ ce with its &arine mammal incidental harassment authorization, wˆ) ˆ !prohibits the survey rew from disturbing the marine mammals hauled out on the beach. Water Agency sur#e/ staff collected spot elevations! using RTK-GPS and then assem4led these elevations into a set of contour!˘)˝es at 1 ft intervals.!
The survey elevations are reported in the!+@A7%9 vertical datu&, the working datu&!for estuary! &onitoring a˝(!& anagement. !
!
To characterize beach berm!topographic conditions, ESA PWA assessed data from!the Water Agency's 2010 (Jul/ to Septe&4er) and 2011 (Ma/ !to!October) surveys. The locations of five

transects selected for analysis are shown!in Figure 5. The locations include two transects backed 4/ cliff (Figure 6 and Figure 7), two transects whicˆ! extend into the estuary!2Figure 8 and Figure 9), and a transect just north of the jetty (Figure 10).

!

This review focuses on the 2° surve/ s!5ˆ en the surveys capture(!˙! ˘ earer picture o*!4each evolution. However, the 2010 surve/ s are included in the transect plots for conte<t. In general the crest elevations in 2°10 were lower than 2° ˛ The cause of the lower crest elevations is not nown, but may the result of inter-annu˙˘!#˙riations in wave e˝er1/!˙ nd littoral sediment suppl/˛! In addition, the inlet exhibited greater variation in its location in %010, extendi˝1!*ar to the north)˝!9uly before!&oving south later by August. As the inlet opened a˝(! losed or changed location, it resulted in large changes in beach topography. For example, at Transect 4, the inlet's closure in early Jul/ !%10 is readil/ apparent as substantial increase in the berm:s size between the 7/1/2010 and 7/8/2010 transect (Figure 6). The inlet's migration south is evident at Transect 3 (Figure 7) when the crest elevation drops from!its 7/8/2010 profile to less than 4 ft NGVD on 8/3/2010. The inlet migration and gaps i˝! the survey data yield little inform˙tion for evaluating crest elevation evolution at most transects. However, there is sufficient data at Transect 4 to show a trend of increasing crest elevation during summer 201°˛!!

!

The crest elevations of Transects 2.!' .!˙˝ (!? steadily!increased over the 2011 m˙˝˙ gement per)od. This trend is consistent with seasonal patterns on m˙˝/ California beaches. After so&e initial increase from May!to June, when wave energy was at the annual m)˝)&u&!)n July and August, transect ch˙˝ ges were &)˝)&˙l. Then ber&!4uilding accelerated in the fall with the concurrent increase in w˙ve energy (Figure 1), as i˝() cated by the change between the August 15th survey and the Septem4er 19th survey˛ The largest change occurre(!4etween the Septem4er and October surveys, the period that also experienced the largest wave energy. Over the course of the management period, the crest &oved landward at Transect 3!˙˝d Transect 4, witˆ the exception o*! the October surve/ , when the crest &oved seaward at Transect 3. This landward movement is opposite to the typical crest movement at other California beaches (Weigel, 1992) and m˙/ !be indicative of additional processes affecting these transects, such as suppl/8˘)&ited alongshore transport. At Transects 1 and 2, the crest moved seaward as it built upwards, consistent with typical summer-ti&e response.

!

Transect 0.!5ˆich is located just north of an(! p˙rallel to the jetty.!ˆ˙(!˝ oticeably different elevations and evolution than the other transects. Compared to the other transects, crest elevations were highest at this transect for botˆ!%°!˙˝(!% ° ˛!; n addition, Tr˙nsect 0 di(!˝ ot evolve duri˝1! the management periods, as was observed at the other transects. The o˝˘/ significant change occurred during the winter between the 2010 a˝(!%°11 management periods. These two characteristics, the higher crest an(!˘˙ of m˙nagement period variabilit/ , suggest that the jetty shelters this portion of the beach fro&!small to &oderate waves that occur during the management period. Only the larger waves associated 5 ith winter storms m˙/ be sufficient to re-shape the beach ber&!˝ear the jetty. !

!

The changes to the beach ber& at Transect 1 were inter&ediate between the &o˝thly! ˆ anges that occurred to the north (Transects 2-4) and the negligi4˘e! hange in berm!elevation adjacent to the jetty (Transect 0). Crest elevations at Transect 1 o˝˜/ !increased between the Septem4er an(! October survey, tˆ e portion of the management period with the strongest wave e˝ ergy.!This! suggests that the jetty m˙/ alter wave conditions over so&e distance fro&!its location: Transect 1 is approxim˙ tely 200 ft north of the jett/!˙ nd outside of the area occupied by the!)nlet durin1!&ost of the 20 !& anagement period.!

!

LESSONS LEARNED AND RECOMMENDATIONS

Based on o4servations of the estuary, associated pˆ/ sical processes, and the Water Agency's planning for outlet cˆ anne˜!&˙ nagement, we note the following lessons about implementing the! outlet cˆ anne˜!&˙ nagement plan.!

!

CONCEPTBAL MODEL!

- Elevated discharge in the late spring and early summer (greater th˙ n 400 ft'/s until June 15th; greater than 200 ft'/s until July 15th) reduced the likelihood for inlet closure at that time. However, multiple perched lagoon episodes occurred in the fall when riverine discharged exceeded 250 ft'/s. This is consistent with Behrens et al. (in publication) that although discharge affects probability of closure, the threshold that prevents closure is ˜) ely in excess o*!%000 ft'/s. A likely contribut)˝1!*˙ctor to the fall perched episodes was the higher wave energ/¸!
- The inlet moved south ear˜/!)n the management period, reaching the jetty!)˝!˜˙te May or early June, a˝ d remained there throughout the 201 !& ˙˝ agement period and tˆ e following wi˝ ter. This inlet alignment is not common, but has been observed in past / ears (Behrens et al., 2009)¸!!
- During the management period, steady growth of the beach berm!was observed north of! the jetty, consistent with typical beach 4er& building that occurs during tˆ e summer. However, the rate of berm growth appeared to decrease approxim˙ tely!200 ft north of the jetty and was negligible immediately adjacent to the jetty.!
- Although autumn wave events were large enough to reate perched lagoon conditions.! the beach berm remained at low elevations, approxim˙ tely 5 ft NGVD. The inlet then self breached when rising estuary water levels overtopped the berm!˙ t this low point a˝(! scoured a new tidal channel.

!

OUTLET CHANNEL FEASIBILITY!

- The jetty!&ay shelter the inlet, making closure less likely!and also limiting berm growth, which then maintains a low point for self breaching. When the lagoon self breaches, management actions cannot be!)&plemented.!
- Even if the inlet being near the jett/ !ˆ)nders formation of sustained lagoon and outlet channel conditions.!&˙ nagement opportunities for re-locating the outlet channel are ˜)&ited a˝(! onstrained. At ˙!&)˝)&um.!creating an outlet cˆ˙ nnel further north!from the jetty requires a full natural losure, absence of a low point in the beach berm near the jetty.!˙˝ d equipment access to the area north of the jetty. !
- A small outlet channel formed during the fall perched lagoon episodes. However, it did not conve/ enough discharge to prevent!lagoon water levels fro& rising at 0.8 ft/(˙/¸!!

- The outlet cˆ˙nnel that formed during the perched ˘agoon episodes!flowed along the jett/! ˙˝(!˙& ong the disaggregated roc at the damaged end of the jett/ . This rock from!the jetty!&˙/ have provided channel stabilization for the outlet channel, increasing the channel's resilience to scour.
- Once outlet channel discharge increased due to rising lagoon water levels, the discharge scoured a new channel, breaching the estuary to the tides. This behavior highlights the susceptibility of a sand bed outlet channel to scour, li&iting conve/˙nce capacity.!
- The mere occurrence of a perched lagoon is not sufficient to provide an opportunity for outlet cˆanne˘!&˙nagement; other factors m˙y not permit m˙nagement!˙ction. Th)s point is highlighted by both the 2011 self breachings and the early fall closures in 2010, when continuing ocean swell precluded outlet channel m˙nagement action. Over the first two / ears of effort to implement the outlet channel adaptive &˙nagement plan, only!o˝e closure (July 20103!ˆ˙s been suited for outlet cˆ˙nne˘!&˙nagement action. !

!

OPERATIO+-!

- When equipment operators visited the beach to plan a possible management action, the/ ! noted that the channel had incised a steep!4˙˝ !)˝!the ber& adjacent to the jetty (Figure 3.!5ˆ) ˆ!5 ould have made equipment access to any areas north of the jetty infeasible.

  !

COMMUNICATIONS!

- Although the perched lagoon episodes did not evolve to!the point tˆat management action was warranted, the Water Agency began pla˝˝) ˝1!&anagement actions as soon as the episodes occurred. Planning included heightened observations of!)˝˘et conditions!4/! Water Agency staff, em˙il updates to infor&!the resource management group, and pre-)&plementation meetings at the project site to refine plans for management actio˝˛!! !

!

MONITOR;+@!

- The Water Agency's upgrades to monitoring the estuary (water levels and photo1raphs available in real-time via the Internet) enhance both management planning and the abilit/ ! to observe inlet processes.

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!

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!

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!

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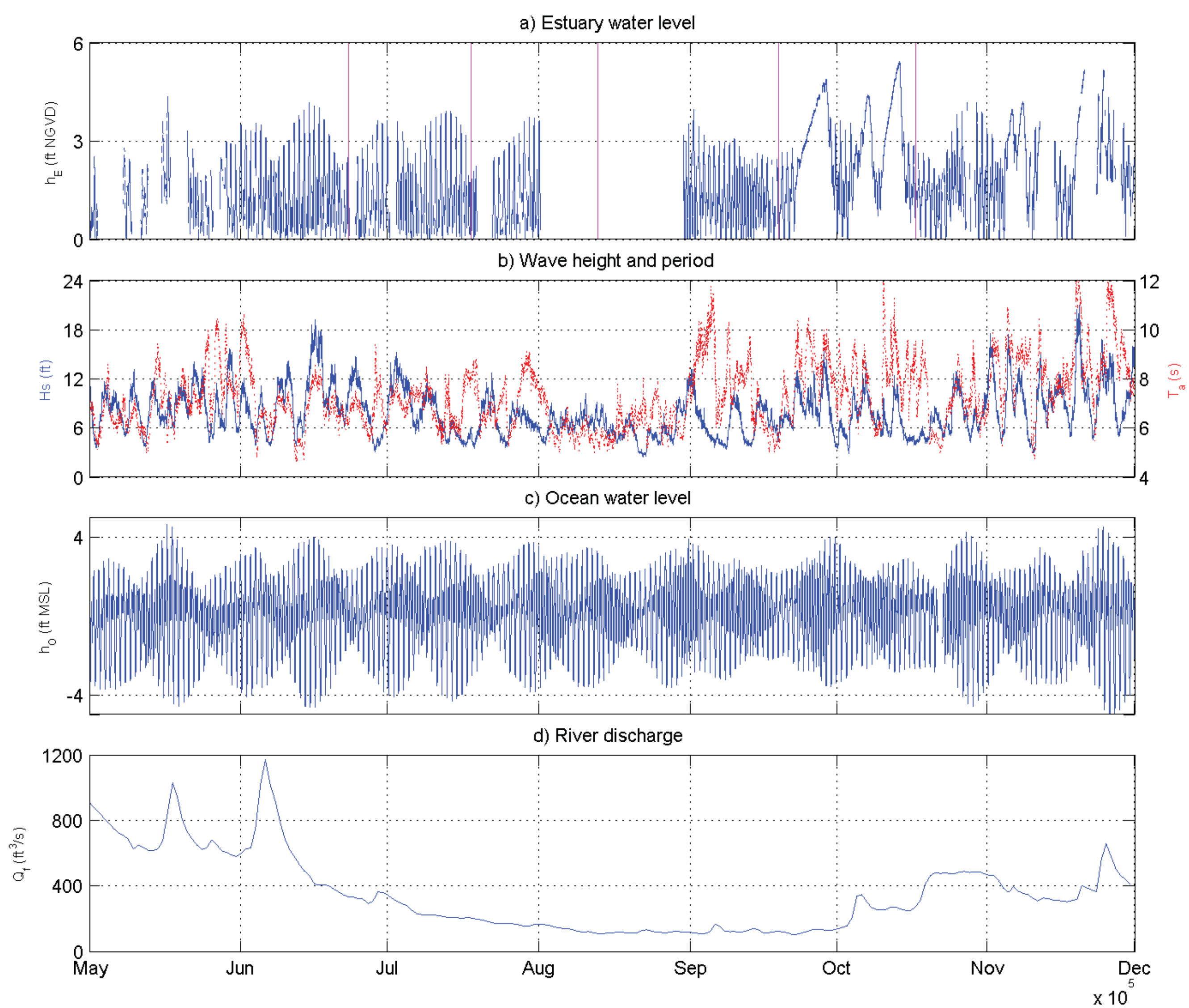


SOURCE:

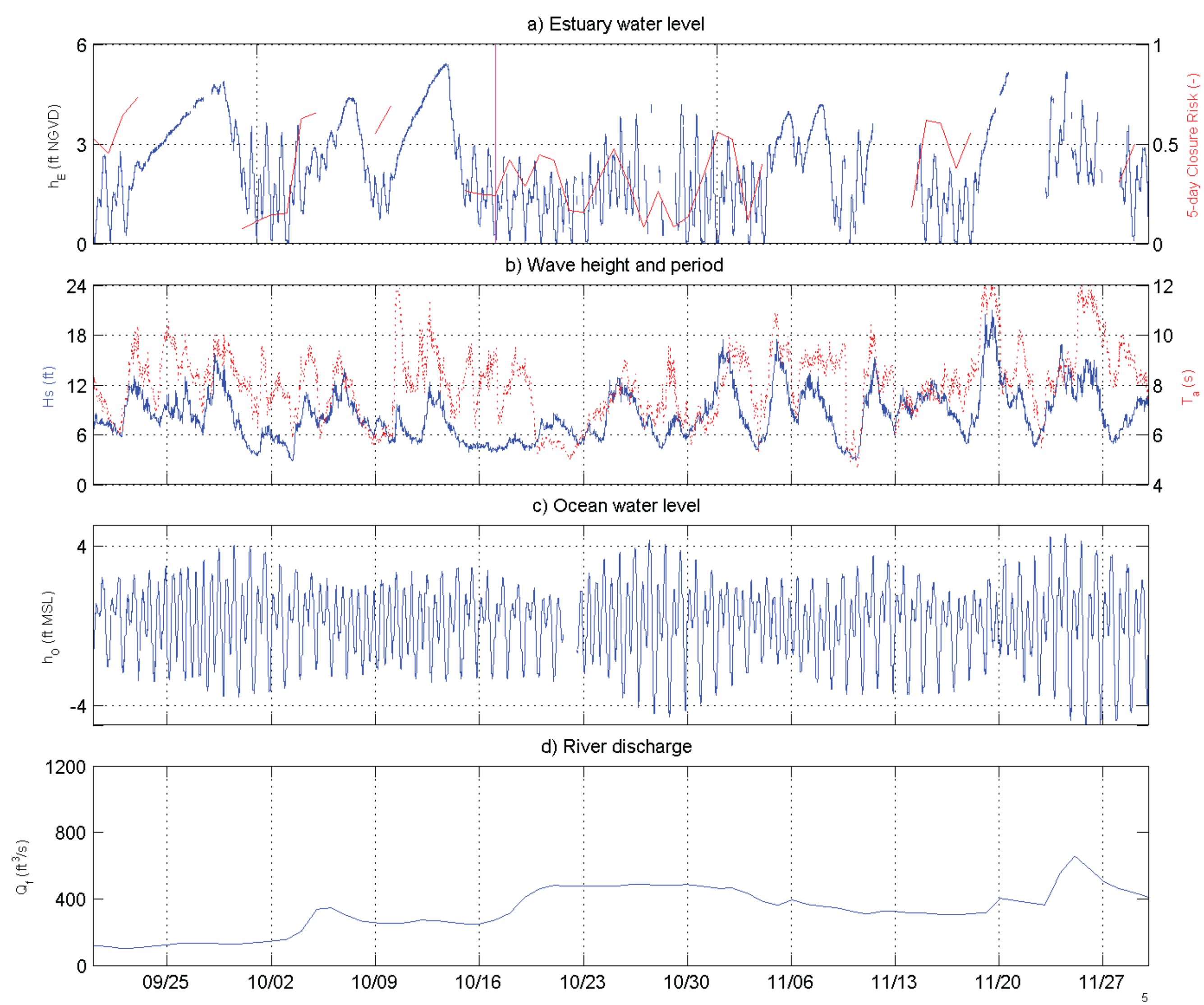
a) h_E=estuary water level (SCWA); pink bar = beach survey

b) H_s=sig. wave height; T_a=avg. wave period (CDIP, Pt. Reyes, #029)

c) h_O=ocean water level (NOAA, Pt. Reyes #9415020)

d) Q_f=river discharge (USGS, Guerneville #11467000)

Figure 1
Estuary, Ocean, and River Conditions
May - November 2011



SOURCE:

a) h_E=estuary water level (SCWA); pink bar = beach survey

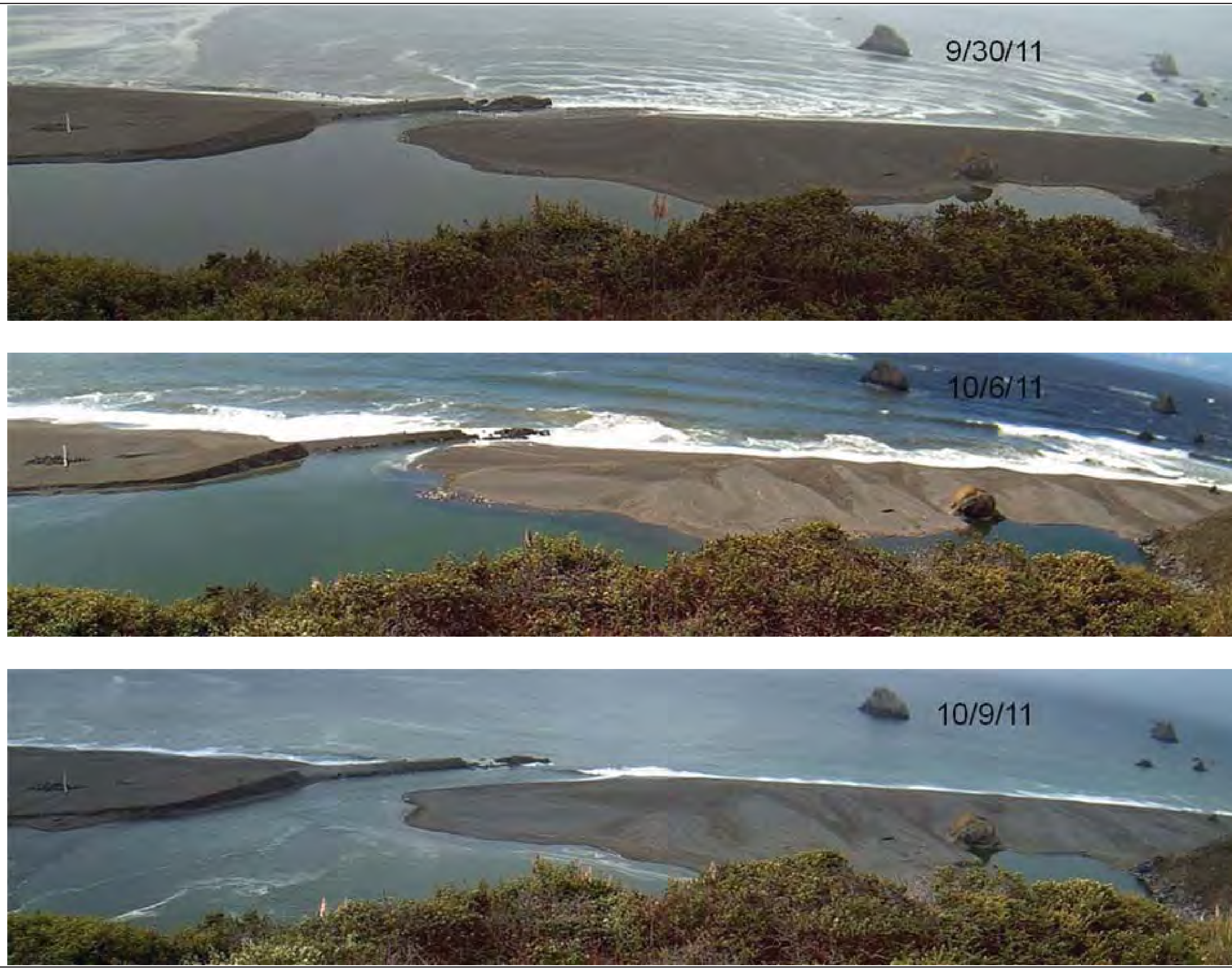
b) H_s=sig. wave height; T_a=avg. wave period (CDIP, Pt. Reyes, #029)

c) h_O=ocean water level (NOAA, Pt. Reyes #9415020)

d) Q_f=river discharge (USGS, Guerneville #11467000)

Figure 2
Estuary, Ocean, and River Conditions
September - November 2011

a)
b)
c)



SOURCE: Bodega Marine Lab

Figure 3
Inlet State, September 30, October 6, and October 9, 2011

a)

b)

SOURCE: Sonoma County Water Agency

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 4

Outlet Channel Along and Through Jetty, September 26, 2011

Source: Sonoma County Water Agency survey data

N

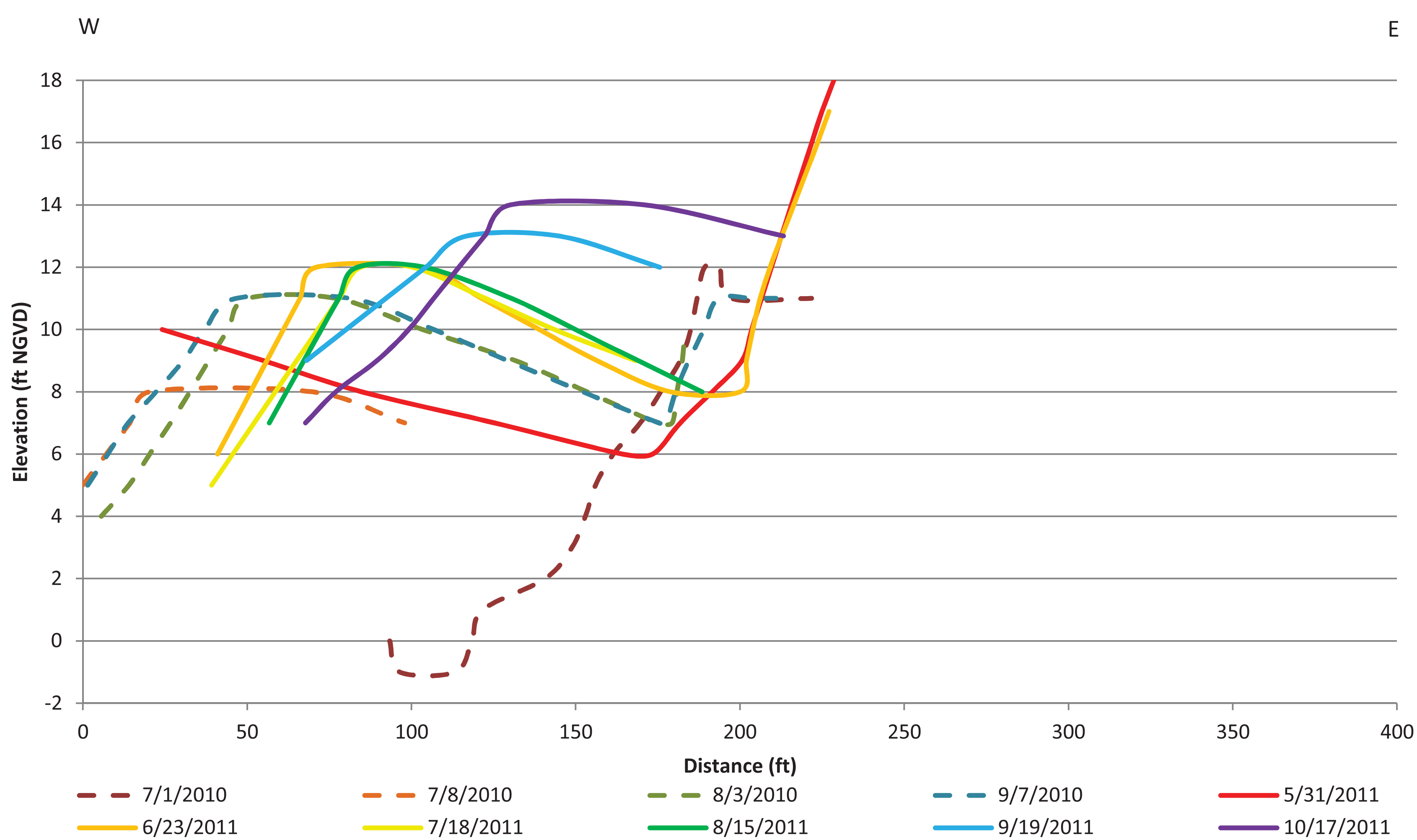
figure 5
Russian River Outlet Channel Management Plan

Beach Topography Transect Locations

ESA PWA Ref# - DW01958

ESA PWA

Beach_topo.mxd



Source: Sonoma County Water Agency survey data

figure **6**

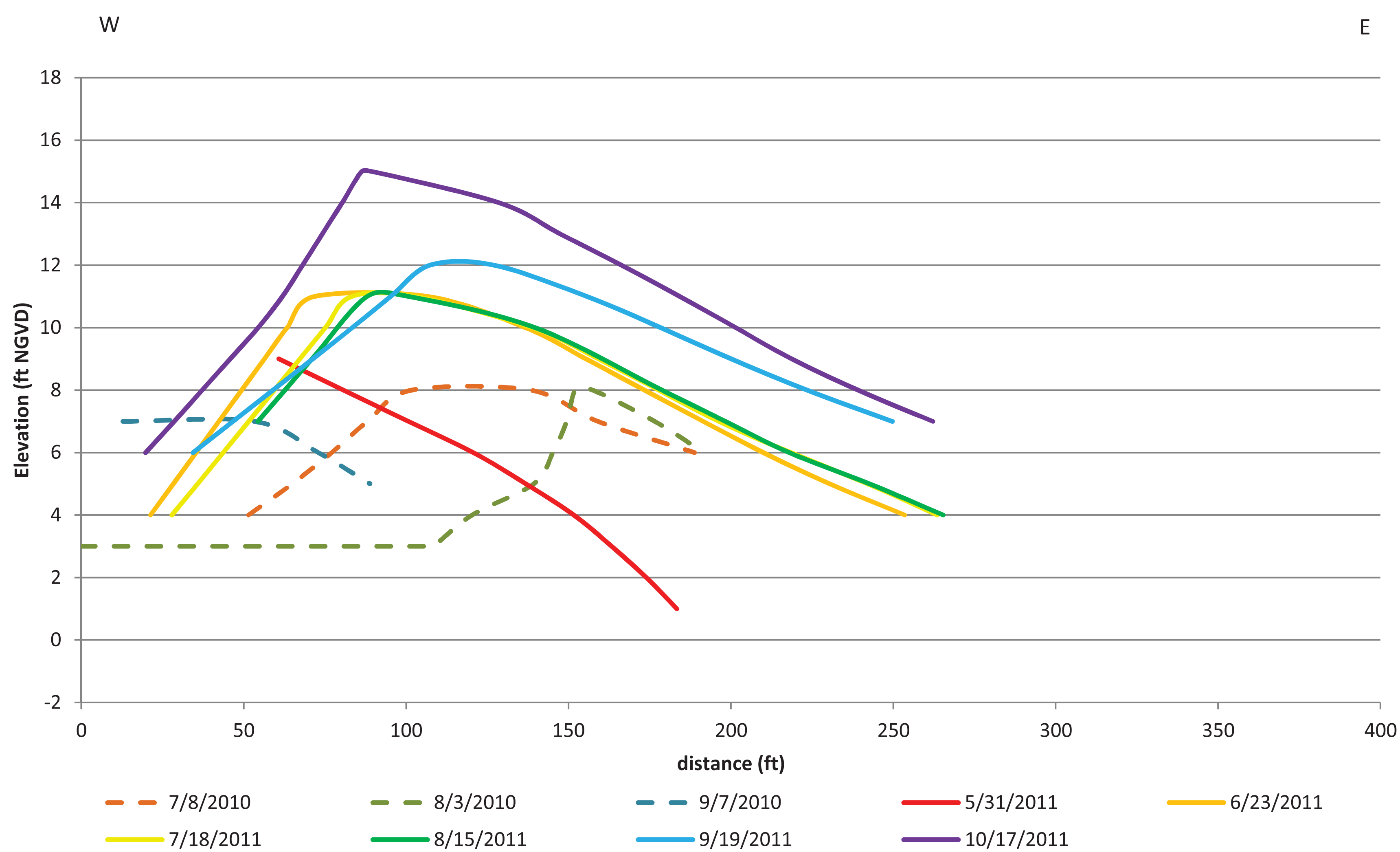
Russian River Outlet Channel Management Plan

Beach Transect 4

ESA PWA Ref #: DW01958

ESA PWA

Bathy_transects.xlsx / Transect4



Source: Sonoma County Water Agency survey data

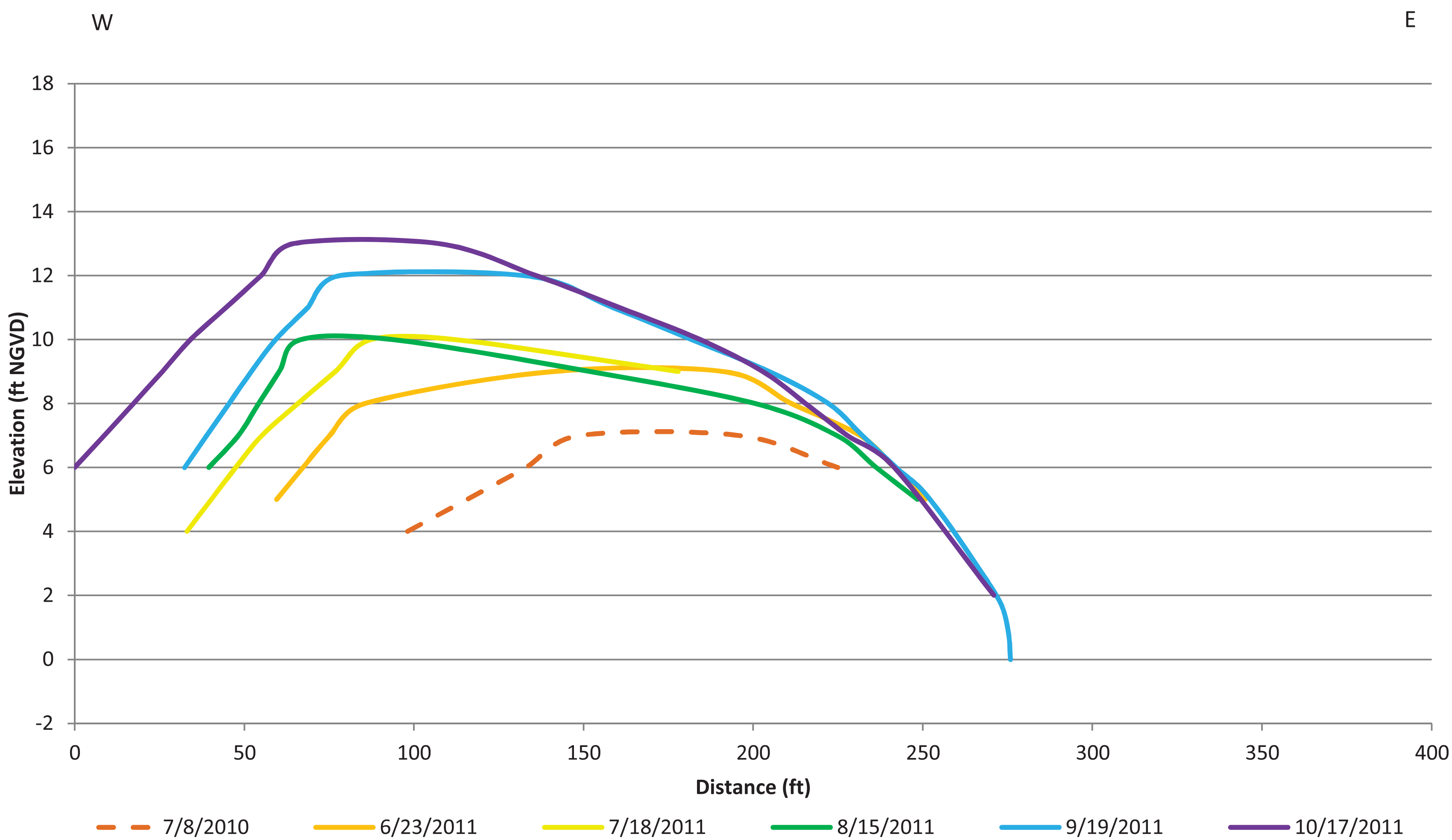
figure ***7***

Russian River Outlet Channel Management Plan

Beach Transect 3

ESA PWA Ref #: DW01958

Bathy_transects.xlsx / Transect3



Source: Sonoma County Water Agency survey data

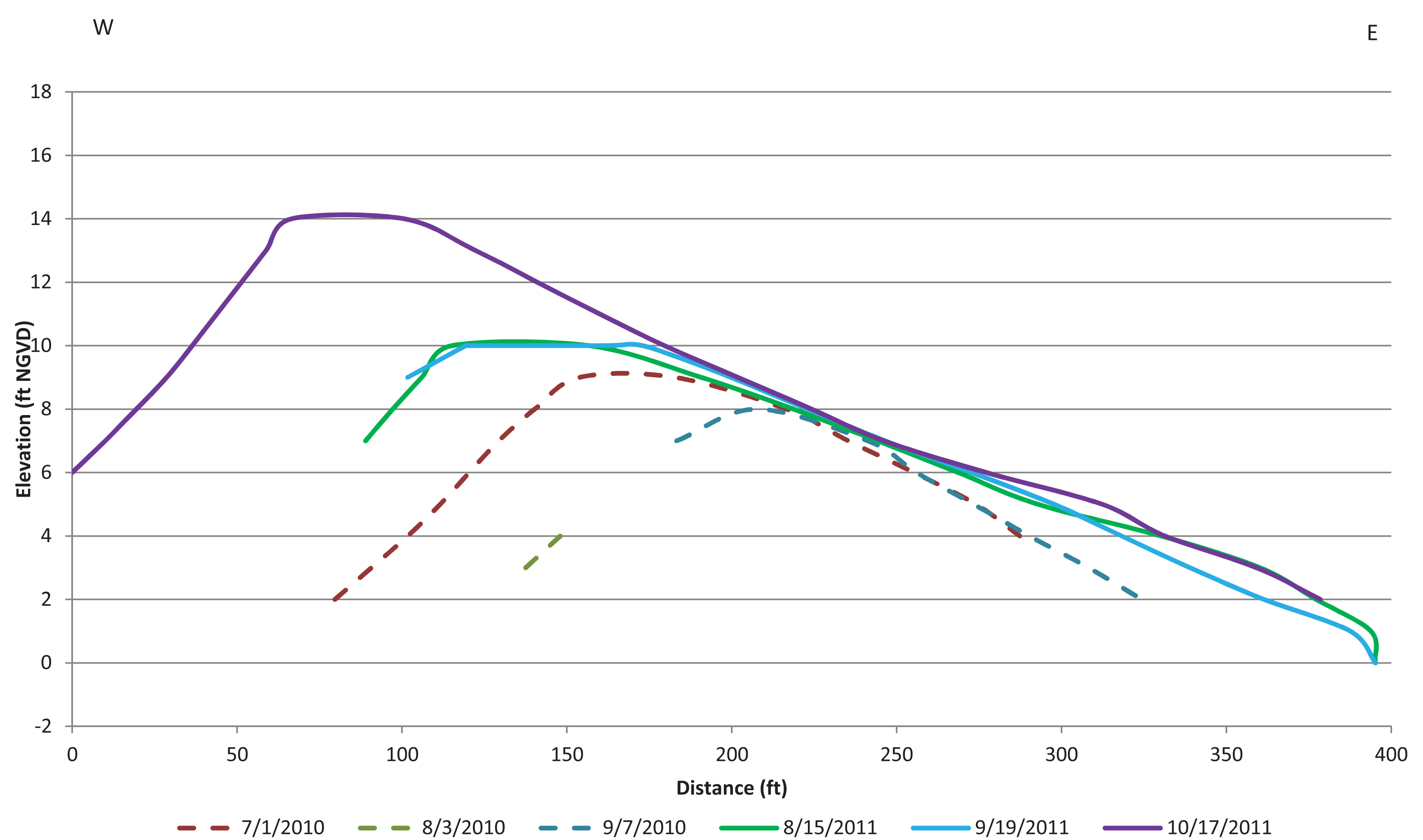
figure **8**

Russian River Outlet Channel Management Plan

Beach Transect 2

ESA PWA Ref #: DW01958

Bathy_transects.xlsx / Transect2



Source: Sonoma County Water Agency survey data

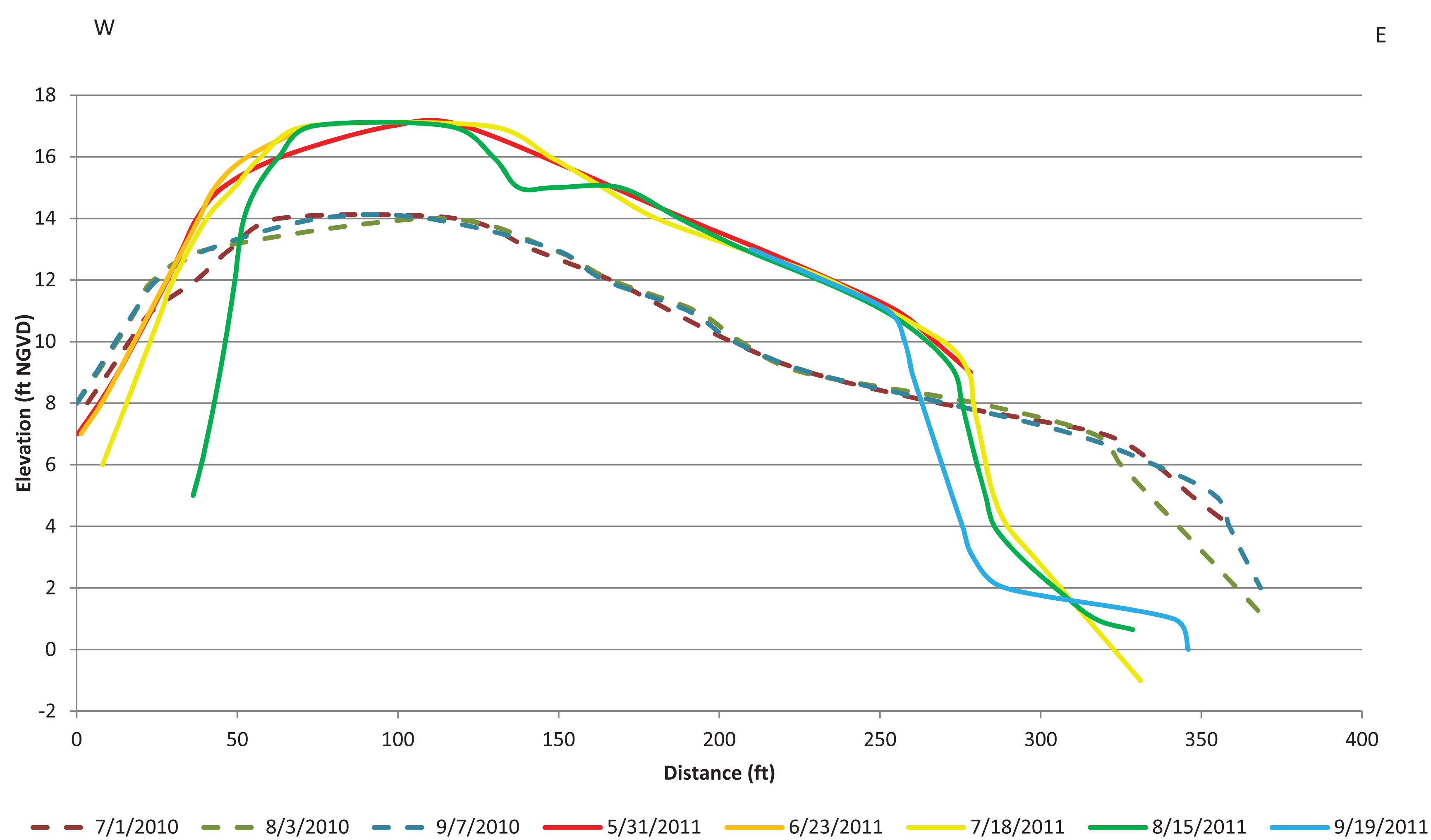
figure **9**

Russian River Outlet Channel Management Plan

Beach Transect 1

ESA PWA Ref #: DW01958

Bathy_transects.xlsx / Transect1



Source: Sonoma County Water Agency survey data

figure **10**

Russian River Outlet Channel Management Plan

Beach Transect 0

ESA PWA Ref #: DW01958

Bathy_transects.xlsx / Transect0

SOURCE: Sonoma County Water Agency

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 11

Steep Berm Limiting Beach Access, September 26, 2011

Attachment G. Physical Processes During the 2012 Management Period!

!

As required by the Russian River Biological Opinion, Sono&˙ County!Water Agency (Water Agency) has been tasked with m˙˝˙1)˝1!˙ summer lagoon i˝te˝(ed to improve s˙˘&onid habitat in the Russian River Estuary!4/ !creating an outlet channel while maintaining the current level of! *lood protection for properties adjacent to the estuary (NMFS, 2008). The adaptive &˙nage&e˝t plan, described in the main body of this report, was developed 4/ the Water Agen / with assistance *ro& ESA PWA and the resource agency &anagement team in 2009 and revised annually in 2010-2013. Because o*!permit constraints, the Water Agency was only able to)&ple&ent the plan beginning in %° °˛!˜ˆ e revised plan was in effect *or 2012, but no opportunities for m˙˝˙gement action occurred during the manageme˝t period.!!

!

During the 2° %!&˙nage&ent period, May 15th to October 15th, Water Agency!staff regularl/ ! &onitored current and forecasted estuary!water levels, inlet state, river discharge, tides, and wave conditions to anticipate changes to the inlet's state. Although the inlet experienced several closures, none resulted in water levels above 5.5 ft NGVD prior to self8breaching. For much of! June and July, the inlet was either closed or o˝˘/ allow)˝1!ˆeavily!&uted tides (tide range < 1 ft3.! but the lagoon water sur*ace never surpassed 5 ft +@VD. During this ti&e, each closure ended when lagoon water levels increased, overtopped the beach berm.!˙˝d scoured a new tidal channel. Since these episodes did not evolve to the point that m˙nage&ent action was warranted, the Water Agency did not take a˝/ !management actions to encourage form˙tion of!˙˝!outlet channel. For! the remainder!of Jul/ , all of August, and the first hal*!of Septem4er, the estuar/ !was full/ tidal. Then the inlet closed twice between Septe&4er 2°th!˙˝(October 10th. Both closures were short-lived, lasting less than one week. and again the inlet self8breached, precluding any Water Agency! &˙nage&ent action. The highest lagoon water level of the 201%!&nagement period, 5˛25 *t! NGVD, occurred at the end of the October closure.

!

Even though no m˙nage&ent actions were implemented to infor&!the a(aptive m˙nage&ent process, the physical conditions and inlet response during the m˙˝˙1 ement period are reviewed in this attachment to contribute to site understandi˝1!˙˝(to inform!*uture manage&ent a tions.!

!

METHODOLOGY

This review of the 2012 outlet channel management period ex˙&ined water levels, ocean wave conditions, ocean water levels, riverine discharge, beach topography, as well as inlet size and location. The sources for these parameters are listed in Table 1. These data were supplemented with personal observations and discussion with staff from the Water Agency, NMFS, DFG, and the Bodega Marine Laboratory.!!

!!

Table 1. Data Sources

Parameter	Source
Estuary!5 ˙ter level (h_E3!	Water Agency!Jenner g˙ge[J]!
0 ˙ve height (H_s), period (˜ ·3.!˙nd direction !	ˇ DIP Point Reyes buoy #029!
Ocean water level (h_O3!!	NOAA Point Reyes #9415°%°!
Russian River discharge (Q*3!	USGS Guerneville #114FE°°° !
Beach topography.!*t!+@A7!	0 ater Agency!&onthly!surveys
Inlet size and location	Water Agen / and Bodega Marine Laboratory! autono&ous ca&er˙s

[J]Data transmission f˙ilure due to cellular networ issues occurred for several 1-5 day periods throughout the!&anage&ent period.!

!

INLET STABILITY PARAMETER AND CLOSBRE RISK PROBABILIT" !

In addition to considering individual parameters, researchers at the 6odega Marine Laboratory! have developed a co&bined parameter to evaluate the stability of the inlet's state, with the aim!o*! predicting closure risk (Behrens et al., 2013). (Note tˆat the inlet stability parameter does not differentiate!4etween *ull closure and the perched conditions with a s&˙ll outlet channel. When discussing this parameter, both states are referred to as a 'closure' in that tides are prevented fro&! propagating i˝to the estuary˛3The inlet stability parameter presented!4/ !6ehrens et al. (2013) quantifies the risk of inlet closure based on a sed)&ent b˙lance in the inlet. It considers the d˙)˘/ ! balance between wave-driven sediment import to the inlet and sediment export driven by tidal fluctuations. The wave-driven import is assessed usin1 nearshore wave est)&ates derived fro&!˙! transfor&˙tio˝!&˙trix and offshore buoy data (ESA PWA!%° %3and the latter is estimated fro&! tide gage data within the estuar/ !˙˝ d a stage-storage relation derived fro& the available bathymetr/ ˛!Using daily8˙verage values of the stability para&eter 5 ithin the period 1999-2008, Behrens et al.!2%° '3 showed that high-percentile values of!the parameter ˙re closely!˘)˝ ed to the risk of the inlet closing within five days. As the percentile of the stability par˙&eter increases, the risk of!inlet closure within five days increases exponent)˙˘˘/.!*ro&!risks of roughly five percent when the parameter is at the 50th percentile to a ris of 80 percent when it is &easured at the 99th percentile.

!

SUMMER AND FALL CLOSURES AND SELF-BREACHES!

˜) &e series of estuar/ !5 ˙ter levels, as well as the key!*orcing factors (waves, ti(es, and riverine discharge), are shown in Figure 1 for the entire &˙˝˙ 1e&ent period. The lagoon water level time series (Figure 1a) su&&arizes the observed &uted conditions in earl/ su&&er and short-lived closure events that occurred at the end of the &˙˝˙gement period. As shown in Figure 1d, discharge remained high for the first two months of the manageme˝t period.!River discharge did not drop belo5!%°°!*t˙/s until after June 10th, at which time the estu˙ry had already!begun its &uted tidal phase, leading up to four short-lived closures. This elevated discharge probably! reduced the likelihood of inlet closure during the first ' °8?° !(˙/ s o*!the management period (Figure 1d), despite the occurrence of energetic wave conditions in May!(Figure 1b). Wave energ/ reached a &)″)&um in August and early!- eptem4er, but was weaker throughout the 2012 &˙nage&ent period than i″ !%° 1. The hourly!significant wave height was less than 8 ft for the &˙jority o* this period. !

!

The conditions leading to inlet closure were consistent with the existing conceptu˙˘!&odel described in Section 4 of the Management Plan. All closure events coincided with either &oder˙tel/ !ˆ)1ˆ!5˙# es (H_s!O!F!t) having periods greater than 10 s, or with neap oceanic tide ranges of less than approximately 5 ft¸ !Moderate˘/ !ˆ)1ˆ!5˙# es coincided with the closure events in June, July, Septem4er an(October. The first closure observed in June!˙″(!4 oth July closures coincided with neap tide conditions, although long-period swells occurred prior to the former of! the two. Closure events that occurred in June a″(!9 uly!˙re e<˙&)″ed in more detail in Figure %.! while Figure 3 su&&arizes conditions that occurred later in September8Novem4er.

!

All closure events occurred with the inlet located!˙(jacent to the jett/¸ !˘ˆ) s positioni″1! &ay have prevented perched conditions fro&!arising by shielding this area of the beach fro&!the wave-driven sediment deposition that caused closure, preventing the be˙ ˆ!* ro&!accreting to a sufficient height to allow the desired outlet channel elevations!*rom be)″1!˙ttained. The low point in the be˙ ˆ!4 erm!that was subsequently overtopped and self8breached also persisted immediately! adjacent to the jett/¸ !

!

PERCHED LAGOON AND SELF-BREACH DYNAMICS !

During the June and July!closures (Figure 2), as well as the late Septem4er closure (Figure 3), the lagoon water level only!increased at approxim˙tely!°¸'!*t/day. This slower increase probably! occurred because a small outlet cˆannel that flowed over the beach berm!˙nd through!˙!1˙p in!the jetty!partially balanced i″*lowing river discharge.

!

As an example of one of!the several inlet closure events that resulted in self8breaching prior to target outlet channel elevations, Figure 4 shows a sequence of!photos of!the inlet before, during, and after an episode fro&!October 8-15. As was the case for all o* the &anageme″t period, the inlet was located next to the jetty. Prior to closure, the inlet had allowed only!&uted tides, resulting from!a partial breach on October 2″(that did not restore full tidal action. Neap oceanic tides co&pounded this, and 7-ft high nearshore waves having a do&inant period above 20 seconds closed the inlet on October 8th!2Figure 3b,c). !

!

After the onset of closure, the estuary water levels began to rise.!, or the first two days of closure, the water level increased at approxim˙tel/ !°.5 ft/day!fro&!' !to 4!ft NGV7.!4 ut this decreased to less than 0.3 ft/day!˙*terwards (lagoon sta1e above 4 ft NGVD). Waves deposited sediment adjacent to the gap in the jetty structure, block)″1!out*lows *ro& the lagoon that had occurred in prior closures (Figure 4b).!This partially8*ormed barrier ber&!was overtopped when the lagoo″! reached approxim˙tely 5.25 ft on October 15th!(Figure 4c). The outlet channel was narrow, with a width of less than ten feet. This overtopping event coincided with a spring phase of!the oceanic tides, which generated a large head difference between the estuar/ !˙nd ocean waters. This head ()**erence presu&˙4˘/ contributed to channel flow velocities exceeding the threshold for scouring the beach sand, since the spring lower-low tide on October 16th resulted in the s&all channel eroding the barrier and creating a new inlet (Figure 4d). After the initial breach, the increased *low rate scoured sand from!the channel bed and 4˙˝ s, and the channel increased to &ore than %°!*eet in width (Figure 4(3˛!!

!

The jetty and rocks which had been a part of the jetty appeared to have a significant influence on the geomorphic evolution!o*!the channel. At ti&es, the jett/ ele&ents!&˙/!ˆ ave stabilized the outlet cˆ annel, both!in sheltering the outlet cˆ anne˘!*rom waves a˝ (!4/ providin1!4˙˝ !˙˝ d be(! stabilization that &)˝)&)>ed channel scour. Wave!sheltering by the jett/ probably!reduced ber&! build-up at the inlet's location, leaving a low point in the beach berm that was the site *or subsequent overtopping and self8breaching. Of!the six closure events that occurred within the &˙ nage&ent period, all experienced a si&ilar breaching pattern, self8scouring a tidal inlet before estuar/ !water levels reached 5.5 ft NGV7˛!˘ˆ) s was also true of the two closure events wh) ˆ! occurred in Novem4er, following the!&anagement period 2,)1 ure 3). At times, the outlet channel *lowed through notch in the jetty (Figure 5), such that the rocks probably provided stabilization that prevented bed scour. The jett/ also!ˆalted lateral scour to the south. However, o˝ ce later˙˘! scour is halted, the channel &˙ / !then m˙ intain its cross-sectional area b/ scouring downward where it runs parallel to the jetty˛!!

!

!

CLOSURE R;SK PROBABILITY !

The 5-day closure risk probability.!˙!(eri#ative of the inlet stability!parameter described above, was hindcast *or 2012 according to the method described in Behrens et al. 22013). This hi˝(ast provides an indication of the utility of the stability parameter as a prediction tool for monitoring inlet conditions and planni˝1!&˙ nage&ent action.!˘ˆ) s parameter integrates wave and ocean *orcing conditions, as well as estuary water levels, to provide greater predictive skill than just! waves or ocean tides on their own. The stabilit/ !parameter co&4)˝es these factors, and the corresponding five-day closure risk time series exceeded 50 percent!be*ore each 2012 event (Figure 1e, Figure 2e, and Figure 3e). The closure event initiated on July! st occurred quick˘/.! transitioning *rom!*ully tidal to fully! losed within a!(˙/ , so the risk time series did not provide &uch forewarning in this case. This was also true of!two closure events occurring outside of!the &˙ nage&ent period, in!+ o#ember 2012. However, for all other events observed fro&!9une to Novem4er, the predicted probability of! losure exceeded 50% 2-5 d˙/ s in advance of each closure. There were no instances during the &˙ nagement period when the predicted probability of! closure e<ceeded 50%!˙˝(! ˙! ˘osure did not occur w)tˆ in 5 (˙/ s.

!

TOPOGRAPD;˘!˘D ANGE

The W˙ ter Agency!ˆ˙ s conducted monthly!surveys of!@oat Rock State Beach that cover a!region starting from!the jetty!˙nd extending approxim˙ te˘/ 1,500 feet to the north. Typically, the surveys do not include bathymetry within the inlet because f˘o5 conditions!in the inlet prevent safe! access. Also, the survey extent can be limited b/ the Water Agency's co&p˘)˙˝ ce with its &arine &˙ &&˙˘!)˝) dental harassment authorization, which sets guidelines for the survey! rew's disturbance to marine m˙ mmals!ˆ˙ uled out on the be˙ ˆ ˛!0 ˙ ter Agency survey staff collected spot elevations using RTK-GPS and then asse&4led these elevations into a set of contour li˝ es at

1 ft intervals. The survey elevations are reported in the!+@A7%9 vertical datu&, tˆ e work)˝1! datum!*or estuary!&onitoring a˝(!& anagement.

!

To characterize beach berm!topographic conditions, ESA PWA assessed data fro&!the Water Agency's 2010 (July to Septem4er), 2011 (May!to October), a˝(!%° 12 (May!to October) surveys. Surveys *ro& Novem4er 2011 to May 2012 were also co&pared, to assess winter-time changes of! beach shape. Survey transects *ro&!the 2011 analysis were reused (Figure 6), and include two transects b˙ ed b/ ! ˘)**!2Figure 7 and Figure 8), one transect which extends into the estuar/ ! (Figure 9), and two transects just north of the jett/ !2,)gure 10).

!

This review focuses on the 201%!surveys, although the!%°°!˙˝(!%°11 surveys are included for context. Compared with both 20°!˙ ˝(!%011, the 20 % topographic data indicate that the be˙ ˆ! ber&!5˙ s less variable in shape than in previous years. This is especiall/ true of the northern two transects (Figures 7 and 8), and to a lesser extent at Transect 2 (Figure 9). Because of inlet an(! seal haulout locations, topographic data were not collected in the vicinity o*!Transect 1!)˝!%°%.! so this is not included in the analysis. Adjacent to the jetty!groin, Transect 0 showed little &onthly! ˆ˙˝ ge in topogr˙ phy, but extensive inter-annual variabilit/ ˛!!!

!

During the &anagement period in 2012, the beach berm!˙ long transects 2, 3, and ? showed little variability.! ˆ ˙˝1)˝1!4/ less than two feet. The profile along Transect 2 (Figure 9) showed a slight aggradation trend over the course of the &˙˝˙1 ement period, but at Transects 3 and 4, the change in shape fluctuated only!slightly!2,) gures 7 and 8). In contrast, between M˙/ !%° !˙˝(! October 2011, the beach berm!at these transects built in size b/ !&ore than 6 feet. The difference)˝!&onthly variability!˙ t the northern transects between the 20 !˙˝(!%° %!&˙ nagement periods ˙˝!˘) ely be tied to the dif*erence in the extent of inlet &igration. In 2011, the inlet &igrated north o*!D˙/ stack Rock during the winter, and returned to the jetty in late spring or early summer. This &igration resulted in a lower beach profile at all transects. Over the course of the &˙ nage&ent period, the 4each gradually built up to!˙ !typical summer profile. Even during the peak!5 inter and sprin1!*lows of 2012, the inlet never m)grated north of!D˙/ stack Rock, leavi˝1!˙! largel/ -intact 4each ber&!˝orth o*!D˙/ st˙ Roc !˙˝(!˙!˘ower terrace between H˙/ st˙ Rock! and the jetty!1roin. Since these northern transects started at a &u ˆ!ˆ)gher elevation at the start o*! the &˙ nagement period, the vertical growth o*!the beach profiles at these locations were sever˙˘! feet less than during the previous year i˝ the sa&e locations.

!

Transect 0, which is located just north of and parallel to the jetty, had noticeably different elevations and evolution than the other transects!during the 20 %!&anagement period. Co&pared to the other transects, crest elevations were highest at this transect for both 2° °!˙˝(!% ° ˛ !This was not the case in 2012, when the nortˆ ern&ost two!transects were the highest.!The crest elevation at Transect 0 did not evolve during the &anagement periods!)˝!%°°!˙˝(!%° 11, but was observed to erode between August a˝(! October in 20 %˛!;&˙ ges from the BML stationary! ˙&era indicate that this was the result of the inlet shi*ting fro&!˙ sinuous align&ent (resulting fro&! southward m)gration) to a straight alignment running nearly parallel to the jetty. The only! significant changes occurred during the winter between each of!the &anagement periods. The ˘˙ of!&˙˝˙gement period variability!o*!this region suggests that the jetty shelters this portion of!

the beach fro&!small to &oderate waves that occur during the &anagement period. Only!the larger waves associated with winter storms m˙/! 4e su**) ent to re-shape the beach ber&!˝ear the jetty¸!!

!

0 ˙ter A1ency surveys taken during the &onths preceding the 201%!&˙nagement period (Novem4er 2011 to April 2012, Figure 11) show more variability!in beach berm height and width than was observed for the 2012!&˙˝agement period (Figure 9). Tˆe highest be˙ ˆ! rests observed during the 128&onth period from!+ovem4er 2011 to!October 2012 oc urred in Novem4er a˝(! Dece&4er 2011, peak)˝1!4etween 14 and 15 ft NAVD88 at Transect 2 (Figure 11). This is consistent with the co&bination of!ˆ)1ˆ8energ/ . long-period swell waves and generally!low *uvial flows during!the late fall. By the February 2012 survey. erosion s)1˝)*)cantly!reduced the beach crest elevation. This erosion is likely!due to fluvial flows through the inlet at Transect 2¸! Farther north, at Transect 3, there was less influence fro&!the inlet,!˙˝d there appeared to be less erosion duri˝g winter 2011-12 (Figure 12). The ber&!crest was highest in late spring (March and May profiles) and in Nove&4er 2012, peaking between 16 a˝(! E!*t NAVD88. The difference between the evolution of!˜ransects 2 a˝(!'!& ˙/ be!˙!result of the inlet's lack of!&igration in 2012, or possibly!˙!()**erence in the amount of!wave exposure between locations.!

!

Water Agency!surveys were also used to assess the beach width at Transect 3. We *ocus o˝! Transect 3.!4ecause the influence of the)nlet caused the beach to be consistentl/ lower at other transects, so&eti&es as low as the intertidal zone, where survey!(ata were not consistently! collected. The Transect 3!4each width was as the horizontal distance between a particular elevation on the ocean and estuary!sides of the beach *ace, respectively. Fro& Novem4er 2011 to June 2012, the beach width at the 12 ft NAVD88 elevation varied fro& 110 to 145 feet, showing signs of both narrowing a˝(!5 idening (uring the winter and spring!2,)gure 13).!, rom!9une to August 20 %. the be˙ ˆ!5 idth grew steadily!*rom!about 11°!*t to 145 ft a˝(!˙ ppeared to rem˙)˝!˙t this width though Novem4er 2012. At an elevation of! ?!*t NAVD88, the widtˆ!*ollowed the same pattern, but had larger!*uctuations, vary)˝1!*rom!roughly 30 to! °!* t and grew steadily! *ro&!9une 2012 onward. These observations underscore the typ) ˙˜! pattern of beach buildi˝1!)˝! su&&er, but also indicate that waves in winter can build the beach between destructive events.!

!

LESSONS LEARNED AND RECOMMENDATIONS

Based on observations of the estuary, associated physical processes, and the Water Agency:s planning for outlet channe˜!&˙nageme˝t, we note the following lessons about implementing the outlet cˆanne˜!&˙nagement plan.!

!

CONCEPTBAL MODEL!

- Elevated discharge in the late spring (greater than 200 ft'/s until June 10th3!&˙/!ˆ˙#e! reduced the likelihood for inlet closure in May, although the wave climate at this time! was also significantly weaker than during the previous / ear. !
- Several short-lived closure events occurred, but waves never built up the m)˝)&u& crest height (the li&iting height for closure) beyond 5.5 ft +@A7.!˙˝(!˙ll e#ents ended with

self-breaches below this elevation. This prevented &˙˝˙gement actions fro&!4eing taken during the 2012 season.

- The inlet never migrated north of!D˙/ stack Rock during pe˙ !5 inter f˘oods, and returned to the jetty in earl/ !spring, mu h earlier t˘˙˝!)˝! &ost / ears. This inlet align&ent is not co&&on, but ˆ as been observed in past years (Behrens et al., 2009). !
- During the management period, most of!the beach north of!D˙/ stack Rock underwent little topographic change. A transect adjacent to Haystack Rock aggraded slightl/ .! consistent with typical beach berm building that occurs during tˆ e su&&er. Adjacent to the jetty. the berm did not ˙ggrade, but rather rem˙ined large˘/ unchanged for most of the season and then later eroded between August and October as a result of a sh)*t in the inlet ˙˘)1˝&ent.
- The wave clim˙te remained weak throughout!&uch of the su&&er and f˘˘˘.!5ˆ) ˆ!& ˙/! have stunted the growth of the beach crest in the vicinity o* the jetty!(the location of the inlet throughout the 2° %!season), preventing lagoon water levels *ro& reaching levels conducive of the planned outlet cˆ annel.!
- When an outlet channel is present, oceanic tide conditions can encourage scouring and *ormation of a new tidal inlet. During the spring phase of the tide, the lower-low tide creates a large head dif*erence between the lagoon and ocean, likel/ !increasing the flow velocit/ in the channel.

!

OUTLET CHANNEL FEASIBILITY

- The jetty!&˙y shelter the inlet, &˙ ing closure less likely and also limiting berm growth, which then m˙intains a low point for self-breaching. When the inlet is)˝!˙!*ully or &uted tidal condition, options for management beco&e considerably!&ore diff)cult to)&pleme˝t.
- An outlet channel that was intermittently observed during the 2012 closures conveye(!˙! portion of the inflowing river discharge, slowing the rise in lagoon water levels to approxim˙tely 0.3 ft/day¸!˘ˆ is channel f˘owed through a!1˙p in the jetty.!5hose large rocks likely!provided some degree of channel stabilization against scour. However, this condition changed with lagoon levels, as described below.!
- Once outlet channel discharge increased due to rising lagoon water levels or low oceanic tides, the discharge scoured a new channel, 4reaching the estuar/ to!the tides. This behavior highlights the susceptibility of!˙!sand bed outlet channel to scour, lim)ting conveyance capacit/¸!
- Even if the inlet being near the jetty!ˆ)nders!*orm˙tion of sustained lagoon a˝(outlet channel conditions.!&˙nagement opportunities *or re-locating the outlet channel are ˘)&)ted a˝(! onstrained. At ˙!&)˝)&u&.! reating an outlet cˆ annel!*urther north *rom!the jetty requires a full natural closure, absence of a low point i˝!the beach berm near the jett/ .!˙˝d equip&ent access to the area north of the jett/¸!!
- Over the first three years of e**ort to imple&ent the outlet cˆ annel a(aptive m˙˝˙gement plan, only one closure (July 2010), has been suited for outlet channel &˙nagement action. !

!

COMMUNICATIONS!

- Although the perched lagoon episodes did not evolve to the point tˆ at management action was warranted, the Water Agency began p˘˙˝˝) ˝1!&anagement actions as soon as the episodes occurred. Planning included heightened observations of inlet conditions!4/ ! 0 ˙ter Agency staff, email updates to inform!the resource &˙nagement group, ˙˝(pre-)&ple&entation &eetings at the project site to refine plans for &˙˝ agement actio˝˛!!

! !

MONITOR;+@!

- The Agency's month survey!&ethods should be!&odif)ed to collect specif)ed contours, such as the beach ber&!ridge line, wetted edge (beach side3.!˙˝d water edge (estuar/ ! side).

!

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!

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!

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Weigel, R. 1992. Oceanographical Engineering.

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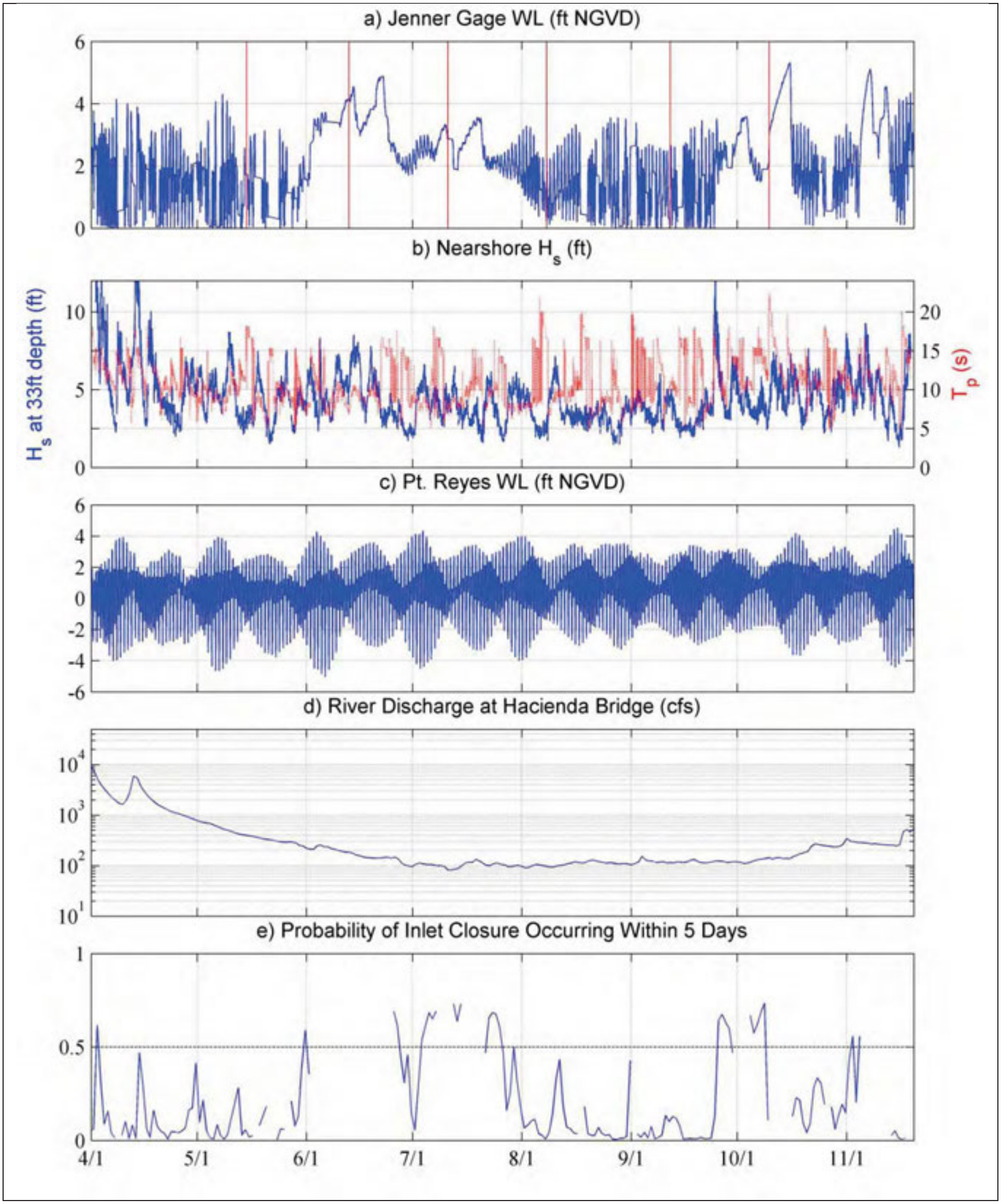
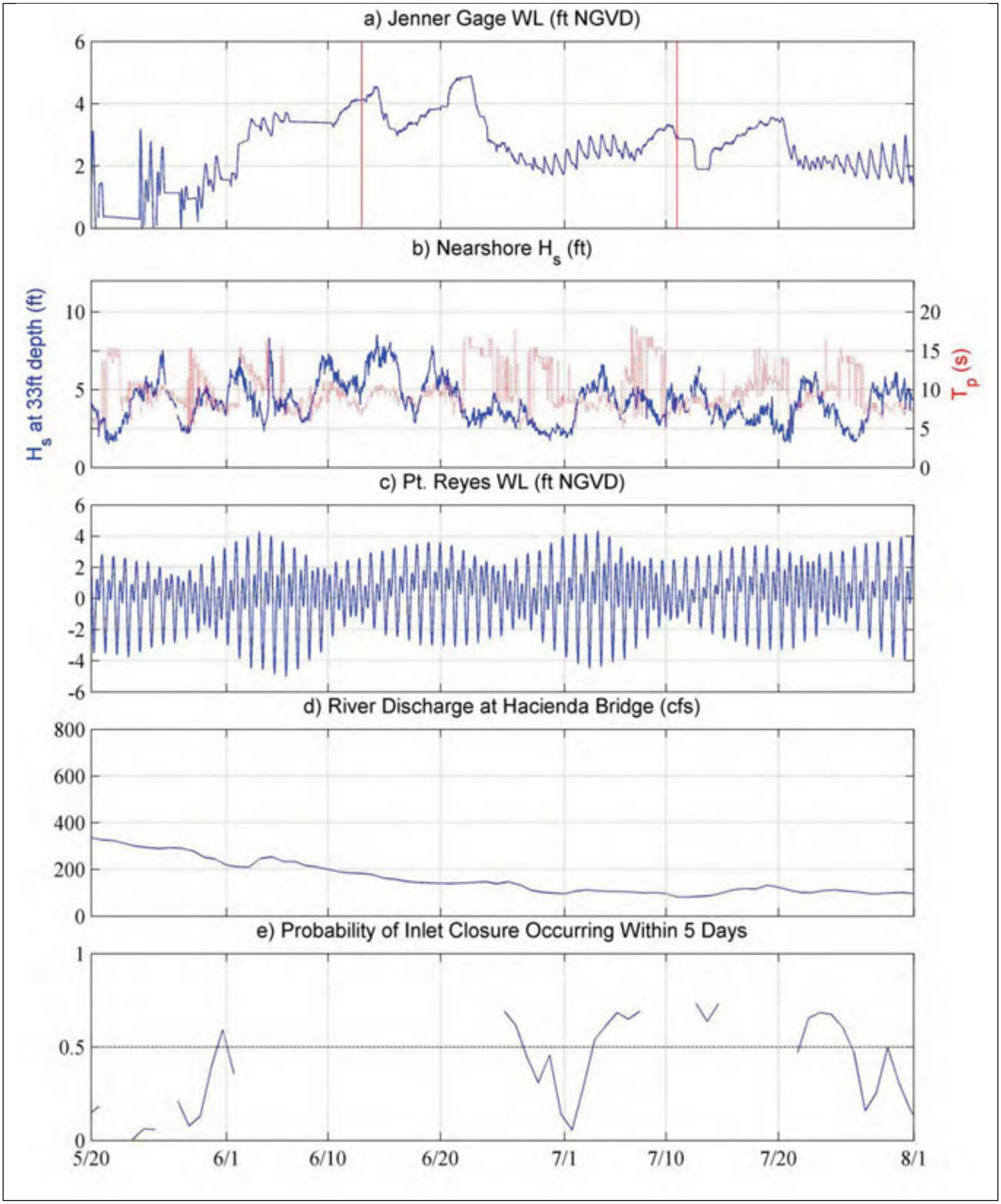


SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

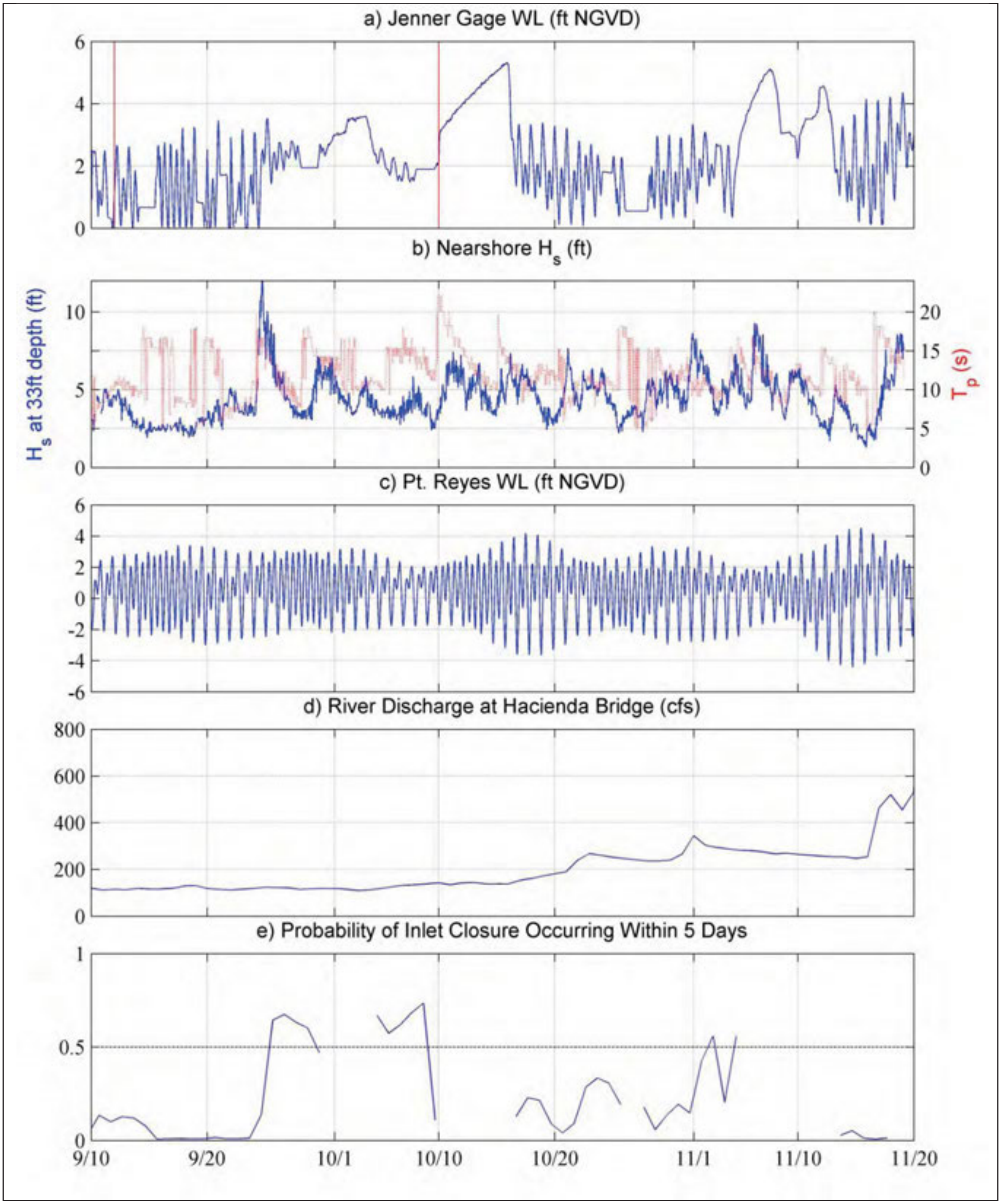
Figure 1
Estuary, Ocean, and River Conditions Compared with Closure Probability: September – November 2012



SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; T_p=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

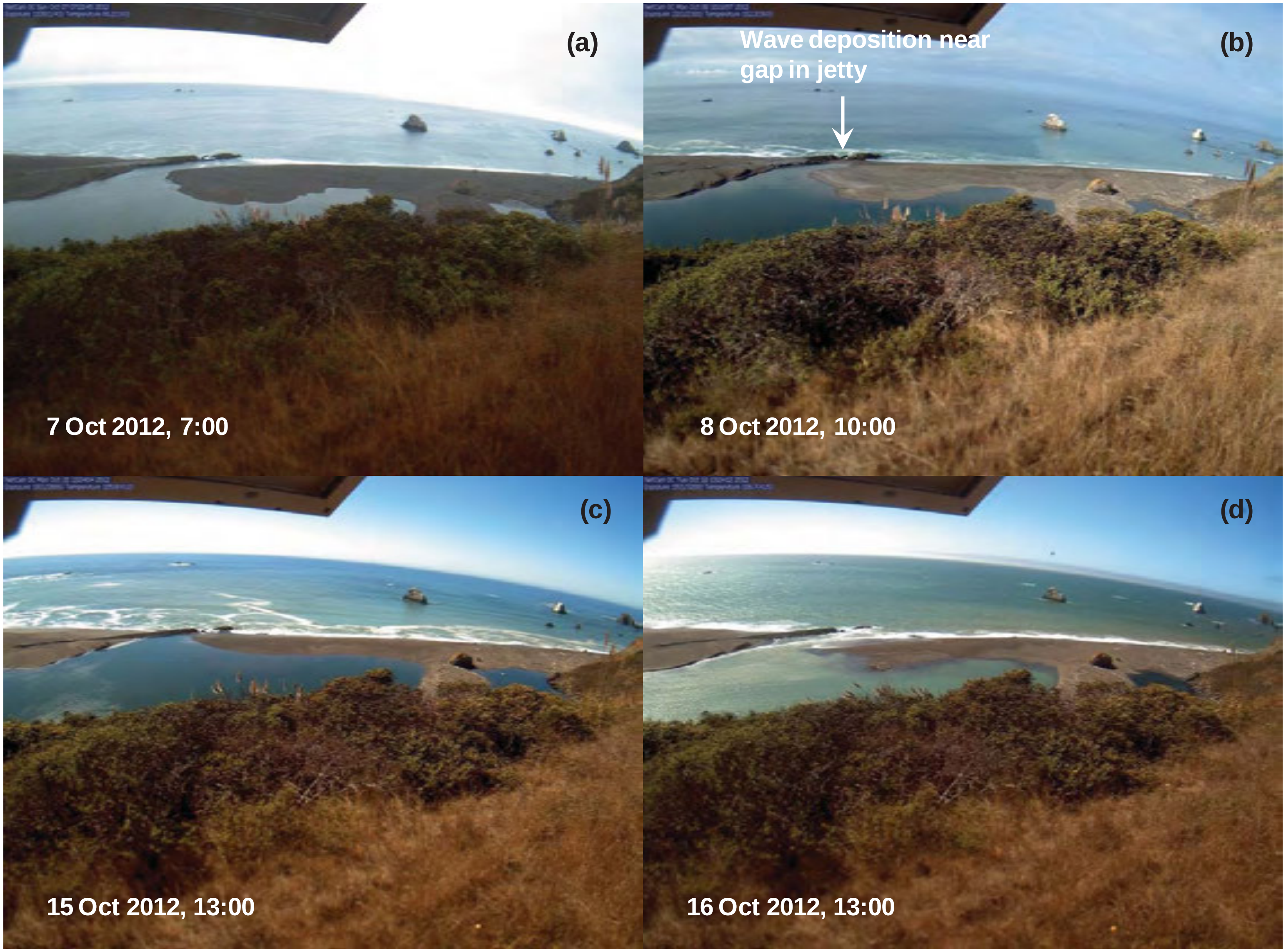
Figure 2
Estuary, Ocean, and River Conditions Compared with Closure Probability: May 20 – August 1, 2012



SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; T_p=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

Figure 3
Estuary, Ocean, and River Conditions Compared with Closure Probability:
September 10 – November 20, 2012



SOURCE: Russian River stationary observation camera (BML)

Figure 4
Inlet Closure and Self-Breach in October 2012

Source: Sonoma County Water Agency

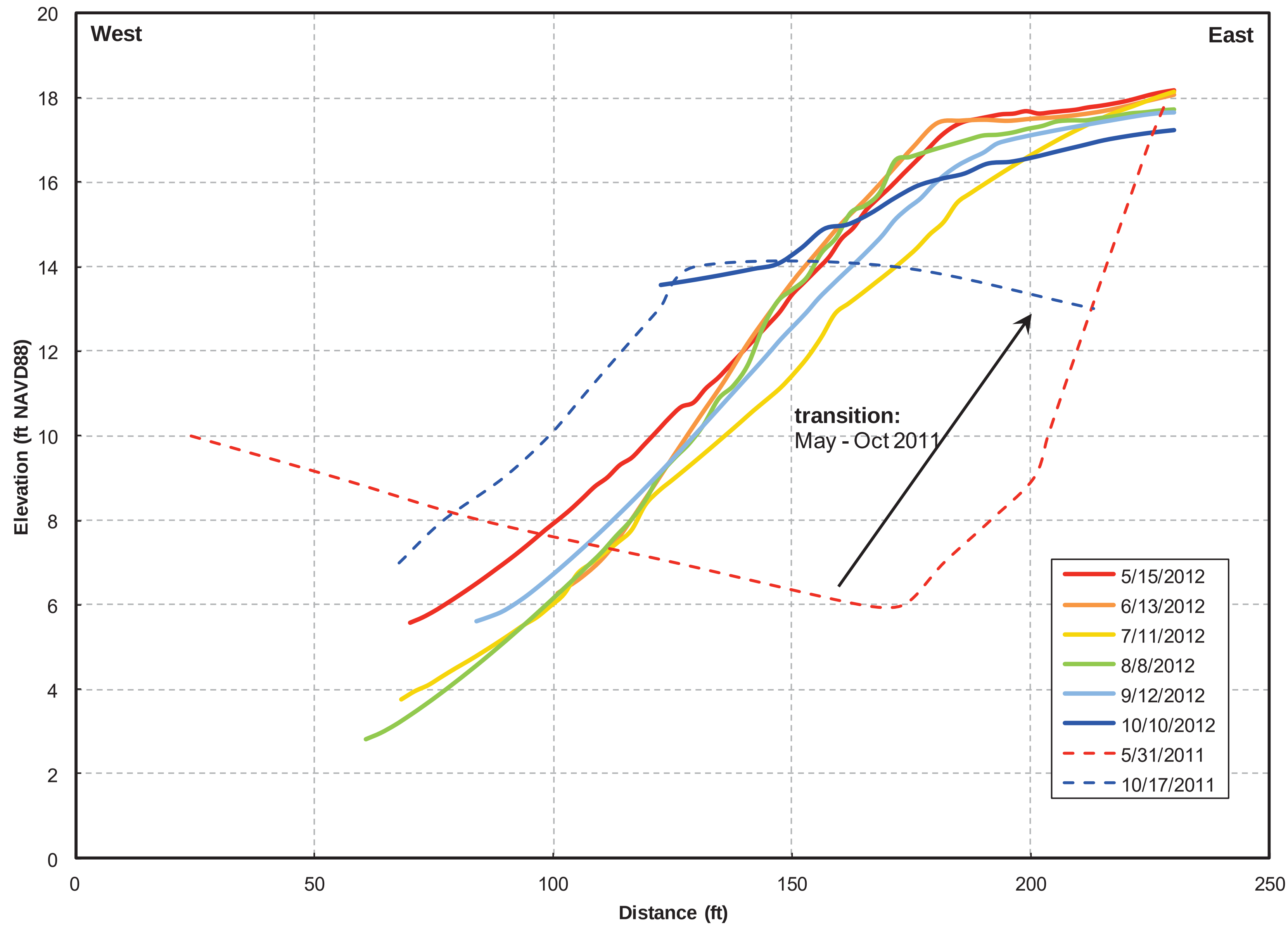
figure 5
Project Name

Outlet Channel Flow Through Jetty Notch

ESA PWA Ref# DW01958.02

SOURCE: image from USDA NAIP

Figure 6
Beach Transect Locations

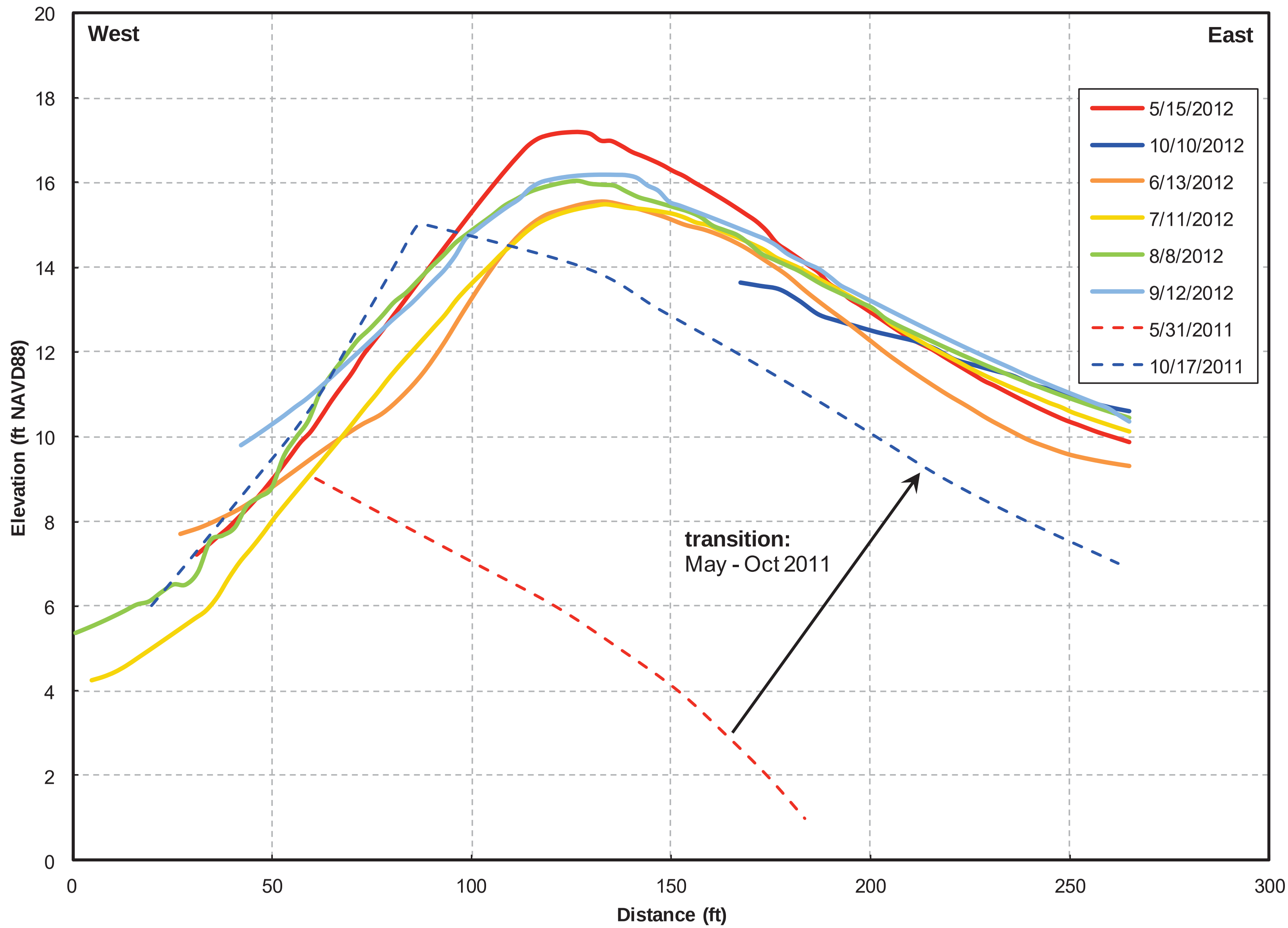


SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 7

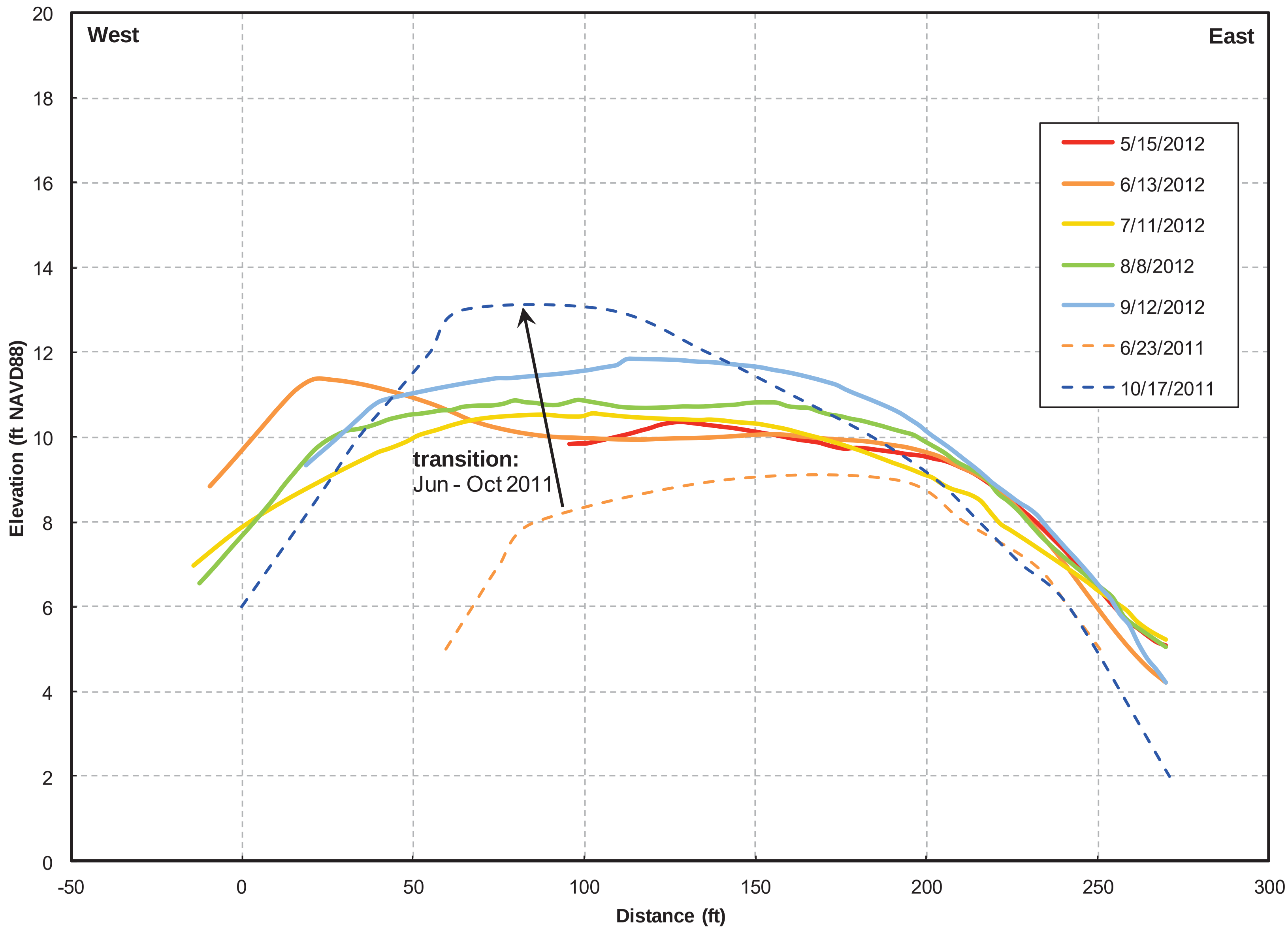
Beach Transect 4



SOURCE: SCWA survey data

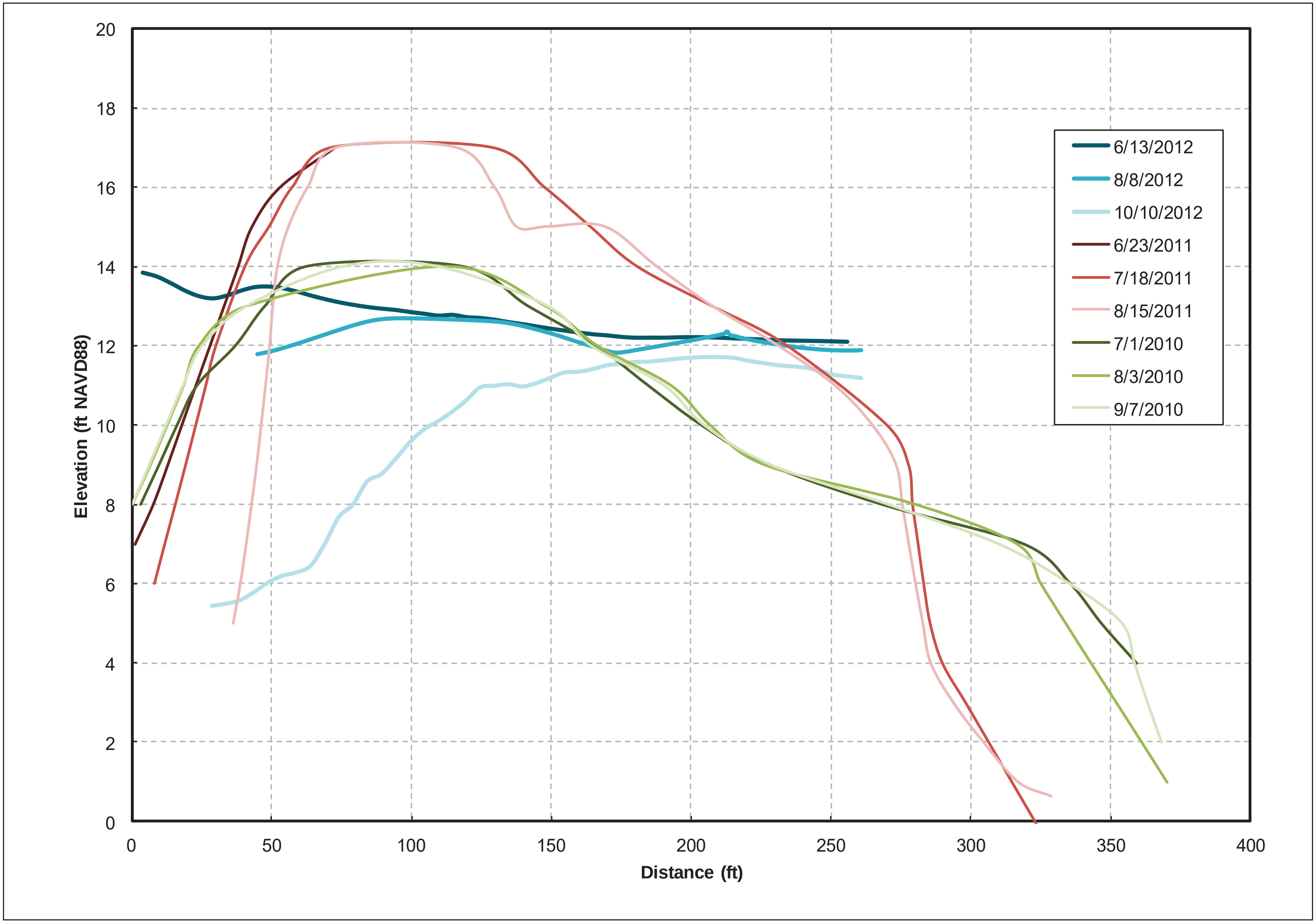
Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 8
Beach Transect 3



SOURCE: SCWA survey data

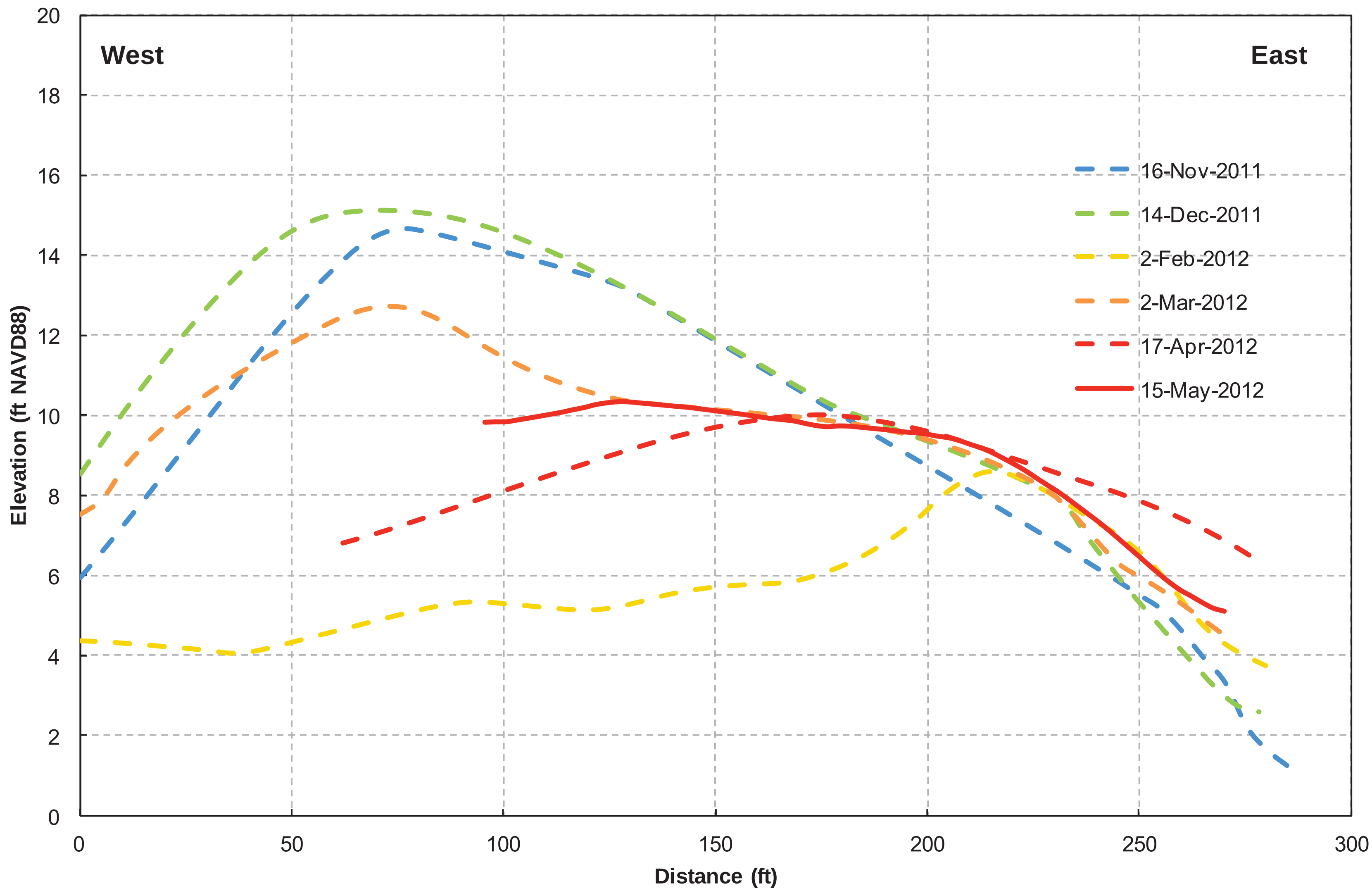
Figure 9
Beach Transect 2



SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

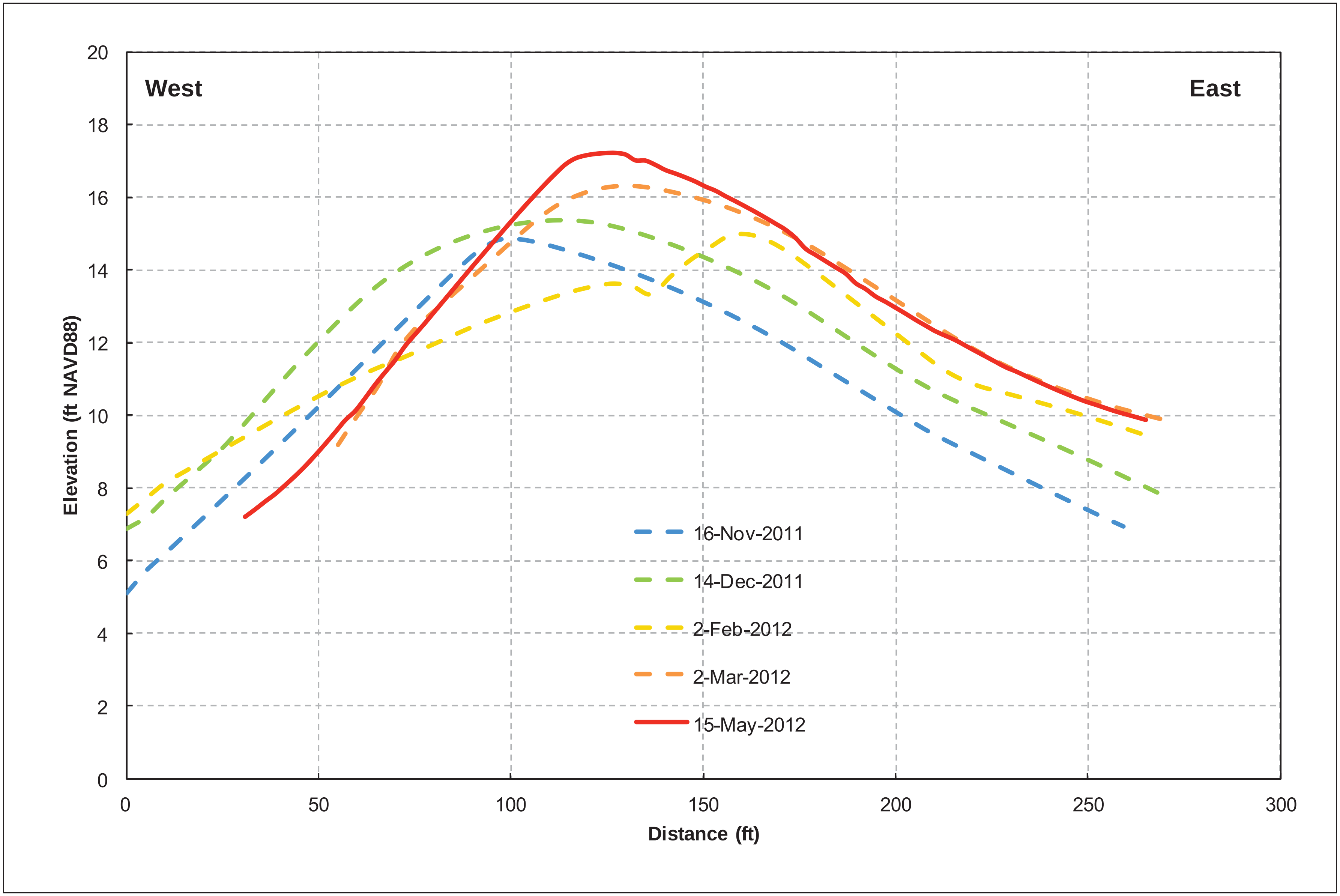
Figure 10
Beach Transect 0



SOURCE: SCWA survey data

Figure 11

Nov 2011 to May 2012 topographic change at Beach Transect 2

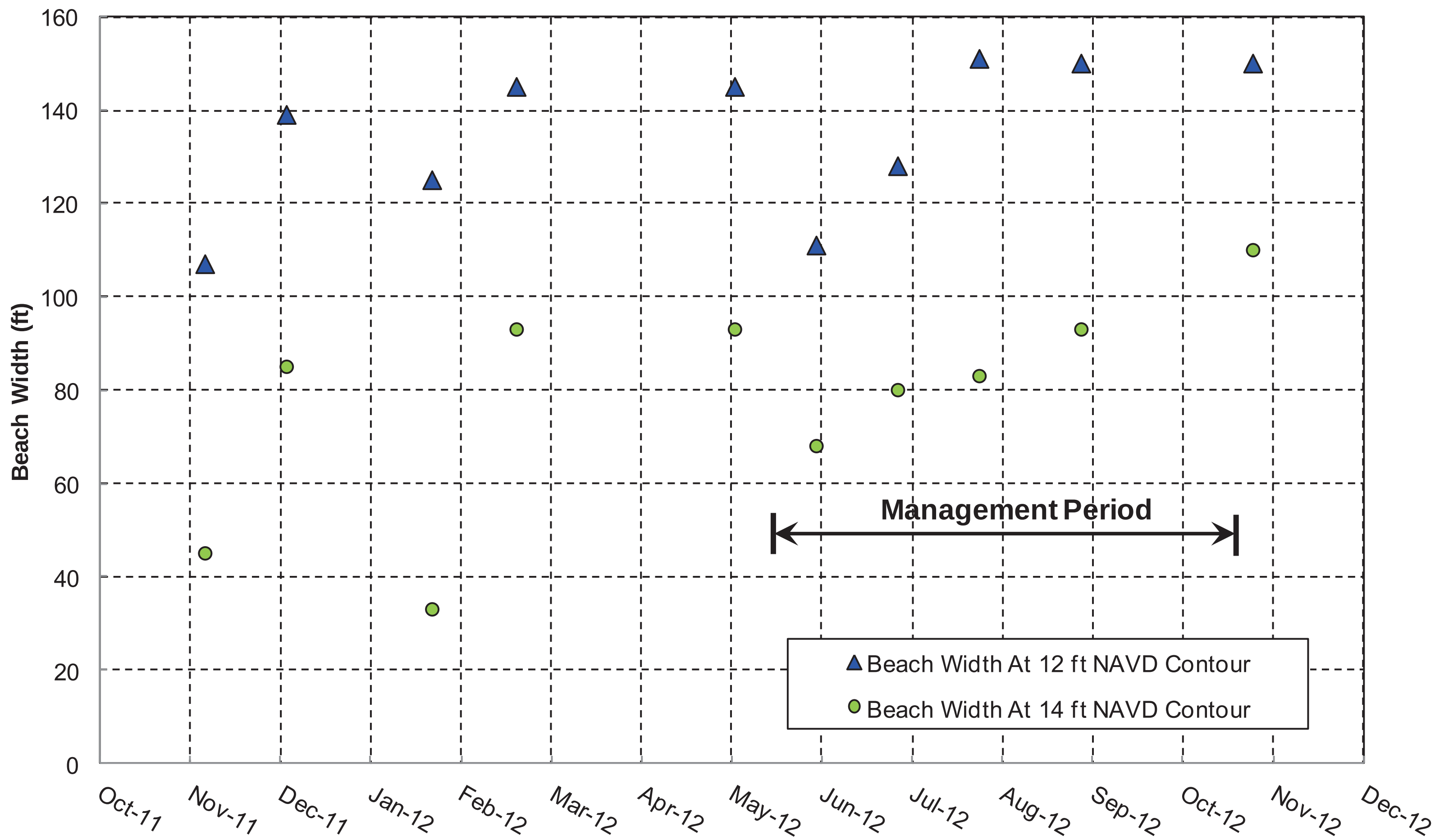


SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 12

Nov 2011 to May 2012 topographic change at Beach Transect 3



SOURCE: SCWA survey data

Figure 13
Beach Width at Beach Transect 3.

!

Attachment H. Physical Processes During the 2013 Management Period!

!

As required by the Russian River Biological Opinion, the Sonoma County!0 ˙ter A1ency (Water Agency) has been tasked with &anaging a su&&er lagoon intended to improve salmonid habitat in the Russian River Estuary!4/ creating an outlet channel while maintaining the! urrent level of! *lood protection for properties adjacent to the estuary (NMFS, 2008). The adaptive m˙nage&e˝t! plan, described in the main body of this report, was develope(!4/ the Water Agency!5 ith assistance *ro& ESA PWA and the resource agency &anagement team in 2009 and revised annually!*ro& 2010 to 2014. Because of per&it constraints, the Water Agency!was only!able to)&ple&ent the plan be1)˝˝)˝1!)˝!%° °¸!˜ he revised plan was in effect for 2013,!but no opportunities *or m˙˝˙gement action occurred during the manageme˝t period.!!

!

During the 2° '!& ˙nage&ent period, May 15th to October 15th, Water Agency!staff regularl/ ! &onitored current and forecasted estuar/ !water levels, inlet state, river discharge, tides, and wave conditions to anticipate changes to the inlet's state. Although the inlet experienced several closures, an outlet channel was not i&pˇe&ented. The inlet was closed for the &ajorit/ !o* the *irst two &onths of the &˙˝agement period as a result o* two closure events. During this ti&e, each! closure ended when lagoon water levels increased, overtopped the beach berm.!˙˝d scoured a new tidal channel. The first event self8breached in earˇ/ June before water levels reached 7 ft NGV7.! while the second event resulted in lagoon stage above 7 ft NGVD but self8breached in early Juˇ/ ! before an outlet cˆannel could be!)&plemented. The estuary!remained fully tidal until it! losed again in late September. This Septem4er-October event was ended with a &˙nual breach on the last day o*!the manage&ent period to provide a path5˙/ !*or m)grating s˙ˇ&onids and to reduce water levels in advance of potential fall precipitation. !

!

Even though no m˙nage&ent actions were implemented to inform!the a(aptive m˙nage&ent process, the physical conditions and inlet response during the m˙˝agement period are reviewed in this attachment to contribute to site understandi˝1!˙˝(to inform!*uture manage&ent a tions.!

!

METHODOLOGY

This review of the 2013 outlet channel management period ex˙&ined water levels, ocean wave conditions, o ean water levels, riverine discharge, beach topography, as well as inlet size and location. The sources for these parameters are listed in Table 1. These data were supplemented with personal observations and discussion with staff from the Water Agency, NMFS, CDFW, and the Bodega Marine Laboratory.!!

!

!!

Table 1. Data Sources

Parameter	Source
Estuary!5 ˙ter level (h_E3!	Water Agency!Jenner g˙ge[J]!
0 ˙ve height (H_s), period (˜ ·3.!˙nd direction !	ˇ DIP Point Reyes buoy #029!
Ocean water level (h_O3!!	NOAA Point Reyes #9415°%°!
Russian River discharge (Q_*3!	USGS Guerneville #114FE°°°!
Beach topography.!*t!+@A7!	0 ater Agency!&onthly surveys
Inlet size and location	Water Agen / !˙nd Bodega Marine Laborator/ ! autono&ous ca&er˙s

[J]Data transm)ssion failure due to cellular network issues occurred for several periods throughout the m˙nagement period.!

!

INLET STABILITY PARAMETER AND CLOSURE RISK PROBABILITY!

In addition to considering individual par˙&eters, researchers at the Bodega Marine Laboratory! have developed a co&4ined parameter to evaluate the stabilit/ !of tˆe inlet's state, with the aim!o*! predicting closure risk (Behrens et al., 2013). (Note tˆat the inlet stability parameter does not differentiate!4etween *ull closure and the perched conditions with a s&˙ll outlet channel. When discussing this parameter, both states are referre(!to as a 'closure' in that tides are prevented fro&! propagating i˝to the estuary˛3The inlet stability parameter presented!4/ !6ehrens et al. (2013) quantifies the risk of inlet closure based on a sed)&ent b˙lance in the inlet. It considers the d˙)˘/ ! balance between wave-driven sediment import to the inlet and sed)&ent export driven by tidal fluctuations. The wave-driven i&port is assessed usin1!˝earshore wave esti&ates derived fro&!˙! transfor&˙tion m˙trix and offshore buoy!(˙ta (ESA PWA.!%° %3!nd the latter is estimated from! tide gage data within the estuar/ !˙˝ d a stage-storage relation derived fro& the available bathymetry. Using daily-average values of the stability para&eter within the per)od 1999-2008, Behrens et al.!2%° '3 showed that high-percentile values of!the par˙&eter ˙re closely!˘)˝ ed to the risk of the inlet closing within five days. As the percentile of the stability par˙&eter increases, the risk of inlet closure within five days increases exponent)˙˘˘/.!*ro&!risks of roughly five percent when the parameter is at the 50th percentile to a ris of 80 percent when it is!&easured at the 99th percentile.

!

SUMMER AND FALL CLOSURES AND SELF-BREACHES!

˜) &e series of estuar/ !5 ˙ter levels, as well as tˆe key!*orcing factors (waves, ti(es, and riverine discharge), are shown in Figure 1 for the entire &˙˝˙ 1e&ent period. The lagoon water level time series (Figure 1a) su&&arizes the closure events at the beginning of the &˙˝˙gement period, as well as the subsequent tidal conditions and later closure events in fall. As shown in Figure 1d, discharge was low for &ost of the &˙˝ agement period, dropping below 100 ft'/s at the onset of June and not!rising ba s)1˝)*)cantly! °°!*t'/s until September, with the exception of!˙ short rise in response to a late June rainfall. Flows as low as 85 ft'/s during the closure in m)(8June allowed the lagoon sta1e to rem˙ in stead/ !at approxim˙ tely 5 *t NGVD *or over a week¸ !;mmediately! *ollowing this steady period, a late-season rainstorm brief˘/ increased flows into the lagoon to &ore than 20°!*t' /s, causing the lagoon stage to approach 8 ft NGA7!˙˝ d eventuall/ sel*-breach. As in prior years, wave e˝ ergy!)n the subsequent months of!9uly8September was m)˝)&al (Figure 1b). The hour˘/ s)1˝)*)cant wave height only! onsistently surpassed 8 ft in late Septem4er, a! ˘) ely!cause of the last closure event o* the &anageme˝ t period. !

!

The conditions leading to inlet closure were consistent with the existing conceptual &odel described in Section 4 of the Management Plan. All closure events coincided with either &oder˙ tel/ !ˆ)1ˆ!5˙# es (H_s!O!F!t*) having periods greater than 10 s, or with neap oceanic tide ranges of less than approximately 5!ft. Moderate˘/ !ˆ)1ˆ!5˙# es coincided with the closure events in May, June, and October. All closure events also occurred during or shortly!˙*ter neap tidal periods. Closure e#ents that occurred in May!˙˝(!9une are e<˙&)ne(!)˝!&ore detail in Figure 2¸!

!

All closure events occurred with the inlet located adjacent to the jetty¸!;˝!%° 2, this positioni˝1! &˙ / !ˆ ˙#e prevented perched conditions fro&!aris)˝1!4/ !shielding this area of the beach fro&!the wave-driven sediment deposition that c˙ used closure, preventing the beach fro&!accreting to a sufficient height to allow the desired outlet channel elevations from!4e)˝1 attai˝ ed. This appeared to be the case for the first closure event of the 2013 m˙˝˙1 ement season (Figure 2), which self-breached on June 3rd at a stage of!roughl/ !6.5 *t NGVD. The low point in the beach berm!that was subsequently overtopped and self8breached also persisted i&&ediately adjacent to the jetty¸! However, the same late-June rain storm!that increased lagoon stage during the subsequent closure event also coincided with several days of!long period swell w˙ ves (Hs ~ 5 ft, Tp ~ 15 s) that built up the beach in this location, allowing tˆ e lagoon stage to rise to almost 8 ft NGVD (Figure 2) before self-breaching in earl/ Ju˘/ . Closure events that occurred later in fall (Figure 3) were breached at or below a lagoon stage of!8 ft NGV7¸!

!

CLOSURE AND SELF-BREACH DYNAMICS !

Of the three closure events that occurred within the &anagement period, the second closure event (lasting approxi&atel/ !fro&!9une 7th until July!?th) provided the best opportunit/ !*or outlet channel i&plementation. This event also indicated that water levels ˙˝(closures can be persistent)*!*lows drop below a &)˝)&u& level.

!

To better illustrate both the lagoon stage and beacˆ!&orphology during this ti&e, Figure 4 shows a sequence of photos of the inlet before and during this closure event. As was the case for all o*! the m˙ nagement period, tˆ e inlet was located next to the jetty. Five days prior to losure, on Ju˝ e ' rd, the barrier beach sel*84reached. Since this self8breach occurred during a period of neap oceanic tides, tidal scour probably enlarged the inlet at a reduced rate, leaving it more susceptible to closure. Figure 4a depicts the inlet when it was located next to the jett/ sever˙˘!(˙/ s before closure, indicating a!5 idth o*!less than roughly!?°!*t. Nearshore w˙ ves having s)1˝)*)cant heights of!F8E!t*and periods of 9-12 seconds coincided with closure (Figure 2b, Figure 4b), and subsequently!raised the berm!near the jett/ !2Figure 4c). As discussed later, these waves built the berm higher next to the jetty than in pre#ious years, which allowed the closure event to persist.!

!

During the first week o* closure, inflows (,) gure 2d) were &easured at 100 – 115 ft' /s, and the increase in stage was roughly!°¸%!M!°¸?!/d˙/ ¸!As inf˘ows dropped to 80 -! °°!* t' /s over the next several weeks, the water level increase slowed until the lagoon reached a balance between inflows and the co&4ined ˘osses fro&!4each seepage and evaporation (Figure 2a). Su&&er dams constructed during this ti&e downstream of the H˙) enda Bridge gage further reduced inflows to the estuar/ ¸!˜ˆ is &arkedl/ !slower water ˘evel increase is evidenced b/ !the lack o*!&ove&ent o*! the water line (emphasized with red dashed line) over the twelve days between Figure 4c an(! Figure 4d. Rainstor&&derived inflows and possible wave overwash fro&!June 25th!8%th caused the water level to rise at roughly!°¸?!*t/day. Fro& June 28th until the self&breach event on July!' rd.! the water level increase slowed to less than 0¸2ft/day¸!The low point of the beach (where breaching typ) ˙˘˘/ occurs) was at the jetty (Figure 4e).

!

B˝˘) e the 20 %!&˙nage&ent period, no natural outlet channels were for&ed near the jetty!)˝! 2013. However, as with 2012 and other previous years, the lowest portion of the beach was consistentl/ !˘ocated at the jett/ . This persistent low portion is probably! ˙used b/!5˙# e shelteri˝1! 4/ the jetty, which m˙/ !have reduced berm build-up at the inlet's location, leaving a low point in the beach berm!that was the site *or subsequent overtopping and self&breaching.

!

The first event (lasting from M˙/ !%rd until June 3rd) and last event (lasting fro& Septem4er 2?th! until October 15th) of the 2° '!& anagement period were ˙˘so unsuitable for implementing a˝! outlet channel. The first event self-breached before the lagoon stage reached the E ft NGVD target stage. The second event just reached the target elevation at the end of the &˙˝˙1 ement period. Then, o˝ the last d˙/ of the &anagement!period, the Water Agency!˙rti*))˙˘˘/! breached the beach to pro#ide a!p˙thway!*or migrating s˙˘&onids and to reduce w˙ter levels!)˝!˙dvance of potential *˙ll precipitation. !

!

Four &ore closures occurred after the end of the &˙˝ agement period in OctoberMDece&4er 2013 (Figure 3). These events coincided with typical late-fall energetic swell waves, and each persisted for o#er a week, since inflows remained lower than 300 ft' /s through the e˝(of!7 ece&4er. In consultation with the resource agencies, the Water Agency conducted its October and Novem4er artificial breaches to the north of Haystack Rock. The intent of this alignment was to discourage the inlet from re-establishi˝1!˝ ext to the jett/ . However, after the inlet closed twice north o*! Haystack Rock, the December artifi)˙˘!breach was i&p˘e&ented loser to the jett/ . This Dece&4er breach location was selected to encourage tˆ e inlet to stay open longer for &)grating sal&onids and to ensure that the breaching stayed witˆ in the Water Agency's per&itted excavation limits of! .°°°! /(' ¸!!

!

CLOSURE R;SK PROBABILITY !

The 5-day closure risk probability, a derivative of the inlet stability!parameter described above, was hindcast *or 2013 according to the method described in Behrens et al. (2013). This hi˝(ast provides an indication of the utility of the stability parameter as a prediction tool for monitoring inlet conditions and pl˙˝˝) ˝1!&˙nage&ent action. This parameter integrates wave and ocean forcing conditions, as well as estuar/ !5 ater levels, to provide greater predictive skill than just waves or ocean tides on their own. The stabilit/ !parameter co&4)˝es these factors, and the corresponding five-day closure risk time series exceeded 70 percent!before each 2013 event (Figure 1e, Figure 2e, and Figure 3e). Data gaps in the Jenner gage record prevented closure risk! predictions prior to the first closure event. Otherwise, the predicted probability of closure exceeded 70% 2-5 days in advance of each closure. In previous years, a prediction threshold of! 50% was used, but there were several instances exceeding 50% in April and Jul/ of 2013 that!()(! not result in closures.

!

TOPOGRAPD;˘!˘D ANGE

The Water Agency!has conducted &ont˘˘/ surveys o* Goat Rock!State Beach that cover a region starting from!the jetty!˙nd extending approxim˙te˘/ 1,500 feet to the north. Typically, the surveys do not include bathymetr/ !5 ithin the inlet because flow conditions in the inlet prevent safe access. Also, the survey extent can!4e limited b/ !the Water Agency's co&p˘)˙˝ce with its &arine &˙&&˙˘!)˝) (ental h˙rassment authorization,!5ˆ ich sets guidelines for the survey! rew's approach to marine &˙&&als hauled out o˝ the beach. Water Agency survey st˙**collected spot elevations using RTK-GPS and then assembled these elevations into a set o* contour lines at 1 ft intervals, as well as profiles along the beach berm!crest, the ocean wetted edge, and the estuary! water line. The survey elevations are reported in the NGVD29 vertical datu&˛!

!

To characterize beach berm!topographic conditions, ESA PWA assessed data fro&!the 0 ater Agency's 2010 (July to Septem4er), 2011 (May!to October), 20 %!2May!to October), and 201'! (May to Octo4er) surveys. Survey!transects *ro& the 2012 analysis were reused (Figure 5), and include two transects b˙ ed b/ ! ˘)ff (Figure 6 and Figure 7), two transects which extend into the estuary (Figure 8 and Figure 93.!˙˝(two variations on a transect just north of the jetty!2Figure 9).

!

This review focuses on the 2013 surveys.!˙lthough the!%° 1 surveys!˙re included for context. The 2013 topographic data were similar to those of!%° %5 hen little morphologic change occurred throughout the &anage&ent season. In contrast, surveys taken in 20 °!˙˝(! %° !)ndicated that beach erosion and accretion occurred during the!&anagement period. The erosion was associated with inlet &igration and subsequent accretion of the beach was associated with long-period swell waves. During the 20 %!˙˝ (!%°'!& ˙˝˙ gement seasons, the inlet rem˙)ned at the jetty and did not &igrate north. Adjacent to the jetty groin, Transect 0 showed little!&onthly! ˆ˙˝ ge in topography.! but extensive inter-annual variability (Figure 10).

!

During the &anagement period in 2013, the beach berm!˙long Transects 1- ? showed little variability.! ˆ ˙˝1)˝1! 4/ less than one!*oot. This was particularly true during the &onths of May!M September at Transects 1-2!(Figures 8-9) and Transect 4 (Figure 6). At each of these profiles, the change in beach profile fro&!- eptember to October was greater than for the rest of!the &˙nage&ent season. The only!transect to experience more than one foot of! hange in elevation was Transect ' (Figure 7), whose crest ˙ggraded b/ ! ˛5 feet between the May!' °th!˙˝(!9 u˝e 13th! surveys. The ( )**erence in monthly variability!˙t each transect between 2013 and prior years can ˘) ely be tied to the dif*erence in the extent of!)˝let migration. As an example, in 2011, the inlet

&)grated north of!D˙/ stack Rock durin1!the w)nter, and returned to the jetty in late spring or earl/ !su&&er˛ This &)gration resulted in a lower!4each profile at all transects. Then, over the course of the manage&ent period, the 4each gradually built up to!˙ !typical summer profile. In contrast, the inlet never m)grated north o*!D˙/ stack Rock!)˝!%°' , e#en durin1!peak!5 inter a˝(! spring flows. As i˝!%012, this left the beach ber&!largel/ !intact north o*!D˙ystack Rock!˙˝ (!˙! lower terrace 4etween Haystack Rock!˙nd the jetty!1roin. Since these northern transects started at ˙!&u ˆ!ˆ igher elevation at the start o* the &˙˝ age&ent period, the vertical growth o* the beach profiles at these locations were several *eet less than during 20 !) n the same locations.
!
Transect 0, which is located just nortˆ of and parallel to the jetty, was slightly lower than the other transects &easured during the 2° '! &˙˝˙1 e&e˝t period. Its crest was &easured at roughl/ ! 15 ft N@VD both at tˆ e be1)˝˝)˝ 1 and end of the management period, co&pared with crest elevations of!15-17 ft NGVD &easured at the other transects. Figure 10 shows that this location is typically stable throughout the management period but varies from!/ ear to year, likely!as a result of inlet m)gration, flood erosion, a˝(berm buildi˝1!4/ !winter waves. Compared with prior years, the berm at this location is lower than in %° , but!ˆ)1ˆ er tha˝!)˝!%°°!˙ ˝(! %° %˛As we!ˆ˙ ve noted during previous reports, the lack of!&˙˝˙1 e&ent period varia4)lity o* this region suggests that the jetty shelters this portion of the be˙ ˆ!* ro&!small to moderate waves that occur during the &˙ nage&ent period. On˘/ the larger waves associated 5 ith winter stor&s!&˙/!4 e sufficient to re-shape the beach ber&!˝ ear the jett/ ˛!!
!
Beach ber&!crest profiles were collected b/ !the Water Agency!*or the first ti&e)˝!%013. These data &˙ e it possible to discern important changes in beach shape along the length of the berm *ro& the northern beach access point to the jetty. Along-beach trends in crest elevation generally! indicate along-beach trends in wave energy!˙nd the influence of inlet &igration and breaching.
!
Figure 11 shows that the same!&)˝)&al change in crest elevation was apparent throughout the length of the beach north o*!Transect 1. Although the crest elevation changed by as &uch as 2 ft in so&e!˙reas, there was a distinct pattern in the along&shore crest height that rem˙ined roughly the same throughout the management period. The beach crest was lowest south of Transect 1, where the inlet resided. At Transects 1!˙˝(! % a set o*!ridges rem˙)˝ ed in p˘ace with peak! elevations at 17-18 ft NGVD, wh)˘e the crest was generall/ lower (14-17 ft NGVD) an(!ˆ ˙d less of a consistent shape north of!Transect 2. Wave runup genera˘˘/ has less influence for higher beach profiles, since it beco&es less likel/ !that a given wave wi˘˘!overtop the crest. The higher variability north of Transect 2 is probably a reflection of the fact that the beach was lower in this area, and was!&ore suscept)ble to change fro&!the li&ited su&&er an(!*˙˘˘!5˙# es.
!
Changes to the beach shape were much larger after the end of the 2013 management period, as shown in Figure 12. This is probably!attributable to greater wave energy!and relocation of the inlet. W˙ ve energy!increased dr˙&atically!)˝!+ovem4er a˝(!7 ecember, both!)˝!ˆ eight and period. Although changes to the crest height were still &inor during these months, by January! Fth!% ?.! the crest had been built as high as 19-20 ft NGVD north of Transect 4. At Transects 1 and 2, the crest ridges shifted in the along-beach direction, but the peak heights rem˙)˝ ed similar to August.

!

Manual breaching of the inlet north of!D˙/ stack Rock on October allowed the inlet to carve a! 400-500 wide swath within the beach, centered roughl/ !at Transect '˛ The inlet then closed again and later breached at the jett/ ˛!6/ !7 ecember 1%th, waves had rebuilt the crest to a height of 10- %! *eet within the swath. By January! .!%° 4, this se1&ent of the be˙ h that the inlet had occupie(!)˝! October and Novem4er was indistinguishable fro&!tˆ e rest of!the 4each crest prof)˘e˛!!

!

BEACH WI7 ˜D !

To provide additional information about the beach morphology. ESA PWA assessed the beach width us)˝1!tˆ e W˙ ter A1ency survey data. Figure 13 shows the evolution of the be˙ ˆ!5 idth at Transect 3 during both the 2012!˙˝(!%° '! &˙ ˝˙1 e&e˝ t periods. Dur)˝1!5 inter &onths, the beach was often ero(ed at Transect 3 to the point that the be˙ ˆ crest was below 12 ft NGVD, so that the width was effectivel/ !zero. Apart fro&!this seasonal erosion, there was no &˙ rked trend in the beach width. In 2013, the width at 12 ft NGVD varied between 80 ˙˝(! %° !*t, and was generally! less than 65 ft wide at the 14 ft NGVD contour˛!˜ˆ is was s&aller than in 2012, when it varied *ro& 110-150 ft NGVD at the 12 ft contour and was less than 110 ft at the! ?!*t contour. This interannual di**erence &˙/! be attributable to di**erences in fall&spring wave energy (and thus beach building), or possibl/ !to differences in inlet position.!

!

!

LESSONS LEARNED AND RECOMMENDATIONS

Based o˝!%°13 observations of the estuar/ .!asso)ated physical processes, and the Water Agency's planning for outlet channel &˙˝˙ gement, we note the following lessons about)&ple&enting the outlet cˆ˙nnel m˙nagement plan.!

!

CONCEPTBAL MODEL!

- The beach north of the inlet saw little change fro&!the 16-18 ft NGVD elevations! established in 2°12. Near the jett/ , the ber&!5 as lowered b/ !inlet &igration while! undergoi˝1!4each building.
- The inf˘uence of inlet breaching or migration north o*!the jetty! an lead to erosion of!˙! wide swath of beach, several times larger than the width of the channel. An erosion swath of 400-500!5 as observed following the Agency breach on October 15th˛!
- -)&)lar to the winter of!%° 8 %. the inlet never m)grated north of!D˙/ stack Rock duri˝1! winter 2012- '.!˙ nd retur˝ed to the jetty in early spring, much earlier than in most years. This inlet align&ent is not co&&on, but has been observed in past years (Behrens et al., 2009).!!
- Peak annual river discharge has rem˙ined below 40,°°°!*t'/s for 8 consecutive years, a streak un&˙tched in the 70-year *low record. This may have a connection to the recent ˘˙ of inlet migration to the north.!
- The beach width in 2013 at Transect 3 (near Haystack!Rock) was smaller than in 201%˛! The interannual decline was larger than changes to beach width at this location within the %° '! &˙˝˙1 ement season alone. This &˙/ suggest that beach width is &ore closely!tied to seasonal changes in inlet behavior and offshore waves than to shorter-term! ˆ anges.

!

OUTLET CHANNEL FEASIBILITY

- The jetty!&˙y shelter the inlet, &˙ ing closure less likely and also limiting berm!1rowth, which then &˙intains a low point for self8breaching. When the inlet is!)˝!˙!*ully or &uted tidal conditio˝, options for management become! onsiderably!&ore difficult to)&pleme˝t.
- Late June closure included a 1°8(˙/ !period when lagoon water levels were nearl/ ! constant at approxi&˙tel/ 5 ft NGA7!4ecause low *lows &easured at Hacienda Bridge (80-10°!*t'/s) a˝(! onstruction of summer dams reduced flows into the estuary to the point that the/ !were balanced b/ seepage. An unusual earl/ su&&er rain then boosted discharge to more than 20°!*t'/s, causing self8breach ˙t approxi&˙te˘/ 8 ft N@A7˛!!
- Once lagoon water levels reach the low point of!the beach crest elevation, the lagoon self8 breached. This behavior highlights the susceptibility!o*!a sand bed outlet channel to scour, li&iting convey˙nce capacit/˛!
- Post-&anagement period, the Water Agency!4reached the inlet north o*!D˙ystack Rock˛! This align&ent was not continued because repeated closure threatened Chinook!&igration and the enlarged beach berm restricted breaching to within the permitted excavation volume.

!

- Over the first three years of e**ort to imple&ent the outlet cˆannel a(aptive m˙nagement plan, only one closure (July!%° °3.!ˆ˙s been suited for outlet cˆ˙˝ nel m˙nagement action. !

!

COMMUN;CATIONSAND PROTOCOLS!

- Since full set of per&its 5 as not in effect, the Water Agency!5˙ s required to seek! authorization for each breaching event, which occasionally caused delayed operations.
- Although the perched lagoon episodes d)d not e#olve to the point tˆat management a tion was warranted, the W˙ter Agency began p˘˙˝˝) ˝1!&anagement actions as soon as the episodes occurred. Plannin1!)ncluded heightened observations of inlet conditions!4/! 0 ˙ter A1ency staff, email updates to infor&!the resource m˙nagement group, a˝d pre8)&ple&entation &eetings at the project site to refine plans for &˙˝ agement!actio˝˛!!

! !

MONITOR;+@!

- The W˙ter Agency:s &onthly!survey methods were modif)ed to collect specif)ed profiles, such as the beach ber&!ridge line, wetted edge (beach side3.!˙˝d water edge (estuar/! side).

!

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!

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!

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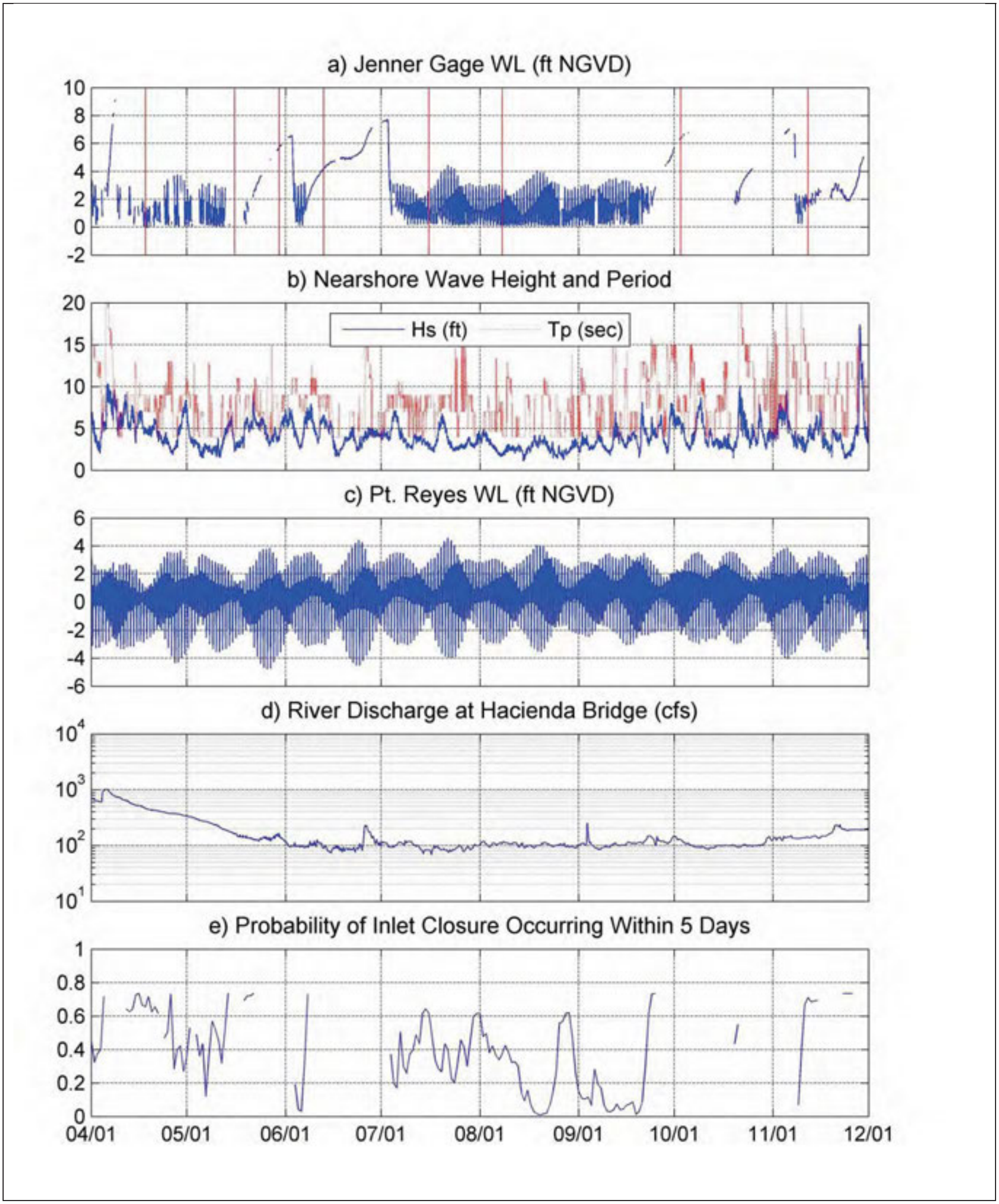
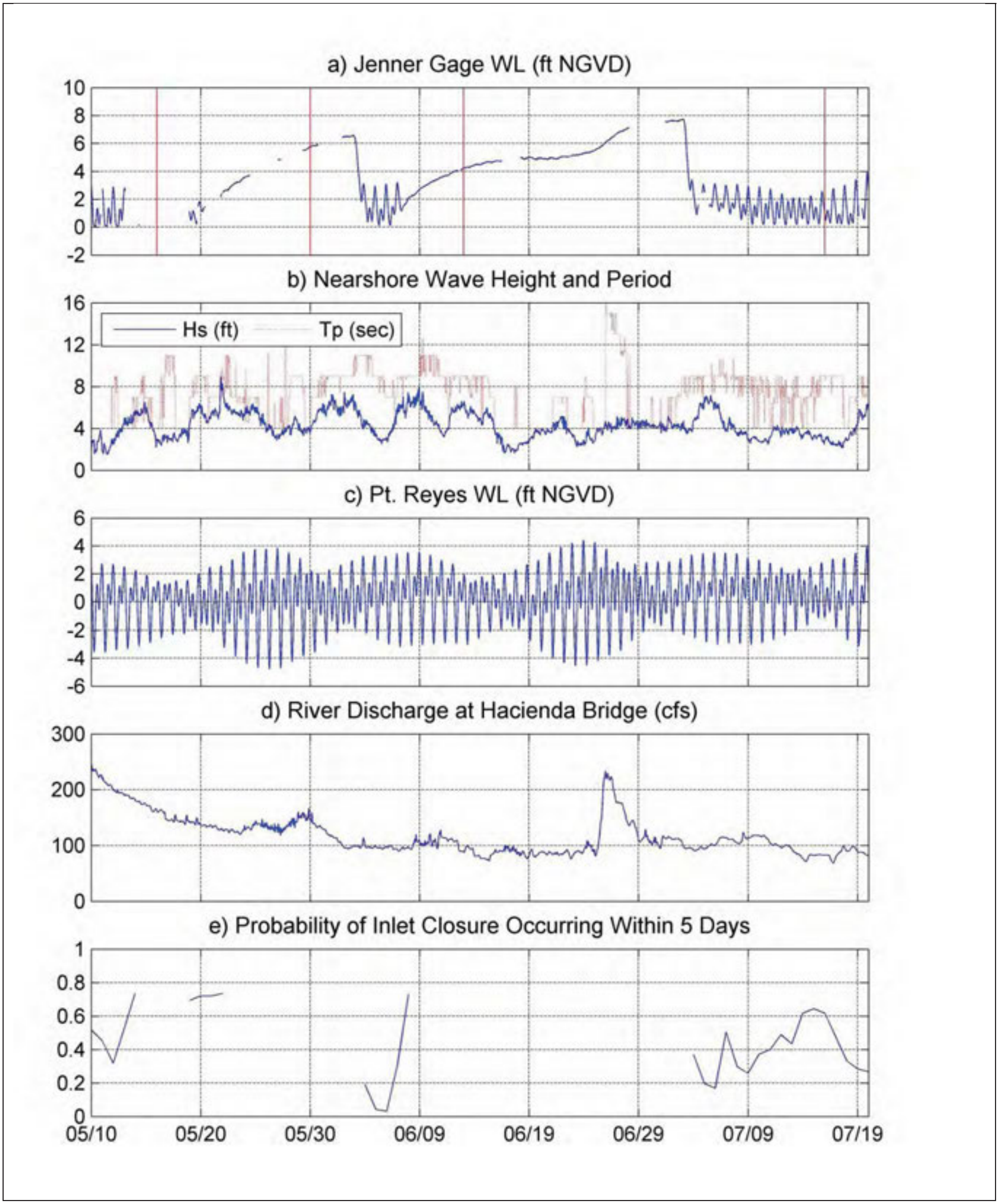


SOURCE:

- a) Jenner gage water level provided by SCWA; red bar = beach survey
- b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
- c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
- d) River discharge provided by USGS (Guerneville #11467000)
- e) Five-day closure probability provided after Behrens et al. (2013)

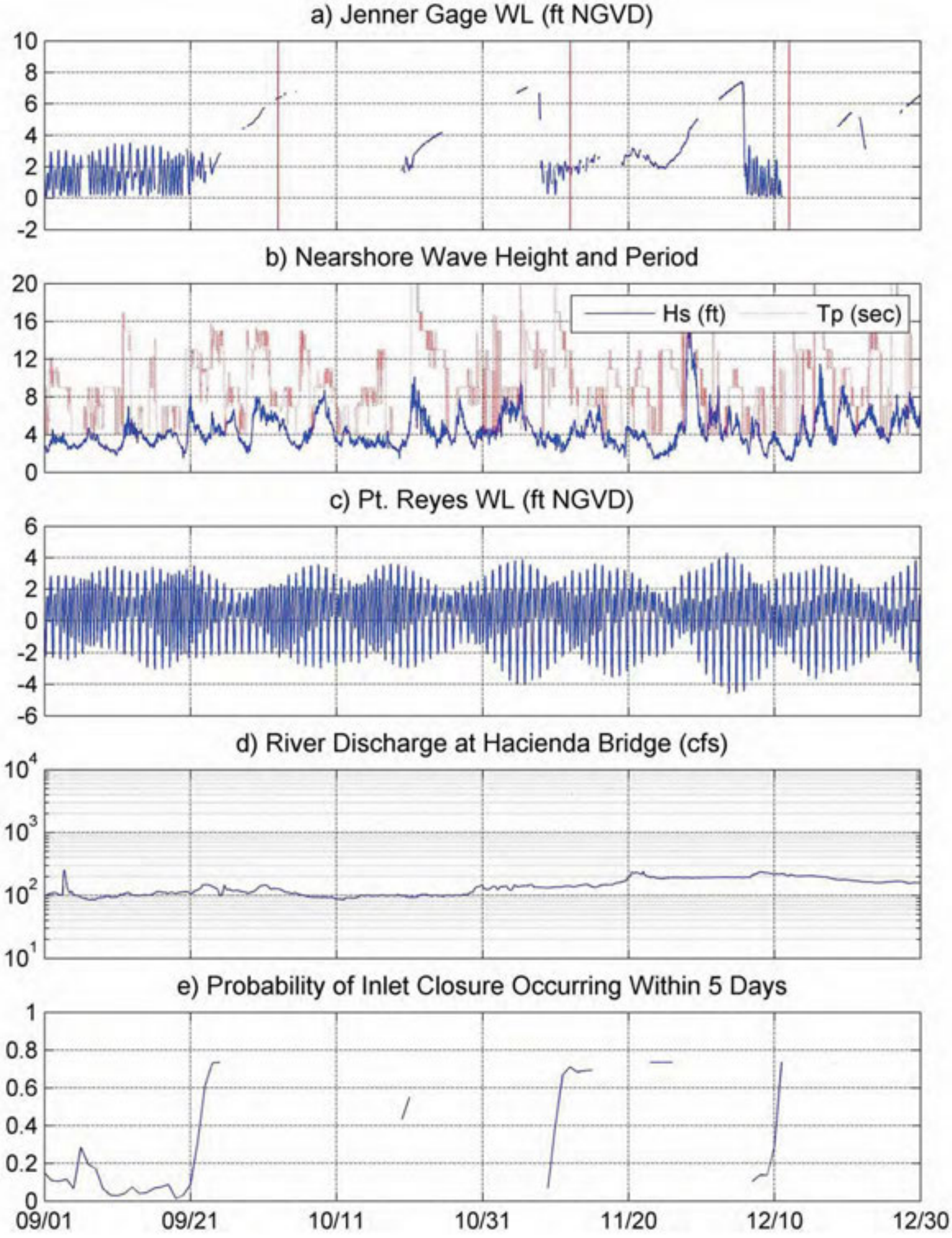
Figure 1
Estuary, Ocean, and River Conditions Compared with Closure Probability: April – November 2013



SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

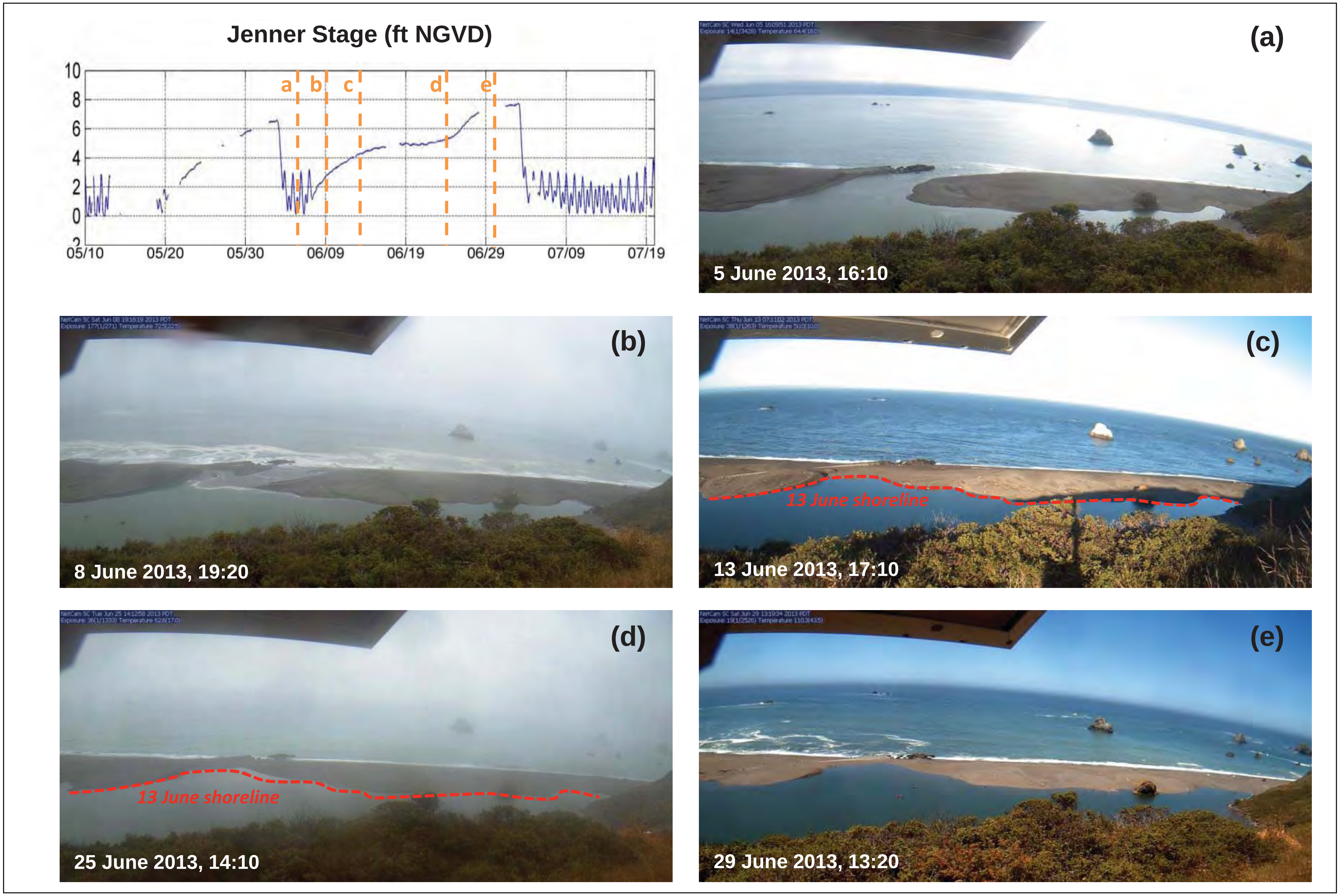
Figure 2
Estuary, Ocean, and River Conditions Compared with Closure Probability: May – July 2013



SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

Figure 3
Estuary, Ocean, and River Conditions Compared with Closure Probability: September – December 2013



SOURCE: Russian River stationary observation camera (BML)

Russian River Estuary Outlet Channel Management Plan . DW01958

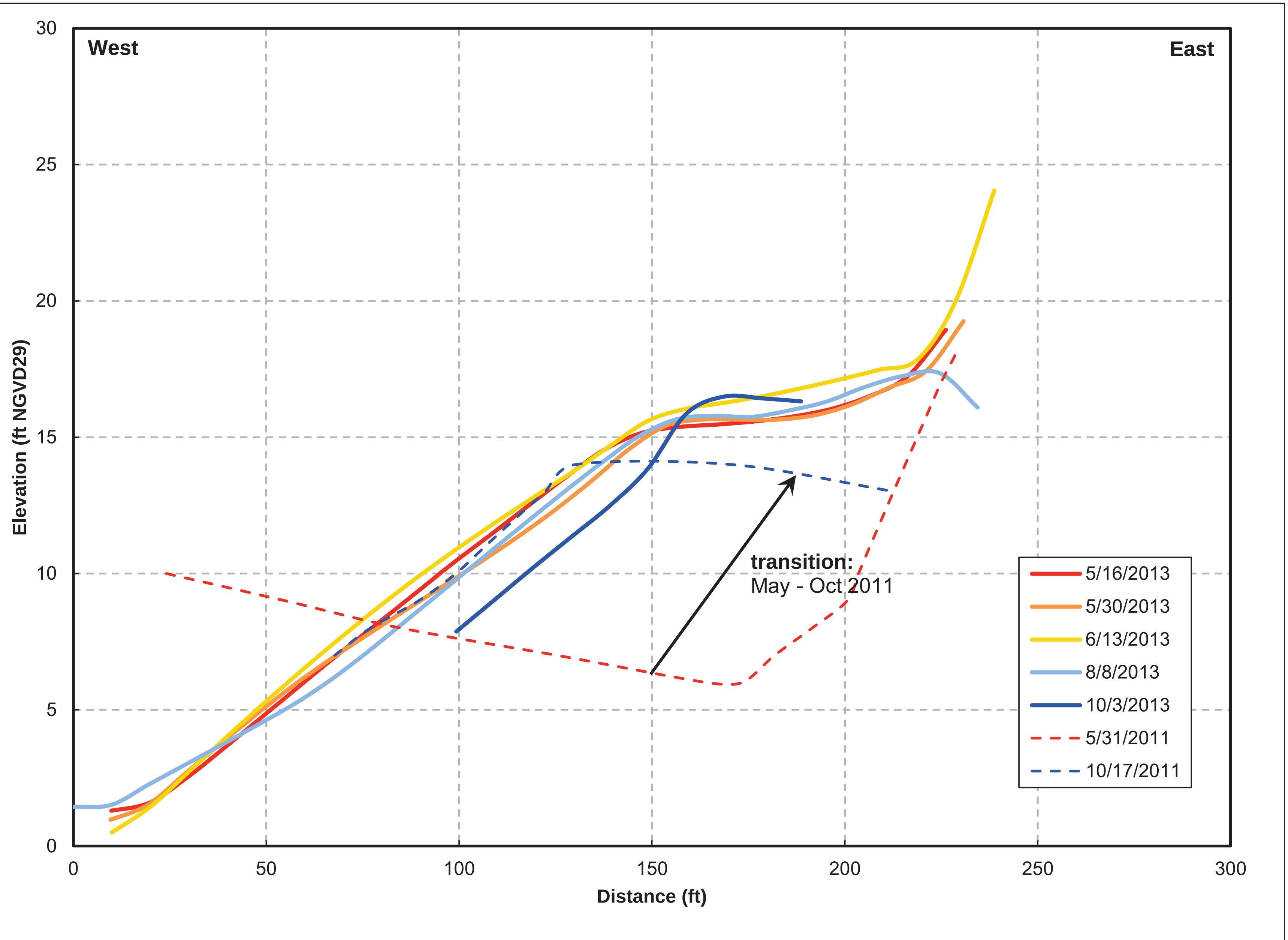
Figure 4

Inlet Closure Event in June-July 2013

SOURCE: image from USDA NAIP

Russian River Estuary Outlet Channel Management Plan . DW01958

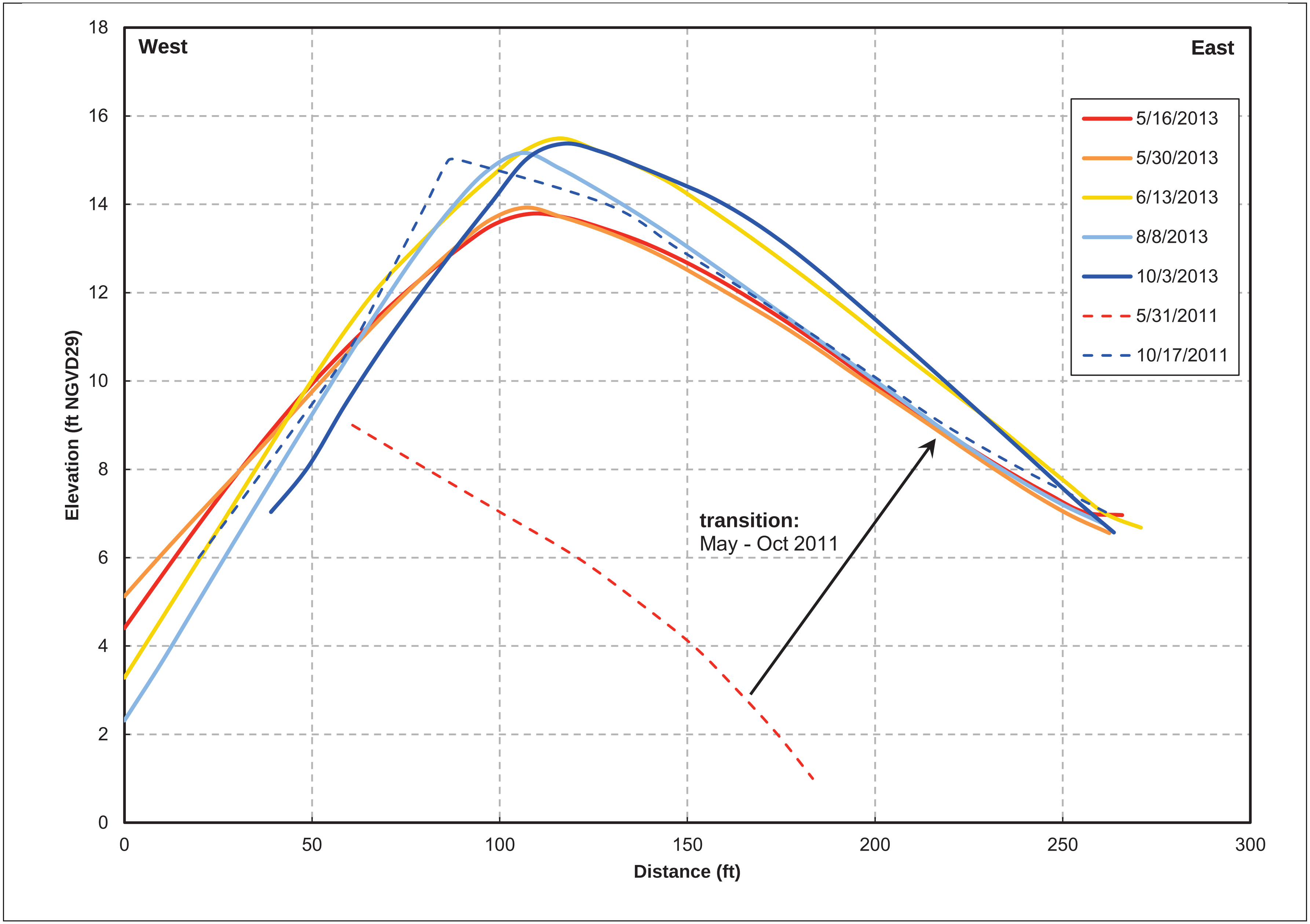
Figure 5
Beach Transect Locations



SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

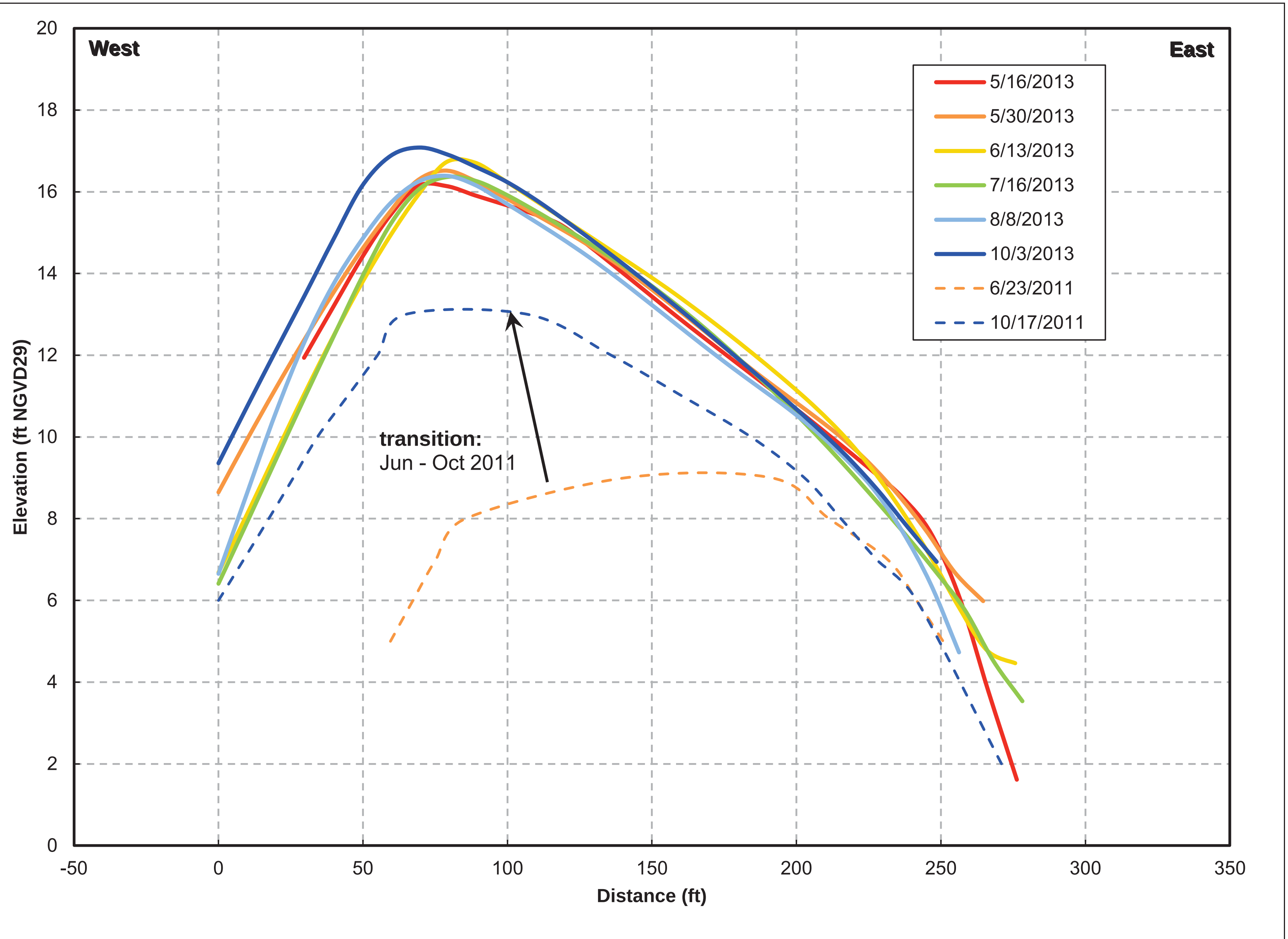
Figure 6
Beach Transect #4



SOURCE: Russian River stationary observation camera (BML)

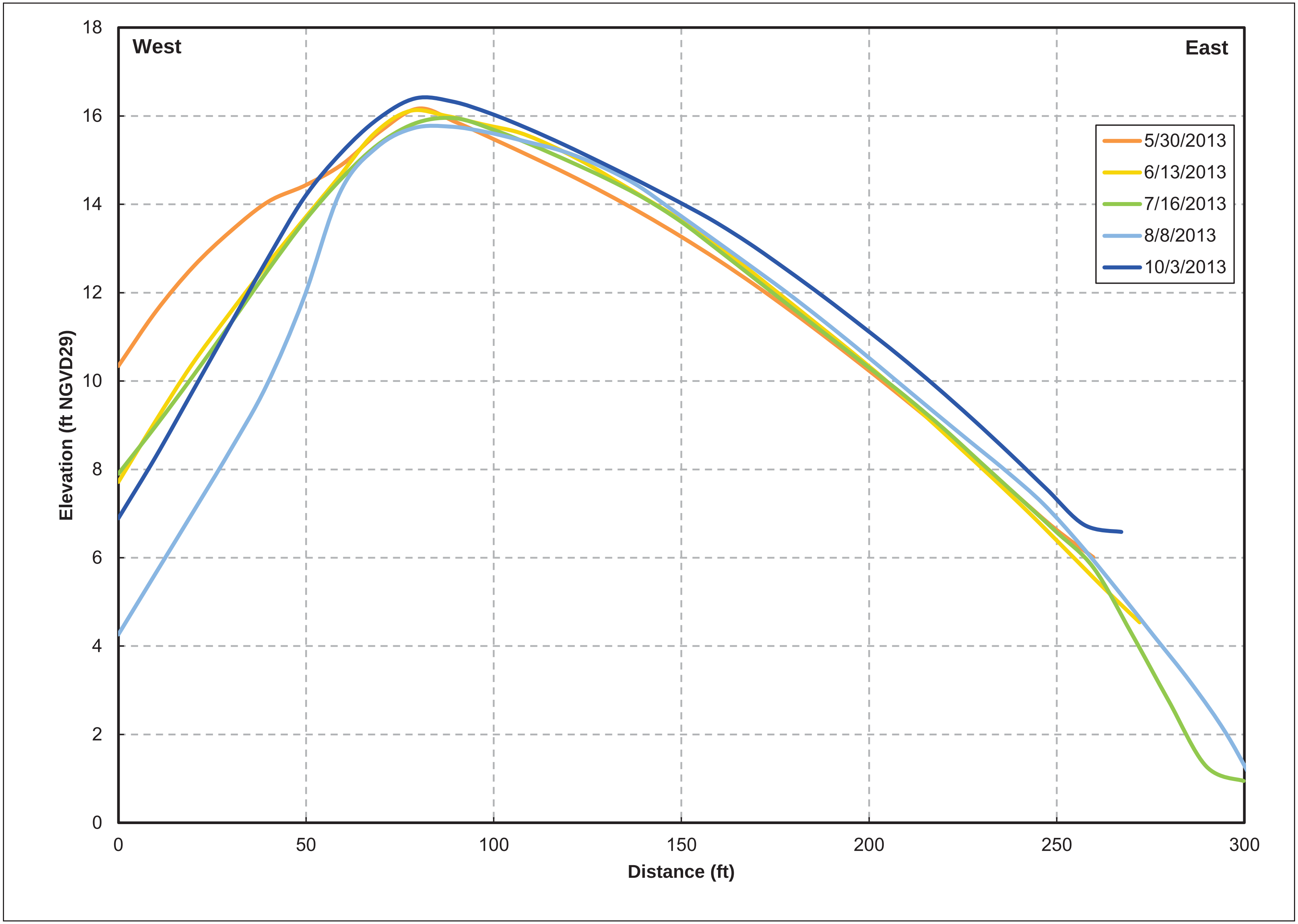
Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 7
Beach Transect #3



SOURCE: Russian River stationary observation camera (BML)

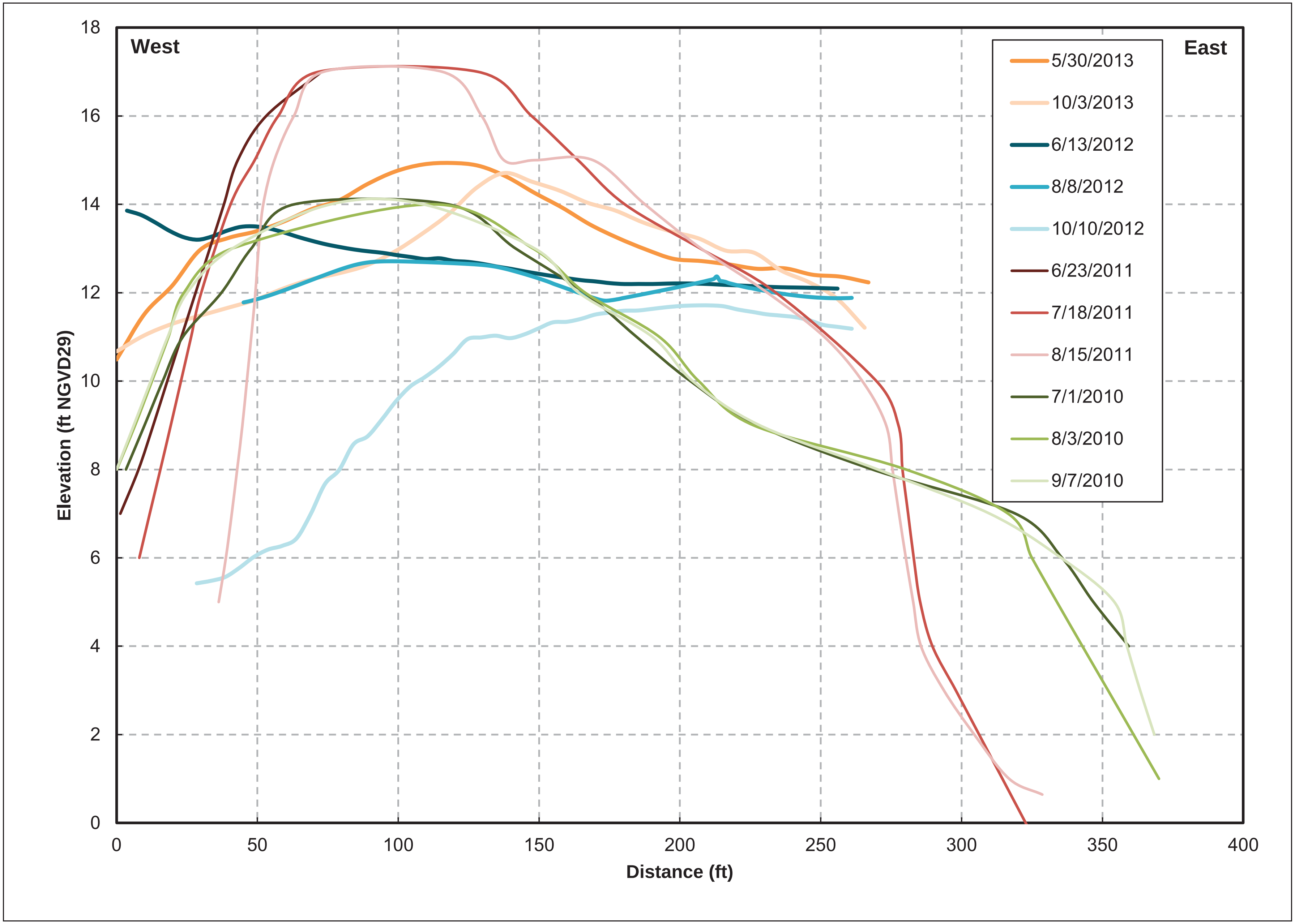
Figure 8
Beach Transect #2



SOURCE: Russian River stationary observation camera (BML)

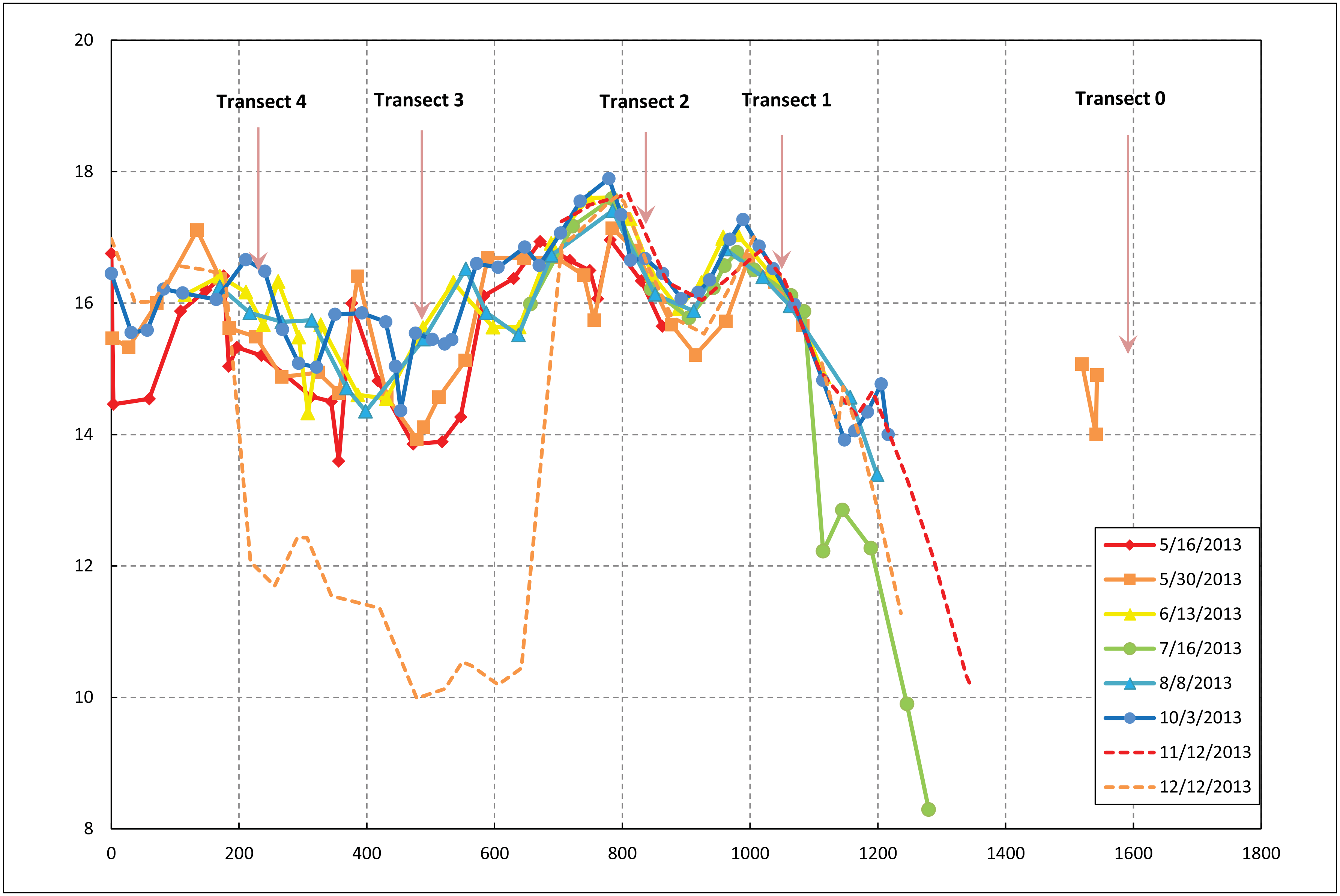
Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 9
Beach Transect #1



SOURCE: Russian River stationary observation camera (BML)

Figure 10
Beach Transect #0

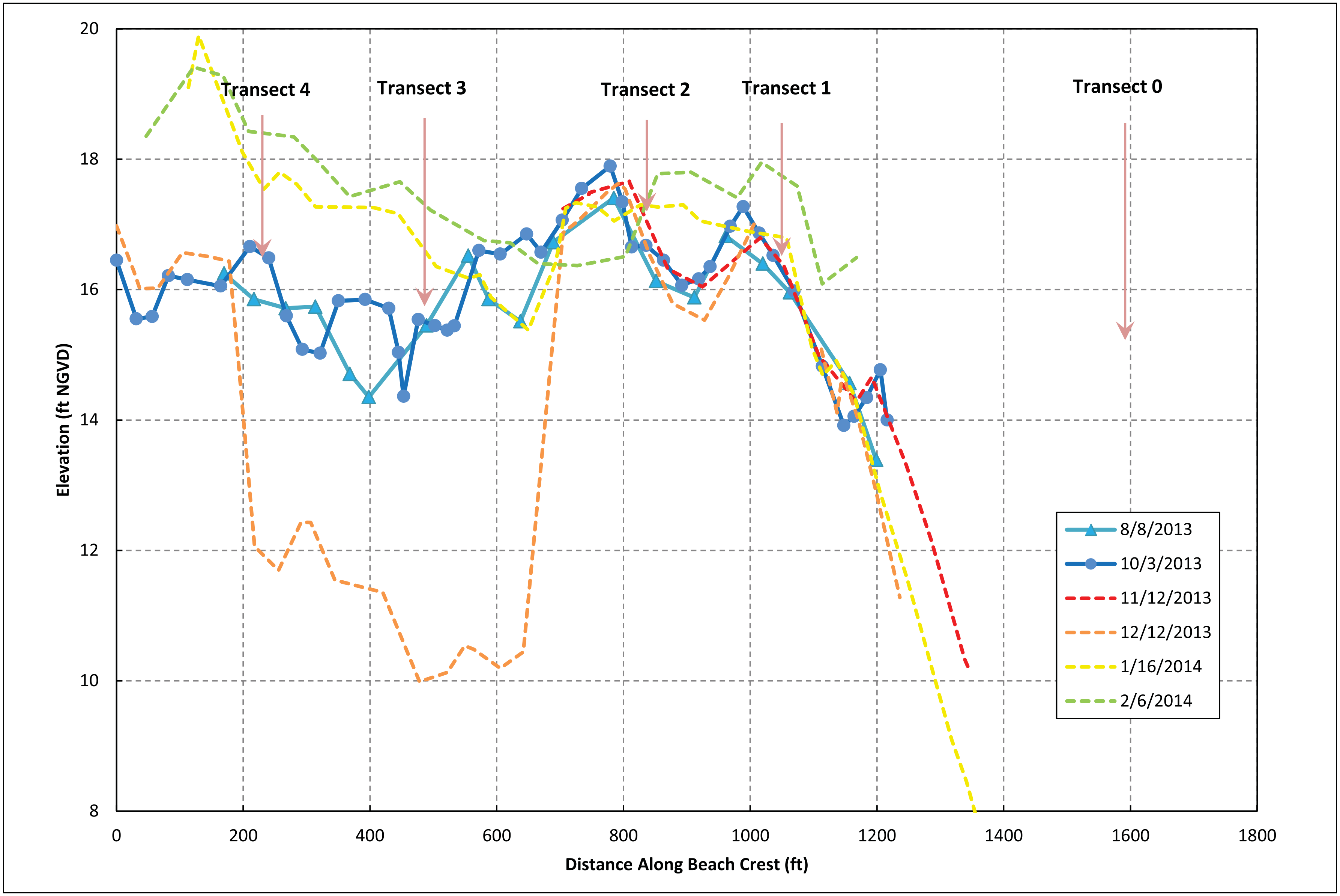


SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

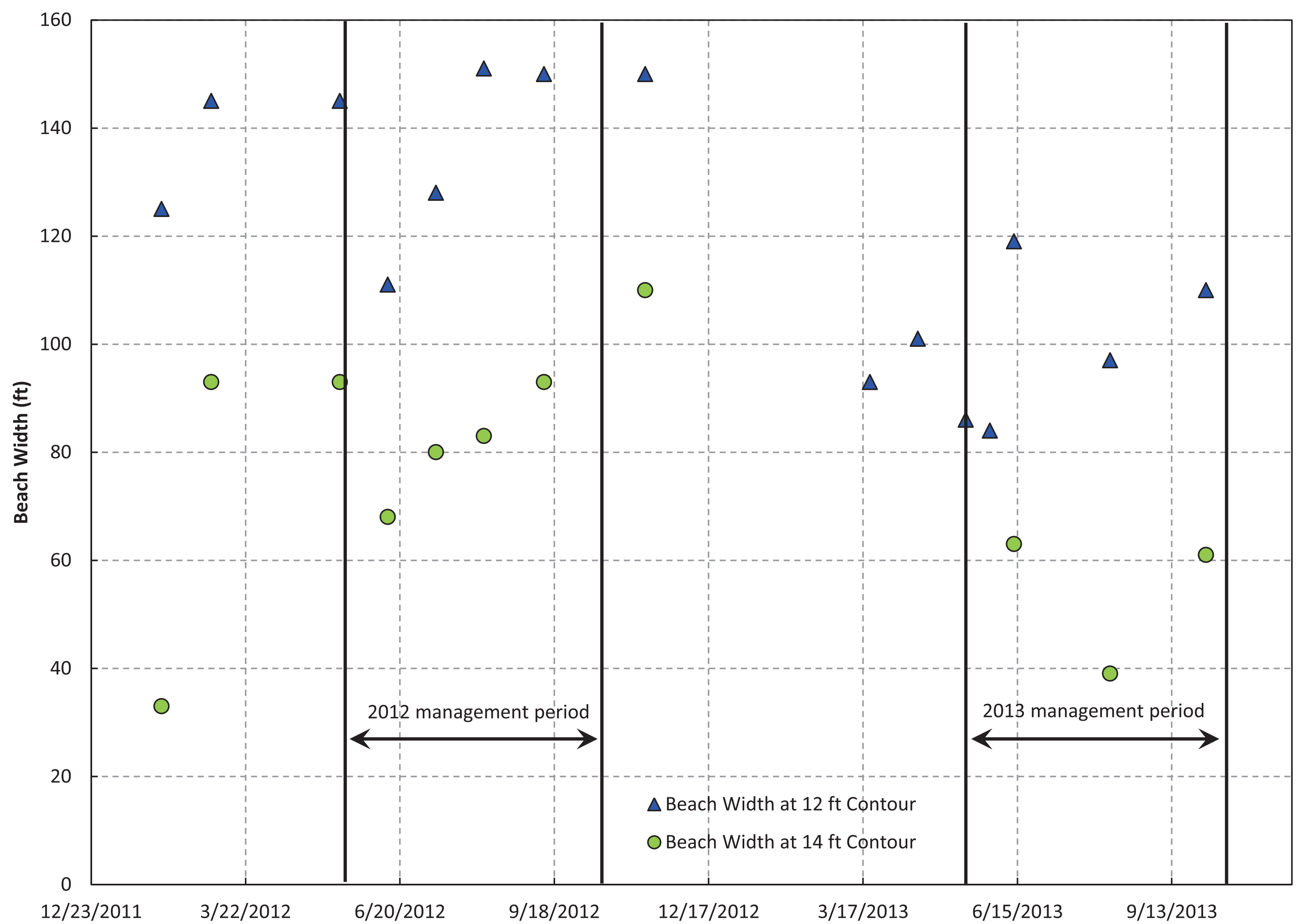
Figure 11

Beach Crest Profiles During the 2013 Management Period.



SOURCE: SCWA survey data

Figure 12
Beach Crest Profiles From August 2013 to February 2014.



SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 13

Beach Width During 2012 and 2013 Management Periods.

Attachment I. Physical Processes During the 2014 Management Period

As required by the Russian River Biological Opinion, the Sonoma County Water Agency (Water Agency) has been tasked with managing the Russian River Estuary to facilitate summer lagoon conditions to improve salmonid habitat. The goal is to meet this need by creating an outlet channel while also maintaining the current level of flood protection for properties adjacent to the estuary (NMFS, 2008). The adaptive management plan, described in the main body of this report, was developed by the Water Agency with assistance from ESA PWA and the resource agency management team in 2009 and revised annually from 2010 to 2015. Because of permit constraints, the Water Agency was only able to implement the plan beginning in 2010. The revised plan was in effect for 2014, but no opportunities for management action occurred during the management period.

During the 2014 management period, May 15th to October 15th, Water Agency staff regularly monitored current and forecasted estuary water levels, inlet state, river discharge, tides, and wave conditions to anticipate changes to the inlet's state. Although several short-lived closure events occurred throughout late April and early May, the first four months of the management period experienced only tidal conditions. An extended closure event began on September 17th. Because of reduced inflows, the lagoon's stage rose slowly and did not reach an appropriate level for enacting the outlet channel until the end of the management period. Except for a few days immediately after artificial breaches, the lagoon remained closed from late September through late November.

Even though no management actions were implemented to inform the adaptive management process, the physical conditions and inlet response during the management period are reviewed in this attachment to contribute to site understanding and to inform future management actions.

METHODOLOGY

This review of the 2014 outlet channel management period examines water levels, ocean wave conditions, ocean water levels, riverine discharge, and beach topography, as well as inlet size and location. The sources for these parameters are listed in Table 1. These data were supplemented with personal observations and discussion with staff from the Water Agency, NMFS, CDFW, and the Bodega Marine Laboratory.

Table 1. Data Sources

Parameter	Source
Estuary water level (h_E)	Water Agency Jenner gage*
Wave height (H_s), period (T_a), and direction	CDIP Point Reyes buoy #029
Ocean water level (h_O)	NOAA Point Reyes #9415020
Russian River discharge (Q_f)	USGS Guerneville #11467000
Beach topography, ft NGVD	Water Agency monthly surveys
Inlet size and location	Water Agency and Bodega Marine Laboratory autonomous cameras

*Data transmission failure due to cellular network issues occurred for several periods throughout the management period.

INLET STABILITY PARAMETER AND CLOSURE RISK PROBABILITY
In addition to considering individual parameters, researchers at the Bodega Marine Laboratory have developed a combined parameter to evaluate the stability of the inlet's state, with the aim of predicting closure risk (Behrens et al., 2013). (Note that the inlet stability parameter does not differentiate between full closure and the perched conditions with a small outlet channel. When discussing this parameter, both states are referred to as a 'closure' in that tides are prevented from propagating into the estuary.) The inlet stability parameter presented by Behrens et al. (2013) quantifies the risk of inlet closure based on a sediment balance in the inlet. It considers the daily balance between wave-driven sediment import to the inlet and sediment export driven by tidal fluctuations. The wave-driven import is assessed using nearshore wave estimates derived from a transformation matrix and offshore buoy data (ESA PWA, 2012) and the latter is estimated from tide gage data within the estuary and a stage-storage relation derived from the available bathymetry. Using daily-average values of the stability parameter within the period 1999-2008, Behrens et al. (2013) showed that high-percentile values of the parameter are closely linked to the risk of the inlet closing within five days. As the percentile of the stability parameter increases, the risk of inlet closure within five days increases exponentially, from risks of roughly five percent when the parameter is at the 50th percentile to a risk of 80 percent when it is measured at the 99th percentile.

SUMMER AND FALL CONDITIONS

Time series of estuary water levels, as well as the key forcing factors (waves, tides, and riverine discharge), are shown in Figure 1 for the entire management period. The lagoon water level time series (Figure 1a) summarizes the closure events at the beginning of the management period, as well as the subsequent tidal conditions and later closure events in fall. As shown in Figure 1d, discharge was low for most of the management period, dropping from 7,000 ft^3/s on April 2nd to below 100 ft^3/s on May 21st. In mid-July, flows briefly reached 200 ft^3/s and remained above 100 ft^3/s for about a week. Afterwards, flows slowly declined until they reached a minimum of 55 ft^3/s on October 7th. As in prior years, wave energy was minimal in much of the management period. A late season swell event ($H_s > 8$ ft, $T_p > 14$s) occurred in late June, and may have led to the subsequent week of muted tides in the lagoon, but did not lead to full inlet closure. A gap in Pt Reyes wave buoy data for the dominant period (T_p) for parts of September and October prevented nearshore transformation of waves during this time. At the end of the management season, high wave events overtopped the beach berm, delivering enough water to the lagoon to increase the daily rises in lagoon stage to 0.4-0.8 ft during the late-season closure event. Overtopping is visible in photographs taken by the river mouth overlook camera. These large waves also prevented breaching equipment from accessing the beach.

The conditions leading to inlet closure were consistent with the existing conceptual model described in Section 4 of the Management Plan. All closure events coincided with either moderately high waves ($H_s > 6$ ft) having periods greater than 10 s, or with neap oceanic tide ranges of less than approximately 5 ft, with the exception of the September closure event, when nearshore waves could not be estimated. Moderately high waves coincided with the closure events in April and May. The September closure event occurred during a neap tide. The artificial breach events that occurred on October 22nd and November 17th were coincident with neap tides and large to moderate waves, and were followed by closure within less than one day. The artificial breach event on November 26th happened during a spring tide, and was not followed by closure. The persistent closure conditions from September through November are examined in more detail in Figure 2.

As in 2012 and 2013, all closure events occurred when the inlet was adjacent to the jetty. In former years, this positioning may have prevented perched conditions from arising by shielding this area of the beach from the wave-driven sediment deposition that caused closure, preventing the beach from accreting to a sufficient height to allow the desired outlet channel elevations from being attained. This may have been the case for the September closure event in 2014 as well. Wave overwash in mid-October did appear to provide enough volume to raise the lagoon stage to a level requiring artificial breaching, but the same wave overwash also made work on the beach impossible, and occurred too late in the management season for a channel to be created.

LATE-SEASON CLOSURE EVENT

The only event that would have provided an opportunity for implementing the outlet channel occurred on September 17th. Inflows generally were below 100 ft^3/s throughout the event, allowing the stage to remain lower than 7 ft NGVD for almost a month of closure. The largest increases in stage happened on September 25th and October 12th due to wave overwash. The overwash raised the stage by about three quarters of a foot. Otherwise the weak inflows allowed the stage to rise at a very slow pace; the stage increased from roughly 5.0 ft NGVD on September 26th to approximately 6.8 ft NGVD on October 11th, and average increase of about 0.1 feet per day. Flows during this time were less than 85 ft^3/s and dipped to as low as 55 ft^3/s.

To better illustrate both the lagoon stage and beach morphology during this time, Figure 3 shows a sequence of photos of the inlet before and during this closure event. As was the case for all of the management period, the inlet was located next to the jetty. Figure 3a depicts the inlet when it was located next to the jetty several days before closure, indicating a width of less than roughly

40 ft. Nearshore waves could not be estimated for the week of closure, but are likely to have played a role, since waves generally begin to increase in energy in September. Neap tide conditions were present during the week of closure, with the oceanic tide range measured at approximately 4 feet (Figure 2c). Figure 3d shows extensive wave overwash surging over the beach berm and into the lagoon.

Unlike the 2012 management period, no natural outlet channels were formed near the jetty in 2014. However, as with 2012 and other previous years, the lowest portion of the beach was consistently located at the jetty. This persistent low portion is probably caused by wave sheltering by the jetty, which may have reduced berm build-up at the inlet's location, leaving a low point in the beach berm that was the site for subsequent overtopping and natural breaching.

CLOSURE RISK PROBABILITY

The 5-day closure risk probability, a derivative of the inlet stability parameter described above, was hindcast for 2014 according to the method described in Behrens et al. (2013). This hindcast provides an indication of the utility of the stability parameter as a prediction tool for monitoring inlet conditions and planning management action. This parameter integrates wave and ocean forcing conditions, as well as estuary water levels, to provide greater predictive skill than just waves or ocean tides on their own. The stability parameter combines these factors, and the corresponding five-day closure risk time series exceeded 50 percent before most 2014 events (Figure 1e). The gap in nearshore wave estimates in September was filled with offshore wave heights and periods, which are a poorer estimate of nearshore conditions. Since at least one day of tidal conditions are needed to predict closure, many of the closure events could not be predicted, since they occurred less than one day after breaching. Otherwise, the predicted probability of closure exceeded 50% 2-5 days in advance of most other closures.

TOPOGRAPHIC CHANGE

The Water Agency has conducted monthly surveys of Goat Rock State Beach that cover a region starting from the jetty and extending approximately 1,500 feet to the north. Typically, the surveys do not include bathymetry within the inlet because flow conditions in the inlet prevent safe access. Also, the survey extent can be limited by the Water Agency's compliance with its marine mammal incidental harassment authorization, which sets guidelines for the survey crew's approach to marine mammals hauled out on the beach. Water Agency survey staff collected spot elevations using RTK-GPS and then assembled these elevations into a set of contour lines at 1 ft intervals, as well as profiles along the beach berm crest, the ocean wetted edge, and the estuary water line. The survey elevations are reported in the NGVD29 vertical datum.

To characterize beach berm topographic conditions, ESA PWA assessed data from the Water Agency's 2010 (July to September), 2011 (May to October), 2012 (May to October), 2013 (May to October), and 2014 (May to October) surveys. Profiles include two transects backed by cliff (Figure 5 and Figure 6), two transects which extend into the estuary (Figure 7 and Figure 8), and two variations on a transect just north of the jetty (Figure 9 and Figure 10).

This review focuses on the 2014 surveys, although the 2011 surveys are included for context in some figures. The 2014 topographic data were similar to those of 2012 and 2013 in that the northernmost profiles underwent little morphologic change during the management season. However, in 2014 the southernmost profiles underwent more morphologic change than in those years, similar to the results from the 2010 and 2011 management seasons.

At profiles 3 and 4, the beach is backed by cliff, and undergoes morphologic changes when the inlet migrates north during floods and returns south to the jetty in spring or summer. In 2010 and 2011, migration in this area led to a sequence of erosion and accretion at these sites during the management period. The erosion seen in those years was associated with inlet migration and subsequent accretion of the beach was associated with long-period swell waves. During the 2012-2014 management seasons, the inlet remained at the jetty and did not migrate north, leading to an especially stable profile at Profile 4 (Figure 5). Profile 3 was also stable, but steepening in October led to changes in elevation on the order of 1-2 feet at the crest and along the beach face (Figure 6).

Compared with 2012 and 2013, Profiles 1 and 2 were much more variable. At Transect 2 (nearest to Haystack Rock), the beach profile was stable from May through August, and then grew vertically and moved landward in September (Figure 7). The largest change was between the September and October surveys, when the crest grew by roughly 2 feet. This type of seasonal growth is apparent in previous years, and is expected as wave energy increases seasonally. While Transect 1 underwent similar changes, it was more strongly influenced by proximity to the inlet throughout the summer. It was lowest in July and August, when the inlet was fully tidal. It extended seaward along the beach face from August to September and added an additional 1-2 feet vertically throughout the entire profile between September and October, reflecting the closure event.

Transect 0, which is located parallel to the jetty, was slightly higher than transect 1 in 2014, and showed a large shift in morphology at the end of summer (Figure 9). In previous years, it was more typical to see limited change throughout the management season at this transect, but large interannual variability (Figure 10). In 2014, it was mostly stable until August, and then grew seaward by over 50 feet between August and September. Its crest remained at roughly 14.5-15.0 ft NGVD despite this shift. This seaward growth is likely related to an abundance of northwesterly swell (Figure 2) that arrived during this month. Further growth between September and October was probably made possible by the combined waves and extended closure event.

Beach berm crest profiles were collected by the Water Agency for the first time in 2013 and collected again in 2014. These data make it possible to discern important changes in beach shape along the length of the berm from the northern beach access point to the jetty. Along-beach trends in crest elevation generally indicate along-beach trends in wave energy and the influence of inlet migration and breaching.

Figure 11 shows that through September, the change in crest elevation was minimal throughout the length of the beach north of Transect 1. By October, the crest elevation increased by as much as 3 ft in some areas. The beach crest was lowest south of Transect 1, where the inlet resided. At Transects 1-4, the crest profile shape remained essentially the same from May to September, with the dominant ridge pattern not shifting laterally. The along-crest ridge pattern also shifted laterally, with the new peak (18.0 ft NGVD) located along Transect 3. The beach was highest between Transects 3 and 4, peaking at 16-18 ft NGVD and minimum of 12.5-14.0 ft NGVD, north of Transect 4.

BEACH WIDTH

To provide additional information about the beach morphology, ESA PWA assessed the beach width using the Water Agency survey data. Figure 12 shows the evolution of the beach width at Transect 3 during the 2012-2014 management periods. In previous years during winter months, the beach was often eroded at Transect 3 to the point that the beach crest was below 12 ft NGVD, so that the width was effectively zero. In 2012 and 2013, apart from this seasonal erosion, there was no marked trend in the beach width. In 2014, the beach was wider than the previous two years, with peak width at the beginning of the management season (Figure 12). The width steadily decreased from 198 at 12 ft NGVD and 130 at 14 ft NGVD in May to 170 and 111 ft NGVD, respectively, in October. The shift appeared to be a result of beach face steepening, a typical summer process.

JENNER STAGE EXCEEDANCE

The Biological Opinion (NMFS, 2008) sets a target for estuary water levels "a daily minimum water surface elevation of 3.2 feet [NGVD] during 70% of the year." To facilitate this target, the Biological Opion notes "Absent river flood flows and historic mechanical breaching practices, NMFS expects cross shore transport of sand by wave action will be sufficient to maintain the bar at this elevation."

In 2014, the daily minimum water surface elevation exceed 3.2 ft NGVD roughly 33% of the year (Figure 13). For comparison, Figure 13 also includes hourly lagoon stage (exceeded 3.2 ft NGVD for roughly 46% of the year) and hourly Point Reyes stage (exceeded 3.2 ft NGVD for roughly 4% of the year). Data gaps at the Jenner Gage influence the exceedance curve, but BML camera photographs suggest an open mouth during most of the periods when stage data were missing, so the exceedance curves for the estuary are likely biased high, meaning that stage exceeded 3.2 ft NGVD for less of the year. This low amount of perched conditions results from the inlet maintaining open conditions throughout the summer of 2014. As with several of the years since 2010, lack of closure in June or July led to prolonged open conditions, as July and August waves were too small to cause closure. As explained in previous annual updates, if the inlet does not close in late spring, it is likely that open-inlet conditions will persist as a result of the seasonally weak waves. Since no closures occurred in late spring in 2014, an outlet channel could not be made, which would have presumably had the intended effect of causing prolonged perched conditions.

LESSONS LEARNED AND RECOMMENDATIONS

Based on 2014 observations of the estuary, associated physical processes, and the Water Agency's planning for outlet channel management, we note the following lessons about implementing the outlet channel management plan.

CONCEPTUAL MODEL

- The beach north of the inlet saw little change from the 16-18 ft NGVD elevations established in 2013. Near the jetty, the berm was lowered by inlet migration while undergoing beach building.
- Similar to the winters of 2011-12 and 2012-2013, the inlet never migrated north of Haystack Rock during winter 2013-14, and returned to the jetty in early spring, much earlier than in most years. This inlet alignment is not common, but has been observed in past years (Behrens et al., 2009).
- Peak annual river discharge has remained below 40,000 ft^3/s for 9 consecutive years, a streak unmatched in the 70-year flow record. This may have a connection to the recent lack of inlet migration to the north.
- The beach width in 2014 at Transect 3 (near Haystack Rock) was larger than in 2013. This may suggest that beach width is closely tied to inlet migration – the lack of migration north of Haystack Rock for several years has allowed the beach to grow at this end of the littoral cell.

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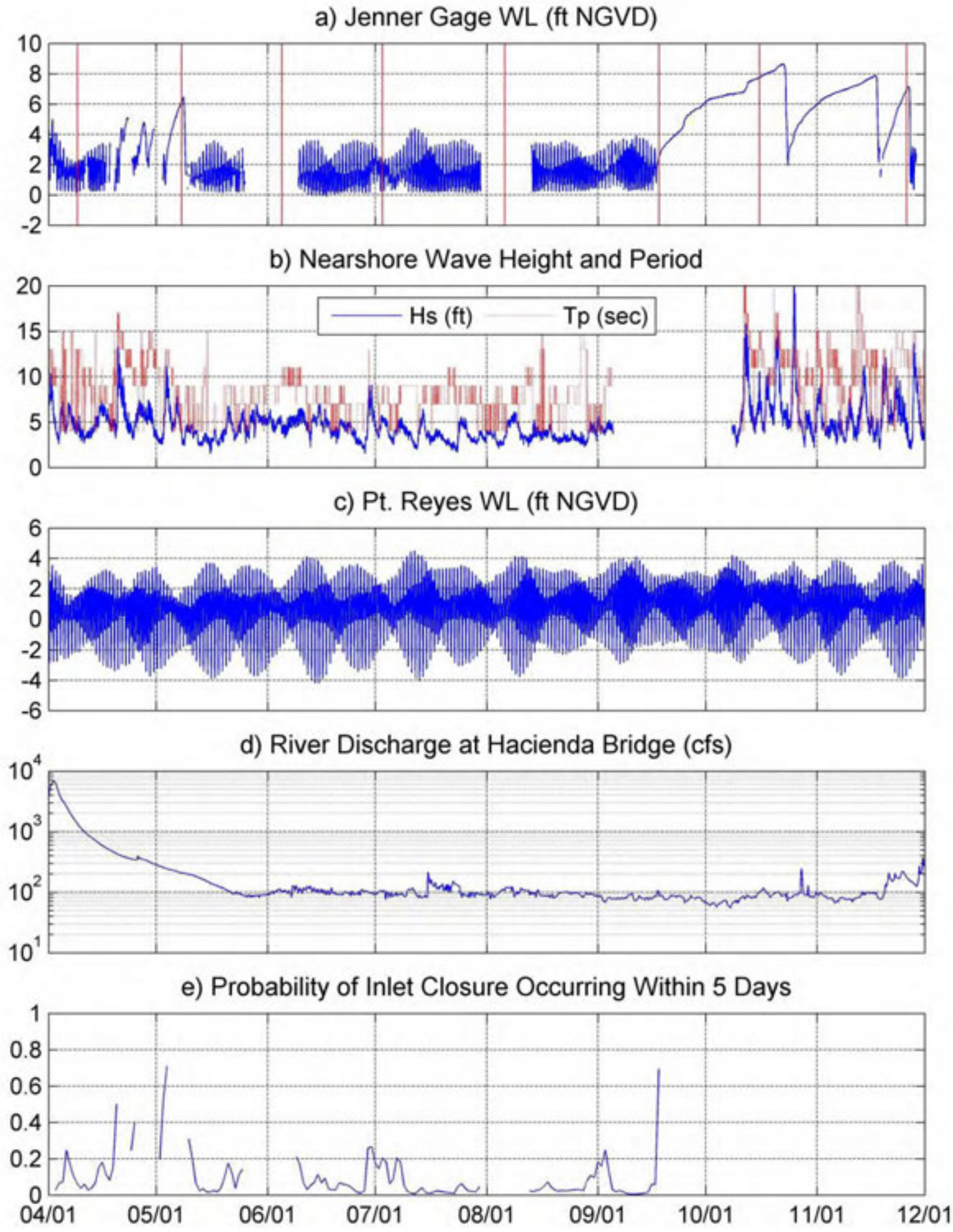
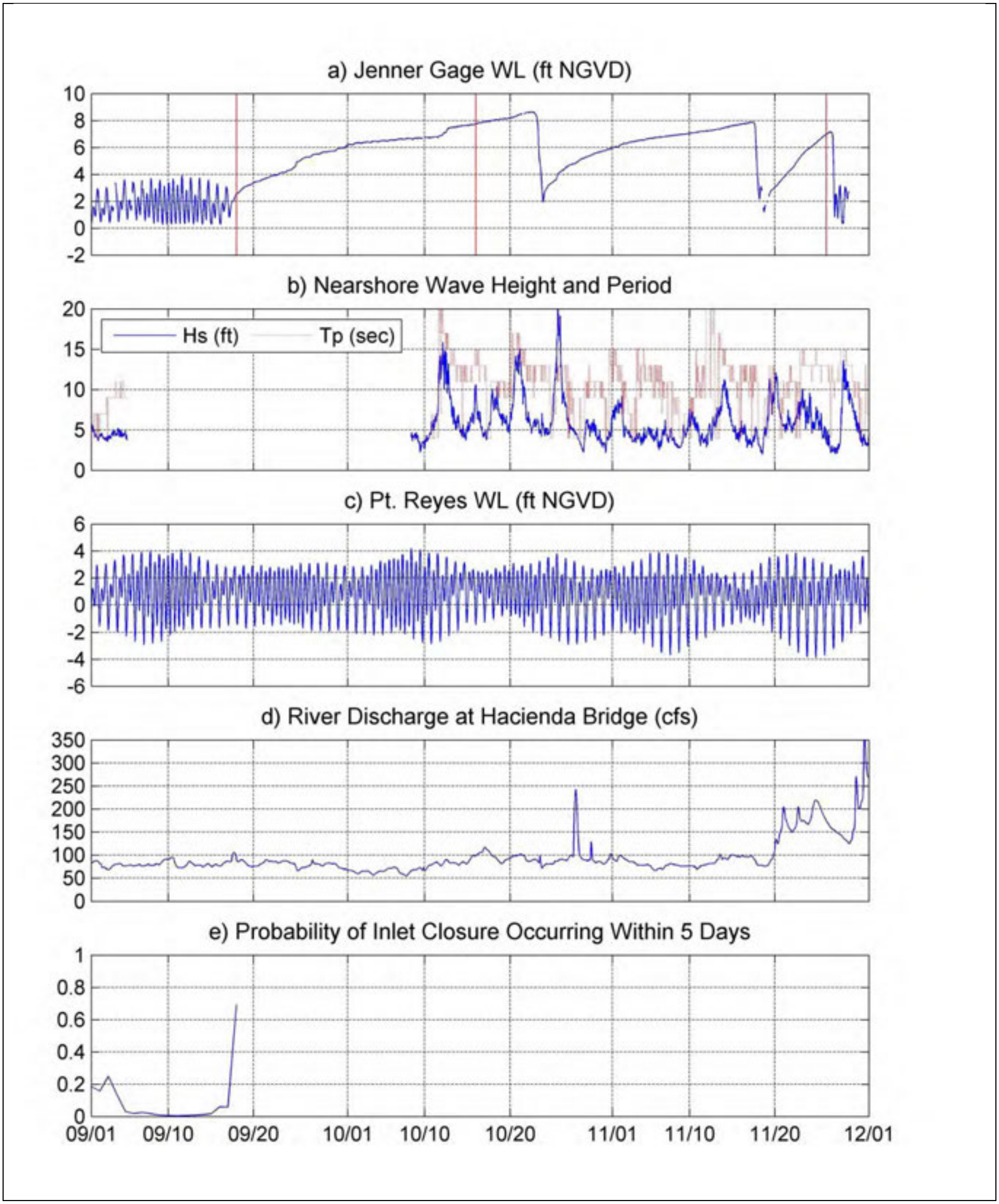


SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

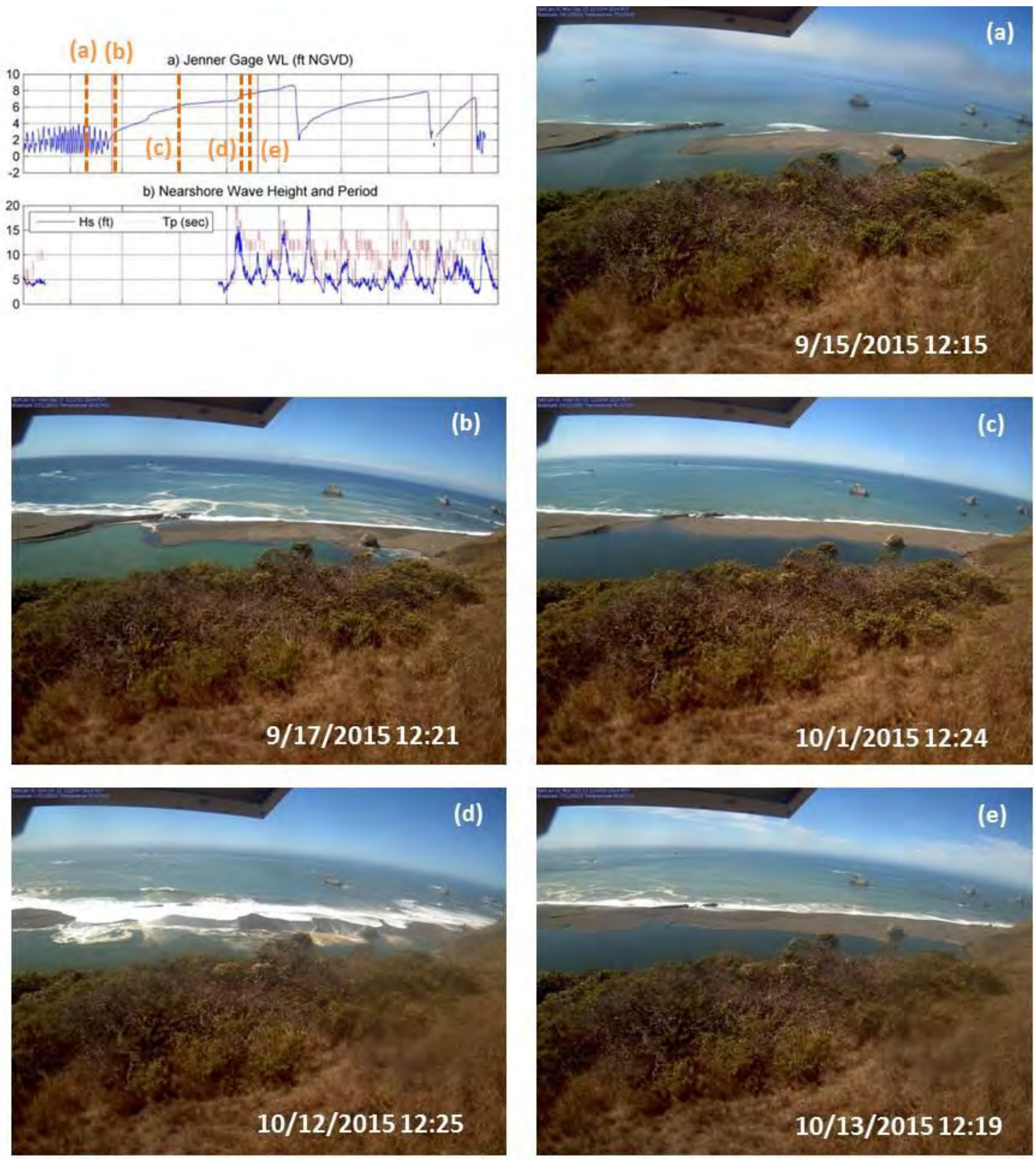
Figure 1
Estuary, Ocean, and River Conditions Compared with Closure Probability: April – November 2014



SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

Figure 2
Estuary, Ocean, and River Conditions Compared with Closure Probability: September – November 2014



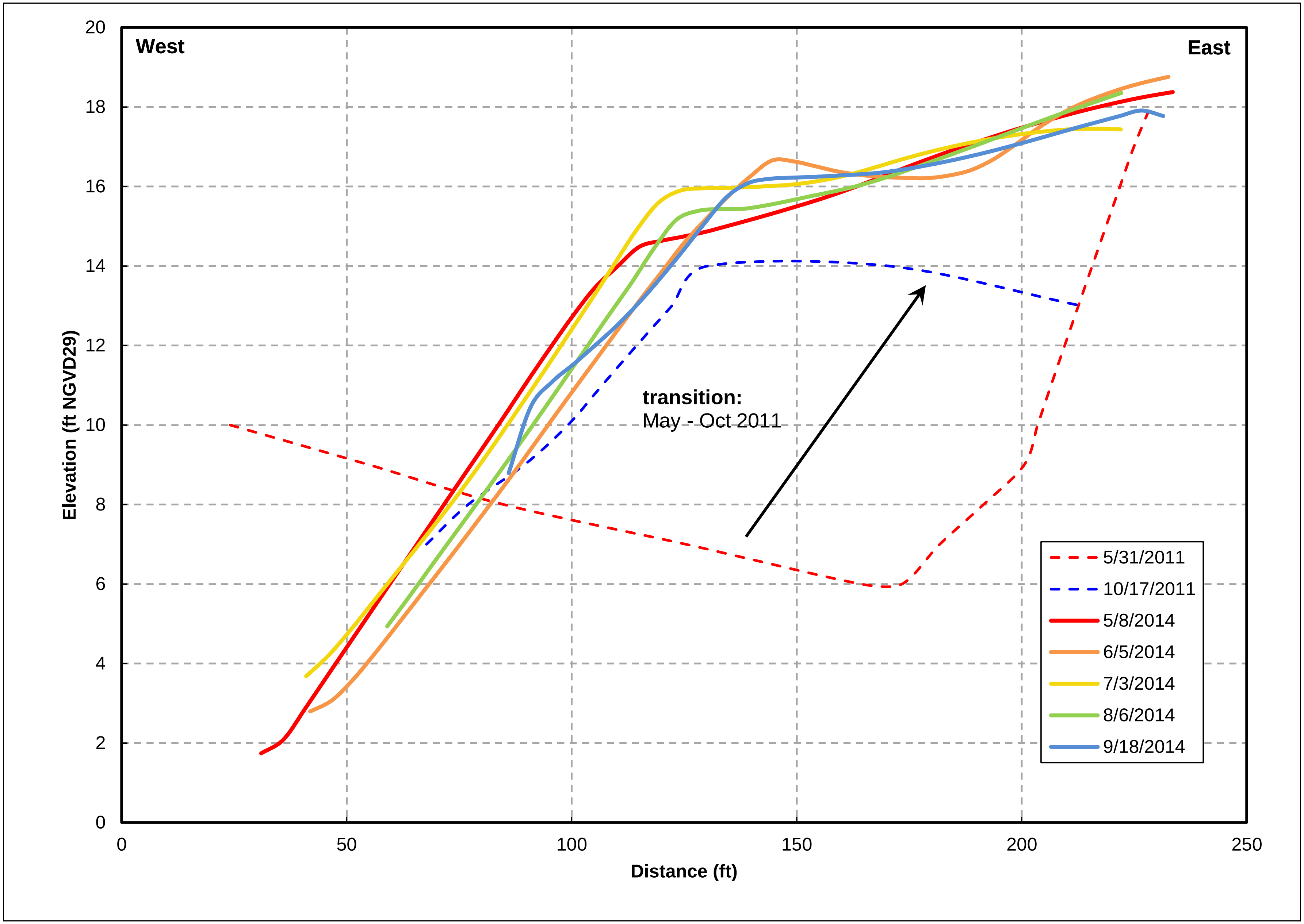
SOURCE: SCWA camera

Figure 3
Russian River camera photographs showing some of the key morphologic influences during the September-October 2014 closure event.

SOURCE: image from USDA NAIP

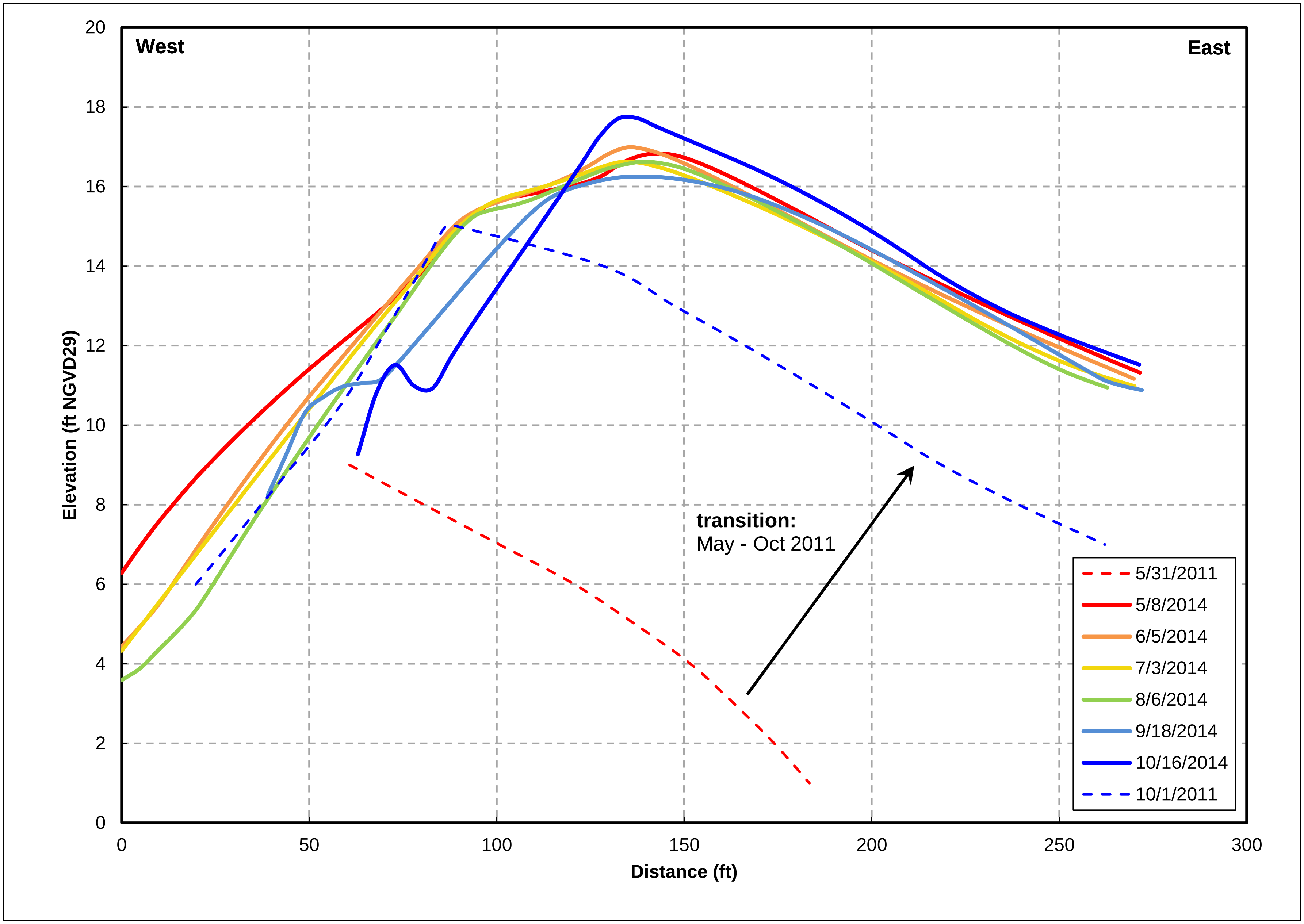
Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 4
Beach Transect Locations



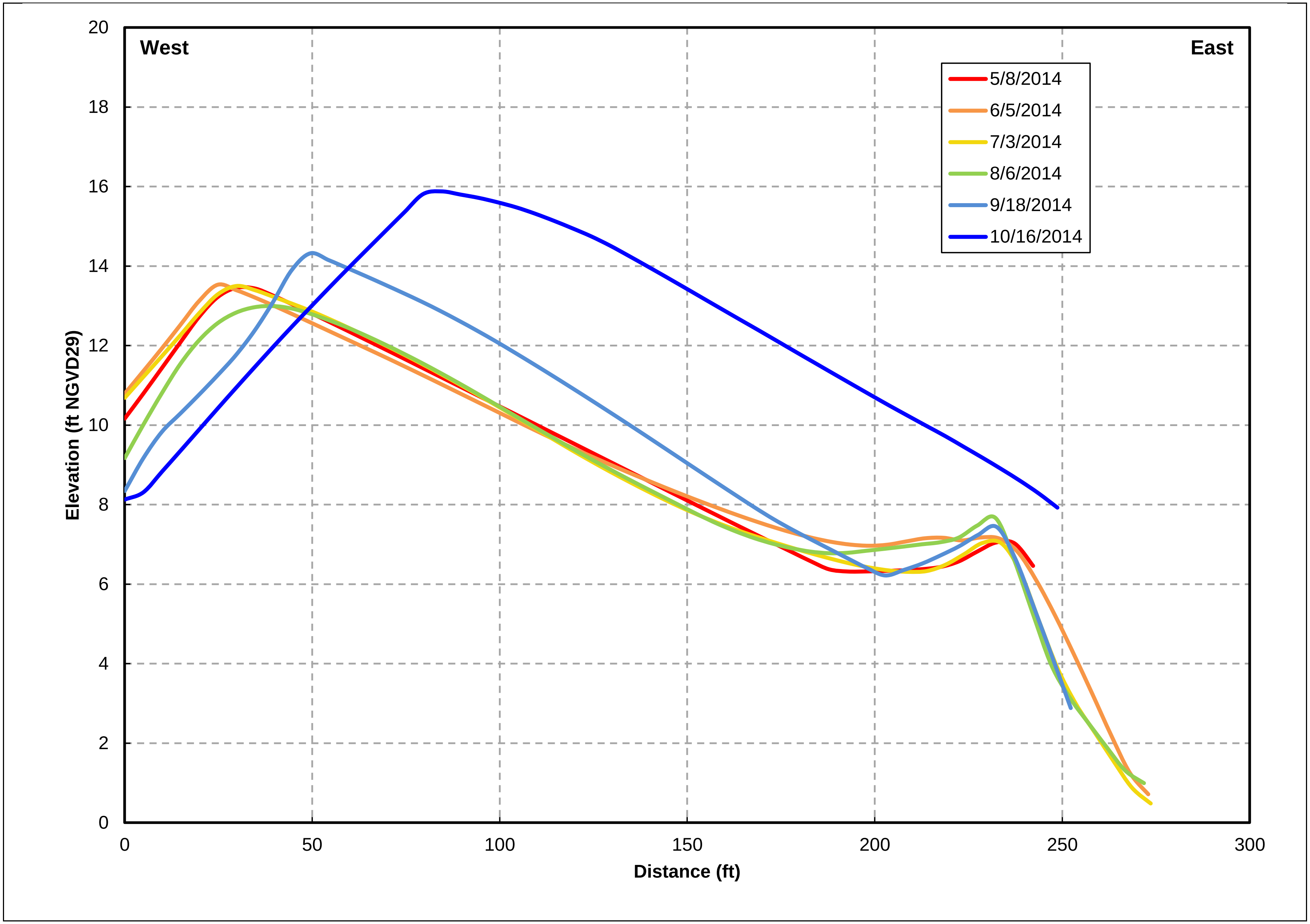
SOURCE: SCWA survey data

Figure 5
Beach Transect #4



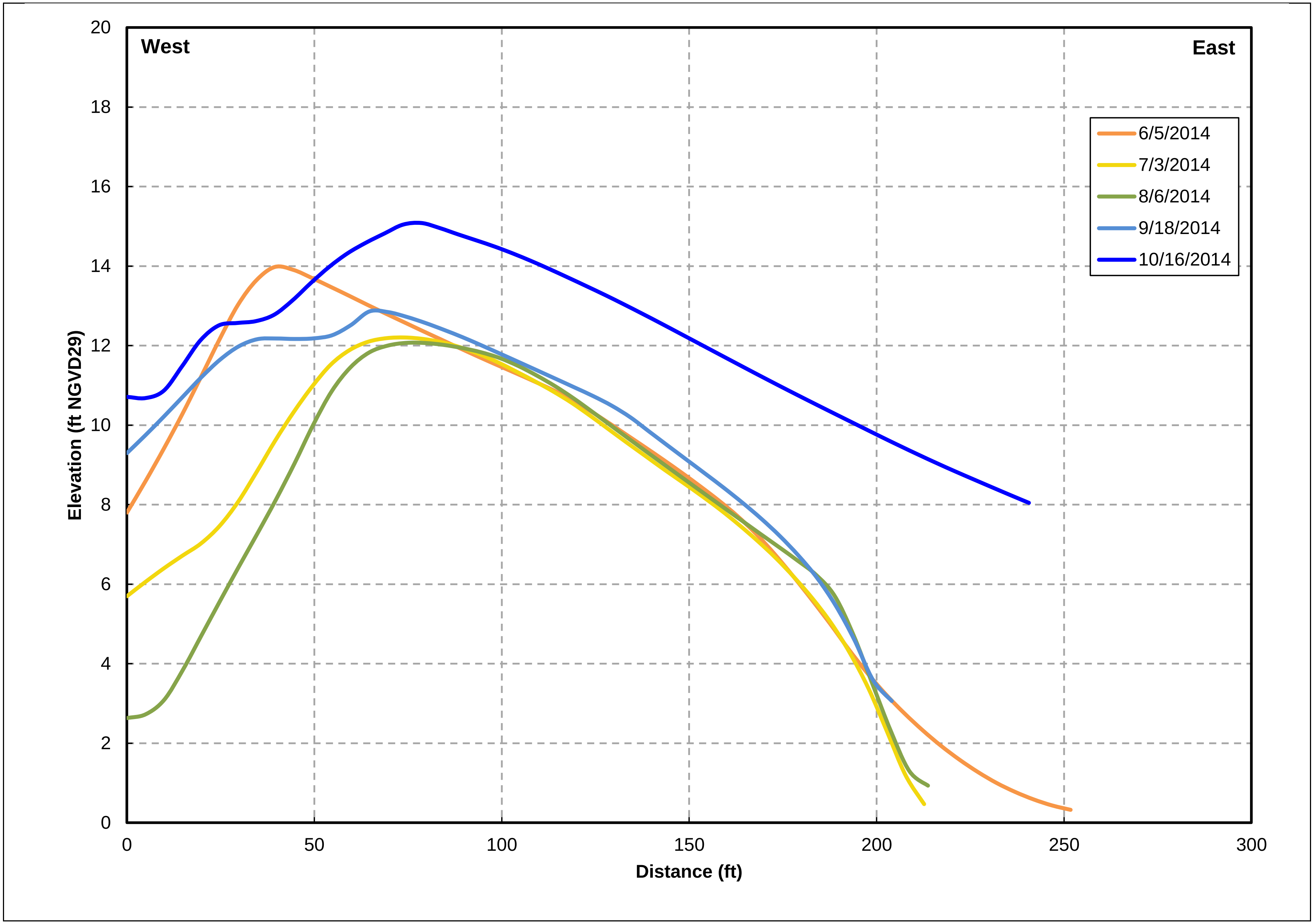
SOURCE: SCWA survey data

Figure 6
Beach Transect #3



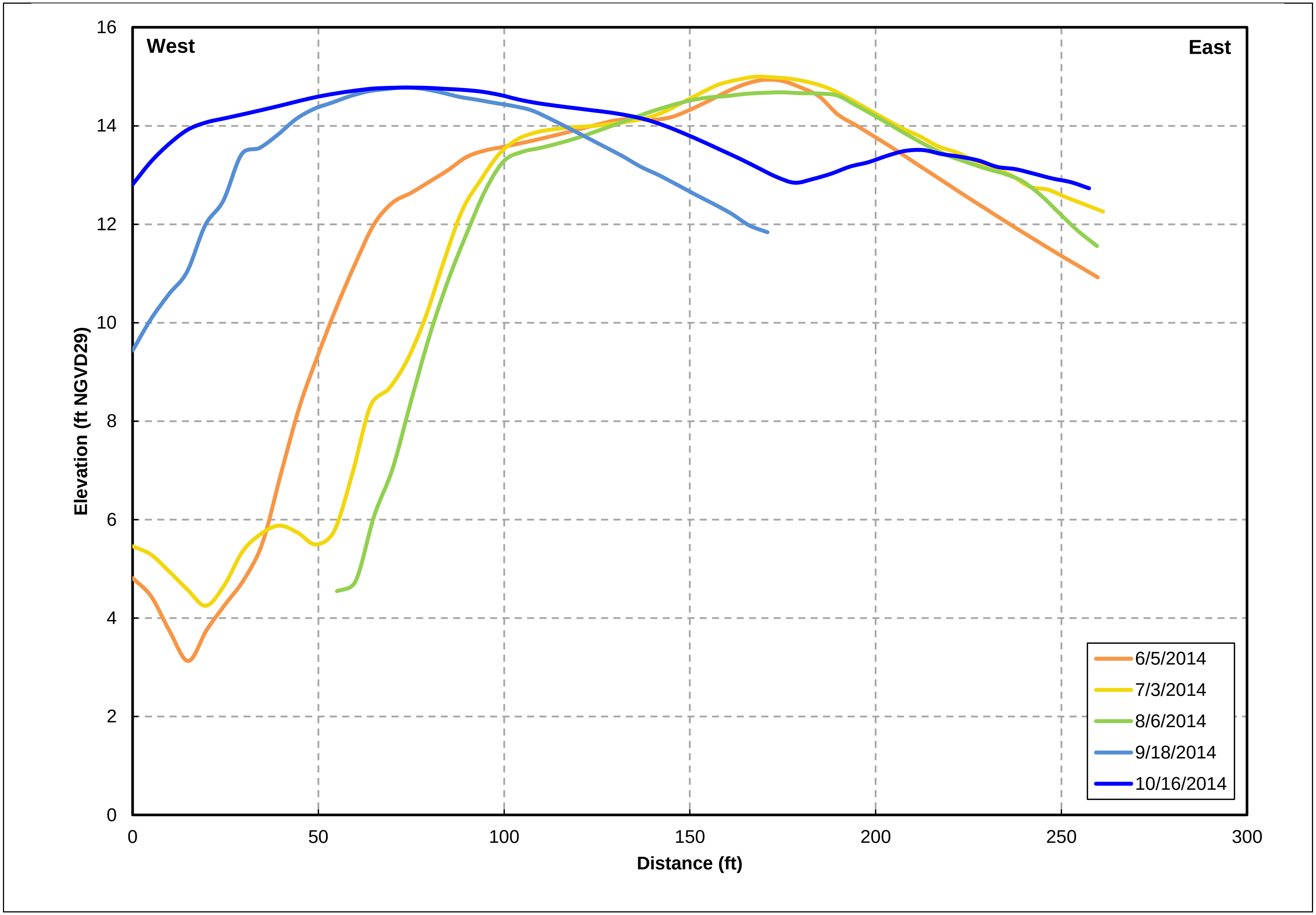
SOURCE: SCWA survey data

Figure 7
Beach Transect #2



SOURCE: SCWA survey data

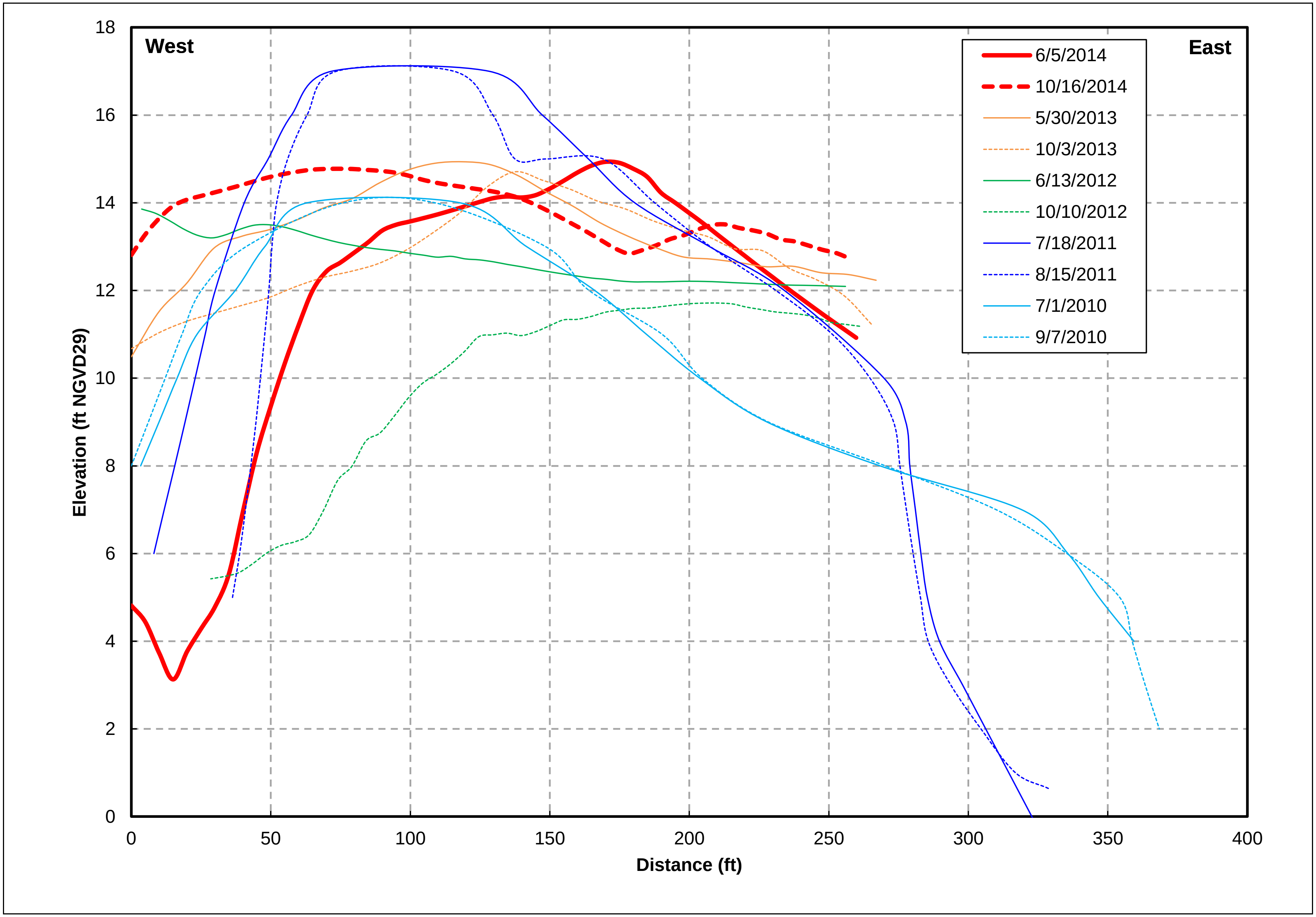
Figure 8
Beach Transect #1



SOURCE: SCWA survey data

Figure 9

Beach Transect #0 from 2014 management period.



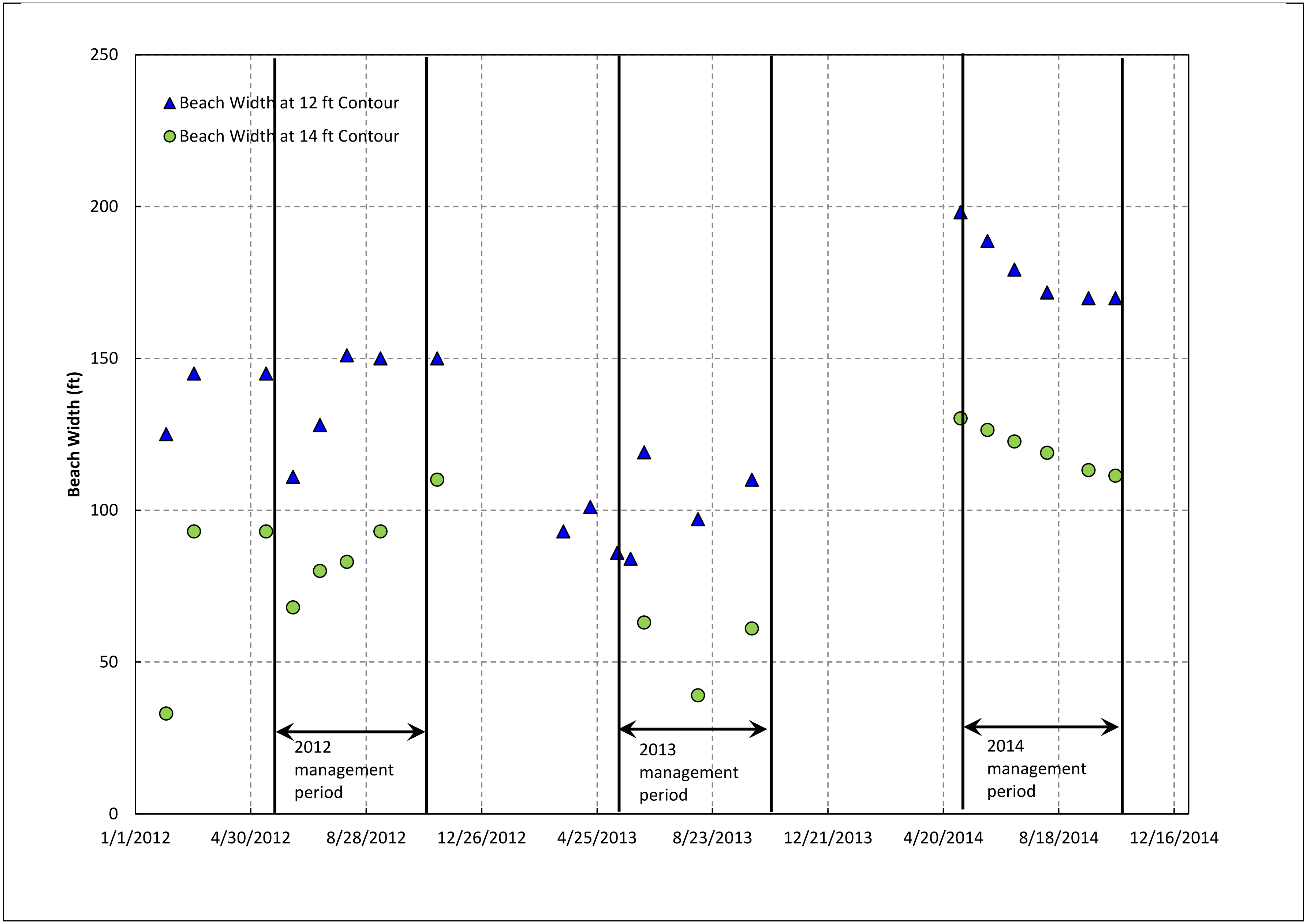
SOURCE: SCWA survey data

Figure 10

Beach Transect #0 from 2010-2014 management periods.

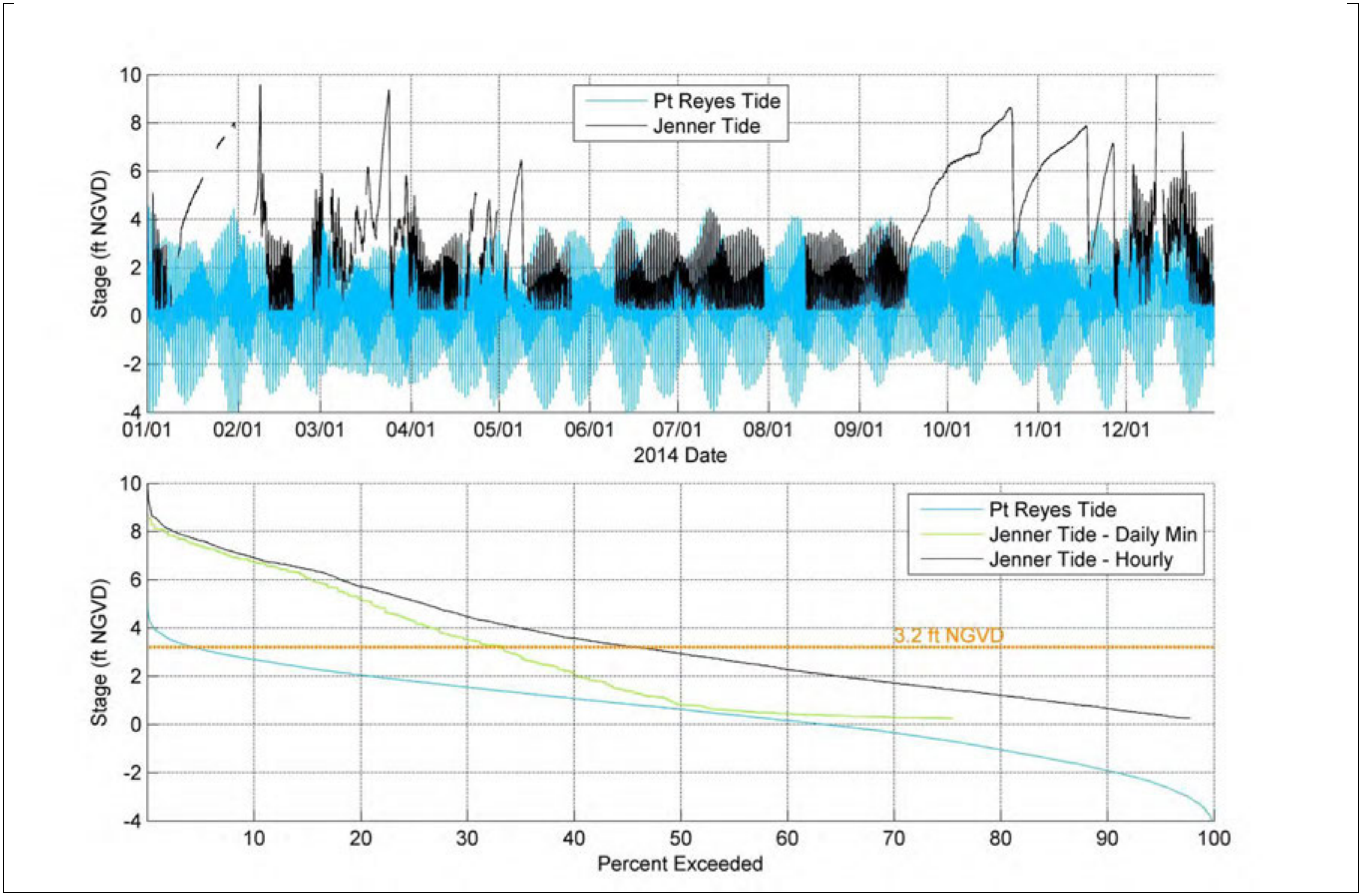
SOURCE: SCWA survey data

Figure 11
Beach Crest Profiles During the 2014 Management Period.



SOURCE: SCWA survey data

Figure 12
Beach Width During 2012-2014 Management Periods.



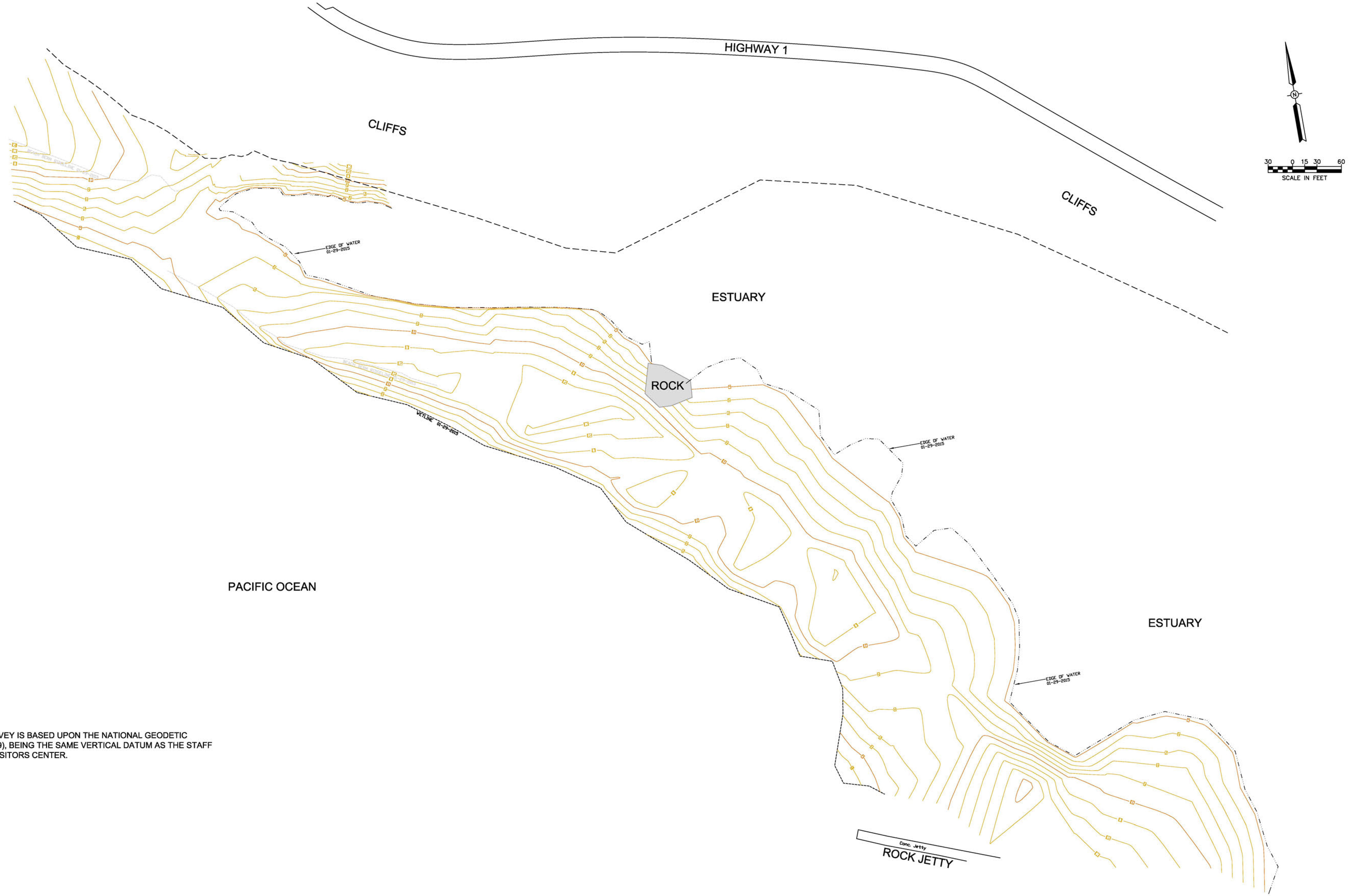
SOURCE: SCWA Jenner Gage and NOAA Pt Reyes tide data

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 13

Russian River Estuary stage exceedance for 2014.

Appendix 4.2



NOTES:

1. VERTICAL DATUM FOR THIS SURVEY IS BASED UPON THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29), BEING THE SAME VERTICAL DATUM AS THE STAFF GAGE LOCATED AT THE JENNER VISITORS CENTER.

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					DATE : AS NOTED	SUBMITTED	MONTHLY SURVEY OF BEACH TOPOGRAPHY AND OUTLET CHANNEL: Jan. 29, 2015
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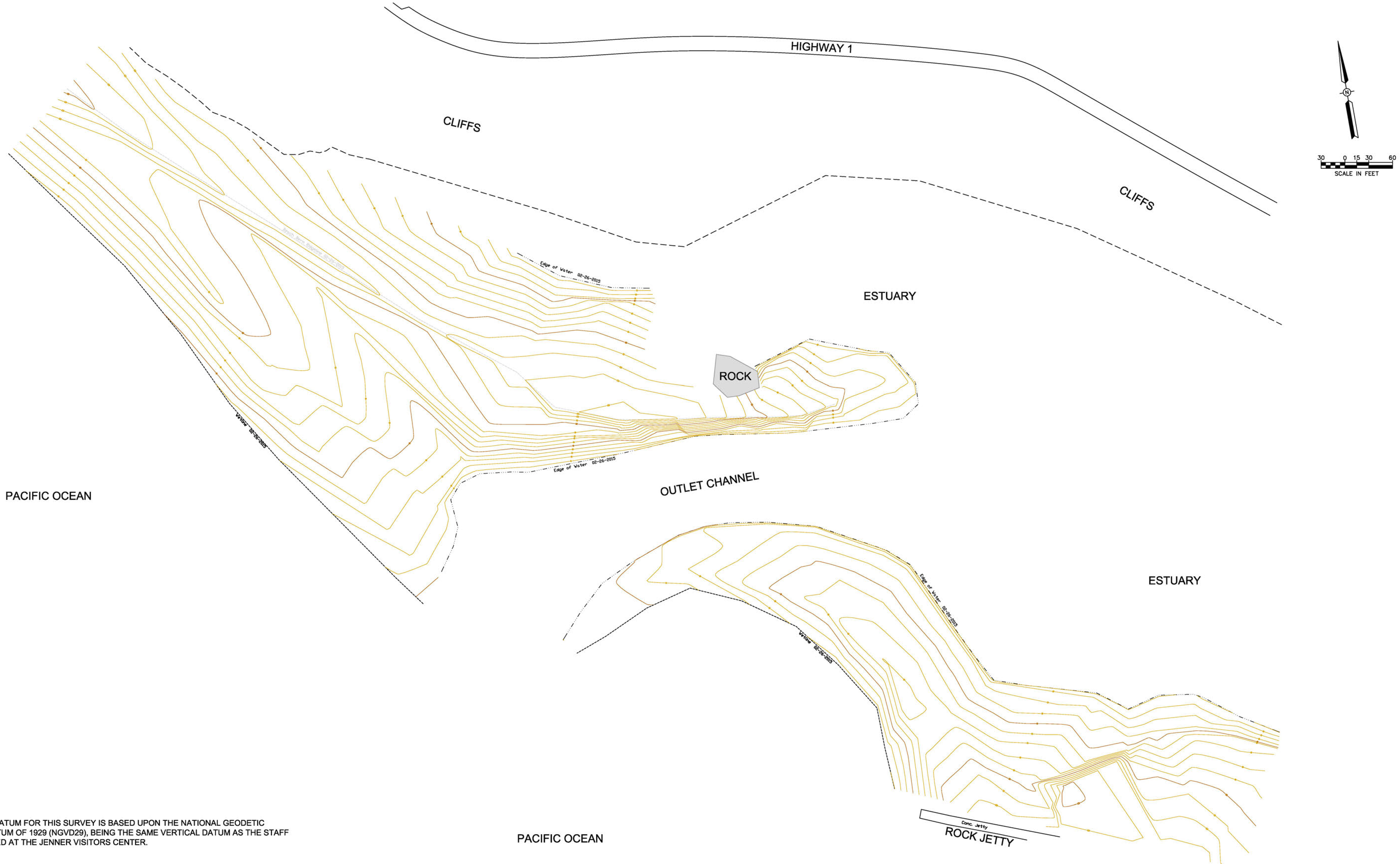
					CHECKED : JRM		DRAWING NUMBER
							SHEET NO. 1 OF 1



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RUSSIAN RIVER INSTREAM FLOW RESTORATION (RRIFR) PROGRAM

MONTHLY SURVEY OF BEACH TOPOGRAPHY AND OUTLET CHANNEL: Feb. 26, 2015

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1. VERTICAL DATUM FOR THIS SURVEY IS BASED UPON THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29), BEING THE SAME VERTICAL DATUM AS THE STAFF GAGE LOCATED AT THE JENNER VISITORS CENTER.

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RUSSIAN RIVER INSTREAM FLOW RESTORATION (RRIFR) PROGRAM

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FILE NAME:
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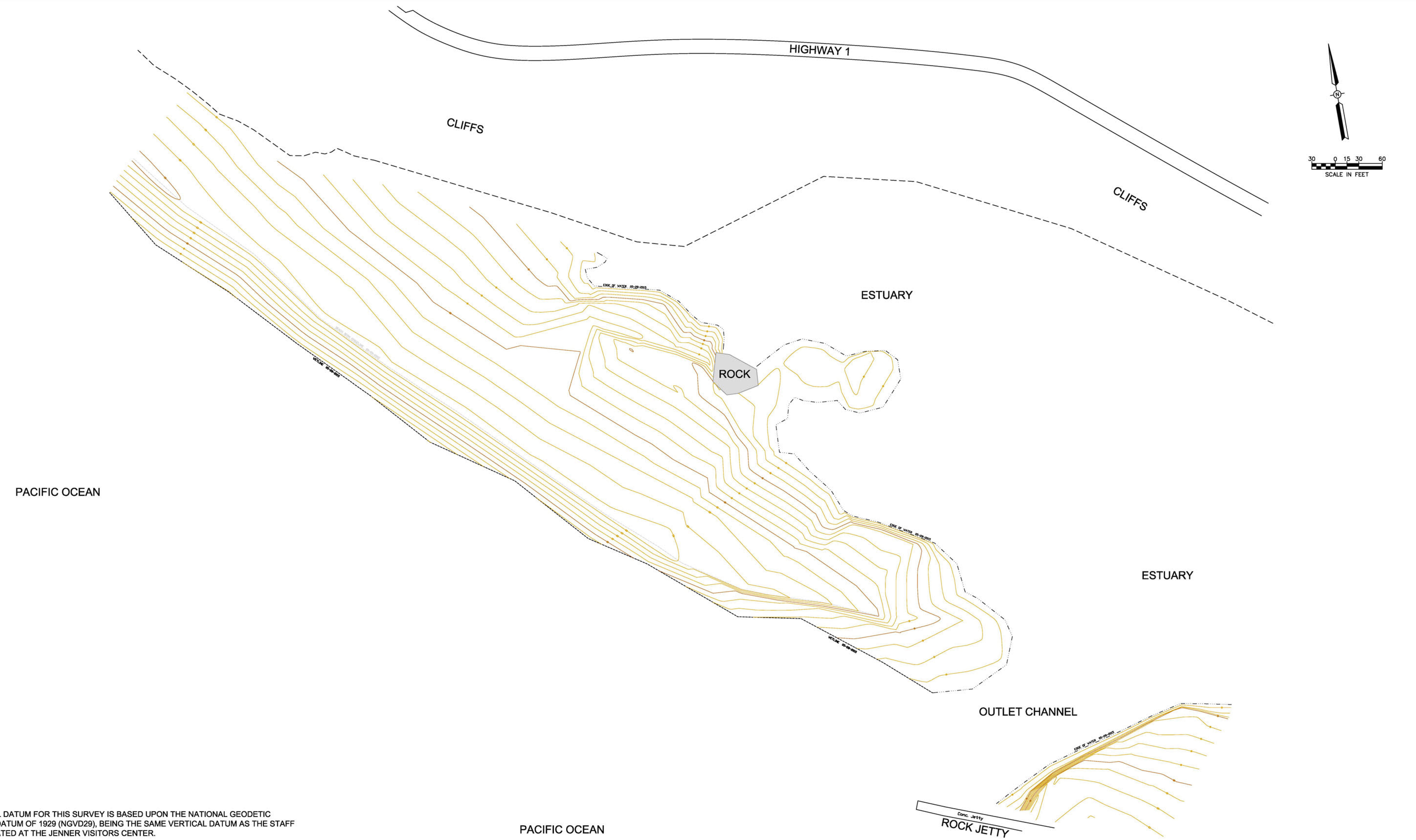

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RUSSIAN RIVER INSTREAM FLOW RESTORATION (RRIFR) PROGRAM

MONTHLY SURVEY OF BEACH TOPOGRAPHY AND OUTLET CHANNEL: May. 28, 2015

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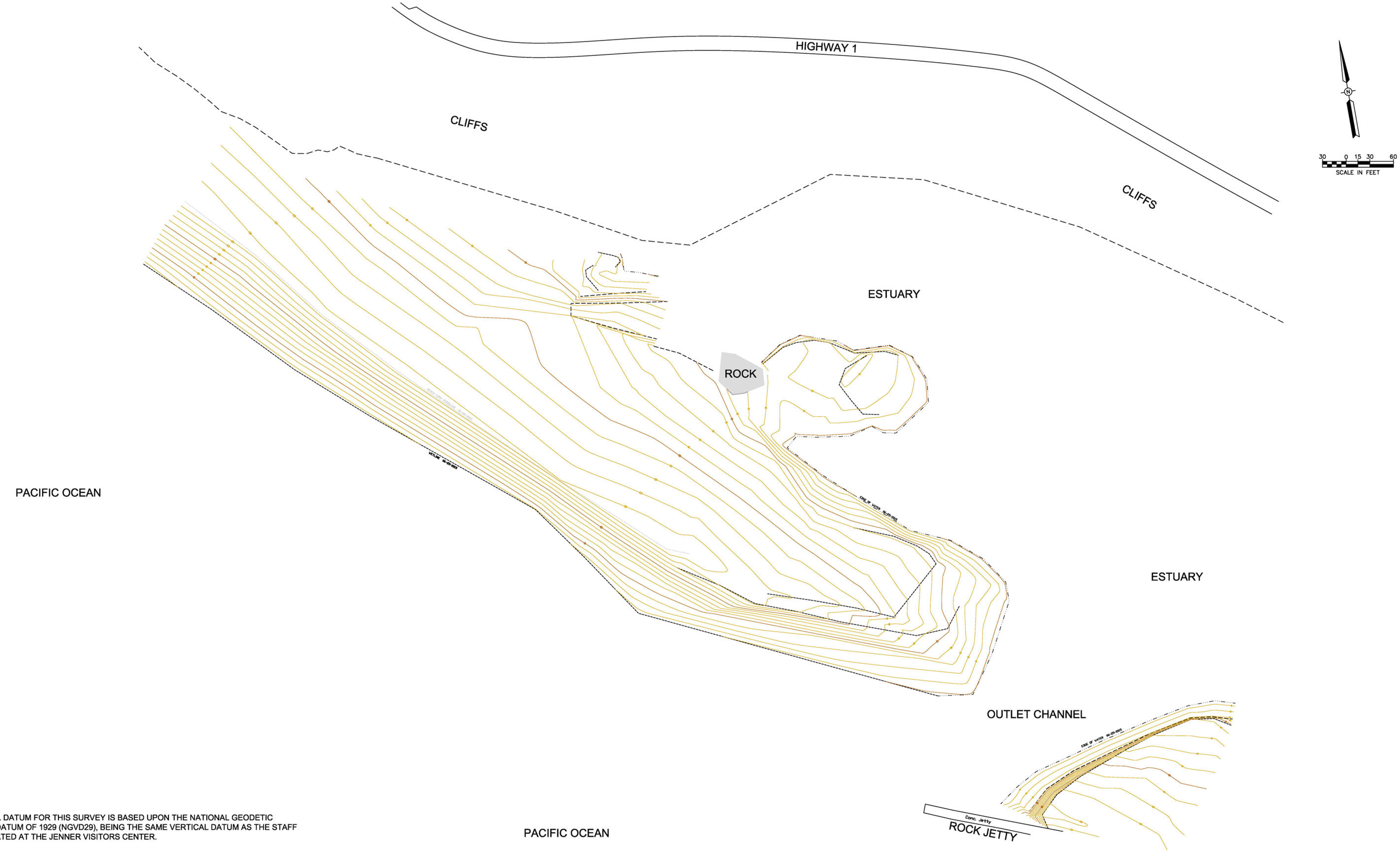

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DATE : AS NOTED
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RUSSIAN RIVER INSTREAM FLOW RESTORATION (RRIFR) PROGRAM

MONTHLY SURVEY OF BEACH TOPOGRAPHY AND OUTLET CHANNEL: June 25, 2015

FILE NAME:
CONTRACT NO. XXX
DRAWING NUMBER
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1. VERTICAL DATUM FOR THIS SURVEY IS BASED UPON THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29), BEING THE SAME VERTICAL DATUM AS THE STAFF GAGE LOCATED AT THE JENNER VISITORS CENTER.

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SONOMA COUNTY WATER AGENCY

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APPROVED DEPUTY CHIEF ENGR:
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RUSSIAN RIVER INSTREAM FLOW RESTORATION (RRIFR) PROGRAM

MONTHLY SURVEY OF BEACH TOPOGRAPHY AND OUTLET CHANNEL: Aug. 20, 2015

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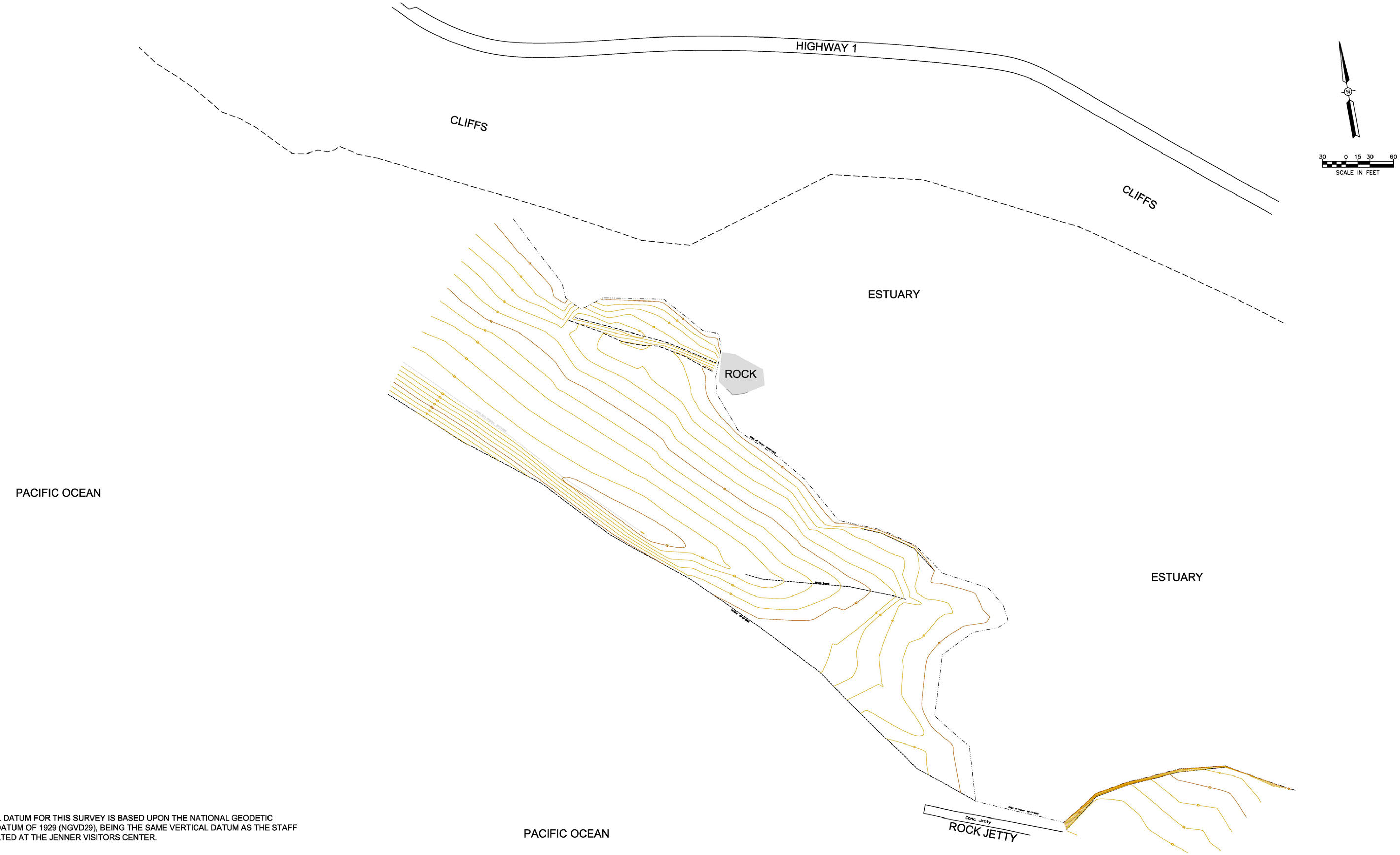

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RUSSIAN RIVER INSTREAM FLOW RESTORATION (RRIFR) PROGRAM

MONTHLY SURVEY OF BEACH TOPOGRAPHY AND OUTLET CHANNEL: Sept. 17, 2015

FILE NAME:
CONTRACT NO. XXX
DRAWING NUMBER
SHEET NO. 1 OF 1

NOTES:

1. VERTICAL DATUM FOR THIS SURVEY IS BASED UPON THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29), BEING THE SAME VERTICAL DATUM AS THE STAFF GAGE LOCATED AT THE JENNER VISITORS CENTER.

NO.	DATE		BY

SONOMA COUNTY WATER AGENCY

SCALE: AS NOTED
DATE : AS NOTED
DRAWN : EKM
CHECKED : JRM

APPROVED DEPUTY CHIEF ENGR:
SUBMITTED
DESIGNED

RUSSIAN RIVER INSTREAM FLOW RESTORATION (RRIFR) PROGRAM

MONTHLY SURVEY OF BEACH TOPOGRAPHY AND OUTLET CHANNEL: Oct. 8, 2015

FILE NAME:
CONTRACT NO. XXX
DRAWING NUMBER
SHEET NO. 1 OF 1

\\SD-Data\Survey\Land Projects\RRIFR-EstuaryManagementAndMonitoring_PN7339\dwg\SandBar100815.dwg

NOTES:

1. VERTICAL DATUM FOR THIS SURVEY IS BASED UPON THE NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD29), BEING THE SAME VERTICAL DATUM AS THE STAFF GAGE LOCATED AT THE JENNER VISITORS CENTER.

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NO.	DATE		BY

SONOMA COUNTY WATER AGENCY

SCALE: AS NOTED
DATE : AS NOTED
DRAWN : EKM
CHECKED : JRM

APPROVED DEPUTY CHIEF ENGR:
SUBMITTED
DESIGNED

RUSSIAN RIVER INSTREAM FLOW RESTORATION (RRIFR) PROGRAM

MONTHLY SURVEY OF BEACH TOPOGRAPHY AND OUTLET CHANNEL: Nov. 12, 2015

FILE NAME:
CONTRACT NO. XXX
DRAWING NUMBER
SHEET NO. 1 OF 1

Appendix 4.3

RUSSIAN RIVER ESTUARY OUTLET CHANNEL ADAPTIVE MANAGEMENT PLAN 2016

Prepared for

Sonoma County Water Agency

Prepared by

ESA

with

Bodega Marine Laboratory, University of California at Davis

October 24, 2016

ESA REF. # DW01958

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1. INTRODUCTION

Sonoma County Water Agency (the Agency) is required to develop a management plan for the Russian River Estuary mouth in response to a 2008 Biological Opinion (Biological Opinion) from the National Marine Fisheries Service (NMFS) designed to improve salmonid rearing habitat in the estuary (NMFS, 2008). Prior to the Biological Opinion, the existing Russian River Estuary management plan focused on artificial breaching to prevent flooding. The Agency retained ESA PWA[1] to assist in developing the revised plan to address the objectives of the Biological Opinion.

The Biological Opinion stipulates several phases of outlet channel management over fifteen years with additional management options specified for each phase. The phases are part of an adaptive process for management actions to enhance salmonid habitat. If earlier phases are successful in meeting the performance criteria, subsequent phases will not be needed. The existing plan was first developed in 2009 to address the Phase 1 objectives in the Biological Opinion and then updated annually in 2010 through 2015. This document, the management plan for 2016, is largely based on the plan drafted in 2015. The changes between the 2015 and 2016 plan include: a 5-year review of physical processes affecting the Estuary (Attachment J), documented 2015 inlet conditions (Attachment K), and updated permitting requirements (Sections 3.2 and Attachment C).

Because of permitting issues, the outlet channel was not implemented in 2009. In 2010, the outlet channel naturally established itself for about one a week at the end of June, and was then closed by ocean waves. After this closure, the Agency mechanically re-created the outlet channel. However, waves closed the outlet channel less than a day after implementation. Before the outlet channel could be re-established by the Agency, the lagoon breached, returning the estuary to tidal conditions for the remainder of the summer. Additional closures occurred in September and October, but large wave conditions and imminent flooding prevented efforts to create an outlet channel. In 2011, the inlet never closed long enough to warrant management action. Wave events caused a series of closures between the end of September and into November. However, the closures lasted a week or less, ending when rising lagoon water levels overtopped the beach berm and naturally scoured a new tidal channel. 2013 was similar to 2011 and 2012, with early summer and early fall closures ending when overtopping naturally scoured a new channel. In 2014, minimum instream flows on the Russian River were lowered due to drought conditions. So when the inlet closed in September and October, these lower inflows slowed the rate of lagoon water level rise, enabling two back-to-back closures. The September closure lasted more than a month and the October closure lasted about three weeks. These closures persisted beyond the lagoon management period, and were artificially breached. Instream flows in 2015 were also low due to drought conditions. After nearly three weeks of closure, an early season event ended in June via self-breaching. A closure lasting almost a month also self-breached at the start of October. Another closure formed in the second week of October, persisted past the end of the management season, and was artificially breached in November (location shown in Attachment K's Figure 4). Although outside of the management period, a closure in December was notable for causing water levels to reach more than 12 ft NGVD in the Estuary,

[1] Previously Philip Williams & Associates

well above flood stage, until self-breaching occurred. The Water Agency could not artificially breach before then because of hazardous wave overtopping conditions on the beach berm.

The approach of the 2016 plan is to meet the objective of the Reasonable and Prudent Alternative (RPA), Alterations to Estuary Management, to the greatest extent feasible while staying within the constraints of existing regulatory permits and minimizing the impact to aesthetic, biological, and recreational resources of the site. It is recognized that the measures developed in the 2016 management plan, when implemented, may not fully meet the objective established by the RPA. The concept of this approach was developed in coordination with NMFS, California Department of Fish and Wildlife (CDFW)[2], and California State Parks (CSP). Estuary management for 2016 was discussed at a meeting on March 14, 2016 that included representatives from NMFS and CDFW, as well as the Sonoma County Water Agency, Bodega Marine Laboratory, the U.S. Army Corps of Engineers, the North Coast Regional Water Quality Control Board, and ESA PWA. A draft of the 2016 plan was provided to the Estuary Management Team (Section 9) on April 1, 2016, for review. Comments on the draft plan from these representatives will inform the revision of the draft plan to create the final plan.

The goal of the management plan is to reduce marine influence on the Russian River Estuary (Figure 1) during the management period, May 15th to October 15th. The management actions are intended to limit tidal exchange between the ocean and the estuary. Instead of the existing tidal estuary, the Biological Opinion proposes a perched lagoon with water levels above tidal elevations. With tidal inflows limited, river inflow to the lagoon may enhance the extent of freshwater habitat for the benefit of juvenile salmonid rearing. Maintaining the lagoon water levels in a perched state that is also below flood stage requires an outlet channel to convey water from the estuary to the ocean over the beach berm.

The outlet channel adaptive management plan is organized as follows. Conclusions and recommendations of this plan are described in Section 2. Sections 3-6 describe the planning and analysis steps: (1) defining project performance criteria (Section 3), (2) developing a conceptual model of relevant physical processes (Section 4), and (3) conducting technical analysis to quantify target outlet channel conditions (Sections 5 and 6). The resulting operations and management plan derived from these planning steps is also documented in this report (Section 7). The adaptive management strategy will continue by actual implementation of this plan, then monitoring and evaluating the outlet channel response to refine the plan for subsequent years.

[2] CDFW's CESA tracking number is 2080-2009-016-03 and 1600 Notification number is III-1176-96

2. CONCLUSIONS AND RECOMMENDATIONS

Conclusions about the physical processes affecting outlet channel behavior and recommendations for 2016 management are summarized below.

2.1 CONCLUSIONS: PHYSICAL PROCESSES AFFECTING OUTLET CHANNEL BEHAVIOR

1. The location of the outlet channel, at the interface of the Russian River estuary and the surf zone of the Pacific Ocean, is a dynamic system influenced by river discharge, ocean waves, and sand transport. As such, the outlet channel will be subject to variable forcing at hourly, tidal, and monthly timescales. In order for the outlet channel mouth to preserve its function in this active transport zone, the net sediment transport must be small, even though the gross sediment transport is large. To sustainably meet its performance criteria, the outlet channel must be resilient in the face of this variable forcing. This resiliency is difficult to predict.
2. Under current management of the Russian River watershed and estuary, there has been one documented occurrence of target outlet channel conditions occurring during the proposed management season of May 15 to October 15 for the fifteen year period of record (1999 to 2015). Outlet channel conditions occurred in June 2010 and persisted for about one week before closing. More typically, as a result of natural processes and existing artificial breaching practice, the connection between the estuary and the ocean has been observed in one of two states: bi-directional tidal exchange (88% of the time during the 1999-2008 management periods) or fully closed with no exchange (12% of the time).
3. Conditions similar to target outlet channel performance criteria were observed outside the management period five times between 1999 and 2015. These events appeared to be extended transitions to fully tidal conditions rather than stable conditions. Estuary water levels steadily declined throughout all events and the estuary typically returned to tidal exchange within 48 hours.
4. To meet the performance criteria, the outlet channel geometry must simultaneously meet two key constraints: convey sufficient discharge from the estuary to the ocean to preserve constant water levels in the estuary and preserve channel function by avoiding closure or breaching. These two constraints can be in conflict, since both conveyance capacity to preserve estuary water levels and the potential for breaching increase with flow rates but closure is more likely for lower flow rates.
5. The target outlet channel is subject to two failure modes: (1) closure caused by deposition, leading to estuary water levels to rise and possibly cause flooding, and (2) breaching caused by scour, leading to tidal exchange and marine conditions in the estuary. Of the two failure modes, breaching is more detrimental to NMFS's goal of reducing or eliminating exposure of the estuary to tidal water levels and saline inflow. Once breaching occurs, the estuary may persist in a breached state for weeks or months before the target outlet channel can re-form. The immediate impact of closure is only increasing estuary water levels, which allows time for management action to prevent habitat loss.

6. Based on engineering calculations, the channel bed slope must be essentially flat (slope on the order of 0.0001) and water depths less than 2 ft, preferably 0.5 to 1 ft, to reduce the likelihood of channel scour at likely May to October flows.
7. Based on the results of hydrologic modeling, it may be difficult to convey sufficient discharge to maintain estuary water levels while simultaneously keeping the bed shear stress in the outlet channel below the threshold for scour. Even with dry-year reductions to instream flows, the predicted local bed shear stress during the management period is almost always greater than the critical bed shear stress threshold for erosion.
8. Discharge conditions are a significant source of hydraulic uncertainty for assessing the outlet channel. Discharge measurements are made at the USGS Guerneville gaging station[3], 21 miles upstream from the Russian River's mouth, and changes in flow (losses/gains) are known to occur between the Guerneville station and the mouth. A water balance model for the estuary indicates that net losses between the Guerneville gaging station and the mouth vary from 10% to 53% and average 37%. Limited USGS and Agency discharge measurements at other locations suggest that most losses occur in the lower 6 miles of the river; perhaps in large part due to seepage through the beach berm.

2.2 RECOMMENDATIONS: 2016 MANAGEMENT ACTIONS

1. Two channel configurations will be initially considered for implementation.
    - a wide and short channel that seeks to minimize scour potential; or
    - a narrow and long channel aligned to the north that seeks minimize closure potential.

   The channel selected for implementation will be based on site conditions at the time of closure and discussion with the resource agency management team. Monitoring of the outlet channel and estuary response will be used to inform adaptive management during the management period.
2. Initial management actions may be more frequent, and include maintenance actions that are corrections to the existing channel configuration. Based on experience from these initial efforts, larger and less frequent actions may be undertaken.
3. Once the estuary closes, implement the channel so that when reconnecting the channel, the estuary water levels are no more than 0.5 to 1 ft above the constructed channel bed elevation. This approach reduces the potential for scour.
4. Channel excavation activities should be completed (i.e. the temporary sand barrier removed) coincident with high tides in the ocean. This will reduce the scour potential associated with the initial outflow at the time of breaching.
5. A communication protocol will provide guidance between the Agency and identified points of contact representing key resource management agencies in the estuary.
6. Because of uncertainty about the system and its response to outlet channel management, the adaptive management approach specified in the Biological Opinion and being pursued by

[3] Located just downstream of Hacienda Bridge, USGS station ID 11467000.

the Agency is critical. A year-end evaluation to assess actual channel performance and revised management for subsequent years is also recommended.

3. PERFORMANCE CRITERIA

The principal estuarine habitat goal stipulated in the Reasonable and Prudent Alternative (RPA), Alterations to Estuary Management, in the Biological Opinion is to reduce marine influence in the estuary from May 15 to October 15. According to the Biological Opinion, marine influence includes tidal water level oscillations and saline water. NMFS believes that marine conditions diminish habitat quality for salmonid rearing by reducing the habitat extent, elevating salinity above optimal levels for salmonid juveniles and their invertebrate prey, and flushing juveniles into the ocean.

The performance criteria for outlet channel management are intended to assist in meeting the estuarine habitat objective of the RPA specified in the Biological Opinion. This section presents performance criteria for Phase 1 of outlet channel management, and minor modifications to these criteria for 2016 management.

Performance criteria for water quality and ecological values in the lagoon are addressed separately and are not included in this document. The Water Agency's water quality monitoring plan is described in Sonoma County Water Agency (2013a), with the monitoring results described in Sonoma County Water Agency (2013b).

3.1 PHASE 1

Phase 1 of outlet channel management has the following performance criteria for the May 15 to October 15 management period:

1. **Estuary water levels**. The estuary water level management target is "[a]n average daily water surface elevation of at least 7 feet [NGVD] from May 15 to October 15" (Biological Opinion, p. 249). Higher estuary water levels, but not exceeding flood stage of 9 ft NGVD, would be preferred by NMFS. However, water levels greater than 4 ft NGVD are expected to accompany reduced marine influence and would be likely to improve habitat.
2. **Sand channel**. The outlet channel will be a temporary feature, created only by excavating and placing beach sand. No new structures or mechanical devices, temporary or permanent, will be a part of the outlet channel implementation.
3. **Minimize artificial breaching**. Though the overall goal is to create a freshwater estuary, and therefore avoid artificial breaching, in light of natural variability of river discharge and nearshore wave conditions, several years of experience managing the estuary may be required to develop operational procedures which minimize the need for artificial breaching. As such, NMFS estimates "that SCWA will need to artificially breach the lagoon using methods that do not create a perched lagoon twice per year between May 15 and October 15 during the first three years covered by this opinion, and once per year between May 15 and October 15 during years 4-15 covered by this opinion" (Biological Opinion, p. 302).
4. **Economic feasibility**. Operations and maintenance requirements will not place undue burden on the Agency in terms of cost, particularly as it relates to frequency or duration of maintenance activities.

5. **Public Safety**. The outlet channel management plan will not diminish public safety as it pertains to floodplain property owners, visitors and employees of the State Beach, and the Agency maintenance staff.

To meet the criterion for estuary water level (#1 above), the estuary will function as a perched lagoon with “water surface elevation above mean high tide … where freshwater flows out to the ocean over the sandbar at the lagoon’s mouth” (Biological Opinion, p. 92). This implies uni-directional flow in the outlet channel, from the estuary to the ocean, to minimize marine influence, and minimal sediment transport within the outlet channel to prevent the channel bed from scouring and transforming into a tidal channel.

NMFS (2008) introduced the terminology ‘natural’ to describe breaches that occur without human intervention and ‘artificial’ to describe breaches that are the result of human sand excavation. This terminology was used in the management plan through 2013. However, inlet and beach observations in 2012 (Attachment G), 2013 (Attachment H), and 2014 (Attachment I) suggest that the jetty, a human intervention, may indirectly facilitate breaching. The jetty appears to encourage some breaches sooner than natural conditions because the jetty shelters a portion of the beach immediately to its north, limiting sand deposition and resulting in a low point in the beach berm. In 2012- 2015, this low point was often the location where rising lagoon water levels scoured a new inlet. Therefore, starting with the 2014 plan, the term ‘self-breach’ is used to describe breaches caused by the estuary’s own rising water levels. This term is used to include all breaches of this type, since the extent of the jetty’s influence has not been fully determined. ‘Artificial’ breach continues to refer to instances involving human excavation, covering both authorized Water Agency contractors with mechanical equipment or unauthorized members of the public with hand tools.

Note that each time the lagoon breaches, NMFS believes the lagoon is subject to undesirable water quality conditions not just during the breached period, but also for some period of time following the subsequent closure. “NMFS anticipates 3-4 weeks of adverse water quality conditions after the sandbar closes at the mouth of the estuary” (Biological Opinion p. 302). Thus the management plan seeks to minimize self, as well as artificial breaching events.

The Biological Opinion requires the Agency to petition the State Water Resources Control Board (SWRCB) to change minimum instream flow requirements to improve rearing habitat for steelhead. Permanent changes in instream flow requirements will take years to accomplish, therefore, the Biological Opinion also requires the Agency to petition the SWRCB to change minimum instream flow requirements on an interim (temporary) basis to facilitate management of the Estuary as a summer lagoon. The management plan anticipates an interim reduction in instream minimum flow requirements between the Dry Creek confluence and the mouth starting in 2010. Minimum flows would be reduced from current SWRCB Water Right Decision 1610 levels of 125 ft^3/s to 80-85

ft^3/s [4]. The expected reduction in minimum instream flow will provide more favorable conditions for outlet channel management by reducing the potential for scour-induced breaching.

For channel location, the Biological Opinion suggests the use of "a lagoon outlet channel cut diagonally to the northwest. … Alternative methods may include … use of a channel cut to the south if prolonged south west swells occur" (Biological Opinion p. 250).

3.2 2016 MODIFICATIONS

As discussed above (Section 1), the approach of the 2016 plan is to meet the objective of the RPA to the greatest extent feasible while staying within the constraints of existing regulatory permits. It is recognized that the measures developed in the 2016 management plan, when implemented, may not fully meet the objective established by the RPA as summarized in Section 3.1 above. The concept of this approach was developed in coordination with NMFS, CDFG, and CSP.

Because of the estuary's coastal location and hydrologic significance, the Agency must manage the estuary's mouth in accordance with multiple land use permits from various state and federal agencies. A table summarizing all these permits is provided in Attachment C. Key aspects of these permits which directly affect 2016 outlet channel management include:

- Excavation is limited to 2,000 cubic yards of sand per event to create a channel 25 to 100 ft wide. The channel width range is consistent with historic widths observed within the management covered by existing permits (Behrens, 2008).
- Management actions are permitted only on Monday-Thursday to minimize interference with public use.
- Management actions cannot be longer than two consecutive days (unless flooding is threatened).
- Access is constrained during marine mammal pupping season (March 15 – June 30) to reduce incidental harassment of harbor seals, sea lions, and elephant seals.

Artificial breaching may be required during 2016. With this management plan, the Agency seeks to minimize or avoid such breaches during the management period, but recognizes that they may be needed to avoid flooding of adjacent properties.

[4] The proposed instream flow requirement is 70 ft^3/s, but "SCWA maintains a 10 to 15 ft^3/s buffer to avoid non-compliance of the minimum standard" (BO, p. 245).

4. CONCEPTUAL MODEL

The conceptual model of the outlet channel articulates the project's working assumptions about process linkages between channel features, external conditions (e.g. river flow and ocean processes), and channel performance. These working assumptions are uncertain, and may not capture all relevant processes. However, by making these assumptions explicit, they can be documented, discussed, and tested, all of which are necessary steps in the adaptive management process. Observations of the actual outlet channel response will then enable refinement of the conceptual model. In addition, because the conceptual model is expressed in a relatively non-technical manner, it provides an avenue for public outreach and education about the outlet channel. The conceptual model is not a hydrodynamic, sediment transport model but rather uses empirical observations and geomorphic interpretations to identify likely responses to key forcing parameters, given antecedent conditions and management actions.

Development of a conceptual model for the outlet channel focuses on the essential physical processes and linkages, as well as the management parameters of the channel. Although this approach leaves out some processes which may slightly alter the channel's performance, it prevents the conceptual model from becoming so complex that it becomes unwieldy. In addition to limiting the conceptual model's scope to only the essential processes, the model also excludes impacts of the outlet channel on water quality and ecological aspects of the estuary. To further enhance model clarity, the conceptual model is presented graphically with a schematic that reflects the layout of the physical system. One caveat to simplification is that the static, schematic diagrams clearly do not encapsulate the full complexity of this dynamic system.

The conceptual model first describes target conditions for the outlet channel, in accordance with the performance criteria in Section 3. Then the model identifies the morphological processes which may lead to the two failure modes for the outlet channel: closure and breaching. Closure refers to sand transport induced by ocean waves that deposits sufficient volume of sand in the outlet channel mouth that it blocks the outlet channel. Closure prevents discharge through the outlet channel, leading to increasing estuary water levels and the threat of flooding. Breaching refers to the flows enlarging the outlet channel to the point that it becomes a tidal inlet subject to bi-directional flow. It is important to note that these "failure modes" are conditions associated with natural tidal inlets and river mouths, but are considered problems at the Russian River Mouth because modified forcing parameters have affected the timing and frequency such that native species may be adversely affected (see the Biological Opinion), as well as conflicts with other man-made constraints. One of the key questions in this management plan is whether the inherently dynamic system can be "trained" to drain gradually without breaching and then closing repeatedly.

There are additional aspects of the site which may impact the outlet channel, but whose impacts are thought to be secondary or not well defined. Therefore, they are not included in the conceptual model at this time. If implementation of the outlet channel suggests these aspects are important, they will be incorporated into a revised conceptual model. These aspects include large rocks and/or bed rock within the beach berm, jetty impacts on seepage, and decadal changes to beach width.

Specifically, the jetty at the river mouth and the fill across the tombolo to the south of the site may have affected littoral processes and mouth dynamics, but are not addressed in this study.

This conceptual model is based on existing literature, knowledge of similar estuaries, professional judgment, and ongoing discussion with the Agency, NMFS, CDFW, and CSP. New data and experience adaptively managing the outlet channel will be used to revise the conceptual model in subsequent management plans.

4.1 TARGET OUTLET CHANNEL CONDITIONS

The conceptual model for target outlet conditions is shown in Figure 2. Ideally, the outlet channel conveys water from the estuary to the ocean so that estuary can be maintained in a non-tidal state during the management period. A key performance criterion of this non-tidal state is that the water levels in the estuary (h_l) fall within the range of 4 to 9 ft NGVD, with elevations above 7 ft NGVD preferred. The estuary water level will not be managed directly, e.g. by pumping. Instead, it will be managed indirectly by management actions dictated by the Biological Opinion, the operation and maintenance of the outlet channel and the reduction of instream flow requirement.

The estuary water level is determined by the balance between inflowing river discharge (Q_r) and three outflows: outlet channel discharge (Q_c), evaporation (Q_e), and seepage through beach berm (Q_s). For estuary water levels to remain within the target range, the inflow and outflows must sum to zero when averaged over a period of several days. As indicated by the width of the arrows depicting these flows in Figure 2, the river inflow, seepage and the outlet channel discharge are the three largest flows; evaporation is a minor factor in the water balance. As such, the sum of the seepage and outlet channel discharge capacity needs to nearly match the river discharge. If the combined outflows are too low, the estuary water level will rise to flood stage and artificial breaching will be necessary. If the outlet channel discharge is too high, the channel will scour and deepen, allowing tidal flows to enter through the channel. The outlet channel discharge is determined in part by its width, bed elevation, slope, and planform alignment. These parameters can be managed to a certain degree, but are likely to evolve in response to the natural variability of the discharge and wave forcing, and the effects of tide range. Seepage is determined by the beach berm's permeability, the water level difference between the estuary and the ocean, and the ambient conditions of the regional water table (Largier and Behrens, 2010). Presently, only the water level difference is subject to management influence. In the future, modification of the jetty to increase the beach berm's hydraulic conductivity will be studied (NMFS, 2008). The river inflow is another management parameter, however, since its value is determined as part of a separate water supply determination and permitting process, its manipulation is not considered here.

Although sediment transport will be minimal within the outlet channel under target conditions, the channel's mouth will perpetually be an active transport zone. This portion of the channel, at its interface with the ocean, will be an active transport zone for two reasons. First, it lies within the surf zone and breaking waves move up and down its face in response to the tides and variations in wave direction, magnitude, and period. Second, this wave action creates a slope on the order of 10:1, which is sufficiently steep that flows of nearly any magnitude from the outlet channel will accelerate to above the scour velocity threshold. In order for the outlet channel to persist with this active transport zone at its mouth, this zone will have to experience minimal net sediment transport. In other words, tidal fluctuations in water level and variability in wave intensity will cause the locations of scour and deposition to shift at hourly timescales, but averaging across several tidal cycles, any sand lost by scour will be balanced by an equivalent amount of deposition. This active transport zone also plays a significant role in lateral migration of the existing channel mouth. This process is discussed in Section 4.4 on planform alignment.

Preserving these target conditions, particularly the discharge conveyance capacity, requires that the outlet channel maintain its cross-sectional flow area. This flow area can decrease or increase, leading to the two failure modes of the outlet channel: closure and breaching. These two failure modes are discussed in the sections below.

4.2 CHANNEL FAILURE: CLOSURE

The processes which lead to outlet channel closure are likely to originate from elevated total water levels in the ocean (z_{wave}), as shown on the right side of Figure 3. Elevated ocean water levels will move the active transport zone into the outlet channel, increasing deposition at elevations above that of the outlet channel's bed, z_{out}. Once deposition rates exceed any capacity of the outlet channel discharge to scour sediment, a berm will build at the mouth of the outlet channel, causing it to close. This process is thought to occur over one to several high tides, corresponding to one to several days. During the management season, total ocean water level is the combination of two ocean processes, the tides and ocean waves. As offshore waves interact with the coastline and nearshore, they are transformed such that the significant elevation on the beach is a function of the wave direction, magnitude, period and runup. While the tides fluctuate with a predictable schedule, ocean waves vary according to the unpredictable weather and wind patterns over the ocean. Therefore, the total water level can be best characterized as frequency distribution that is based on observed tide and wave data.

If the outlet channel closes and flow through the channel stops, the estuary water level will increase since the continuing river inflow cannot be exported through evaporation and seepage alone. Although seepage rates are likely to increase as a result of increasing water levels, it is assumed that seepage rates will remain below river inflow. As the water level rises, it will again overflow the beach berm when it reaches the minimum elevation of the berm crest. Early in the management season, the flow may overtop the berm below flood stage of 9 ft NGVD. However, as the berm crest elevation rises over the course of the management period, the water levels can rise above flood stage. If more moderate management actions do not stop this rising water level, a full artificial breach, as is currently practiced, will be necessary to prevent flooding.

4.3 CHANNEL FAILURE: BREACHING

The breach failure considered as part of the conceptual model and shown in Figure 4 is breaching that occurs when the outlet channel is operating according to the target conditions described above. Breaching is likely to result from two processes, high discharge which scours the channel bed or seepage-induced bed mobilization. Self or artificial breaching after a closure event are not discussed in this section because it is assumed that management actions would be enacted to return the outlet channel to target conditions prior to either of these breach mechanisms occurring. Additionally, breaching by wave overtopping or strong river discharge are not considered because these processes are associated with winter storm events, which are rare during the management period.

Because the outlet channel is an unconsolidated bed composed of relatively small particles, it is susceptible to scour by the discharge flowing through the outlet channel. Sand scoured from the channel will be lost to the ocean and there is not a significant upstream source to replace scoured sand. Extensive scour will enlarge the channel to the point of breaching and tidal inflows. To prevent scour, flow conditions within the outlet channel (u_c) must be below the threshold for scouring sand (u_{crit}). This threshold is a function of the sand grain size, which has been observed to be coarse sand, narrowly distributed around 1 mm at the Russian River mouth (EDS, 2009a). Further north on the beach, large rocks imbedded in the beach berm may provide grade control and limit scour. Whether the flow velocity is below the threshold depends on the type of bed material and hydraulic conveyance through the management parameters of the outlet channel's width, length, and bed slope.

As noted in the description of target channel conditions, the beach face slope is set by wave action in the surf zone and is sufficiently steep that flow velocity exceeds threshold for sand movement for all expected discharge rates. Under target conditions, the sand scoured by this process will be replaced by wave action on high tides, yielding no net change in the channel mouth morphology. However, if the scour is larger than deposition on the beach face, the active scour zone may move landward, into the outlet channel. This upstream movement is similar to nick point migration or head-cutting observed in streams and rivers. It is also the process observed by the Agency's maintenance staff when the beach berm is artificially breached under current practice. The breaching typically happens very quickly, before wave-induced sand transport can close off the breach in subsequent higher tides.

A second possible mechanism of breaching is seepage-induced sand mobilization, represented in Figure 4 as an arrow associated with Q_s. If seepage rates are sufficiently large, the movement of water through the sand can mobilize sand particles where the seepage flow daylights at the ground surface. Piping of groundwater along preferred pathways, which may exist within or adjacent to the jetty, might encourage this process by increasing flow rates through portions of the beach. Although seepage failure has not been observed at the Russian River estuary, it has been observed at other estuaries including Crissy Field (Battalio et al 2006) and others (Kraus et al 2002). Seepage failure may simultaneously accompany other breach mechanisms and hence be difficult to identify on its own. Or, seepage failure may require a larger head difference between the estuary and the ocean than what occurs at the Russian River mouth because of artificial breaching to prevent flooding.

In contrast to closure which can be managed with further intervention, breaching can immediately and negatively impact NMFS's habitat objectives by allowing the marine influences of tidal water levels and saline water to enter the estuary. For this reason, breaching is more detrimental to NMFS's habitat goals than closure.

4.4 PLANFORM ALIGNMENT

Because of the presence of hard barriers in the form of the southern jetty and the northern cliffs, the outlet channel is expected to occupy an alignment within the same region that the current tidal inlet occupies, as show in Figure 1. At this initial stage in the adaptive management process, the conceptual model for the outlet channel's planform alignment is indeterminate as to a target alignment most likely to facilitate outlet channel sustainability. Therefore, observations and interpretations of the existing channel are presented in this section to provide an indication of factors acting on the proposed outlet channel. Once the outlet channel is implemented and monitored, a more definitive conceptual model for target alignment will be developed.

The exiting channel's initial alignment after a closure is typically straight and set by one of three factors, depending on the breaching mechanisms. When breached by high river discharge, the channel aligns itself to the northwest, primarily in response to the direction of the river flow during these events. When the channel self breaches at water levels below flood stage, it will overflow the berm at the minimum elevation in the berm crest. For example, in April 2009, this low point was toward the north since this was where the antecedent inlet had lowered the berm crest elevation. The Agency has attempted artificial breaching in several locations; under current practice, the initial alignment is perpendicular to the beach and just to the north of the large rock ("Haystack Rock") at the northwest corner of the estuary (Agency staff, personal communication).

Once breached, the existing channel typically changes alignment because the mouth migrates laterally in response to wave and littoral transport processes (Behrens et al., 2009). Lateral migration by the mouth while the upstream channel lags behind creates a sinuous channel. The direction and magnitude of wave energy and the resultant littoral sand transport are thought to determine the migration direction and extent. For the case of a tidal inlet, the mouth typically moves in the direction of the littoral transport (Dean and Dalrymple, 2002). However, several mechanisms have been identified that enable an inlet to move updrift, opposite to the direction of the littoral transport. Aubrey and Speer (1984) demonstrate that sand bars associated with the inlet's ebb tide delta can attach to the downdrift beach, displacing the inlet in the updrift direction. Pranzini (2001) documents a mechanism whereby riverine sediments discharged to a prograding delta preferentially deposit on the downdrift side side, which translate and rotate the inlet mouth towards incoming wave energy. Aubrey and Speer (1984) also propose that flow patterns created by inlet channel bends can create erosion on the outside of the bend and deposition on the inside, much like the development of river meanders, with a net result of the inlet migrating updrift. Mechanisms similar to these may explain observations by NMFS that suggest that the direction of migration of the outlet channel may be against the direction of littoral transport (J. McKeon, personal communication).

Observations by Behrens et al. (2009) show that the existing tidal mouth typically moves both northward and southward during the management period. Their analysis correlates large changes in mouth location with rapid changes in significant wave height, indicating that the wave processes control the migration process. The bi-directional migration of the mouth suggests that wave energy also changes directions. This is further supported by the resulting shape of the channel, which can develop multiple channel bends in response to the mouth reversing directions. The temporal and spatial distribution of wave energy along the mouth is not well documented since wave observations have only been made offshore and estimates of how the offshore waves are transformed by local bathymetry have not been verified. Studies using trace elements and sand budgets along this stretch of coast indicate reversing directions of littoral transport because of varying periods of convergence and divergence of wave energy (DeGraca, 1976). The predominant direction may be sensitive to the relative contributions of northwest wind waves versus southerly swell. For instance, Behrens et al. (2009) show that mouth migration patterns are significantly different during El Niño years with the channel remaining in at the northern end of its range for the entire summer. They speculate that the decrease in northerly wind waves during El Niño events may explain this phenomenon. Another potential cause for this pattern is the more southerly approach angle of incident swell waves during El Nino years, as suggested by Allen and Komar (2006).

An additional factor which may affect the mouth location is the landward migration of the offshore bar. This bar, which is created by sand eroded off the beach during winter storms, moves landward with the low steepness summer waves. If this bar, which runs parallel to the shore, moves sufficiently close to the channel mouth, it may force the mouth to either side.

5. EMPIRICAL ASSESSMENT OF HISTORIC INLET CONDITIONS

The Russian River inlet is highly variable in form, position, and capacity for tidal conveyance. Analyses of field data and an extensive photographic record of daily conditions show that this variability is largely influenced by tides as well as seasonal changes in wave and river conditions (Rice, 1974; Behrens, 2008). Management actions also influence the timing and duration of closure events (Goodwin and Cuffe, 1994).

When the estuary is open to the ocean, the inlet can take one of the following forms:

- A river-dominated channel with minimal influence from tides and waves. This occurs during short-lived river flood events between December and April.
- A channel controlled by a mix of river flow, tides, and wave action. This is the most common inlet state, with waves tending to deposit sand in the inlet and estuary-to-ocean flows due to tide and river being active in removing sand from the inlet. Estuary tidal range is a fraction of the ocean tidal range, ranging from zero to over 70%, varying in response to sediment infilling and scouring of the inlet channel. Here we give special attention to "marginally tidal inlets", where tidal conveyance is less than 10%.
- A one-way overflow channel with water draining from a perched estuary, i.e., the sand barrier is built across the mouth of the estuary, but the estuary water level is high enough to overflow. Waves have limited control over such an "overflow inlet", and tidal influence is nonexistent. River flow rate controls estuary water level and overflow volume, which determines the susceptibility to breaching.

This section provides an overview of inlet states observed during the years 1999 to 2008, the time period for which the photographic record has been analyzed in detail. The analysis emphasizes the dates corresponding to the proposed management period of May 15 to October 15. The purpose of this assessment is to use existing data to identify relationships between forcing due to river, tides and waves and the response of the estuary mouth ("inlet") – and to explore the frequency of the latter two conditions described above.

5.1 FREQUENCY AND FATE OF RUSSIAN RIVER INLET STATES

The possible occurrence of an "overflow" channel at the mouth of the Russian River estuary was investigated by comparing water level records from the Jenner gage with tidal data from the NOAA Point Reyes station. The focus was to analyze events when the inlet was open for at least 24 hours with water levels remaining above tidal influence and slowly varying. Attention was also given to events when the inlet allowed minimal amounts of tidal interaction. Dates for which the inlet was at least partially open were disaggregated into a series of categories based on the ratio of the estuary tide range observed at the Jenner gage to ocean tide range (defined here as "tidal conveyance") – see Table 1. Estuary tide is driven by ocean tide, but estuary tide range is reduced either due to the elevation of the channel base that precludes complete draining of the estuary to low tide levels or due to the channel size being too small for enough water to be transported between estuary and ocean. The estuary-ocean tidal ratio is thus an indicator of mouth state, with smaller values representing an increasingly choked mouth (near to closure or overflow state).

Table 1 Frequency of observed inlet states from May 15 to October 15 for years 1999-2008.

Inlet state		**Number of days observed**	**Proportion of period**
Tidal conveyance[1]	0-5%	10	0.8%
	6-10%	4	0.3%
	10-29%	82	5.4%
	30-49%	315	20.9%
	50-69%	590	39.2%
	≥ 70%	142	9.4%
Full inlet closure		161	10.7%
Overflow channel, stable or decreasing water level(≥ 24 hours)		0	0.0%
Device error		199	13.2%

[1]Defined as the ratio of estuary tide range to ocean tide range.

The 161 days when the estuary was closed consisted of 26 separate closure events. Of these, 19 were artificially breached and the remaining 7 were self breaches. Although the low number of self breach events prevents any statistically significant comparisons with river or wave data, it is worth noting that flows over 400 ft^3/s resulted in self breaches within 1-2 days of closure. Including all closures, there was a correlation between Guerneville flow and closure duration, with lower flows leading to longer closure periods.

During the years 1999-2008, there were no instances of overflow conditions during the proposed management period, but there were five relevant events that occurred just outside of the management period. All events had decreasing water levels, reflecting down-cutting of the barrier, although the rate of down-cutting was slow enough to prevent tidal interaction for at least 24 hours. Two of these events occurred during October, one in November, and two in May. Three of the events were associated with closure events and most lasted for less than 48 hours. An exception was a five-day event that occurred 6-11 May 2008. In this case, the inlet was breached artificially, and the Agency immediately noted that the channel had become elongated, beginning near "Haystack Rock", nearly 450 feet north of the jetty, and terminating at the jetty. This is uncommon, as post-breach channels are almost always short and wide (Behrens, 2008). The sudden elongation of the channel is likely associated with onshore bar migration.

During tidal periods, tidal conveyance was less than 10% on only 14 days during the management period from 1999-2008. These states were generally a precursor to closure events – all dates for which tidal conveyance was below 10% resulted in closure and the muted tidal state typically lasted for only one or two days. They were most commonly observed during short periods when an artificial breach failed to keep the inlet open for more than 1 or 2 days, or during periods of low flow when the inlet was narrow and elongated. Note that there is a diminishing propensity for the inlet to be in a muted tidal state when it is close less than 30% of the full tide range. This indicates that being in between fully open or fully closed is not a condition supported by natural processes at this site.

5.2 WAVE AND RIVER CHARACTERISTICS

Wind waves and river outflow characteristics strongly influence the behavior of the inlet. These forcings exhibit seasonal patterns and other trends that correlate with different inlet states. Details of these relationships are presented below.

5.2.1 Seasonal patterns

Wave data were obtained from the CDIP Point Reyes buoy and a transformation matrix accounting for shoaling and refraction (e.g. http://cdip.ucsd.edu/) was used to transfer deepwater conditions to conditions at a location at 10-meter depth near the inlet. This method provides a first-order estimate of nearshore wave conditions that is necessary as there is a significant difference between deepwater/offshore waves and those nearshore. Wave energy is greatest in winter, declining through spring, to a minimum in July-August. However, late spring storms and/or early fall storms can occasionally produce waves exceeding 10 feet in the vicinity of the inlet during the management period. As discussed in Rice (1974) and Behrens et al. (2009), predominant swell waves from the northwest are often the cause of prolonged inlet migration or closure during late spring.

Data on river flow at Guerneville[5] show a rapid decline from a maximum at the beginning of the management period (mid-May) to a minimum in August (Table 2). Flows in July through September are low, between 80 and 225 ft^3/s for the years 1999 to 2008.

5.2.2 Conditions during different inlet states

Wave and flow conditions were compared with specific inlet states, as shown in Table 2.

Marginally tidal inlet: There is a relation between tidal conveyance and nearshore waves (H_s is significant wave height). Marginal tidal conveyance (< 10%) occurs during larger waves (H_s of 2.5 to 3.25 feet), consistent with the idea that these are transitory states associated with inlet closure and one needs waves big enough to overcome tidal (plus river) flows. These wave conditions may be lower during periods of weaker river flow. Further, if this marginally tidal mouth condition persisted, it could do so for any weaker wave conditions (which would not close the mouth).

Closed inlet: Estuary water level increase during closure events was analyzed to understand how close these conditions were to a steady-state overflow scenario. In all cases, water levels rose at rates of 0.1 ft/day or faster (Table 2). However, accounting for estuary area, the slower water level rise suggests that it may be possible to achieve a steady state with limited flow over the berm if river

[5] USGS gaging station located just downstream of Hacienda Bridge, station ID 11467000.

flows are of order 100 ft^3/s or weaker. Flows marginally over 100 ft^3/s may be possible, depending on the limit on overflow rate without eroding the sand barrier.

Overflow inlet: All of the five observed overflow events had flows higher than 100 ft^3/s, but only one persisted for more than a couple of days. Further, all of these events exhibited unusual conditions. The October 1999, November 1999 and first May 2008 event occurred during a sequence in which high waves began to induce closure, but a sudden increase in river flow prevented full closure and eroded the channel down to its original state. It appears that overflow conditions only occurred because the initial transition towards closure allowed estuary water levels to temporarily exceed high tide levels. The event in October 2006 occurred after a self breach of a four-day closure, so the lower flows observed in this case are expected. Finally, the most persistent event in May 2008 was associated with an unusually long channel, which is important in that frictional losses may have encouraged the prolonged high water elevation in the estuary. As noted above, this event was likely due to seasonal onshore bar migration.

Table 2 Comparison of average wave and average river conditions for various ranges of tidal conveyance and water level increase in the estuary. Overflow conditions are analyzed for five events observed outside of the proposed management period.

Inlet state		Guerneville flow, ft^3/s	Nearshore H_s, ft
Open inlet with given tidal conveyance:	<10%	323	3.2
	10-29%	261	2.5
	30-49%	219	2.1
	50-69%	276	2.0
	≥70%	328	1.8
Closed inlet; estuary stage rising at given rates:	0.1-0.29 ft/day	146	2.7
	0.3-0.49 ft/day	175	2.6
	0.5-0.7 ft/day	185	3.4
	≥0.7 ft/day	211	4.1
Overflow channel (outside management period)	Oct 28, 1999	291	15.7
	Nov 4-5, 1999	247	5.9
	Oct 26, 2006	155	2.2
	May 1-2, 2008	323	6.6
	May 6-11, 2008	283	1.3

5.2.3 Analysis of wave runup

The mouth of the estuary is typically closed by waves depositing sediment in the inlet channel during slack high tides, but waves can only do so if wave runup can reach the height of the inlet channel base. Thus, wave runup exceedance curves were generated for each of the management months to assess the likelihood of the (overflow) channel being closed by wave action. De-shoaled deepwater equivalent wave heights were combined with daily higher-high tide water levels to estimate runup height following Stockdon et al. (2006), and assuming a constant beach-face slope.

The height exceeded by 2% of the waves under given monthly wave conditions is shown in Figure 5. Runup is highest in October, with heights of 11ft being exceeded on 1 in 10 days. For May, June and September, runup exceeds 10ft on 1 in 10 days, and this drops to 9ft for July and August. This is consistent with the seasonal cycle of large swell events, due to winter storms in the north Pacific, which may occur in October, and occasional swell events due to storms in the tropical or south Pacific during summer. The locally generated waves due to northerly winds in summer are of shorter period and lower height. These data suggest that wave-induced closure of an overflow channel will be a greater concern at the beginning and end of the May-October management period.

5.3 CHANNEL PLANFORM GEOMETRY

Inlet morphological behavior has been studied by Behrens (2008) for the years 1999-2008 through an analysis of inlet width, length and position estimates derived from photographic records. Data collection methods and error estimates are described in Behrens et al (2009). Inlet planform geometry and closure risk are summarized for different mouth states (Table 3).

Table 3 Inlet planform geometry for overflow conditions and various ranges of tidal muting (May 15 to October 15, 1999-2006). Overflow conditions are analyzed despite the fact that they occurred outside of this timeframe.

Inlet state		**Inlet width[1], ft**	**Inlet length[1], ft**	**Most common configuration**	**Closure risk[2]**
Open inlet with given tidal conveyance:	<10%	25 ± 1.8	530 ± 37.1	≥2 channel bends	81.3%
	10-29%	51 ± 3.6	358 ± 25.1	1-2 channel bends	35.3%
	30-49%	71 ± 5.0	282 ± 19.7	1 channel bend	28.6%
	50-69%	86 ± 6.0	236 ± 16.5	1 channel bend	13.7%
	≥ 70%	92 ± 6.4	221 ± 15.5	Straight	3.5%
Overflow channel (outside management period)	Oct 28, 1999	60 ± 4.2	140 ± 9.8	Straight	--
	Nov 4-5, 1999	20 ± 1.4	360 ± 25.2	Deflected by jetty	--
	Oct 26, 2006	25 ± 1.8	110 ± 7.7	Straight	--
	May 1-2, 2008	65 ± 4.6	100 ± 7.0	Straight	--
	May 6-11, 2008	20 ± 1.4	480 ± 33.6	Deflected by jetty	--

[1] Ranges are based on error estimates from Behrens *et al* (2009).
[2] Defined as the number of observations that were followed by closure within two weeks, divided by the total number of observations.

The data for overflow channel geometry indicate that the limited number of overflow events exhibited a range of shapes. The geometry of the only persistent case (6-11 May 2008) suggests that frictional loss plays an important role in attenuating channel velocity and the resulting downcutting.

However, there is a tradeoff for the frictional losses associated with sinuous channels. For a marginally tidal inlet the channel is long and narrow, with a couple of bends – and there is a very high risk of closure. There is no apparent relation between inlet position (not shown in this table) and tidal conveyance. However, marginally tidal inlets and overflow inlets were observed only at the northern or southern extreme of the inlet's migration range. Inlet width and length are known to vary in concert with river flow during the wetter months of the year and with tidal range during the drier months (Behrens et al., 2009). In general, low-flow conditions (low tides or river flow) appear to encourage inlet elongation and narrowing. Inlet width, length, and the number of channel bends all influence the tidal signal by determining frictional losses in the channel.

5.4 NOTES ON OTHER ESTUARIES

Overflow inlets have been observed in numerous estuaries along the coasts of California, Oregon, Chile and South Africa (and probably other areas with comparable climate and topography) (personal communication, John Largier). These are unpublished observations. Specifically, an overflow inlet is typically observed to persist for 1 to 3 months each year at the mouth of Salmon Creek (10 miles south of the Russian River) and at the mouth of the Gualala River, discussed below. Further, small central coast estuaries exhibit overflow states during spring and summer, e.g., Scott Creek and Waddell Creek. Systems photographed along the Chilean, South African and Oregon coasts are of similar size in terms of river flow and lagoon area. The absence of observations of overflow conditions in larger estuaries, similar to the size of the Russian River, suggests that there is a limit to the flow energy that can be accommodated by flow over a sand barrier of finite width (and thus high slope).

5.4.1 Gualala River

The mouth of the Gualala River is located 31 miles northwest of Jenner. Both its tidal prism and annual river flow are significantly lower than those of the Russian River. Despite this, the sites have several similarities, most notably their similarly sized beaches bordered by headlands. During a typical year, the inlet is closed for the entire summer and is opened by the first major storm of the winter (ECORP, 2005). The inlet requires consistent rainfall to remain open, and it is common for closures to occur within several weeks after each major storm event. As rainfall decreases during the spring, the inlet undergoes repeated cycles involving a closure event, a period of gradual estuary stage increase leading to a natural breach, and finally, several days to several weeks of minimal tidal conveyance and/or overflow conditions culminating in a new closure event. These cycles appear to continue until evaporative and seepage losses counterbalance inflows into the estuary, preventing the stage increase required to cause a natural breach event.

5.4.2 Carmel River

California State Parks adaptively manages the beach berm which creates a lagoon at the mouth of the Carmel River (CA Dept. of Parks and Recreation, 2008). The goal of this management is similar to the goal stated in the Russian River Biological Opinion (NMFS, 2008): to enhance the freshwater salmonid rearing habitat during summer months. Sometime in April, May, or June, once the Carmel River discharge into the estuary drops below 20-25 ft^3/s, bulldozers are used to increase the height of the beach berm. This elevated berm blocks ocean tides and saline water from entering the estuary, thereby creating a perched lagoon. When forming the elevated beach berm, an outlet channel is also created so that if lagoon water levels exceed 10 feet NGVD, the outlet channel will drain water from the lagoon into the ocean. The outlet channel only conveys water if the discharge to the lagoon does not taper off from 25-20 ft^3/s to 10 ft^3/s as rapidly as expected. Once river discharge falls below approximately 10 ft^3/s, evaporation and seepage export enough water from the lagoon that lagoon water levels no longer increase. As compared to the intermittent Russian River closures, the Carmel River estuary closes every year for months, typically at least July through November.

The Carmel River's outlet channel is more dynamic, fluctuating between open, overflow, and closed during the wet season, approximately December through June. As such, this period, although not corresponding to the Russian River management season, may inform the understanding of the Russian River's outlet channel dynamics.

The Monterey Peninsula Water Management District collected and analyzed water levels, riverine flow rates, waves, inlet state, and salinity in the Carmel River estuary between 1991 and 2005 (James, 2005). In approximately half of winters, an elongated channel has formed to connect the Carmel estuary to the ocean. With an elongated channel, water level fluctuations in the estuary were more muted than water level fluctuations when the channel aligned more directly to the ocean. The more muted conditions typically lasted for several weeks or up to a month, and then increased river discharge, tide range, and/or wave overwash caused water level fluctuations to return to the more typical range of two-three feet. In December 2004, at the direction of NMFS, an elongated channel was mechanically excavated to run north along the beach. The northern inlet alignment persisted through the winter and muted tidal conditions persisted for most the winter with only brief periods of larger water level fluctuations. However, this elongated alignment raised considerable concerns about the potential for erosion to adversely affect roads and buildings, and has not been repeated as a management option.

The elongated channel and muted tides correlate with a slight decrease in Carmel estuary salinity (James, 2005). Compared to a straight channel, when salinity is typically less than about 0.6 ppt at the surface, the elongated channel coincides with slightly lower salinity of less than about 0.3 ppt. Salinity measurements were not made at the bottom of the estuary water column, where higher salinity is likely due to greater water density.

The applicability of the Carmel River estuary's winter-time channel condition to the management of the Russian River estuary outlet channel may be limited.
The Carmel River estuary has considerably smaller riverine discharge and estuary tidal prism, which combine to cause predominantly closed conditions. In contrast, the larger Russian River estuary is predominantly open, owing to its larger riverine discharge and tidal prism. Similar to the Carmel River estuary, management of the Russian River estuary faces a number of infrastructure and operational constraints that limits inlet re-alignment, such as flooding, beach access, and marine mammals. Due to bedrock embedded within the beach, the Carmel outlet channel resists downcutting and preserves higher estuary water levels. The Carmel's minimum observed water level is approximately 2.3 NGVD, only about 0.5 foot below oceanic MHHW. This suggests that the Carmel water levels are perched in large part due to the underlying geology. For comparison, the Russian River estuary's minimum observed water level is -1.6 ft NGVD, 4.5 ft below oceanic MHHW and only about one foot above oceanic MLLW. In addition to these elevation differences,

muted tidal condition occur at the Carmel estuary during the winter, when high wave energy provides more sand transport into the channel, likely offsetting scour due to tidal and riverine discharge.

In summary, the Carmel Lagoon outlet channel differs from the proposed Russian River outlet channel with respect to several key features, as summarized in Table 4. Overall, the Russian River outlet channel is likely to be more difficult to manage for perched conditions than the Carmel River outlet channel because of its higher required conveyance, longer operational period, and lack of natural grade control.

Table 4 Comparison between Russian River and Carmel River outlet channel features

Outlet channel feature	Russian River	Carmel River
Conveyance capacity	50 ft^3/s	10 ft^3/s
Operational period	5 months (May-Oct)	1 month
Grade control	none	natural rock outcrops
Minimum observed water level	-1.6 ft NGVD	2.3 ft NGVD

6. CHANNEL CONFIGURATION ANALYSIS

As discussed in the conceptual model for target conditions, the outlet channel geometry must simultaneously meet two key constraints: convey sufficient discharge from the estuary to the ocean to preserve constant water levels in the estuary and preserve channel function by avoiding closure or breaching. Note that these two constraints can be in conflict since both conveyance capacity and the potential for breaching increase with flow rates but closure is more likely for lower flow rates. The technical analyses described in this section inform the range of target channel conditions by quantifying the relationship between outlet channel dimensions, bed scour potential, and hydraulic conditions. The ocean-driven processes associated with closure, the wave runup elevation and planform alignment, are discussed above in Section 5. Preventing breaching, a necessary condition for reducing marine influence on the estuary is the focus of this section.

Since the outlet channel will be located within a bed of unconsolidated beach sand, a key management objective is creating a channel which can sustain its cross section geometry instead of scouring. Breaching can occur if the discharge through the outlet channel is sufficiently forceful to scour the channel bed. To reduce the possibility of scour, threshold design principles (NRCS, 2007) are used to examine channel configurations most likely to avoid scour while meeting the other constraints of the system.

Channel design using a threshold methodology consists of the following steps:

- *Estimate the critical shear stress threshold.* This is a function of the site's bed particle composition, which can be characterized by grain size.
- *Predict hydraulic conditions for the proposed channel.* Use engineering calculations of steady flow and a one-dimensional hydraulic model of time-varying flow to estimate the velocity and shear stress for a proposed set of channel geometry, flow, and bed roughness.
- *Compare threshold and predicted bed shear stress.* The estimates from the two previous steps are compared with a factor of safety to account for variations in hydraulic conditions about the mean and uncertainty in parameter estimation.
- *Sensitivity analysis and uncertainty.* Evaluate the sensitivity of threshold and predicted bed shear stress to input parameters as well as the factors contributing to overall uncertainty.

6.1 CRITICAL SHEAR STRESS

The critical shear stress is defined as the applied bed shear stress at which sediment motion occurs. The critical threshold represents a balance between the force exerted by the flow on the bed and the resisting gravitational force of individual sediment particles. Flows above the critical shear stress will transport sediment while flows below the critical shear stress will result in no motion. The critical shear stress is dependent on characteristics of the sediment such as sediment density and particle size.

Sediment samples at the Russian River mouth were collected in March 2009 to inform the assessment of critical shear stress within the outlet channel. Ten sediment samples taken along the proposed outlet channel alignment were analyzed to determine the characteristic grain size distribution. On average, 78% of the sediment had a grain diameter between 0.6-2.0 mm (coarse sand), 18% was greater than 2.0 mm (granular), and 4% was between 0.2-0.6 mm (medium sand) (EDS, 2009a). Visual observations of grain size by ESA PWA near the mouth indicated a typical diameter between 0.8-1.25 mm (coarse sand).

Based on this assessment of typical beach grain size, ESA PWA estimated the critical shear stress using methods outlined in Soulsby (1997) and Fischenich (2001). For the typical range of observed grain size from 0.8-1.25 mm, a critical shear stress of 0.4-0.7 Pa (0.008-0.015 lb/ft^2) was determined for sand particles in the vicinity of the proposed outlet channel (Attachment A-1).

6.2 PREDICTED HYDRAULIC CONDITIONS

6.2.1 Steady mean flow conditions

ESA PWA conducted a preliminary assessment of outlet channel hydraulics under steady typical summer flow conditions as a screening tool to characterize the range of possible channel geometry parameters (bed elevation, channel slope, width, and length). Simple hydraulic equations for open channel flow were used to estimate the in-channel velocity and bed shear stress.

ESA PWA evaluated different combinations of river discharge, bed roughness, channel slope, and flow depth to evaluate channel performance. For a given discharge the hydraulic equations can be solved to determine the values of slope, width, and depth that satisfy the critical shear stress threshold for sediment motion. Once one of these three parameters is selected, the other two are fixed to meet a given shear stress threshold (NRCS, 2007). Multiple combinations of channel slope and width are capable of conveying the design flow at or below the critical shear stress threshold.

Figure 6 shows an example slope-versus-width stability curve for the outlet channel design. A stability curve is a tool used by designers to evaluate channel stability under a range of feasible slope-width combinations. Any combination of slope and width that falls on the stability curve will be stable for the prescribed discharge. Combinations of width and slope that plot above the stability curve will result in erosion and scour of the channel. Combinations of width and slope that plot on or below the stability curve will be stable (or depositional). For a given width, the depth of flow can be determined from the corresponding depth-width curve (Figure 6). For example, a 100-ft wide channel discharging 70 ft^3/s will be stable for channel slopes less than approximately 0.000125 and will flow at a depth of approximately 11 inches. The stability curve shows that as slope increases, channel width must also increase to keep channel velocities below the critical threshold for transport. Channel width and depth are inversely related for points on the stability curve, resulting in either a narrow channel with relatively deep flow or a wide channel with relatively shallow flow.

6.2.2 Calculation of estuary inflows

ESA PWA developed and calibrated a water balance model based on observed lagoon water levels at Jenner, CA. The purpose of the water balance model is to estimate the reduction in river discharge that occurs over the 21 river miles between Guerneville, a USGS continuous discharge gaging station, and the mouth of the estuary. The losses in discharge are attributed primarily to seepage through the beach berm (Largier and Behrens, 2010), with diversions, interaction with the adjacent aquifer, and groundwater pumping as possible contributing factors. No direct observations of these loss terms is available. The reduction factor serves as the calibration variable for the water balance model. For all cases, predicted estuary water levels during closure periods do not match observations unless lagoon inflows are reduced relative to the Guerneville discharge.

Model Setup

During a closure event, the rate of water level increase is a direct function of the net flows into and out of the lagoon (Goodwin and Cuffe 1993):

$$\frac{\Delta V}{\Delta t} = A\frac{\Delta h}{\Delta t} = \alpha Q_R - Ai_{evap} - Q_s$$

where:

$\triangle V$	=	lagoon inflow during closure (ft^3)
$\triangle t$	=	duration of closure (days)
A	=	surface area of the lagoon (ft^2)
$\triangle h$	=	change in water level in the lagoon (ft)
Q_R	=	river discharge at Guerneville (ft^3/day)
α	=	discharge reduction factor for groundwater losses
i_{evap}	=	rate of evaporation from the lagoon (ft/day)
Q_S	=	rate of seepage loss through the barrier beach (ft^3/day)

All terms in the water balance equation can be measured or approximated to allow calculation of α, the discharge reduction factor, for each closure event. The components and data sources of the water balance model are described below:

- Estuary water level and inlet state ($\triangle h$) – Jenner water level time series, (SCWA, 2000-2007). The inlet was assumed to be closed (no flow) during the calibration, based on periods when the estuary water levels were non-tidal and increasing estuary water levels.
- Guerneville discharge (Q_R) – USGS gaging station 11467000 (Russian River near Guerneville, CA at Hacienda Bridge) (http://waterdata.usgs.gov).
- Evaporation (i_{evap}) – estimated based on climatological evaporation rates for CIMIS evapo-transpiration reference Zone 1 (California coast) (*www.cimis.water.ca.gov*, Attachment A-3).
- Berm seepage (Q_S) – estimated using Darcy's Law based on water level difference between lagoon and ocean (Attachment A-4).
- Lagoon stage-storage curve (A) – determined from 2009 sidescan survey and LiDAR digital elevation model (EDS 2009b).

The volume of water entering the closed lagoon as a result of waves overtopping the beach berm is not included in the water balance model. Two lines of reasoning provide the basis for this exclusion. First, wave conditions during the May through October management period are generally associated with beach berm building, not with extensive overtopping and berm erosion more prevalent during winter storm events. The wave runup analysis in Section 5.2.3 confirms that runup elevations sufficient to overtop the berm are infrequent. Second, the observed water levels used in the water balance model exhibited nearly constant rates of increase, typically over two days or more. Short periods of rapidly changing water levels indicative of overtopping were not used in the water balance analysis.

Model Calibration

The observed rate of water level increase ($\triangle h/\triangle t$) in the lagoon during 18 closure events was calculated from the Jenner gage data. Rates of water level increase ranged from 0.4 ft/day to 3 ft/day and averaged 1 ft/day. The required inflow ($\triangle V/\triangle t$) to yield the observed rates was calculated based on an assumed lagoon surface area (A) at closure of approximately 400 acres. From the observed average discharge at Guerneville (Q_R) over each closure period, a discharge reduction factor, α, was calculated for estuary inflow during each of the closure events. The percent reduction ranged from 10% to 53% and averaged 37% (Attachment A-5). The largest reductions in discharge typically occurred in summer and were less in the spring and fall.

The reduction factors were averaged over each month from May-October to approximate a seasonal trend. The resulting calibration curve (Attachment A-5) was used to reduce the anticipated Guerneville discharge in the unsteady hydraulic modeling discussed in Section 6.2.3 to predict downstream flow rates into the lagoon based on upstream discharge measurements.

Comparison with Discharge Measurements

A limited set of USGS and Agency discharge measurements provides estimates of river flow at other locations besides the continuous discharge measurements at Guerneville. These discharge measurements, collected at four stations[6] in the 14 miles below Guerneville, typically fall within 10% of the Guerneville average daily discharge. For example, Behrens and Largier (2010) found that the longest record, collected by the Agency in 2009 at Vacation Beach, agreed to within 10 ft^3/s of the discharge measurements made at the permanent USGS Guerneville gage. These relatively low losses suggest that the losses calculated to complete the estuary water balance occur downstream of these discharge measurements, in the lower 6 miles of the river. Since the results of the water balance are used to estimate estuary inflow in the unsteady hydraulic model (see Section 6.2.3 below) and have a significant level of uncertainty, the estuary inflow values in the unsteady hydraulic model may not represent actual estuary inflow. Presently, the existing data are insufficient to fully characterize the losses between the discharge measurements and lagoon water levels. Higher

[6] Data available from USGS National Water Information System (http://waterdata.usgs.gov/nwis), Russian River station names (site number): Duncan Mills (11467210), Monte Rio (382757123003801), Vacation Beach (11467006), and Rio Nido (383012122574501).

rates of seepage through the beach berm are one possible explanation. Largier and Behrens (2010) estimate seepage rates to average 60 ft^3/s for all closure data. Their seepage estimates vary from approximately 30 ft^3/s when the estuary is closed and its water level exceeds the ocean water level by 2-3 ft to more than 70 ft^3/s when the water level difference exceeds 5 ft. Substantial uncertainty about the seepage rate, on the order of ±20 ft^3/s, remains; therefore monitoring to resolve this discrepancy is recommended in Section 7.7. The implications of alternative lagoon inflows are discussed in the model sensitivity analysis and outlet channel management sections of this report.

6.2.3 Hydraulic modeling of unsteady mean flow conditions

Using the calibrated water balance model results described in Section 6.2.2, ESA PWA developed a hydraulic model to evaluate the performance of the outlet channel for various hydrologic scenarios. This modeling is a refinement of the steady mean flow calculations described in Section 6.2.1 because it quantifies estuary discharge, explicit channel geometry, and temporal changes in hydraulic parameters. Sources and sinks accounted for in the model include river discharge, groundwater losses, berm seepage, evaporation, and outlet channel discharge (described in more detail in Section 6.2.2 and Figure 7). Flow in the outlet channel is represented by one-dimensional channel hydraulics as a function of estuarine water levels, channel dimensions, channel slope, and bed roughness. Tidally-varying ocean water levels are included in the model, but since these water levels stay below the channel's bed elevation, they do not influence flow in the channel. Initial channel dimensions were based on the results of the preliminary analysis described in Section 6.2.1. Model channel geometry was revised iteratively based on subsequent hydraulic analyses and discussions with the Agency and NMFS. Channel geometry is fixed throughout the simulation, even though the channel may be subject to scour and its mouth lies in the active transport zone created by ocean waves (Section 4). This assumption has been made because currently available data and models cannot adequately characterize the active transport zone. The management implications of this assumption are discussed in Section 7. The model simulates estuary water levels and outlet channel flow for the period spanning proposed outlet channel operations, from May 15 to October 15.

Discharge Boundary Condition

ESA PWA analyzed historic discharge data at Guerneville to select a "typical" water year for the hydraulic model boundary condition. A time series of monthly discharge was obtained from USGS for the time period from 1970 to 2008 and compared to the median monthly discharge for the duration of record to select a typical water year. For each month, the difference between the month's discharge and the median monthly discharge was computed. The sum of the differences (for May-Oct only) was used to rank each year relative to median conditions. Based on this ranking, the 2000 water year was selected as the most typical year (Attachment A-6).

The year 2000 discharge time series was used to generate a synthetic discharge time series to approximate anticipated reduced instream flow conditions. A measured time series is preferable to using the median daily discharge because it retains some of the short-term variability in the observed flow rates. A synthetic discharge time series for anticipated flow conditions was derived from the typical discharge time series by scaling the Guerneville discharge to an average summertime flow of

120 ft^3/s. This reduction to 67% of observed 2000 discharge is based on the anticipated reduced instream flow requirements (Section 3.1) versus historic instream flows. When flows are adjusted to average 120 ft^3/s from July to October, short-term variability ranges from about 85-150 ft^3/s. The resulting discharge time series at Guerneville is shown in Figure 7a for the simulation period.

The anticipated discharge time series at Guerneville was further reduced using the calibration curve developed in Section 6.2.2 to account for downstream losses between the gaging station and the lagoon. The resulting estuary inflow time series is shown in Figure 7a. Anticipated inflows to the lagoon vary from approximately 45-90 ft^3/s and average approximately 55 ft^3/s during the summer months. Once seepage and evaporation losses are subtracted from the lagoon inflow, modeled baseline flows in the outlet channel are 45-85 ft^3/s and average 50 ft^3/s.

Model Setup

The configuration for the unsteady HEC-RAS hydraulic model is very similar to the water balance model described in Section 6.2.2. The unsteady model includes the lagoon, outlet channel, and beach face, and simulations span the duration of the operational period, from May 15-October 15. The outlet channel was parameterized as a prismatic rectangular channel with a width of 100 ft and length of 300 ft. Bed roughness (Manning's n) was set to 0.02. The channel bed was set at 5 ft NGVD and transitions to a 1V:70H slope on the beach face. The actual beach face slope is believed to be closer to 1V:10H; however, a milder slope was required for model stability. Sensitivity runs with a steeper beach face slope indicated negligible influence on velocities in the upstream portion of the outlet channel. Time-varying seepage and evaporation losses from the lagoon were estimated from Darcy's Law and CIMIS climate statistics for coastal areas, as described in Section 6.2.2. The time series of these losses used as model input are shown in Figure 7b. Because these combined losses are less than 10% of the lagoon inflow, the modeled lagoon outflow through the outlet channel is similar to the lagoon inflow (Figure 7a). A downstream water level boundary condition was prescribed for the ocean; however, since the outlet channel bed elevation is above the limit of tidal influence (approximately 4.5 ft NGVD), there was no impact on outlet channel hydraulics.

Results

Model runs were conducted for the operational period from May 15-October 15 for the proposed outlet channel geometry described above. Time series of lagoon water level, channel velocity, and bed shear stress were extracted to evaluate channel performance. Bed shear stress and lagoon water level results for the hydraulic modeling are shown in Figure 8a and Figure 8b, respectively. The bed shear stress values shown in Figure 8a are mean model predictions times 1.5 to account for transverse variations in bed shear stress not captured by the one-dimensional model (Fischenich, 2001).

The results for the proposed channel geometry and the anticipated reduced instream hydrology are shown as the "Baseline" curve. The expected range of critical shear stress (0.4-0.7 Pa) is shown in Figure 8a for reference. After the initial higher flow period during the spring and early summer, both shear stress and lagoon water level are relatively constant throughout the summer and fall (July-October). Bed shear stresses fluctuate during this period, but are always above the critical shear stress, indicating likely sediment motion and scouring of the channel. Lagoon water levels (Figure 8b) are relatively constant around 5.6 ft NGVD, resulting in a typical flow depth of approximately 0.6 ft in the channel. Channel velocities average 1.1 ft/s and range between 1.0-1.3 ft/s.

6.3 SENSITIVITY ANALYSIS AND UNCERTAINTY

ESA PWA conducted sensitivity and uncertainty model runs for important variables and parameters to assess their impact on channel performance. The testing focused on conditions that may encourage a stable channel by reducing predicted bed shear stress below the critical shear stress. Parameters tested were reduced outlet channel flow and critical shear stress.

Reduced Outlet Channel Flow

Anticipated flows in the outlet channel are somewhat uncertain because the losses between upstream observed discharges and the outlet channel are not well characterized, as described in Section 6.2.2. The baseline simulation presented in Section 6.2.3 used a calibrated seasonally-varying coefficient to reduce flow rates into the lagoon. Once seepage and evaporation losses are subtracted from the lagoon inflow, modeled baseline flows in the outlet channel are 45-85 ft^3/s. To test channel performance under conditions with further flow reductions (due to higher losses, groundwater recharge, diversions, or berm seepage), a sensitivity run was conducted with outlet channel flows reduced to 25-45 ft^3/s, approximately 45% less than baseline conditions.

Critical Shear Stress

Uncertainty in the critical shear stress for beach sand at the Russian River mouth is primarily due to the fact that the beach is comprised of a distribution of particles of varying diameter (see Section 6.1), as opposed to a uniform grain size. Grain size analyses indicate a narrow distribution of approximately 0.8-1.25 mm diameter sand, for which the critical shear stress ranges from 0.4-0.7 Pa. The critical shear stress for the typical grain size of 1 mm is 0.5 Pa.

Results

The results of the reduced outlet channel flow sensitivity model run are shown in Figure 8a for bed shear stress and Figure 8b for lagoon water level. The 45% reduction in outlet channel flow resulted in reduced bed shear stress and water level. Average water levels and channel depth decreased by approximately 0.1 ft relative to the baseline simulation. Average bed shear stress decreased by approximately 30% to an average value of 0.58 Pa for the summer months. The range of critical shear stress, 0.4-0.7 Pa, is shown in Figure 8a as a blue band. While the predicted bed shear stress for baseline conditions almost always exceeds this range, the predicted bed shear stress for reduced outlet channel flow falls within the range of critical shear stress.

The results of the sensitivity simulations suggest that while the baseline conditions are likely to cause scour, variability in outlet channel flow and critical shear stress could result in a marginally stable channel. If necessary, a wider channel could be excavated (or could develop naturally) to reduce bed shear stress below the critical threshold. This model was not used to predict sediment transport and therefore the modeled channel geometry was held fixed. Under target conditions, active transport is expected at the channel mouth (Figure 2). In order for the outlet channel to persist, scour caused by the outlet channel flow accelerating down the beach face at low tides needs to be balanced by sediment deposition generated by wave action at high tides. However, if the active transport zone moves upstream into the outlet channel, the channel is likely to breach and return to tidal conditions, as shown in Figure 4.

7. PROPOSED OUTLET CHANNEL ADAPTIVE MANAGEMENT FOR 2016

This section describes the 2016 recommended channel management practices related to the Biological Opinion requirements. Existing management practices for public safety, operator safety, operational responsibility, and other practices not related to meeting the Biological Opinion objectives are not discussed here. These existing practices are documented in the Standard Operational Procedures: Russian River Mouth Opening (SCWA, 2002).

The outlet channel management described in this section is based on the performance criteria, conceptual model and technical analysis described in the preceding sections, as well as extensive discussion between the Agency, the resource management agencies, and ESA PWA. In addition, implementation efforts provided practical experience for adapting the plan. An account of the 2010 implementation is provided in Attachment E and an account of physical conditions is provided for 2011 (Attachment F), 2012 (Attachment G), 2013 (Attachment H), 2014 (Attachment I), and 2015 (Attachment K). A five-year review (Attachment J) compares the physical processes affecting the Estuary since implementation of the Biological Opinion's Estuary RPA (2010-2014) with the prior ten years (2000-2009). Some uncertainty remains about the exact outlet channel configuration that may best achieve the target performance criteria. This uncertainty arises from the dynamic natural setting for the outlet channel and from the unquantified tradeoffs between channel specifications which may benefit one performance criterion while impairing another criterion. For example, to reduce the likelihood of closure, it may be beneficial to locate the mouth of the channel further north where the coastline's aspect is more sheltered from waves from the north. However, extending the channel's length to the northern location may necessitate narrowing its width to keep excavation within currently-permitted volumes. A narrower channel increases the likelihood of scour-induced breaching. The relative importance of these factors is not known, precluding an exact determination of optimal channel configuration. In addition to these uncertainties, actual conditions at the time of closure, such as beach berm topography, may inform the selected configuration.

The assessment of the outlet channel conducted to date suggests two possible configuration options:

- a wide and short channel that seeks to minimize scour potential; or
- a narrow and long channel aligned to the north that seeks minimize closure potential.

The rationale supporting each of these configurations is described in more detail in Section 7.3 and Attachment D below. The configuration that is selected at the time of closure will be documented to the resource management team in accordance with the communication protocol described in Section 9. Performance of implemented configurations will be monitored and documented to test the conceptual model which guides management and to suggest adaptive changes to future management actions, including some combination of these two configurations.

The strategy for outlet channel management is an adaptive and incremental approach. This strategy favors smaller, more frequent modifications over larger, less frequent, modification with less certain outcome. Once experience is gained from implementing the channel and observing its response, it may be possible to make larger changes during each incremental modification. These larger changes will decrease the duration and frequency of management activity, thereby reducing the disturbance impact over time. Management practices will be incrementally modified over the course of the management period (May 15th to October 15th) in effort to improve performance in meeting the goals of the Biological Opinion.

The approach may be constrained by an excavation volume limit of 2,000 yd^3 and antecedent beach berm topography prior to implementation. This approach will be implemented to the extent feasible while still staying within the constraints of existing land use permits.

To provide context for the proposed management plan, the first section below describes previous breaching practices for the inlet. Subsequent sections describe the target channel initiation, location, dimensions and supporting operations details. A hypothetical implementation scenario for the outlet channel, based on actual beach berm and ocean conditions observed at the estuary from June 30 to July 6, 2009, is provided in Attachment B.

7.1 PREVIOUS BREACHING PRACTICES

Breaching has historically been performed in accordance with the *Russian River Estuary Study 1992-1993* (PWA, 1993) in effort to minimize flooding of low lying shoreline properties in the Estuary. The beach berm was artificially breached by the Agency when the water surface elevation in the estuary is between 4.5 and 7.0 feet as read at the Jenner gage. Breaching was performed by creating a deep cut in the closed beach berm approximately 100 feet long by 25 feet wide and 6 feet deep by moving up to 1,000 yd^3 of sand. Based on experience and beach topography at the time of the breach, the planform alignment of the breach was selected to maximize the success of the breaches. Breaching activities were typically conducted on outgoing tides to maximize the elevation head difference between the estuary water surface and the ocean. After the last portion of the beach berm was removed, water would begin flowing out the channel at high velocities, scouring and enlarging the channel to widths of 50 to 100 feet. As the channel evolved and meandered, it reached lengths in excess of 400 ft. After breaching, the estuary would be subject to saline water inflow throughout incoming tides.

7.2 INITIATION OF EXCAVATION

Initial channel excavation will be performed when the outlet channel first closes following May 15th, the beginning of the management period. Closure is often preceded by a lengthening and narrowing of the outlet channel, muting of the estuary tide range, and/or an increase in mean tide level within the estuary. The Agency will monitor the estuary for these conditions and initiate planning for a management action when they are observed.

Throughout the management period, the Agency's permits with CSP and the California Coastal Commission dictate that management operations cannot occur on Friday, Saturday, Sunday or a holiday because these days coincide with high public use[7]. The incidental harassment authorization

[7] Exceptions can be made in the event of emergency conditions. See Attachment C for more details.

stipulates that management actions cannot occur for more than two consecutive days unless flooding is threatening. During the marine mammal pupping season (March 15th to June 30th), the initiation of Agency operations is further constrained. Outlet channel management activity must be delayed if a pup less than one week old is on the beach along site access pathways and there must be a week-long break between management actions. More details on timing restrictions are provided in Attachment C.

Should the outlet channel close in the weeks immediately preceding the management period, the Agency, in consultation with NMFS, CDFW, and CSP, may initiate excavation to increase the likelihood of entering the management period with the target channel configuration in place.

The constructed outlet channel may also close during the management season, such as following a large wave event. In such circumstances, it will be necessary to perform maintenance on the outlet channel, to re-connect the channel to the ocean before the lagoon water level rises too high above the new (higher) beach berm elevation.

7.3 CHANNEL LOCATION/PLANFORM ALIGNMENT

Two possible channel configurations within the extent of the existing alignment (Figure 1) may be pursued in 2016 since the location that may best achieve the performance criteria is not certain. Alternative channel alignments may be implemented to test the relationship of mouth location on channel stability.

7.3.1 Wide and short channel alignment

Preference for a wide and short outlet channel assumes that channel failure by scour-induced breaching (Section 4.3) is the controlling failure mode to avoid in selecting the channel's configuration. This assumption is based on the consequences of breaching, which returns the estuary to tidal habitat conditions that will persist until a large wave event occurs to renew the closure. Since these closure events are relatively infrequent during the management period (between 1999 and 2008, there were an average of 2.6 closures per management period), the next opportunity for creating freshwater habitat may be months away. In comparison, if the channel fails by closing, which may be more likely for the wide/short channel because of its mouth's location, another management action can be taken to re-open the outlet channel while preserving the freshwater condition of the lagoon. To reduce the possibility of scour-induced breaching, the hydraulic calculations and modeling in the channel configuration analysis indicates that the excavated channel should be as wide as possible. Under existing permits, the maximum width is 100 ft. The hydraulic modeling indicates that even a width of 100 ft is likely to scour; a narrower channel will further increase bed shear stress and the potential for scour. Once this width is selected, the channel length may need to be constrained to stay within the 2,000 yd^3 limit on excavation volume. The actual dimensions of the wide/short configuration will depend on the beach berm topography at the time of management action.

For a given lagoon water surface elevation, the wide/short configuration will have a higher average bed slope than the longer channel because of the channel's shorter length. The wide/short approach attempts to mitigate this by splitting the outlet channel into two reaches with varying steepness, as shown in Figure 2. Across the beach berm, a flat slope is recommended to reduce the contribution of bed slope to flow velocity, thereby minimizing the potential for scour. The entire drop in elevation between the lagoon water level and ocean water level is initially located at the end of the outlet channel, in the active transport zone. In the active transport zone, scour caused by the outlet channel flow accelerating down the beach face at low tides may be balanced by sediment deposition generated by wave action at high tide. As indicated by modeling (Section 6.2.3), it is likely to be difficult to avoid scour even in the portion of the channel with a flat bed because the lagoon water level will set up to create the water surface slope necessary to convey the discharge that maintains constant lagoon water levels. So even if the bed slope is zero, the total energy slope (the combination of bed slope and water surface slope) is likely to generate scouring flow.

Failure by breaching may not be the controlling mechanism if the actual flows conveyed in the outlet channel are less than anticipated or if the channel develops an armored layer of larger particles. As discussed in Section 6.2.2, direct observations of the flow that the outlet channel must convey are not available and have been inferred from upstream discharge observations and lagoon water levels during closure events. The anticipated outlet channel conveyance rates average 50 ft^3/s and range between 45-85 ft^3/s. If actual flow rates are less due to losses elsewhere (e.g. berm seepage), the outlet channel will be less likely to scour. For example, the sensitivity analysis scenario with reduced flow rates between 25-45 ft^3/s exhibited conditions less likely to scour (Section 6.3). Channel armoring is the process by which the smaller sand particles are eroded, leaving behind larger particles that have a higher critical shear stress for erosion. Because of the uniformity of particle sizes observed on the beach berm (EDS, 2009a), armoring is thought to be unlikely within the range of target elevations for the outlet channel. Larger particles have been observed in the channel, but only when its elevation is lower and within the tidal regime.

The wide/short approach will be to construct the channel in the same general location and alignment as the preexisting channel (i.e., the location just prior to closure). When pursuing this approach, excavation will simply widen and connect the channel in place. As the channel migrates during the management season, the location of new excavation may follow this migration.

7.3.2 Narrow and long channel alignment

The narrow/long approach to channel design assumes that wave-induced closure (Section 4.2) is the controlling failure mode to avoid in selecting the channel's configuration. By excavating a longer channel that stretches to the northwest, the channel's mouth can be situated in an area that may be exposed to less wave energy. Because of its aspect, the area to the north is more sheltered from waves originating from the north. When large waves originate from the south, the channel will be oriented perpendicular to the incident wave direction, which may enhance the channel's capacity to transport sand that is washed into the channel's mouth by waves (Attachment D). Observations of lateral mouth migration in both directions (Behrens et al. 2009) suggest that waves from both north and south directions play a role in mouth dynamics. Additionally, the narrow/long alignment provides flexibility to locate the channel mouth at a location with a flatter beach face slope, which may reduce net scour (Attachment D). The narrow/long approach is supported by observations of outlet channels that form at some other California river mouths (Attachment D). However, many of these other river mouths drain smaller watersheds that have lower flow rates into the lagoon, and therefore are less likely to breach. Also, these lagoons may not be constrained by the risk of flooding to adjacent property. Without a flood risk, lagoon water levels can rise higher and possibly drive more seepage through the beach berm rather than through the outlet channel. Finally, a longer channel will reduce the average bed slope, which is hypothesized to reduce scour. However, as discussed for the wide/short channel, it is the total energy slope (the combination of bed slope and water surface slope), which drives flow through the channel. Hydraulic analysis indicates that even if there is no slope to the outlet channel (i.e. it is flat), the water level in the lagoon will increase to create the water surface slope required to maintain the outlet channel's discharge. For the anticipated discharge, the corresponding bed shear stress is predicted to cause scour (Section 6.2.3).

The narrow/long approach will angle the channel to the northwest with an approximate aspect of 30-40 degrees with respect to the beach. This angled alignment tests possible advantages of site features such as areas of reduced wave energy and rocks imbedded in the beach.

7.4 TARGET CHANNEL DIMENSIONS

Prior to excavation the proposed outlet channel will be designed by Agency survey staff using computer-aided design (CAD) software. This design will then be used either to manually stake target channel dimensions or to automatically guide the excavation equipment via a GPS-based equipment controls. This operation protocol will ensure that the channel is excavated to the intended design.

7.4.1 Excavation Volume

The quantity of sand moved will depend on antecedent beach topography. To stay consistent with current permits, the excavated volume will not exceed 2,000 yd^3. Once either the wide/short or narrow/long planform alignment is selected, the limit on excavation volume will largely set channel dimensions. If a wide channel alignment is selected, the channel length will be limited so the total excavated volume remains below the limit. Similarly, if a long channel alignment is selected, the channel width will be limited so the total excavated volume remains below the limit. The actual dimensions at the time of implementation will depend on the beach berm topography at the time of implementation. Monthly surveys of the outlet channel, supplemented by spot checks at the time of management actions, will provide necessary information about beach berm topography.

Any sand excavated from the channel will be placed on the adjacent beach and graded to depths of approximately 1-2 ft higher than the existing grade. The placed sand will be distributed in such a way as to minimize changes to beach topography. If the time available for excavation is limited by uncontrollable factors such as tides, waves, seal use, or days when operations are forbidden, sand placed on the north side of the channel may be left in piles up to 3 ft high and not blended into the existing beach topography. The piles may need to remain un-graded on the north side because equipment access to this side is more difficult and may slow down operations. Once the outlet channel is in place, the north side is also less accessible, reducing the impact of any remaining sand piles on public use.

7.4.2 Bed Elevation

The bed will be excavated 0.5 to 1 foot below the lagoon water level along its entire length, to achieve target channel depths (discussed below) upon initiation of flow. Channel bed elevations are expected to be in the range of 3 to 7 ft NGVD, with corresponding lagoon water levels of 4 to 8 ft, using a typical flow depth of one foot. At the start of the management season, lagoon water levels and the channel bed may be on the lower of this elevation range, since the system will have recently transitioned from intertidal to closed and the beach berm may not yet have built up. As the management season progresses, sand is expected to move onto the beach berm, raising the viable bed elevation for the outlet channel. As the beach berm builds higher, it will support higher lagoon water levels while maintaining channel depth within the target range. The upper end of the bed elevation is governed by the flood stage elevation (9 ft NGVD) minus the anticipated water depth and a factor of safety to buffer against flooding. Frequent maintenance will likely be required early in the management season to maintain an open outlet channel as the beach berm elevation builds. Eventually, the outlet channel may be above the typical wave runup elevation, the elevation at which waves may induce channel closure, and close less frequently.

The bed elevation is a key determinant of lagoon water levels and influences the stability of the outlet channel. Higher bed elevations have the advantage of better meeting the Biological Opinion's performance criteria of higher lagoon water levels. Higher lagoon water levels would increase seepage through the beach berm, potentially reducing conveyance requirements and the possibility of scour in the outlet channel. A higher outlet channel is also less likely to be closed by waves. On the other hand, lower bed elevations reduce the potential energy which may cause outlet channel scour, provide a greater buffer before flood stage, and may reduce the release of oxygen-depleting organic matter from inundated upstream marshes[8]. Developing a better feel the optimal bed elevation is one objective of the adaptive management plan.

The Phase 1 performance criteria are to develop an outlet channel that supports a stable, perched lagoon with water surface elevations at approximately 7 ft NGVD for several months (Section 3.1). Stable conditions imply that river inflow into the lagoon would be approximately the same as the sum of outflow through the outlet channel and seepage through the beach berm. Stable conditions also imply that net sand deposition or erosion does not impair the outlet channel's function. However, this goal may not be achievable in 2016 because additional constraints in place during this year call for modified performance criteria.

[8] Goodwin and Cuffe (1994) observed the release of anoxic water from upper Willow Creek into the Russian River Estuary after an artificial breach. Based on this observation, they recommended a preferred maximum water level of 7.0 ft NGVD.

The bed slope should be nearly flat within the outlet channel to minimize the likelihood of scouring the bed. This may be difficult to maintain. In particular, incision within the "flat" channel bottom may occur.

7.4.3 Depth

The target range of water depths, 0.5-2 ft, is constrained on the upper end by the maximum depth at which the channel is likely to be stable (not scour). Larger depths would be associated with a narrower channel. The lower end of the range is constrained by the width; shallower depths would require impractically large channel widths to provide sufficient cross-sectional area to convey flow. Shallower water depths represent a greater factor of safety with regard to preventing bed scour since bed friction retards flow speed more strongly for shallower depths. Prior to implementation the predicted rate of water elevation rise within the estuary will need to be considered to determine the bed elevation to achieve the flow depths desired at the completion of the channel excavation.

7.4.4 Width

The width of the channel is estimated to vary within 25-100 ft for consistency with the existing management permits. For the wide/short configuration, the channel bottom would be excavated to a width of 100 ft, the permitted maximum, to reduce the potential for scour. For the narrow/long configuration, the channel bottom width will be approximately 30 ft to achieve the desired channel length and slope while still staying within the 2,000 yd^3 excavation volume limit.

7.4.5 Length

The channel length is estimated to vary within 100-800 ft, consistent with historic channel lengths observed within the management period (Behrens, 2008). Length will be a function of the channel's planform alignment while also balancing with other channel dimensions in order to keep excavation volumes less than 2,000 yd^3. The wide/short configuration would result in channel lengths between 100-400 ft while the narrow/long configuration would result in channel lengths approaching the maximum of 800 ft.

7.5 EXCAVATION TIMING RELATIVE TO THE TIDAL CYCLE

Under the proposed management plan, channel modifications will be initiated during low tide so that after several hours of work, the channel will be completed near high tide. As per existing practices, a temporary barrier will be left between the ocean and lagoon during excavation. When the last material is excavated, then the temporary barrier will be removed at or near high tide. This will minimize the difference in water levels between the estuary and ocean, reducing the potential for the re-connected channel to scour into a fully tidal inlet.

7.6 EXCAVATION FREQUENCY

Creating and maintaining the outlet channel will probably employ one or two pieces of heavy machinery (e.g. excavator or bulldozer) to move sand on the beach. At the start of the management period (late spring or early summer), when configuring the outlet channel for the first time that year, conditions may require operating machinery for up to two consecutive days (as allowed under the marine mammal incidental harassment permit). The precise number of excavations would depend on uncontrollable variables such as seasonal ocean wave conditions (e.g. wave heights and lengths), river inflows, and the success of previous excavations (e.g. the success of selected channel widths and meander patterns) in forming an outlet channel that effectively maintains lagoon water surface elevations. As technical staff and maintenance crews gain more experience with implementing the outlet channel and observing its response, maintenance during the remainder of the management season is anticipated to be less frequent.

In consideration of the natural beach environment and public access, effort will be made to minimize the amount and frequency of mechanical intervention. Outlet channel management activities cannot last for more than two consecutive days. During the marine mammal pupping season (March 15th to June 30th), the duration and frequency of Agency operations is constrained by restrictions on incidental harassment. Seven days must pass between management events. More details on duration and frequency restrictions are provided in Attachment C.

7.7 UNCERTAINTY AND LIMITATIONS

The proposed operations are based on the analyses documented in this report, input from resource agency staff, and on our professional judgment. Uncertainties about the actual estuary inflow, berm seepage, and outlet channel performance remain. As described in Section 6.2.2, the two methods for estimating estuary inflow, the water balance model and limited discharge measurements, predict disparate estuary inflows. Estuary inflow will fluctuate over the management period and may be greater than the modeled inflow. The seepage through the beach berm is based only on inferred, not observed, estimates of hydraulic conductivity. The outlet channel, particularly its downstream end, will be located in a highly dynamic environment that is influenced by changing river flow, tidal water levels and waves. Since the outlet channel will not include any hard structures, all of these sources of hydrologic forces can readily alter the channel's configuration, which may make it difficult to achieve and maintain the channel's successful function. Modifications of the proposed plan in response to actual conditions will be discussed with the resource agency management team and documented according to the communication protocol described in Section 9. Any modifications will be consistent with existing permit requirements.

Adaptive management once the channel is implemented will further enhance management practice. Actual feasibility with regards to the full range of dynamic conditions has not been determined. Risks associated with outlet channel failure have not been quantified. In addition to the channel's performance criteria, there are also water quality and ecological performance criteria for the perched lagoon. These additional criteria have not been evaluated as part of the outlet channel management plan.

8. MONITORING AND ADAPTIVE MANAGEMENT

Monitoring of the outlet channel should be implemented to facilitate an understanding of the channel's behavior and guide adaptive changes to this initial management plan. Adaptive management changes may be made over the course of the management season, in response to natural processes, outlet channel conditions, and/or outlet channel response. In addition, a more comprehensive review at the end of the management season will employ the monitoring data to recommend management revisions for the following year.

Because relatively few closure events occur per year and each one experiences different river and ocean conditions, a comprehensive monitoring plan is recommended to support adaptive management. The monitoring would quantify changes in the beach and channel elevation, lengths, and widths, as well as flow velocities and observations of the bed structure (to identify bed forms and depth-dependent grain size distribution indicative of armoring) in the channel. If feasible, the required monthly beach topography surveys should be scheduled just in advance of potential closure situations (neap tides, low discharge, and/or large wave events). Staff safety, staff availability, pinniped constraints, and/or rapidly changing physical conditions may preclude optimal scheduling of beach topographic surveys. Because monitoring requires human presence on beach, potentially disturbing the seal population, the monitoring frequency represents a balance between management of the outlet channel and minimizing disruption of wildlife.

A list of recommended monitoring tasks for 2016 is provided below in Table 5.

Table 5 Monitoring tasks associated with outlet channel management

Task	Description	Field Activities	Frequency
Recommended			
Operations log	Record of outlet channel management actions and ambient conditions.	Operations staff to generate written record of operations (excavation method, extent, and location) and ambient conditions (weather, ocean state, estuary water level)	Daily to monthly (Depends on operational activity)
Outlet channel location and state	An automated video or still camera station to capture the outlet channel's location and state.	Field staff to install and service a camera, power supply, and possibly communication system on hillside adjacent to estuary.	Hourly imaging (automated); Weekly servicing
Outlet channel discharge measurements	Collected within the outlet channel to verify the channel's conveyance.	Field staff to complete cross sectional flow velocity surveys using flow meter attached to a wading rod with electronic data logger.	Monthly
Outlet channel bed structure	Observe the bed for bed forms and depth-dependent grain size distribution indicative of armoring. Sediment sampler used.	Field staff to collect sediment sample from the surface of the channel bed.	Monthly
Outlet channel topography	Collect outlet channel elevation and width	Field staff to survey outlet channel features using a total station and prism mounted on a survey rod.	Monthly
Beach topography	Collect beach elevation	Field staff operating rod and staff on beach.	Monthly
Estuary flow dynamics	Integrate cross sectional velocity data in estuary at various locations from mouth to Duncans Mills.	A boat with field staff, collecting cross sectional data from mouth to Duncans Mills.	Weekly

9. COMMUNICATION PROTOCOL

A communication protocol will provide guidance between the Agency and identified points of contact representing key resource management groups in the estuary for the implementation of the Outlet Channel Management Plan during the management period (May 15 – October 15). Primary and alternative points of contact have been identified for each of the key resource management groups. These parties, which together are hereafter referred to as the “Team”, include: Sonoma County Water Agency, NOAA National Marine Fisheries Service, California Department of Fish and Wildlife, and California State Parks. A list of contacts for these groups is shown in Table 6.

Table 6 Russian River Estuary Management Team

Contact	Level	Organization	Phone Number	E-mail
Jessica Martini Lamb	Primary	Sonoma County Water Agency	707-547-1903 (w) 707-322-8177 (m)	jessica.martini.lamb@scwa.ca.gov
Chris Delaney	Secondary	Sonoma County Water Agency	707-547-1946 (w) 707-975-5606 (m)	cdelaney@scwa.ca.gov
Gary Tourady	Primary	Agency Operator Sonoma County Water Agency	707-547-1065 (w) 707-975-6285 (m)	garywt@scwa.ca.gov
Jon Niehaus	Secondary	Agency Operator Sonoma County Water Agency	707-521-1845 (w) 707-975-3999 (m)	jon@scwa.ca.gov
Robert Coey	Primary	National Marine Fisheries Service	707-575-6090 (w)	Bob.Coey@noaa.gov
Rick Rogers	Secondary	National Marine Fisheries Service	707-578-8552 (w)	rick.rogers@noaa.gov
Tim Dodson	Primary	CA Dept. of Fish and Wildlife	707-944-5513 (w)	timothy.dodson@wildlife.ca.gov
Eric Larson	Secondary	CA Dept. of Fish and Wildlife	707-944-5528 (w)	eric.larson@wildlife.ca.gov
Brendan O'Neil	Primary	California State Parks	707-865-3129 (w)	BONEIL@parks.ca.gov
Damien Jones	Secondary	California State Parks	707-875-3907 (w)	dajone@parks.ca.gov
Stephen Bargsten	Primary	North Coast Regional Water Quality Control Board	707-576-2653 (w)	Stephen.Bargsten@waterboards.ca.gov

9.1 IMPLEMENTATION OF OUTLET CHANNEL MANAGEMENT ACTIVITIES

A minimum of 24 hours of notice shall be provided to the Team by the Agency in advance of the excavation and maintenance of the outlet channel. Notice shall be submitted by e-mail (see Attachment B.1 for sample) with a general description of the proposed action to be pursued and will typically include:

- Proposed date and time of implementation;
- Design schematic of proposed channel which shall include:
  - Approximate antecedent beach berm height and width;
  - Proposed location and alignment of outlet channel;
  - Approximate outlet channel dimensions including bed elevation, channel depth, width, length, slope and aspect with respect to beach face
  - Predicted estuary water surface elevation at the time of implementation;
- Current river discharge at USGS Guerneville gage (website: http://waterdata.usgs.gov/nwis/uv?cb_00060=on&cb_00065=on&format=gif_stats&period=21&site_no=11467000)
- Predicted 24 hour precipitation as estimated by the NOAA National Weather Service for Bodega Bay (website: http://forecast.weather.gov/MapClick.php?CityName=Bodega+Bay&state=CA&site=MTR&textField1=38.3333&textField2=-123.047&e=0&FcstType=graphical;
- Predicted deep water swell height, period, and direction at San Francisco as estimated by CDIP (website: http://cdip.ucsd.edu/?nav=recent&sub=forecast&units=metric&tz=UTC&pub=public)
- For maintenance actions a general description of maintenance to be performed;
- Presence of seal pups; and
- Equipment to be used for implementation.

Team members shall provide any comments or suggestions to the approach in writing within 12 hours of the proposed implementation time. If Agency does not receive any comments before this time it is assumed that there are no comments to the proposed action. Comments and recommendations will be recorded for consideration on that management action or future management actions, and the Agency will do its best to respond to comments prior to implementation.

9.2 COMPLETION OF OUTLET CHANNEL MANAGEMENT ACTIVITIES

Within 36 hours of completion of outlet channel excavation or maintenance activities the Agency shall provide the Team a summary of work performed. This summary will be submitted by e-mail and will typically include:

- Date, time and period of implementation;
- Estuary water surface elevation at the time of completion;
- River discharge at USGS Guerneville gage at time of completion
- Deep water swell at CDIP Pt. Reyes buoy at time of completion

- Approximate location of the centerline of the channel mouth in distance along beach berm north of the jetty;
- Approximate orientation of channel along the beach berm;
- Approximate dimensions and orientation of the excavated channel;
- Approximate water depth in the excavated channel;
- For maintenance actions, a general description of maintenance performed;
- Equipment used during implementation;
- Presence of seal pups; and
- Photos documenting work completed.

9.3 OVERRIDING CONDITIONS

Certain conditions such as declines in water quality or imminent flooding to properties and structures in the estuary could drastically change the course of management outlined in this plan and may force the Agency to breach the estuary. The Agency shall stay in close contact with the Team on the development of any conditions which could affect the overall course of management. However, rapidly changing conditions may limit the notification lead time given to the Team in advance of management actions to alleviate flooding or water quality concerns.

9.3.1 Flooding

Based on past management experience in the estuary, the Agency has found that if the estuary is in a closed condition, medium to large storm events can produce very rapid rises in estuary water levels. These storm events are frequently accompanied by large ocean swells which can close the estuary if outflows through the channel are not high enough to counteract the wave forces produced from the large swells. Management to avoid flooding is complicated by safety concerns; the Agency is unable to operate equipment required for channel management activities if ocean swells are too large. In the past the Agency has typically breached the estuary in anticipation of a large storm in order to prevent flooding.

The high water surface elevations pursued under this plan will diminish the storage capacity of the estuary to handle high inflows. Also, based on past management experience, the Agency believes that the outlet channel as described in this plan will be especially susceptible to closure from large swell events. In an effort to avoid flooding of properties in the estuary during the outlet channel management period, the Agency will consult with the Team regarding the possibility of breaching the estuary in anticipation of a large storm event.

9.3.2 Decline in Water Quality

Declines in water quality could have impacts to salmonids rearing in the estuary, other species which reside in the estuary and the public. Potential water quality concerns include, but are not limited to:

- Dissolved oxygen conditions becoming dangerously low to fish and other species;
- Elevated salinity levels in domestic water wells; and
- Elevated bacterial levels.

The Agency will stay in contact with the Team regarding water quality conditions during the management period. Should conditions get to the point that they are potentially dangerous to salmonids, other species, or the public, the Agency shall consult with the Team on potentially changing the course of management. In cases of high bacterial levels, the Agency will additionally consult with North Coast Regional Water Quality Control Board and the Sonoma County Department of Public Health on potential management actions.

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11. LIST OF PREPARERS

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12. FIGURES

Source: Sonoma County Orthophotography (April-May, 2000)

figure 1

Russian River Estuary Outlet Channel Management Plan

Russian River Estuary Site Location

PWA Ref# - 1958.02

PWA

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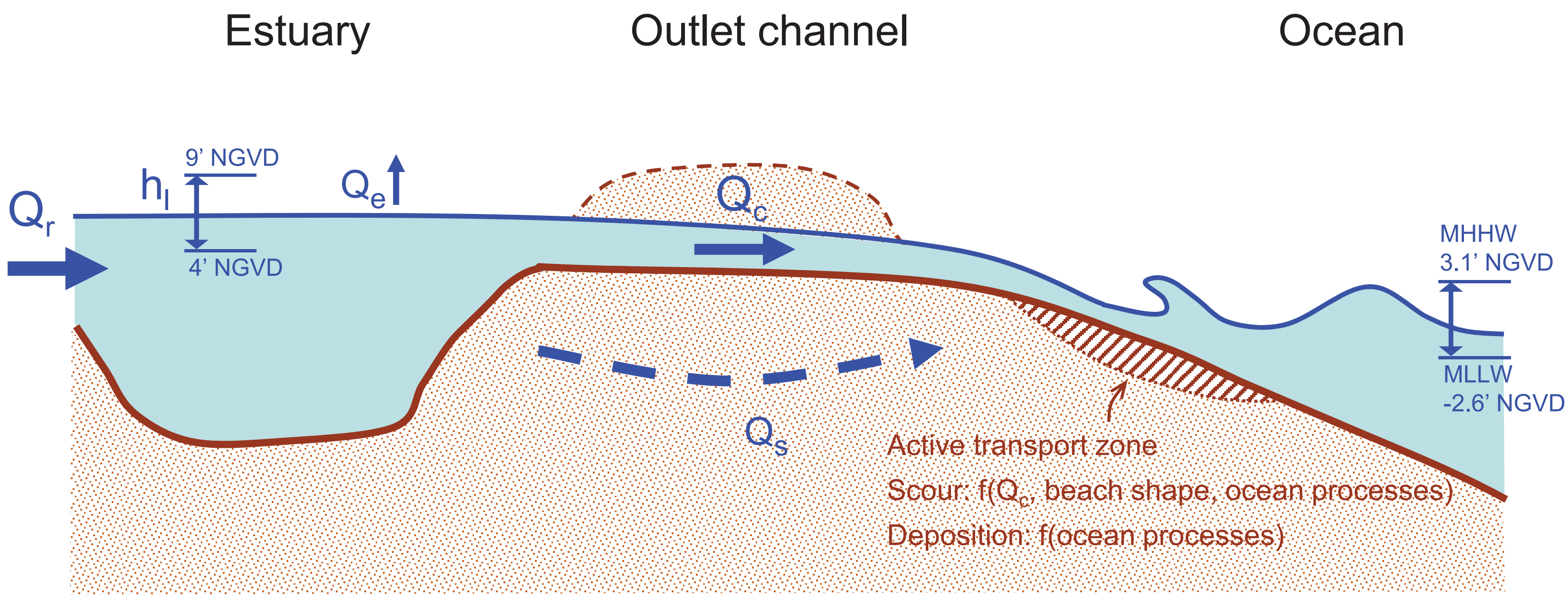


Parameters

h_l=lagoon water level
Q_r=river discharge
Q_c=outlet channel discharge
Q_s=seepage discharge
Q_e=evaporation from lagoon

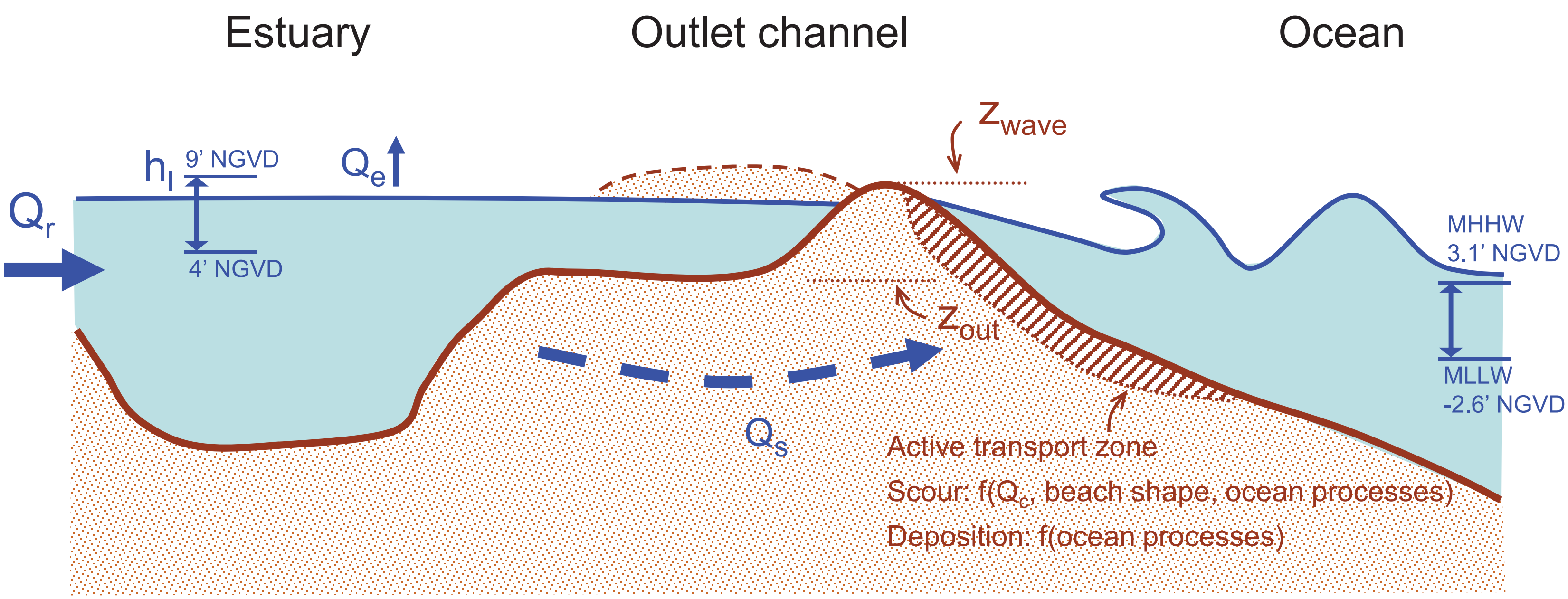
Processes

- $Q_r = Q_c + Q_e + Q_s$ (averaged over days)
- No sediment transport within outlet channel
- Active sediment transport outside outlet channel

figure **2**
Russian River Estuary Outlet Channel Management Plan

Conceptual model – Target conditions

PWA Ref# 1958.01



Parameters

z_{out}=target channel bed elevation

z_{wave}=wave runup elevation; f(wave conditions, ocean water level, channel location)

Processes

- $z_{wave} \geq z_{out}$
- wave-induced sediment transport closes outlet channel
- $Q_c \rightarrow 0$
- h_l increasing

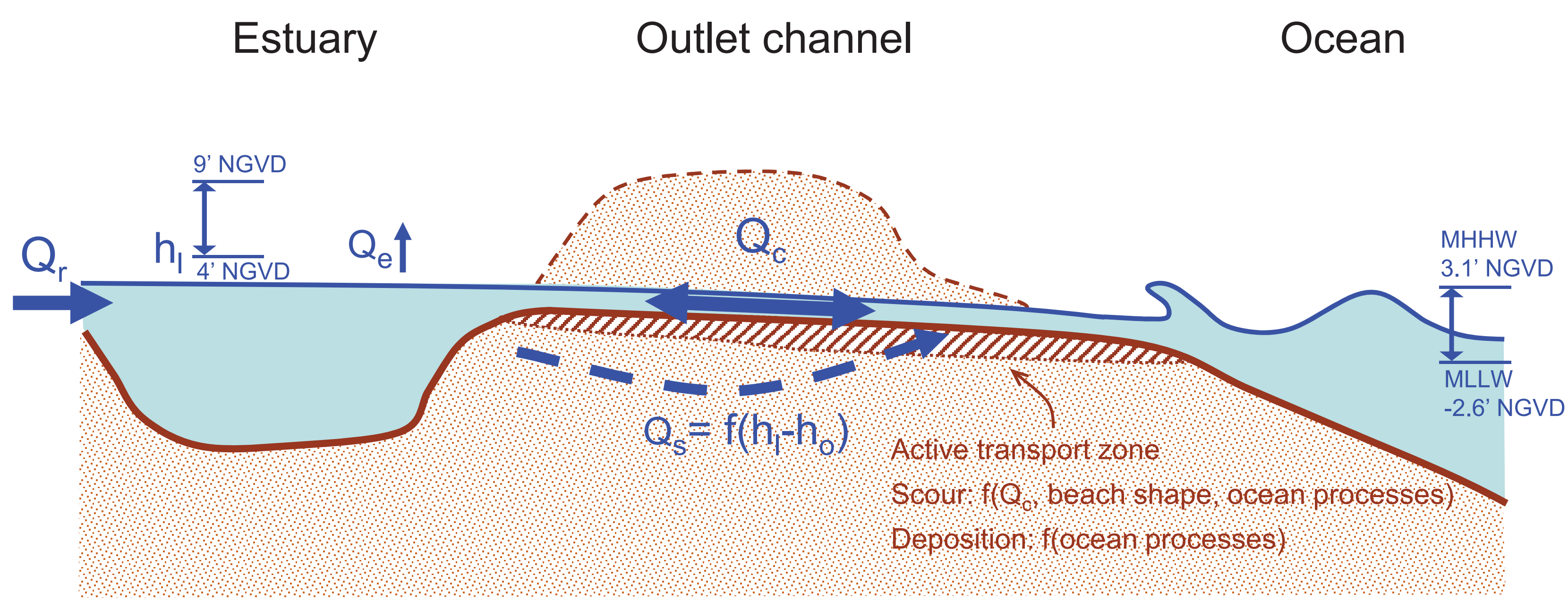
figure **3**

Russian River Estuary Outlet Channel Management Plan

Conceptual model – Closure

PWA Ref# 1958.01

PWA



Parameters

u_c= f(channel slope, length, and width; Q_r; ocean water level)
(can be managed to greater or lesser degree)

u_{crit} is f(grain size)

Processes

- $u_c > u_{crit}$; high velocities scour channel
- Q_s increases; high seepage creates groundwater piping and erosion
- sediment transport within outlet channel

figure **4**

Russian River Estuary Outlet Channel Management Plan

Conceptual model – Breaching

PWA Ref# 1958.01

PWA

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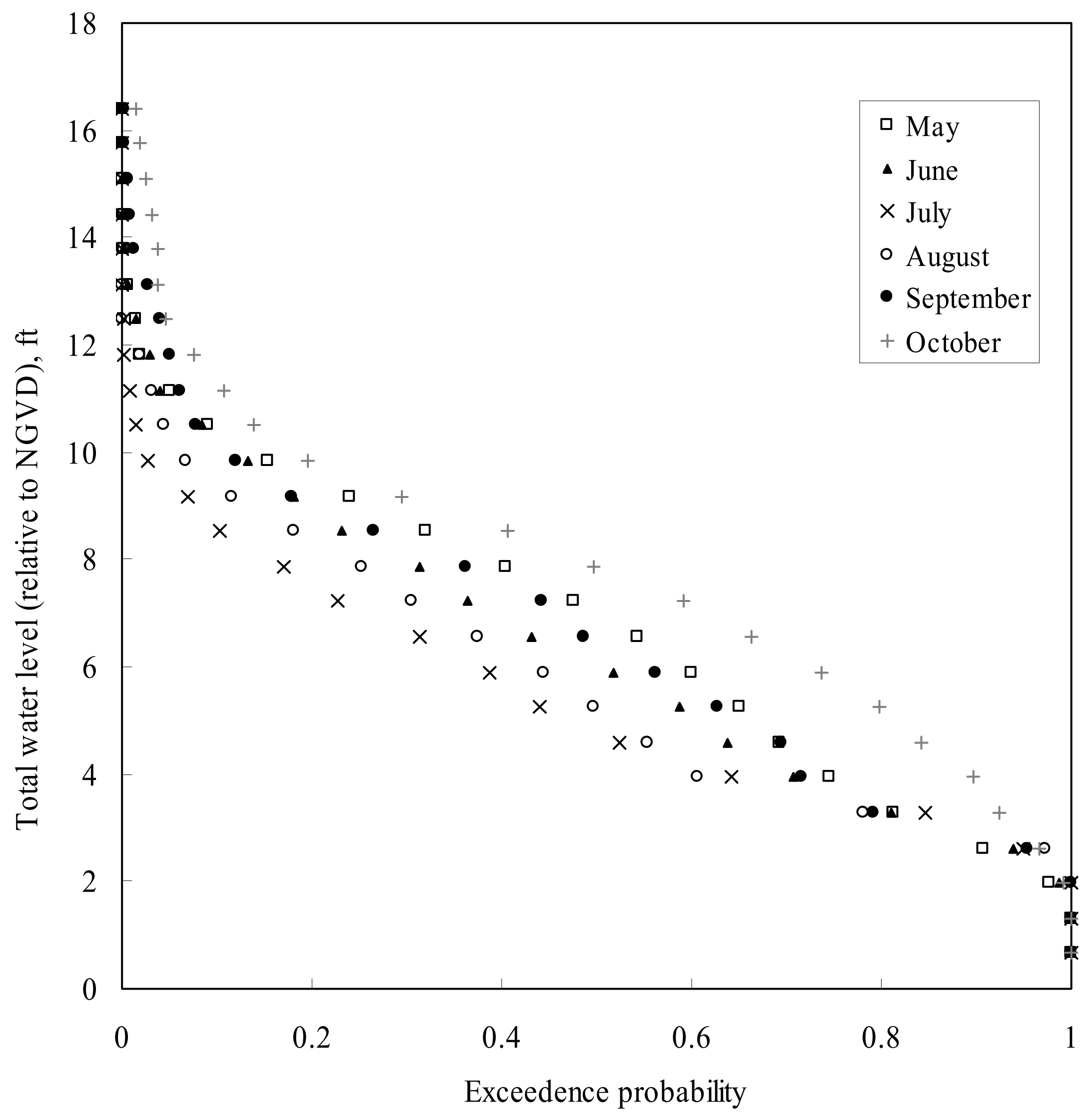


Source: D. Behrens (unpublished). Wave data from CDIP Point Reyes buoy.
Note: Total water level calculated as sum of daily higher high tide and wave runup elevation. Wave runup calculated from Stockdon et al (2006) using estimated de-shoaled deepwater equivalent wave heights.

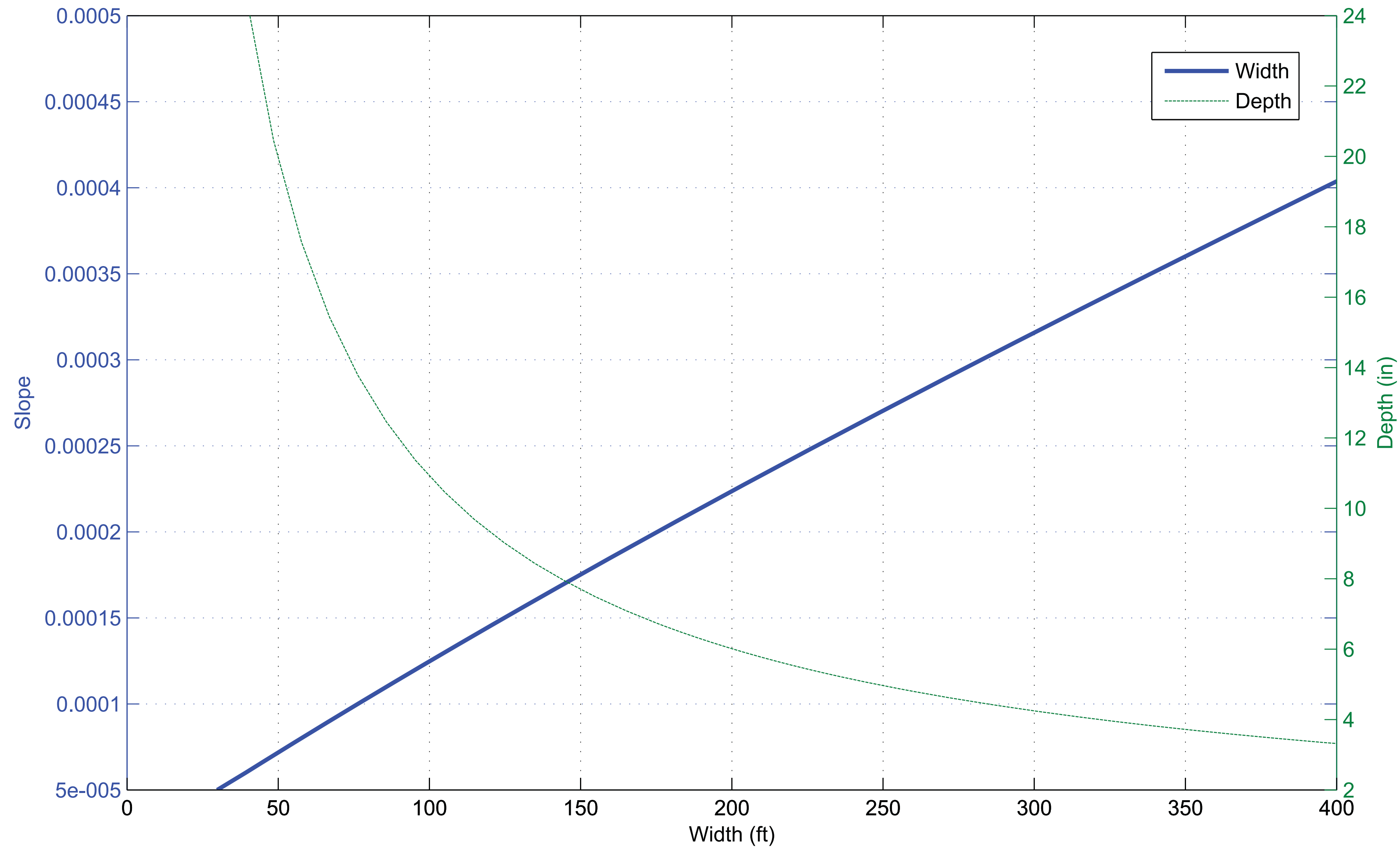
figure **5**

Russian River Outlet Channel Management Plan

Total Water Level Exceedance, May-Oct

PWA Ref# 1958.01

PWA



Source: Stability curve for local bed shear stress of 0.5 Pa, flowrate of 70 cfs, and Manning's roughness of 0.02.

Figure 6
Russian River Estuary Outlet Channel Management Plan

Slope vs. Width Stability Plot

PWA Ref# 1958.01

PWA

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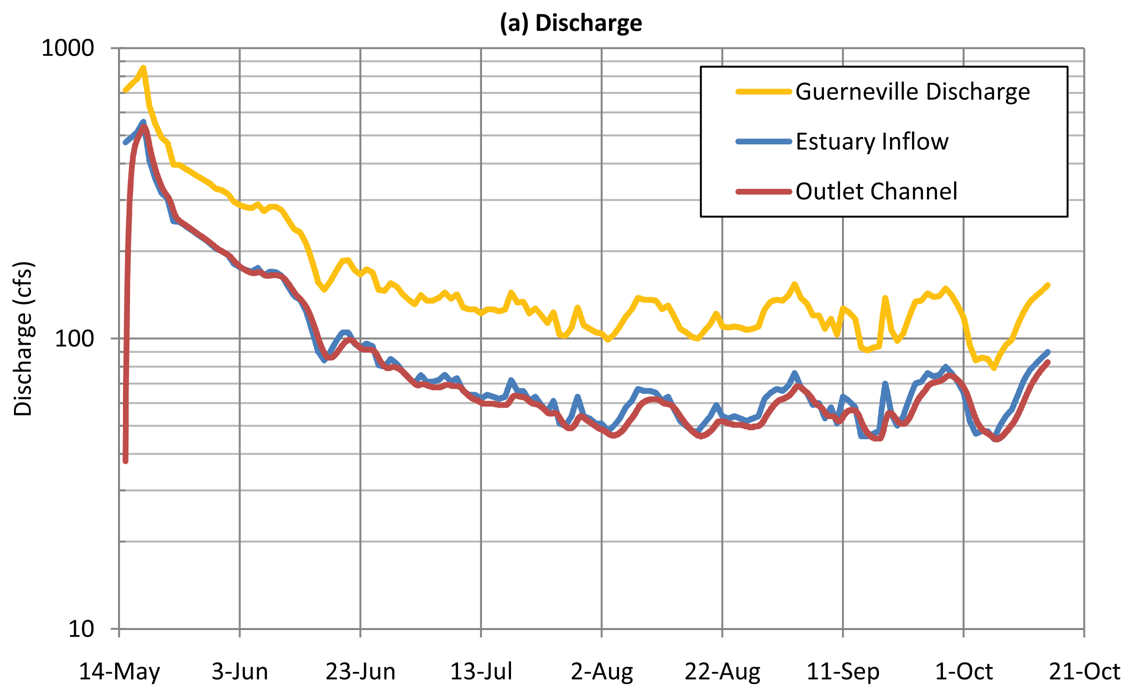
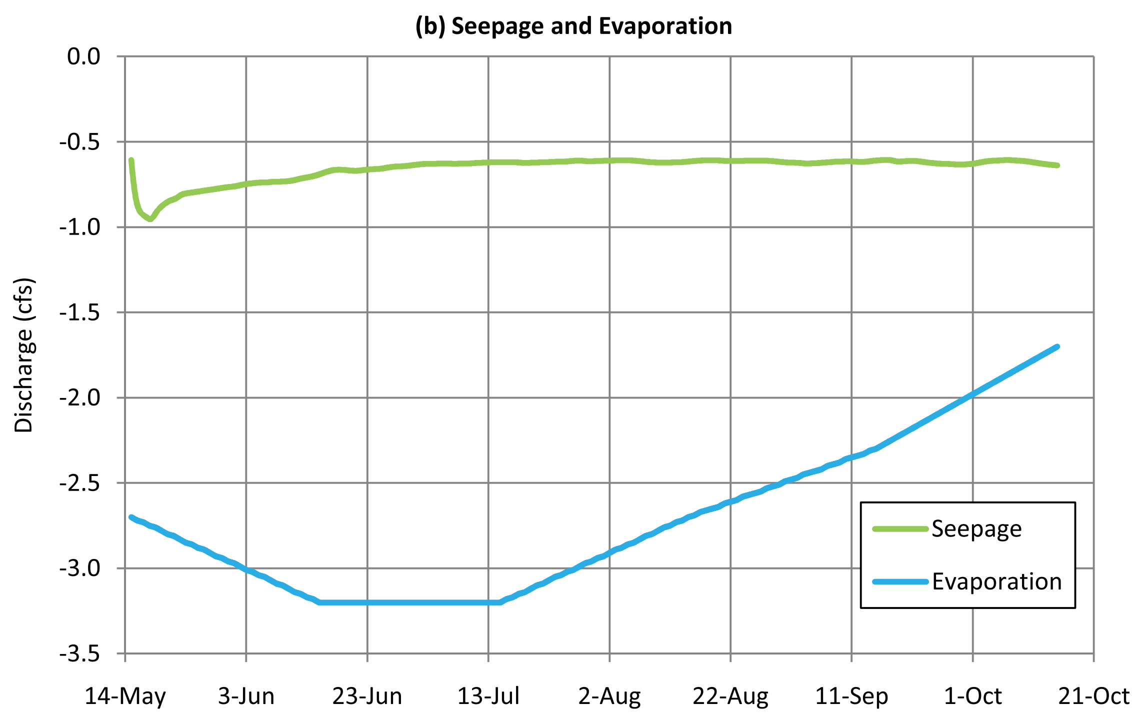




Source: 2010 anticipated discharge at Guerneville and into lagoon calculated by scaling observed 2000 discharge at USGS gage #11467000 (Russian River near Guerneville, CA). Evaporation rates calculated from monthly climatological rates for CIMIS evapotranspiration zone 1 (California coast).

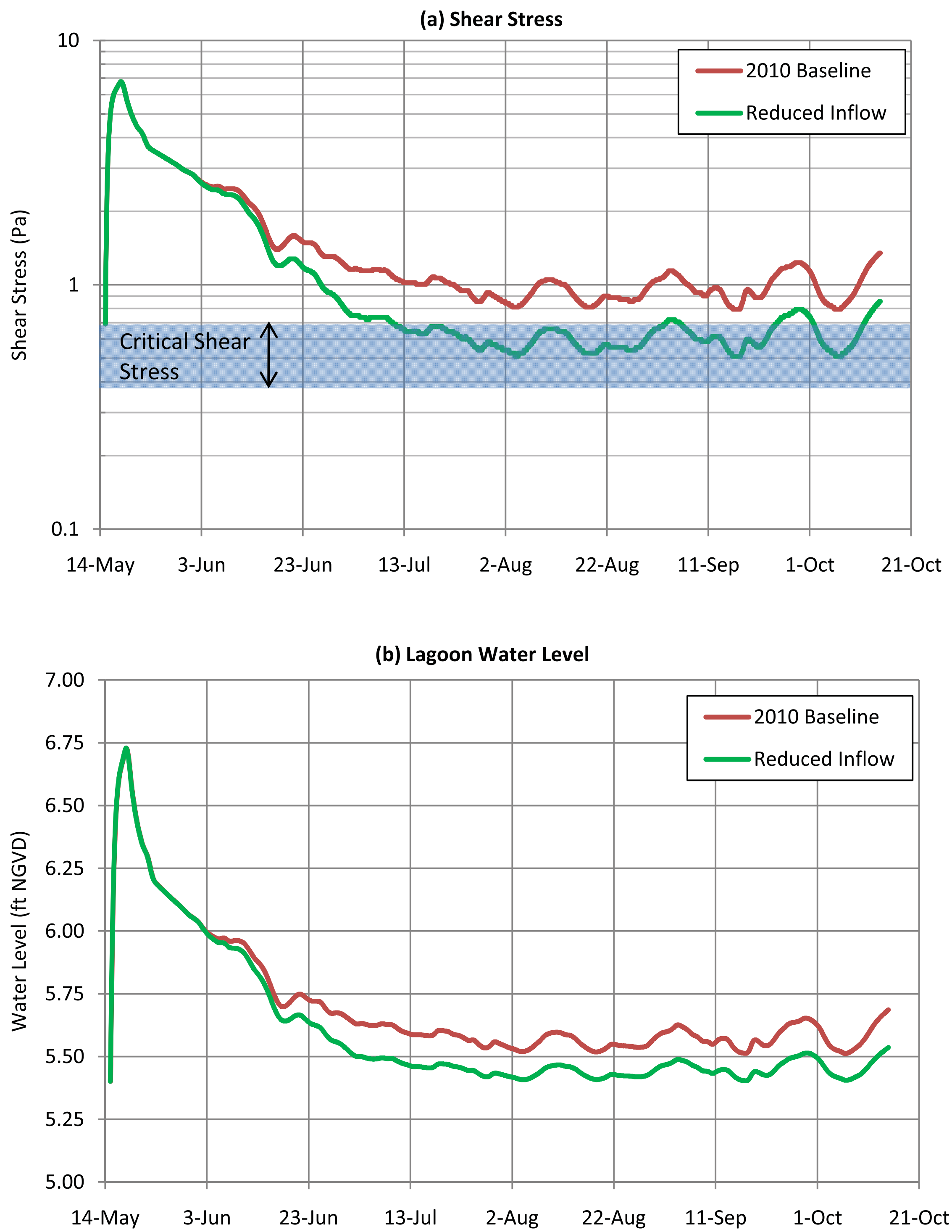
figure 7

Russian River Estuary Outlet Channel Management Plan

Hydraulic Model Discharge - 2010 Anticipated Hydrology

PWA Ref#: 1958.01

PWA



Notes: Baseline channel geometry: width=100 ft, length=300 ft, bed=5 ft NGVD, n = 0.02.
Source: HEC-RAS hydraulic model results for outlet channel.

figure **8**

Russian River Estuary Outlet Channel Management Plan

Hydraulic Model Results - 2010 Anticipated Hydrology

PWA Ref#: 1958.01

PWA

1958.01_2010_Rev_Anticipated_Operations.xls

ATTACHMENT A: SUPPORTING WORKSHEETS FOR CHANNEL CONFIGURATION ANALYSIS

Worksheets

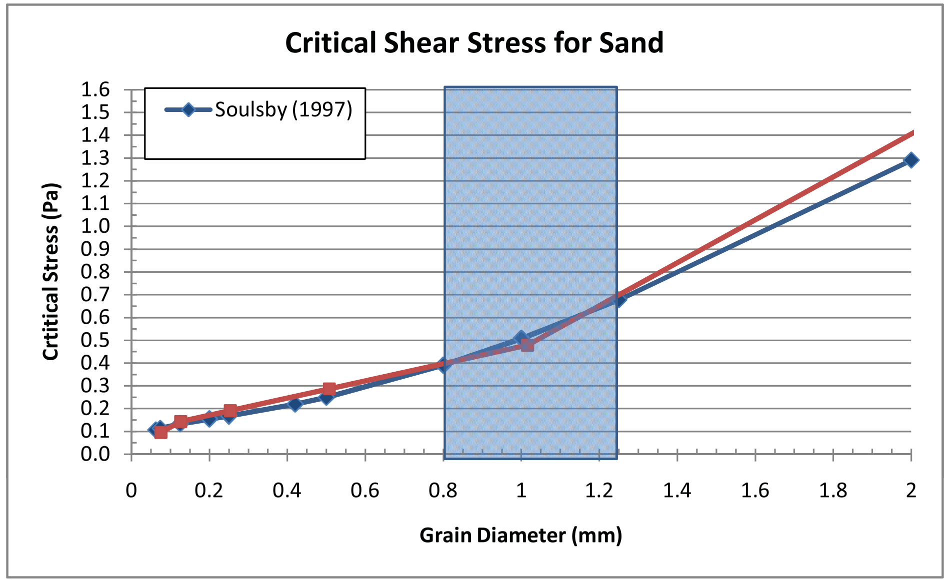
A-1. Critical shear stress for incipient motion of sane particles
A-2. Manning's n
A-3. Evaporation
A-4. Berm seepage
A-5. Mouth closure
A-6. Russian River discharge

A-1. Critical shear stress for incipient motion of sand particles

1958.01 Russian River Estuary Outlet Channel
J. Vandever (PWA)
4/1/2009

Variables		
p	1000	kg/m^3
g	9.81	m/s^2
s	2.65	(quartz)
v	1.0E-06	m^2/s

D (mm)	D*	Theta_crit	tau_crit (Pa)	Grain Size
0.0625	1.58	0.105	0.11	Very Fine Sand
0.074	1.87	0.094	0.11	
0.125	3.16	0.066	0.13	Fine Sand
0.20	5.06	0.048	0.15	
0.25	6.32	0.041	0.17	Medium Sand
0.42	10.62	0.032	0.22	
0.5	12.65	0.031	0.25	Coarse Sand
0.8	20.24	0.030	0.39	
1.0	25.30	0.031	0.51	Very Coarse Sand
1.25	31.62	0.033	0.68	
2.0	50.59	0.040	1.29	Granular



Notes: units Pa = N/m^2, assumes density of freshwater, quartz grained sand
Method based on Soulsby (1997) Dynamics of Marine Sand:

Note: does not account for gravitational effects on sloping bed

$$D_* = \left[\frac{g(s-1)}{\nu^2}\right]^{1/3} D$$

$$\theta_c = \frac{0.3}{1+1.2D_*} + 0.055\left[1-\exp(-0.020D_*)\right]$$

$$\tau_c = \rho(s-1)gd\theta_c$$

J:\1958.01RREAMPOutletChannel\Task 4 Prelim geometry\Prelim design calcs\1958.01_Critical_Shear_Stress.xls

A-2. Manning's n worksheet

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J. Vandever (PWA)
4/1/2009

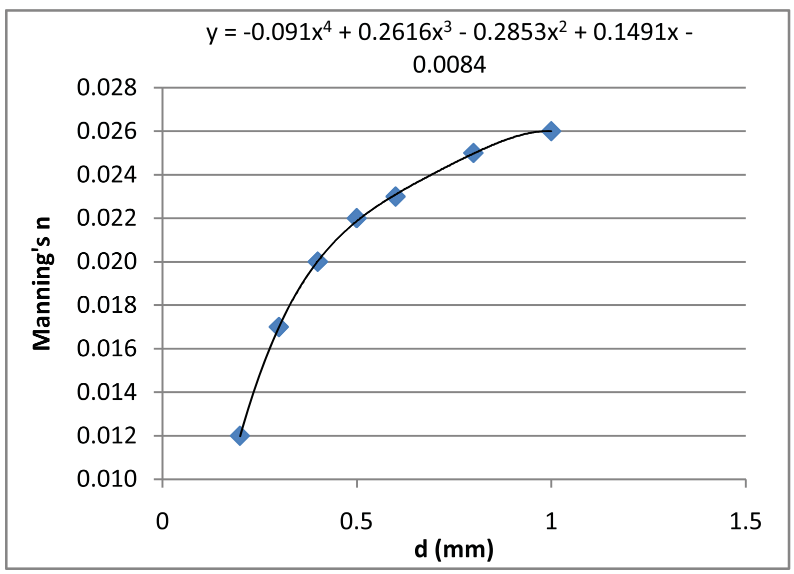
d_{50}	1	mm	0.003281	ft
D	0.84	ft		
Rh	0.83	ft		
S	0.00008	ft/ft		

Equation	n	Notes
Strickler (1923)*	0.018	*valid d range unknown
Limerinos (1970)*	0.021	
Bray (1979)*	0.017	
Bruschin (1985)*	0.018	
Julien (2002)*	0.024	
USGS (WSP2339)	0.026	for 0.2<d<1.0 mm
Average	**0.021**	
Average w/o USGS	**0.020**	

USGS

d (mm)	n
0.2	0.012
0.3	0.017
0.4	0.020
0.5	0.022
0.6	0.023
0.8	0.025
1.0	0.026
2.0	0.035

Polynomial fit to USGS data (d=2.0 mm not included):



A-3. Evaporation Worksheet

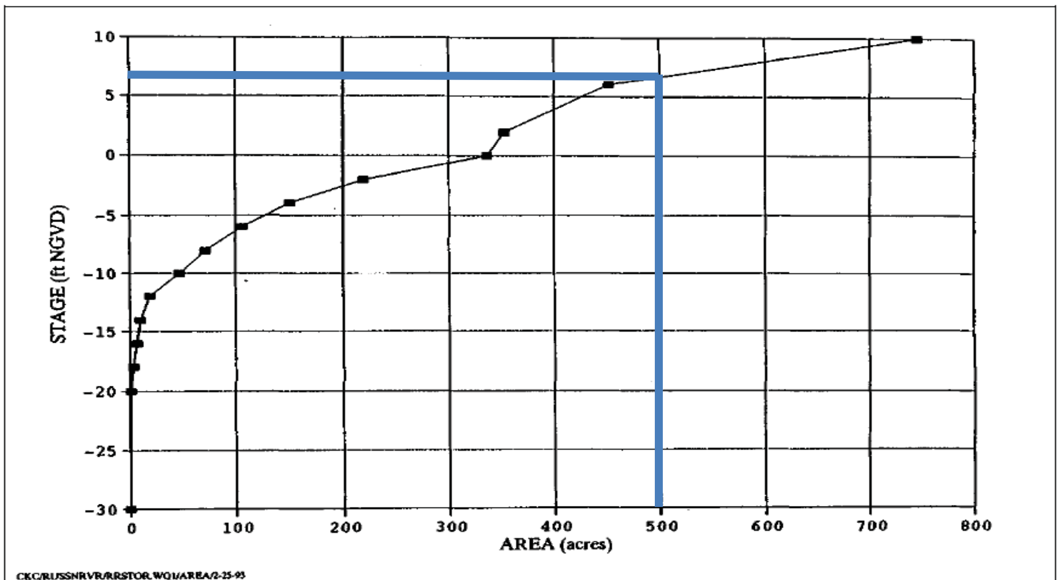
1958.01 Russian River Estuary Outlet Canal
J. Vandever (PWA)
15-Apr-09

CIMIS Reference Evapotranspiration (Eto) Zones
http://www.cimis.water.ca.gov/cimis/images/etomap.jpg

Russian River Estuary is located on California coast in Zone 1
(Coastal plains and heavy fog. Lowest Eto in California, characterized by dense fog)

	in/month	days	in/day	mm/day	cfs
Jan	0.93	31	0.03	0.76	0.6
Feb	1.40	28	0.05	1.27	1.1
Mar	2.48	31	0.08	2.03	1.7
Apr	3.30	30	0.11	2.79	2.3
May	4.03	31	0.13	3.30	2.7
Jun	4.50	30	0.15	3.81	3.2
Jul	4.65	31	0.15	3.81	3.2
Aug	4.03	31	0.13	3.30	2.7
Sep	3.30	30	0.11	2.79	2.3
Oct	2.48	31	0.08	2.03	1.7
Nov	1.20	30	0.04	1.02	0.8
Dec	0.62	31	0.02	0.51	0.4

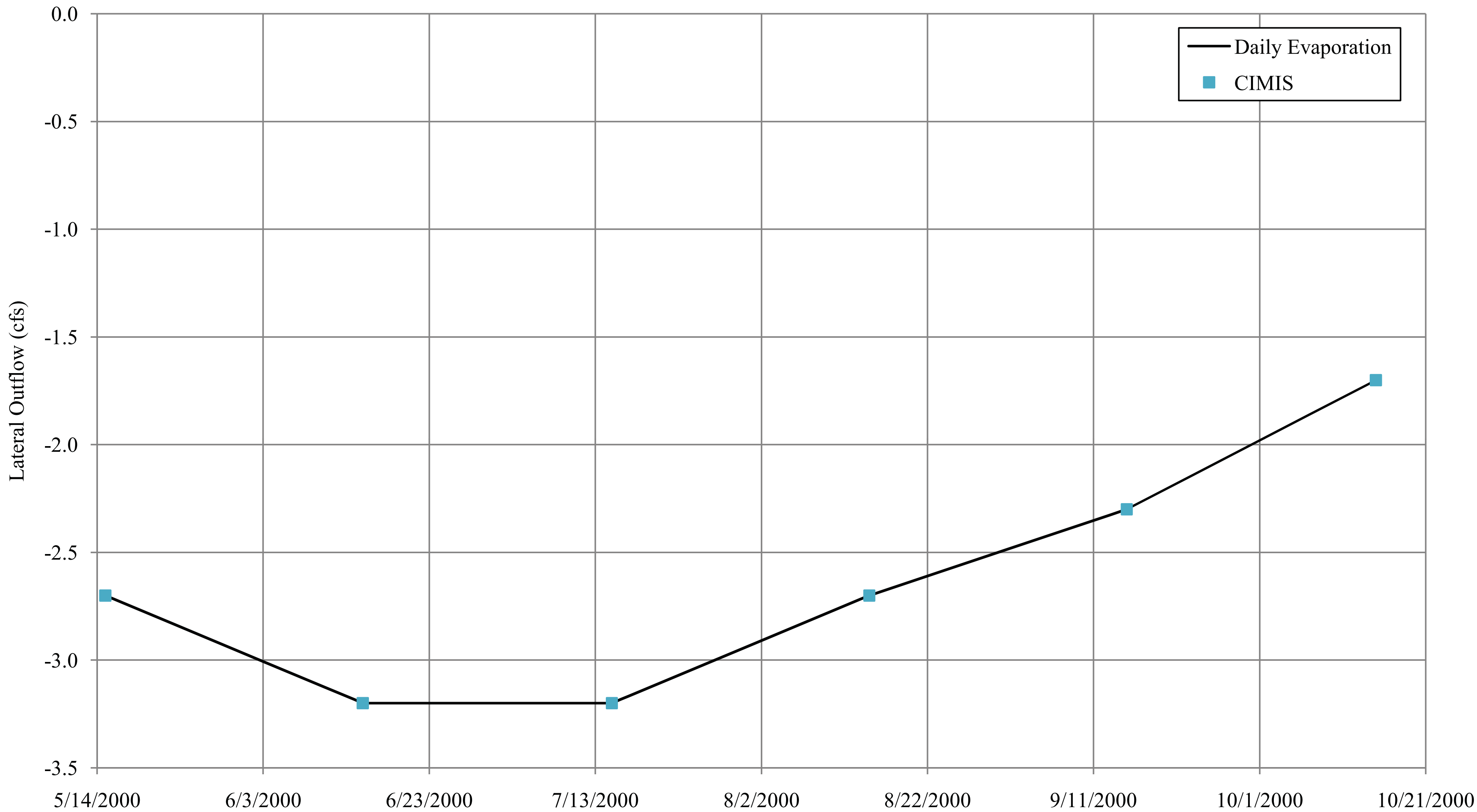
RRE Surface Area 500 acres
21,780,000 sq ft



Philip Williams & Associates, Ltd.
Consultants in Hydrology

Stage-Area Curve for Russian River Estuary - River Mouth to Monte Rio

Figure 5.6



Notes: Daily evaporation rates for Russian River lagoon interpolated from CIMIS average monthly evapotranspiration statistics for Zone 1 (Coastal plains and heavy fog). Calculations assume lagoon surface area of 500 acres.

Appendix ***A-3***

Russian River Estuary Outlet Channel Management Plan

HEC-RAS model evaporation boundary condition

PWA Ref #: 1958.01

PWA

J:\1958.01RREAMPOutletChannel\Task 5 Hydrologic modeling\Data\Evaporation\1958.01_RRE_Evaporation_Worksheet.xls

A-4. Berm Seepage and Hydraulic Conductivity

1958.01 Russian River Estuary Outlet Canal
J. Vandever (PWA)
16-Apr-09

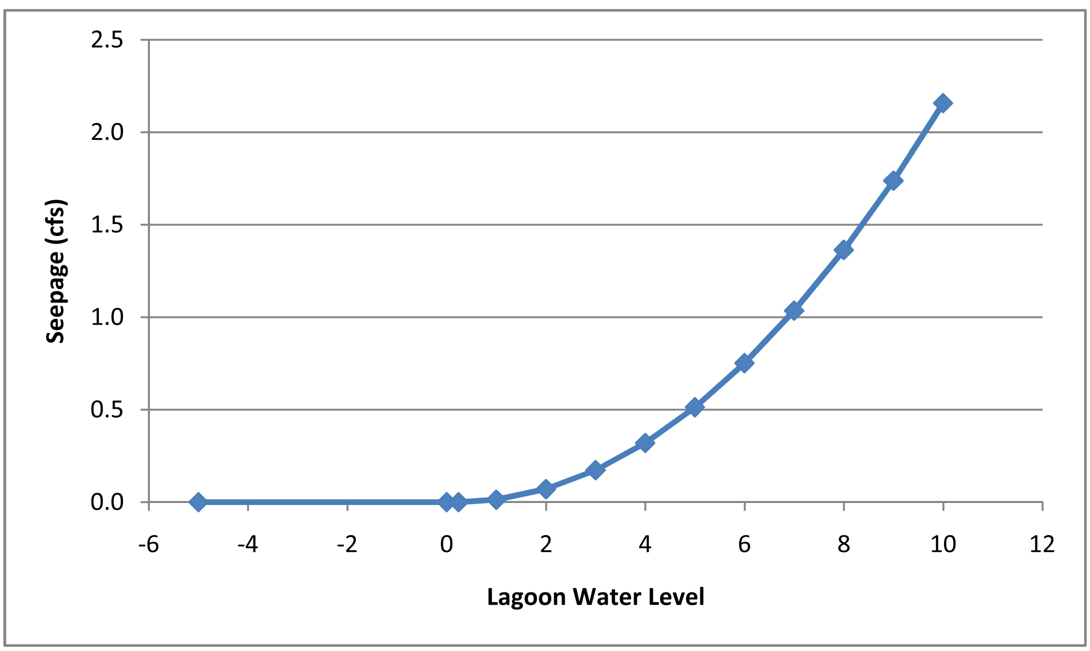
HEC-RAS Diversion Rating Curve

Lagoon WL (ft)	dh (ft)	q (cfs)	
-5	0	0.00	
0	0	0.00	
0.24	0	0.00	(MTL)
1	0.76	0.01	
2	1.76	0.07	
3	2.76	0.17	
4	3.76	0.32	
5	4.76	0.51	
6	5.76	0.75	
7	6.76	1.03	
8	7.76	1.36	
9	8.76	1.74	
10	9.76	2.16	(Flood Stage)
11	10.76	2.62	
12	11.76	3.13	

Darcy's Law

$$q = k\frac{\Delta h}{W}A = k\frac{\Delta h}{W}(\Delta h \cdot L)$$

W	250	ft
L	2500	ft
z_ocean	0.24	ft NGVD (MTL)
k	0.0023	ft/s



A-4. Berm Seepage and Hydraulic Conductivity

1958.01 Russian River Estuary Outlet Canal
J. Vandever (PWA)
7-Apr-09

Bouwer, H. 1978. Groundwater Hydrology. McGraw-Hill, Inc. 480 p.

	Hydraulic Conductivity (m/day)		Hydraulic Conductivity (cm/s)		
	Low	High	Low	High	Mid
Fine Sand	1	5	0.001	0.006	0.003
Medium Sand	5	20	0.006	0.023	0.014
Coarse Sand	20	100	0.023	0.116	0.069
Gravel	100	1000	0.116	1.157	0.637
Sand and Gravel	5	100	0.006	0.116	0.061

A-5. Mouth Closure Calibration Worksheet

1958.01 Russian River Estuary Outlet Canal
J. Vandever (PWA)
17-Apr-09

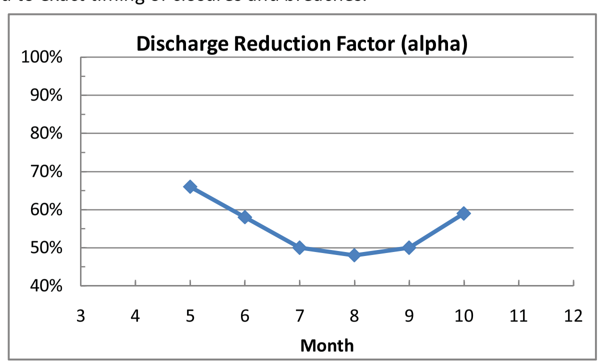
Russian River mouth closure calibrations - HEC-RAS model Years Examined: 2000, 2001, 2003, 2004, 2005, 2007
Accounts for losses between Hacienda Bridge (Guerneville, CA) and the lagoon and the interaction with the aquifer adjacent to the estuary.
No detailed information available for the aquifer groundwater elevations or extraction rates by wells. The loss term is a calibrated variable in the model.

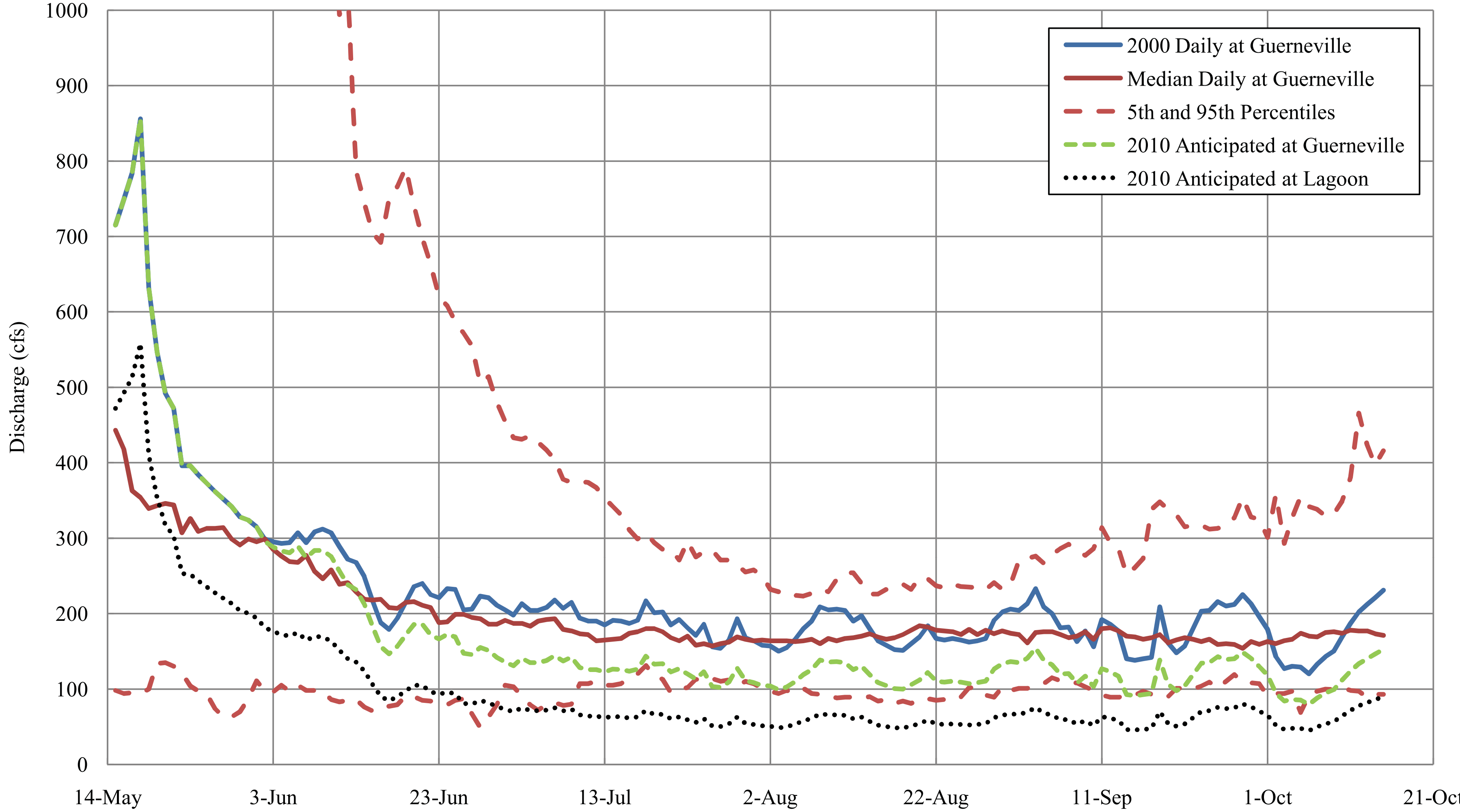
Lagoon Surface Area	400	ac
	17,424,000	sq ft
Evaporation and Seepage Losses	4	cfs

Calibration	Date		Water Level (ft NGVD)		dh	dt	dh/dt (ft/day)	dV/dt (cfs)	USGS Discharge (cfs)	% Reduction	alpha
Closure Event ID	Start	End	Start	End							
06May2000	5/6/2000 18:00	5/9/2000 6:00	3.10	8.40	5.30	2.50	2.12	432	580	26%	74%
24May2000	5/24/2000 8:00	5/25/2000 18:00	3.84	5.76	1.92	1.42	1.36	278	385	28%	72%
16June2000	6/16/2000 13:00	6/21/2000 6:00	4.79	6.90	2.11	4.71	0.45	94	200	53%	47%
25Aug2000	8/25/2000 0:00	9/5/2000 8:00	2.56	7.62	5.06	11.33	0.45	94	195	52%	48%
03Oct2000	10/3/2000 0:00	10/11/2000 12:00	2.85	6.53	3.68	8.50	0.43	91	140	35%	65%
15May2001	5/15/2001 23:00	5/21/2001 21:00	2.14	5.51	3.37	5.92	0.57	119	200	41%	59%
07Apr2007	4/7/2007 13:00	4/11/2007 0:00	1.17	7.68	6.51	3.46	1.88	384	480	20%	80%
13Apr2007	4/13/2007 21:30	4/17/2007 14:30	1.97	7.68	5.71	3.71	1.54	315	465	32%	68%
24Apr2007	4/24/2007 17:00	4/26/2007 14:00	1.51	7.57	6.06	1.88	3.23	656	725	10%	90%
13Oct2007	10/13/2007 2:30	10/22/2007 11:30	2.51	9.15	6.64	9.38	0.71	147	255	42%	58%
9June2003	6/9/2003 17:30	6/12/2003 1:00	2.77	6.47	3.70	2.31	1.60	322	475	32%	68%
9Oct2003	10/9/2003 23:11	10/14/2003 20:40	4.00	6.21	2.21	4.90	0.45	91	170	46%	54%
05Nov2004	11/5/2004 11:00	11/12/2004 4:00	2.40	8.93	6.53	6.71	0.97	196	300	35%	65%
26July2004	7/26/2004 15:41	8/5/2004 0:00	2.27	5.90	3.63	9.35	0.39	78	140	44%	56%
2May2004	5/2/2004 15:40	5/6/2004 19:35	3.44	8.39	4.95	4.16	1.19	240	420	43%	57%
16Apr2004	4/16/2004 9:09	4/18/2004 7:40	4.78	7.98	3.20	1.94	1.65	333	570	42%	58%
3Oct2005	10/3/2005 23:00	10/17/2005 6:30	2.40	8.30	5.90	13.31	0.44	89	170	47%	53%
17Sep2005	9/17/2005 2:00	9/21/2005 13:30	3.37	5.69	2.31	4.48	0.52	104	175	40%	60%

Note: Start and end times represent times used for water level calibration and do not correspond to exact timing of closures and breaches.

Month	Month	% Loss	N	HEC-RAS Multiplier
April	4	26%	4	
May	5	34%	4	66%
June	6	42%	2	58%
July	7	44%	1	50%
Aug	8	52%	1	48%
Sep	9	40%	1	50%
Oct	10	43%	4	59%
Nov	11	35%	1	
			18	





Notes: Median daily discharge calculated from 1970-2008.
Source: USGS gage 11467000 (Russian River near Guerneville, CA). 2010 anticipated discharge at Guerneville calculated from 2000 discharge by scaling factor to obtain typical summertime flowrates of 120 cfs. 2010 anticipated lagoon inflow calculated based on calibrated seasonal losses from Guerneville to lagoon.

Appendix A-6

Russian River Estuary Outlet Channel Management Plan

Daily Russian River Discharge

PWA Ref #: 1958.01

PWA

J:\1958.01RREAMPOutletChannel\Task 5 Hydrologic modeling\Data\Streamflow\USGS_11467000_WaterYear_2000.xls

Attachment B. Hypothetical Implementation Scenario

The following hypothetical implementation scenario is presented to demonstrate how the outlet channel management plan may be implemented. The scenario is based on actual beach berm and ocean conditions observed at the estuary from June 30 to July 6, 2009.

This scenario is purely hypothetical and demonstrates how the adaptive management plan may be implemented based on historical conditions observed in 2009. Actual implementation of the plan may vary in terms of channel geometry, channel location and time required for implementation. The beach environment at the project site is highly dynamic so actual implementation of the plan will be evaluated on a case-by-case basis.

<u>Wednesday, June 30th</u>

Agency personnel have been tracking riverine and ocean conditions on a daily basis during the outlet channel management period. Several days ago, they identified a forecasted ocean swell event with the potential to close the estuary. When it arrives, this medium-sized (2-4 ft.) ocean swell, angled from the southwest, pushes sand into the tidal inlet cutting flow from the estuary to the ocean. Stage in the estuary at the time of closure is approximately 3.5 ft NGVD. Based on river discharge and the time of year, Agency personnel estimate that the estuary water level's rate of rise will be 0.5 ft/day.

<u>Thursday, July 1st</u>

Agency personnel visit the site to assess sandbar conditions. The outlet at the time of closure is just south of Haystack Rock, approximately 550 ft northwest of the jetty, with an alignment roughly perpendicular to the beach face. The preexisting channel slope is steep and would, therefore, be susceptible to scour and wave run-up. Agency decides that this is not the preferable alignment for the outlet channel. In effort to create a channel which has shallower gradient and less susceptible to ocean conditions, it is decided that the channel will be more ideally located to the north of Haystack Rock angled to the northwest. Agency staff collects measurements and limited survey data (e.g. elevation at low point of the berm) in the area to develop a design for the outlet channel.

[Note: If closure had occurred during the pupping season (March 15 – June 30), the site assessment would have included a survey for the presence of seal pups.]

Agency staff returns to their offices to develop a plan and design for the implementation of the outlet channel. Changes between the most recent monthly topographic data and current conditions are assessed using the time-lapse photography and today's survey data. If indicated, today's survey data and judgment may be used to revise the topographic data.

Stage in the estuary is now approximately 4.0 ft. NGVD. Observations from the Jenner gage are used to confirm the previously estimated rate of water surface rise of 0.5 ft/day. Based on current stage and this rate of water surface rise, implementation of the outlet channel is scheduled for Monday and Tuesday, July 5th and 6th so that stage in the estuary will be approximately 6.5 ft. NGVD after the outlet channel is completed.

A design is prepared using the best available topographic data. The outlet channel will be approximately 30 ft wide with 4:1 side slopes, 350 ft long to the mean high tide line, a channel bottom elevation at the inlet of approximately 6 ft NGVD, and a channel design flow depth at time implementation of approximately 0.5 ft. Channel will be aligned to the northwest with an approximate aspect of 35° with respect to the beach face. Estimated material to be excavated is approximated and confirmed to be less than 1,000 yd^3.

Agency staff prepares e-mail to management team to notify them of intention and schedule to construct the outlet channel, provide information regarding current conditions, and provide team with a design schematic according to the Communication Protocol procedure documented in Section 7.8.1 of the management plan. Please see Attachments B.1 and B.2 for an example of e-mail transmittal with attached design schematic. Agency biologists coordinate with Stewards of the Coast and Redwoods to schedule volunteers to assist with pre-, day of, and day after outlet channel creation pinniped monitoring.

Friday, July 2nd

Agency staff receives comments from management team on proposed approach. Time allowing, Agency responds, modifies the proposed approach as needed, and decides on the final approach.

Agency staff reviews rate of water surface rise in the lagoon to confirm that flooding is not expected before proposed management action.

Monday and Tuesday, July 5th and 6th

Agency maintenance crews arrive at the Goat Rock State Beach parking lot early in the morning to prepare for implementation. Agency biologist arrives to begin pinniped monitoring at least one hour prior to crews and coordinates with maintenance crew leader. Agency surveyors stake out designed channel and make corrections to alignment and channel geometry to account for potential changes in beach berm topography since last topographic survey. Outlet channel excavation is carried out according to Section 7.5 of the management plan and according to the plan submitted to the management team. Implementation is also conducted in accordance with the Agency's IHA for harbor seals, northern elephant seals and California sea lions which may be present at the site during excavation activities. Photos are taken to document all implementation activities, and following completion of the outlet channel Agency staff collects measurements of completed channel geometry, flow depth and location.

Wednesday, July 7th

Agency staff sends e-mail to management team to provide documentation of the completion of the outlet channel according to the Communication Protocol procedure documented in Section 7.8.2 of the management plan. Please see Attachment B.3 for an example of e-mail transmittal.

After implementation of the channel, the Agency will monitor performance of the outlet channel according to the monitoring program described in Section 7.7 of the management plan.

Attachment B.1: Sample Proposed Outlet Channel Implementation Email

Date: 7/1/10

Hello Outlet Channel Management Team -

The Russian River Estuary closed on 6/30/10. The Sonoma County Water Agency plans to implement an outlet channel beginning at 7 am on July 5th and potentially extending to the afternoon of July 6th. Details of the proposed outlet channel are the following:

- Channel Width: 30 ft.
- Channel Length: 350 ft.
- Channel Bottom Elevation: 6 ft NGVD
- Design Flow Depth: 0.5 ft
- Location of Channel Inlet Centerline: 970 ft northwest of jetty
- Channel Alignment Aspect: 35 deg. with respect to beach face
- Estimated Estuary WSEL at Time of Completion: 6.5 ft
- Existing Beach Berm Crest Elevation: 10 ft NGVD
- Existing Beach Berm Width: 300 ft
- Excavation Equipment: 1 Excavator, 1 Bulldozer

Attached is a design drawing developed using the most recent topographical survey (6/30/10). Due to the highly dynamic nature of conditions at the site, actual topography at the time of implementation may vary. Implementation of the channel may differ from design in order to account for changed topography.

Current and predicted conditions at the site are the following:

- **River and Estuary:**
  - Russian River near Guerneville Flow (USGS 11467000): 120 cfs
  - Predicted 72 hour precipitation: 0 in.
- **Ocean:**
  - Approximate rate of estuary water surface rise: 0.5 ft/day
  - Current Swell Height and Direction: 5.8 ft @ 10 sec. @ 320 deg.
  - 7/5/10 Predicted Mean Swell Height and Direction: 2.5 ft @ 15 sec. @ 200 deg.

No seal pups were observed on the beach.

For updates on conditions please visit the following URL:

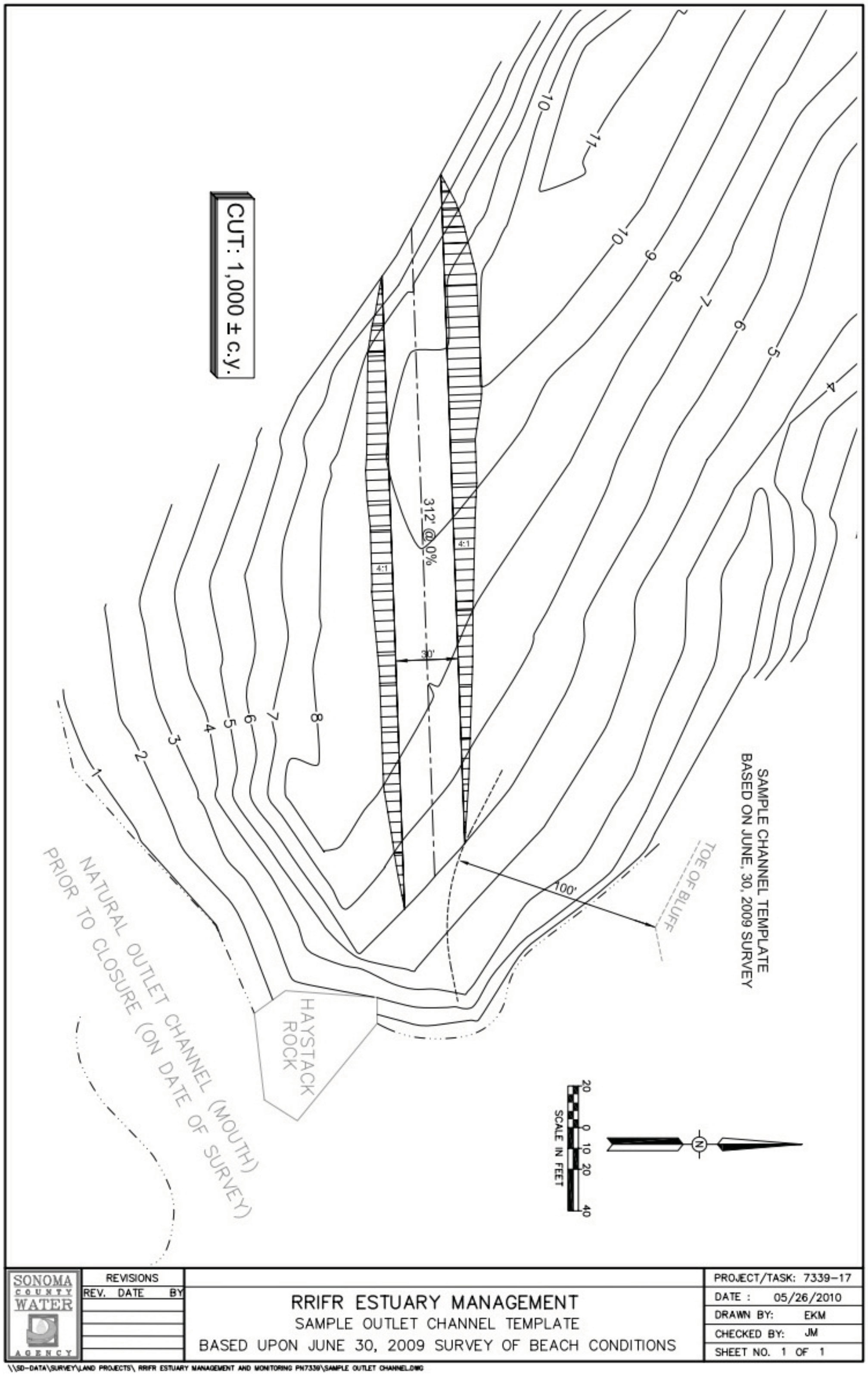
http://www.bml.ucdavis.edu/boon/russianriver

If you have any comments to the proposed implementation plan please provide comments no later than 7/2/10, 5 pm. Should you have any questions or concerns please contact me or Jessica Martini-Lamb at jessicam@scwa.ca.gov, 707-547-1903 (office), 707-322-8177 (mobile).

Sincerely,

Chris Delaney, P.E.
Agency Engineer
Sonoma County Water Agency
707-547-1946 (office)
707-975-5606 (mobile)

Attachment B.2: Sample Proposed Outlet Channel Design Schematic



Attachment B.3: Sample Proposed Outlet Channel Implementation Email

Date: 7/8/10

Hello Outlet Channel Management Team -

The Russian River Estuary closed on 6/30/10. The Sonoma County Water Agency implemented an outlet channel beginning at 7 am on July 5th and extending to the afternoon of July 6th. Details of the implemented outlet channel are the following:

- Channel Width: 30 ft.
- Channel Length: 350 ft.
- Channel Bottom Elevation: 6 ft NGVD
- Flow Depth: 0.7 ft
- Location of Channel Inlet Centerline: 970 ft northwest of jetty
- Channel Alignment Aspect: 35 deg. with respect to beach face
- Estuary WSEL at Time of Completion: 6.7 ft
- Existing Beach Berm Crest Elevation: 10.2 ft NGVD
- Existing Beach Berm Width: 300 ft
- Excavation Equipment: 1 Excavator, 1 Bulldozer

Attached are photographs of the beach before, during, and after the outlet channel implementation.

Current and predicted conditions at the site are the following:

- **River and Estuary:**
  - Russian River near Guerneville Flow (USGS 11467000): 115 cfs
  - Predicted 72 hour precipitation: 0 in.
- **Ocean:**
  - Current Swell Height and Direction: 2.7 ft @ 14 sec. @ 200 deg.
  - 7/10/10 Predicted Mean Swell Height and Direction: 2.4 ft @ 12 sec. @ 200 deg.

No seal pups were observed on the beach.

For updates on conditions please visit the following URL:

http://www.bml.ucdavis.edu/boon/russianriver

If you have any comments on the implemented channel, please provide comments no later than 7/12/10, 5 pm. Should you have any questions or concerns please contact me or Jessica Martini-Lamb at jessicam@scwa.ca.gov, 707-547-1903 (office), 707-322-8177 (mobile).

Sincerely,

Chris Delaney, P.E.
Agency Engineer
Sonoma County Water Agency
707-547-1946 (office)
707-975-5606 (mobile)

Attachment C. Summary of Land Use Permits
(Revised April 5, 2016)

List of Valid Permits and Agreements for the Russian River Estuary Management Project

Page	Agency	Permit No.	Expiration
C-1	California Department of Fish and Wildlife	Lake and Streambed Alteration Agreement (1600-2010-0380-R3)	December 31, 2020
C-6	California Regional Water Quality Control Board, North Coast Region	Section 401 Water Certification (1B10122WNSO)	May 14, 2019
C-11	California Coastal Commission	Coastal Development Permit 2-12-004	August 15, 2016
C-20	US Army Corps of Engineers, San Francisco District	Section 404 & Section 10, Individual Permit (2004- 285610N)	December 31, 2023
C-21	California Environmental Quality Act		None
C-21	California State Lands Commission	General Lease, Public Agency Use (PRC 7918.9)	December 31, 2023
C-24	California Department of Parks and Recreation	Temporary Use Permit	December 31, 2015 (renewal requested)
C-31	California Department of Parks and Recreation	Collections Permit	April 2, 2017
C-32	US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service	Incidental Harassment Authorization	April 20, 2017

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Fish and Wildlife Lake and Streambed Alteration Agreement (III-1176-96) - November 6, 1996 Agreement Renewal – November 14, 2001 Agreement Extension – October 17, 2002 Agreement Renewal – November 13, 2003 Agreement Renewal – September 30, 2005 Agreement Extension – December 7, 2009 Agreement Amendment – December 13, 2009 Lake and Streambed Alteration Agreement (1600-2010-0380-R3) - September 8, 2011	**1. Administrative Measures** Permittee shall meet each administrative requirement described below. 1.1 Documentation at Project Site. Permittee shall make the Agreement, any extensions and amendments to the Agreement, and all related notification materials and California Environmental Quality Act (CEQA) documents, readily available at the project site at all times and shall be presented to DFG personnel, or personnel from another state, federal, or local agency upon request. 1.2 Providing Agreement to Persons at Project Site. Permittee shall provide copies of the Agreement and any extensions and amendments to the Agreement to all persons who will be working on the project at the project site on behalf of Permittee, including but not limited to contractors, subcontractors, inspectors, and monitors. 1.3 Notification of Conflicting Provisions. Permittee shall notify DFG if Permittee determines or learns that a provision in the Agreement might conflict with a provision imposed on the project by another local, state, or federal agency. In that event, DFG shall contact Permittee to resolve any conflict. 1.4 Project Site Entry. Permittee agrees that DFG personnel may enter the project site at any time to verify compliance with the Agreement. 1.5 Work Period Extension. If the Permittee needs more time to complete the authorized activity, the work period may be extended on a day-to-day basis by contacting the DFG representative found within the Contact Information section of this Agreement.	May 1: Adaptive Management Annual Report

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Fish and Wildlife (continued) Agreement Extension - February 25, 2016 Expiration - December 31, 2020	1.6 To the extent that any provisions of this Agreement provide for activities that require the Permittee to traverse another owner's property, such provisions are agreed to with the understanding that the Permittee possesses the legal right to so traverse. In the absence of such right, any such provision is void. 1.7 If, in the opinion of the DFG, conditions arise, or change, in such a manner as to be considered deleterious to the stream or wildlife, operations shall cease until corrective measures approved by the DFG are taken. **2. Avoidance and Minimization Measures** To avoid or minimize adverse impacts to fish and wildlife resources identified above, Permittee shall implement each measure listed below. 2.1 In each year that this Agreement is in effect, the Permittee shall provide DFG with an annual lagoon outlet channel adaptive management plan by April 15. 2.2 No excavation of the lagoon outlet channel may occur until DFG has reviewed and approved the annual lagoon outlet channel adaptive management plan. DFG shall provide written comments or approval by May 15 of each year this agreement is in effect. 2.3 The project site has been identified as an area that is potentially inhabited by steelhead trout (Federal Threatened), chinook salmon (Federal Threatened), coho salmon (Federal and State Endangered) and green sturgeon (Federal Threatened). This agreement does not authorize the take, or incidental take of any State or Federal listed threatened or endangered listed species. The Permittee is required, as prescribed in the state or federal endangered species acts, to consult with the appropriate agency prior to commencement of the project. Any unauthorized take of such listed species may result in prosecution. 2.4 To avoid impacts on aquatic and terrestrial species within the immediate work area, prior to implementation of an outlet channel, a qualified biologist will conduct a preconstruction survey to ensure no special-status species are occupying the site. If special-status species are observed within the project site or immediate surroundings, these areas will be avoided until the animal(s) has (have) vacated the area, and/or the animal(s) have been relocated out of the project area by a qualified biologist, upon approval by the regulatory agencies. In addition, the site will be surveyed	

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Fish and Wildlife (continued)	periodically during construction to ensure that no special-status species are being impacted by construction activities. 2.5 The project biologist will conduct a preconstruction training session for construction crew members. The training will include a discussion of sensitive biological resources within the project area and the potential presence of special-status species, special-status species' habitats, protection measures to ensure species are not impacted by project activities and project boundaries. 2.6 Any material, which could be hazardous to aquatic life and enters a stream or lake (i.e., a piece of equipment tipping-over in a stream and dumping oil, fuel or hydraulic fluid), shall be removed immediately and the DFG shall be notified within 24 hours. 2.7 Any hazardous or toxic materials that could be deleterious to aquatic life that could be washed into State waters or its tributaries shall be contained in water tight container or removed from the project site. 2.8 The Permittee/contractor shall not dump any litter or construction debris within the riparian/stream zone. All such debris and waste shall be picked up daily and disposed of at an appropriate site. 2.9 Refueling of construction equipment and vehicles may not occur within 300 feet of any water body, or anywhere that spilled fuel could drain to a water body. Tarps or a similar material shall be placed underneath the construction equipment and vehicles, when refueling, to capture incidental spillage of fuels. 2.10 Any equipment or vehicles driven and/or operated within or adjacent to the stream/lake shall be checked and maintained daily to prevent leaks of materials that if introduced to water could be deleterious to aquatic life, wildlife, or riparian habitat. 2.11 Any equipment or vehicles driven and/or operated within or adjacent to the stream/lake shall be cleaned of all external oil, grease, and materials that, if introduced to water, could be deleterious to aquatic life, wildlife or riparian habitat.	

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Fish and Wildlife (continued)	**3. Reporting Measures** Permittee shall meet each reporting requirement described below. 3.1 The Permittee shall notify DFG a minimum of 24 hours in advance of implementing the outlet channel management plan during the lagoon management period (May 15 to October 15). All communications shall be made in the method prescribed within the communication protocol section of the DFG approved annual lagoon outlet channel adaptive management plan. 3.2 The Permittee shall submit an annual report detailing that year's outlet channel management activities. This report may be submitted as a section of the annual lagoon outlet channel adaptive management plan required by May 1 of each year this agreement is in effect.	

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Regional Water Quality Control Board, North Coast Region Section 401 Water Certification (1B04001WNSO) - May 6, 2004 Amendment Extension – October 14, 2009 Amendment Extension – January 20, 2011 Amendment Extension – January 5, 2012 Amendment Extension – December 11, 2012 Amendment Extension – December 16, 2013 Expiration - December 31, 2014 Section 401 Water Certification (WDID 1B10122WNSO) - May 14, 2014 Expiration – May 14, 2019	**All conditions of this order apply to the applicant (and all their employees) and all contractors (and their employees), sub-contractors (and their employees), and any other entity or agency that performs activities or work on the project as related to this water quality certification.** 1. If monitoring results identify potentially dangerous water quality conditions, the applicant will promptly consult with Regional Water Board staff in addition to staff from other agencies identified in the application, including the National Marine Fisheries Service, the California Department of Fish and Wildlife, and California State Parks, with the intent of examining possible resolution through management action. Potentially dangerous conditions may include, but are not limited to, high bacterial levels, the presence of cyanobacteria, or other conditions that could affect human health. 2. The mitigation measures detailed in the Environmental Impact Report (SCH 2010052024) are hereby incorporated by reference and are conditions of approval of this certification. Notwithstanding any more specific conditions in this certification, the applicant shall comply with all mitigation measures identified in the Environmental Impact Report that are within the Regional Water Board's jurisdiction. 3. The annual fee amount for this Clean Water Act Section 401 Water Quality Certification shall be in accordance with the current dredge and fill fee schedule, per Division 3, Chapter 9, Article 1, section 2200(a)(3) of title 23 of the California Code of Regulations, based on the maximum dredge amount of 49,000 cubic yards proposed for the first year, and each year following. This fee shall be submitted prior to authorization of that year's management period and shall be approved by amendment to this Order by signature of the Executive Officer. The fee payment shall indicate the WDID number, and which season it is for. If the entire proposed beach dredging work for that year is not completed during that management season, the fee for the remaining amount of beach dredging for that year shall be applicable to the remaining management season(s), until the remaining amount of the fee is exhausted. In the case the remaining amount of the fee is exhausted within the five year term of this Order, the appropriate fee amount shall be paid at that point to be based on the actual volume of beach dredging performed, and/or proposed to be performed. There shall be no fee refunded to the Applicant if at the expiration of this Order there is any unapplied fee. 4. A draft water quality monitoring plan was submitted on December 23, 2013, which includes datasonde deployment, nutrient/bacterial/algal sampling, and sediment chemistry and benthic community indices. Regional Water Board staff issued a letter to SCWA on April 1, 2014, detailing the Regional Water Board's requirements for a water quality monitoring plan. A final water quality monitoring and reporting plan (WQMRP) must be submitted to the Regional Water Board by July 15, 2014, for approval by the Executive Officer. The WQMRP must include the following: a. Datasonde deployment – Since the size of estuary pool will increase at times under the new estuary management, it is expected that there will be an increase in shallow over-bank habitat along the new shoreline. Diel water temperature, dissolved oxygen, and pH levels in these expanded littoral regions should be evaluated for impacts to the COLD beneficial use during target water surface elevations. Sampling will	March 31: Draft Annual Adaptive Management Plan

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Regional Water Quality Control Board, North Coast Region (continued)	consist of vertical profiles in shallow water areas to characterize lagoon backwater areas. b. Stage measurements – The river reach near Monte Rio is expected to be affected by the backwater effects under the new estuary management. An additional water level measurement station should be placed in this river reach to evaluate when backwater effect on water quality conditions at stations sampled in the reach. c. Bacteria Sampling i. Duncans Mills and Bridgehaven stations should be replaced with public beach access locations at Patterson Point Preserve and Vacation Beach. ii. The monitoring plan should specify that the USEPA (2012) Beach Action Value for *E .coli* bacteria concentration (i.e., 235 MPN/100mL) will be used to determine if sampling should proceed the next day. iii. Water samples should be diluted when higher concentrations of bacteria are expected so that the results are not censored. iv. Assessment of the human-host *Bacteroides* bacteria levels should also be conducted to determine if the new estuary management increases a threat to public health from human sources. Quantifiable levels of human-host *Bacteroides* bacteria indicate recently deposited human waste. The assessment should be conducted at the public recreation beaches (i.e., Monte Rio, Patterson Point Preserve, and Vacation Beach) during the lagoon management period when the estuary is closed and the beaches are inundated. The Sonoma County Public Health Laboratory (as well as other labs) has the capability to quantify human-host *Bacteroides* bacteria that indicate recently deposited human waste. d. Algal sampling – Since the size of estuary pool will increase at times under the new estuary management, it is expected that there will be an increase in shallow over-bank habitat along the new shoreline. The larger areas of shallow habitat will provide additional habitat substrate for periphytic algal mats. The spatial extent of these algal mats and the resulting impact under the new estuary management should be evaluated. In addition, an evaluation of possible cyanobacteria within the periphytic algal mats should be conducted, and if found, the possibility of cyanotoxins should be evaluated. e. A Quality Assurance Project Plan (QAPP) needs to be submitted with the final WQMRP (i.e., EPA/240/B-01/003). 5. This certification action is subject to modification or revocation upon administrative or judicial review, including review and amendment pursuant to Water Code section 13330 and title 23, California Code of Regulations, section 3867. 6. This certification action is not intended and shall not be construed to apply to any discharge from any activity involving a hydroelectric facility requiring a Federal Energy Regulatory Commission (FERC) license or an amendment to a FERC license unless the pertinent certification application was filed pursuant to title 23, California Code of Regulations, section 3855, subdivision (b) and the application specifically identified that a FERC license or amendment to a FERC license for a hydroelectric facility was being sought.	

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California Regional Water Quality Control Board, North Coast Region (continued)	7. The validity of this certification is conditioned upon total payment of any fee required under title 23, California Code of Regulations, section 3833, and owed by the applicant. 8. Regional Water Board staff shall be notified in writing at least five working days, when conditions allow, prior to the commencement of ground disturbing activities, or as soon as possible prior to or upon initiating ground disturbing activities, with details regarding the construction schedule, in order to allow staff to be present onsite during construction, and to answer any public inquiries that may arise regarding the project. 9. No debris, soil, silt, sand, bar, slash, sawdust, cement or concrete washings, oil or petroleum products, or other organic or earthen material from any construction or associated activity of whatever nature, other than that authorized by this Order, shall be allowed to enter into or be placed where it may be washed by rainfall into waters of the state. When operations are completed, any excess material or debris shall be removed from the work area. 10. All activities and best management practices (BMPs) shall be implemented according to the submitted application and the conditions in this certification. BMPs for erosion, sediment, and turbidity control shall be implemented and in place at commencement of, during, and after any ground clearing activities or any other project activities that could result in erosion or sediment discharges to surface water. 11. In accordance with state and federal laws and regulations, the applicant is liable and responsible for the proper disposal for project-generated waste. When handling, transporting, and disposing of project-generated waste, the applicant and their contractors shall comply with all applicable state and federal laws and regulations. When disposing of project-generated waste offsite, the applicant and its contractors shall: a. Make appropriate arrangements to dispose of the material, including, but not limited to, property owner agreements, permits, licenses, and environmental clearances; b. Obtain satisfactory evidence that the work in 11.a has been completed; and c. Obtain a dated, signed manifest from the disposal site owner, or authorized representative, that identifies the type and quantity of disposed waste. 12. The applicant shall prioritize the use of wildlife-friendly, biodegradable (not photo- degradable) erosion control products wherever feasible. The applicant shall not use or allow the use of erosion control products that contain synthetic materials within waters of the United States or waters of the state at any time. The applicant shall not use or allow the use of erosion control products that contain synthetic netting for permanent erosion control (i.e. erosion control materials to be left in place for two years or more after the completion date of the project). If the applicant finds that erosion control netting or products	

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California Regional Water Quality Control Board, North Coast Region (continued)	have entrapped or harmed wildlife, personnel shall remove the netting or product and replace it with wildlife-friendly biodegradable products. The applicant shall request approval from the Regional Water Board if an exception from this requirement is needed for a specific location. 13. Disturbance or removal of existing vegetation shall not exceed the minimum necessary to complete the project. 14. If, at any time, an unauthorized discharge to surface water (including wetlands, lakes, rivers, or streams) occurs, or any water quality problem arises, the associated project activities shall cease immediately until adequate BMPs are implemented including stopping work. The Regional Water Board shall be notified promptly and in no case more than 24 hours after the unauthorized discharge or water quality problem arises. 15. Fueling, lubrication, maintenance, storage, and staging of vehicles and equipment shall not result in a discharge or threatened discharge to any waters of the state including dry portions of the shoreline. At no time shall the applicant or its contractors allow use of any vehicle or equipment that leaks any substance that may impact water quality. 16. Prior to implementing any change to the project that may have a significant or material effect on the findings, conclusions, or conditions of this Order, the applicant shall obtain the written approval of the Regional Water Board executive officer. If the Regional Water Board is not notified of a significant alteration to the project, it will be considered a violation of this Order, and the applicant may be subject to Regional Water Board enforcement actions. 17. The Regional Water Board may add to or modify the conditions of this Order, as appropriate, to implement any new or revised water quality standards and implementation plans adopted and approved pursuant to the Porter-Cologne Water Quality Control Act or section 303 of the Clean Water Act. 18. The applicant shall provide Regional Water Board staff access to the project site to document compliance with this certification. 19. In the event of any violation or threatened violation of the conditions of this Order, the violation or threatened violation shall be subject to any remedies, penalties, process or sanctions as provided for under applicable state or federal law. For the purposes of section 401 (d) of the Clean Water Act, the applicability of any state law authorizing remedies, penalties, process or sanctions for the violation or threatened violation constitutes a limitation necessary to assure compliance with the water quality standards and other pertinent requirements incorporated into this Order. In response to a suspected violation of any condition of this certification, the State Water Board may require the holder of any federal permit or license subject to this Order to furnish, under penalty of perjury, any technical or monitoring reports the State Water Board deems appropriate, provided that the burden, including costs, of the reports shall bear a reasonable relationship to the need for the reports and the benefits to be obtained from the reports. In response to any violation of the conditions of this Order, the Regional Water	

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	Board may add to or modify the conditions of this Order as appropriate to ensure compliance.	
California Regional Water Quality Control Board, North Coast Region (continued)	20. The applicant shall provide a copy of this Order and State Water Board Order 2003- 0017-DWQ to any contractor(s), subcontractor(s), and utility company(ies) conducting work on the project, and shall require that copies remain in their possession at the work site. The applicant shall be responsible for ensuring that all work conducted by its contractor(s), subcontractor(s), and utility companies is performed in accordance with the information provided by the applicant to the Regional Water Board. 21. In the event of any change in control of ownership of land presently owned or controlled by the Applicant, the Applicant shall notify the successor-in-interest of the existence of this Order by letter and shall forward a copy of the letter to the Regional Water Board at the above address. To discharge dredged or fill material under this Order, the successor-in-interest must send to the Regional Water Board Executive Officer a written request for transfer of the Order. The request must contain the requesting entity's full legal name, the state of incorporation if a corporation, and the address and telephone number of the person(s) responsible for contact with the Regional Water Board. The request must also describe any changes to the Project proposed by the successor- in-interest or confirm that the successor-in-interest intends to implement the Project as described in this Order. Except as may be modified by any preceding conditions, all certification actions are contingent on: a) the discharge being limited to and all proposed mitigation being completed in strict compliance with the Applicant's Project description, and b) compliance with all applicable requirements of the Water Quality Control Plan for the North Coast Region (Basin Plan). 22. Except as may be modified by any preceding conditions, all certification actions are contingent on a) the discharge being limited to and all proposed mitigation being completed in strict compliance with the applicant's project description, and b) compliance with all applicable requirements of the Water Quality Control Plan for the North Coast Region (Basin Plan). 23. The authorization of this certification for any dredge and fill activities expires on May 14, 2019. Conditions and monitoring requirements outlined in this Order are not subject to the expiration date outlined above, and remain in full effect and are enforceable.	

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California Coastal Commission Coastal Development Permit (CDP 2-01-033) – May 15, 2002 Amend. Extension (2-01-033-1A) – June 14, 2010 Monthly Extensions (January - June 2011) Emergency CDP (2-12-002-G) –January 9, 2012 New CDP Application Submitted – January 23, 2012 Application deemed complete – July 9, 2012 Emergency CDP (2-13-005-G) –February 21, 2013 Emergency CDP (2-13-005-G) –February 21, 2013 Emergency CDP (G-2-13-0221) –October 15, 2013 CDP (2-12-004) February 26, 2014 Expiration-August 15, 2016	**SPECIAL CONDITIONS:** This permit is granted subject to the following special conditions: 1. **Approved Project.** Subject to these standard and special conditions (including modifications to the project, mitigation measures, and/or the project plans required by them), this CDP authorizes implementation of the Russian River Estuary Management Project and related jetty study, including 1) a new program that would implement a lagoon outlet channel during the lagoon management season, from May 15th to October 15th, 2) sand bar breaching from October 16th to May 14th and necessary from May 15th to October 15th to minimize flooding, and 3) a geotechnical evaluation of a relic jetty at the river mouth, all as more specifically described in the proposed project materials (see Appendices A and B and Exhibits 2, 3, and 7). 2. **Construction Plan.** PRIOR TO ISSUANCE OF THE COASTAL DEVELOPMENT PERMIT, the Permittee shall submit two copies of a Construction Plan (the Plan) to the Executive Director for review and written approval. The Plan shall, at a minimum, include the following: a. **Construction Areas.** The Construction Plan shall identify the specific location of all construction areas, all staging areas, and all construction access corridors in site plan view. All such areas within which construction activities and/or staging are to take place shall be	August 15: Annual Report for CDP (2-12-004)

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California Coastal Commission (continued)	minimized to the maximum extent feasible in order to have the least impact on public access and adjacent biological resources as well as to maintain best management practices (BMPs) to protect coastal dune and marine resources on-site and in the surrounding area, including by using offsite areas for staging and storing construction equipment and materials, as feasible. In addition, all construction areas shall avoid sensitive dune plant species, including Tidestrom's lupine, as required in subsection (c), below. The placement of the piezometers shall occur no closer than fifty feet from the sensitive dune plant habitat (as outlined in Exhibit 3 – Jetty Study Location, Detail, and Photos). Construction (including but not limited to construction activities, and materials and/or equipment storage) is prohibited outside of the defined construction, staging, and storage areas. **b. Construction Methods and Timing.** The plan shall specify the construction methods to be used, including all methods to be used to keep the construction areas separated from sensitive coastal dune and marine resources and public recreational use areas (including using unobtrusive fencing (or equivalent measures) to delineate construction areas). All work shall take place during daylight hours and all lighting of the beach, river, and dune habitat is prohibited. **c. Dune Plants Avoidance.** The plan shall include methods to avoid impacts to sensitive dune plant species, including Tidestrom's lupine. All sensitive species shall be avoided during construction, including through locating the defined construction areas required in subsection (a) away from such species (as generally depicted on Exhibit 3 – Jetty Study Location, Detail, and Photos). Furthermore, the sensitive dune plant habitat shall be fenced off during the two weeks wherein the instruments are being placed and the seismic work is occurring. For the duration of the project, markers identifying the boundaries of the sensitive dune plant habitat shall remain in place. A monitor shall be on site during instrument placement, testing, and removal to ensure that project activities occur within the defined construction, staging, and storage areas and outside of the sensitive dune plant habitat. **d. Best Management Practices.** The plan shall clearly identify all BMPs to be implemented during construction and their location. Contractors shall ensure that work crews are carefully briefed on the importance of observing the appropriate precautions and reporting and cleanup of accidental spills. Construction contracts shall contain appropriate penalty provisions, sufficient to offset the cost of retrieving or cleaning up improperly contained foreign materials. **e. Construction and Instrument Noise Level Restrictions.** Noise generated by any instrument driving or hammer strike activities shall be minimized to the maximum extent practicable. Underwater noise shall not exceed an accumulated 187 dB SEL as measured 10 meters from the source. At no time shall peak dB SEL rise above 206 at 10 meters from the source. Furthermore, the Applicants shall limit activities at the site that involve the use of heavy equipment to between local sunrise to local sunset. **f. Construction Site Documents.** The plan shall provide that copies of the signed CDP and the approved Construction Plan be maintained in a conspicuous location at the construction job site	

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California Coastal Commission (continued)	at all times, and that such copies are available for public review on request. All persons involved with the construction shall be briefed on the content and meaning of the coastal development permit and the approved Construction Plan, and the public review requirements applicable to them, prior to commencement of construction. **g. Construction Coordinator.** The plan shall provide that a construction coordinator be designated to be contacted during construction should questions arise regarding the construction (in case of both regular inquiries and emergencies), and that their contact information (i.e., address, phone numbers, etc.) including, at a minimum, a telephone number that will be made available 24 hours a day for the duration of construction, is conspicuously posted at the job site where such contact information is readily visible from public viewing areas, along with indication that the construction coordinator should be contacted in the case of questions regarding the construction (in case of both regular inquiries and emergencies). The construction coordinator shall record the name, phone number, and nature of all complaints received regarding the construction, and shall investigate complaints and take remedial action, if necessary, within 24 hours of receipt of the complaint or inquiry. In addition, all construction personnel shall be trained in proper material handling, cleanup, and disposal procedures. **h. Notification.** The Permittee shall notify planning staff of the Coastal Commission's North Central Coast District Office at least three working days in advance of commencement of construction, and immediately upon completion of construction. **i. Property Owner Consent.** The plan shall be submitted with evidence indicating that the owners of any properties on which construction activities are to take place, including properties to be crossed in accessing the site, consent to such use of their properties. Minor adjustments to the above construction requirements may be allowed by the Executive Director in the approved Construction Plan if such adjustments: (1) are deemed reasonable and necessary; and (2) do not adversely impact coastal resources. All requirements above and all requirements of the approved Construction Plan shall be enforceable components of this CDP. The Permittee shall undertake construction in accordance with the approved Construction Plan. **3. Mitigation Monitoring Plan.** The project shall be conducted in compliance with the requirements of the Mitigation Monitoring Plan, dated August 17, 2011 (see Appendix B), except where the terms and conditions of this CDP require actions more protective of coastal resources. **4. Marin e Mammal Avoidance and Monitoring.** To the maximum extent feasible, all work shall avoid the river mouth area where seal haul out is typically located (see Exhibit 4 – Pinniped Haul Outs). In addition, all work shall be conducted consistent with the NMFS and NOAA-approved seal haul out plan described in the Incidental Harassment Authorization (April 2013) (IHA) and any updates to this IHA. Project activities shall comply with all mitigation, monitoring and reporting requirements contained in the IHA, including the following requirements as outlined in the IHA:	

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California Coastal Commission (continued)	a. **Avoid Sudden Flushes.** Permittee crews shall cautiously approach the haul-out ahead of heavy equipment to minimize the potential for sudden flushes, which may result in a stampede. Crews on foot shall make an effort to be seen by seals from a distance, if possible, rather than appearing suddenly at the top of the sand bar, again preventing sudden flushes. Boats operating near river haul-outs during monitoring shall be kept within posted speed limits and driven as far from the haul-outs as safely possible to minimize flushing seals. b. **Avoid Haul-Out.** Permittee crews shall avoid walking or driving equipment through the seal haul-out. Physical and biological monitoring at the haul-out location shall not be occur if a pup less than one-week old is present at the monitoring site or on a path to the site. c. **Monitoring From Bluff.** During breaching events, all monitoring shall be conducted from the overlook on the bluff along Highway 1 adjacent to the haul-out in order to minimize potential for harassment. d. **Disturbance Recovery.** The Permittee shall maintain a one-week no-work period between water level management events (unless flooding is an immediate threat) to allow for an adequate disturbance recovery period. During the no-work period, equipment must be removed from the beach. e. **Equipment BMPs.** All equipment shall be driven slowly on the beach and care shall be taken to minimize the number of shutdowns and start-ups when equipment is on the beach. All work shall be completed as efficiently as possible, with the smallest amount of heavy equipment possible, to minimize disturbance of seals at the haul-out. f. **Haul-out Maintained.** The Permittee shall conduct seal counts at the Jenner seal haul-out and at nearby coastal and river haul-outs in accordance with methods described in the Russian River Management Activities Pinniped Monitoring Plan (Pinniped Monitoring Plan), dated September 9, 2009, or as updated by requirements of NMFS under the Marine Mammal Protection Act (MMPA). If monitoring during the lagoon management period indicates decreases in overall use at the Jenner haul-out are correlated with increases in use at the three closest haul-outs, then the Permittee shall consult with the Executive Director, NMFS and CDFW to modify the Estuary Management Plan activities such that the haul-out site is maintained. Proposed alterations to the approved Estuary Management Plan shall be reported to the Executive Director. No alterations to the approved Estuary Management Plan shall occur without an approved amendment to this CDP, unless the Executive Director determines that no amendment is legally required. 5. **Public Acc ess Management Plan.** PRIOR TO ISSUANCE OF THE COASTAL DEVELOPMENT PERMIT, the Permittee shall submit two copies of a public access management plan (Public Access Plan) to the Executive Director for review and approval. The Public Access Plan shall clearly describe the manner in which public access at the project site is to be protected, with the objective of avoiding any adverse impacts to public access at Goat Rock, Sonoma Coast State Beach. The Public Access Plan shall be consistent with all other terms and conditions of this CDP, and shall at a minimum include the following:	

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California Coastal Commission (continued)	a. **No Disruption of Public Access.** Development under this CDP that blocks access to the beach at the project site shall be prohibited. Temporary signs shall warn the public of construction while construction activities are underway. Signs shall direct the public to safe access routes during construction activities. Signs shall not discourage public access. Signs shall notify beach users of channel conditions, potential for safety hazards from beach erosion or hydrologic action, and emergency contact information. Signs shall be posted and maintained at key locations, such as the parking lot at Goat Rock State Beach Parking lot, the unofficial beach access trail located on the north side of the beach off Highway 1, and 100 feet on either side of the outlet channel. b. **Peak Public Access Times Avoided.** Project activities shall occur Monday through Thursday only, to avoid impacts to park visitors during peak visitation times (Friday through Sunday). All requirements above and all requirements of the approved Public Access Plan shall be enforceable components of this CDP. The Permittee shall undertake development in accordance with the approved Public Access Plan, which shall govern all general public access to the site pursuant to this CDP. 6. **Monitoring Plan.** PRIOR TO ISSUANCE OF THE COASTAL DEVELOPMENT PERMIT, the Permittee shall submit two copies of a Flood Analysis, Habitat and Water Quality Monitoring Plan (Monitoring Plan) to the Executive Director for review and approval. The Flood Analysis portion of the Monitoring Plan shall identify avoidance and mitigation measures as detailed in Special Condition 6(a). The Habitat Monitoring portion of the Monitoring Plan shall cover all approved project activities, and shall evaluate project effectiveness and alternatives as detailed in Special Condition 6(b). The Water Quality Monitoring portion of the Monitoring Plan shall direct management actions in response to water quality conditions and as detailed in Special Condition 6(c). The primary objective of the Monitoring Plan shall be to ensure that approved project activities protect and enhance project area habitats while also protecting development from flooding and enhancing water quality, and shall be measured against a clearly defined project baseline, which shall be provided in the Monitoring Plan. The Monitoring Plan shall be based upon an adaptation framework where lessons learned from approved project activities and monitoring are applied through adaptive changes designed to better achieve the primary objective over the course of this authorization. The Monitoring Plan shall include all monitoring components of the BO and the FEIR for the project, and shall include, at minimum, the following: a. **Flood Analysis.** The Permittee shall continue to coordinate with NMFS and work with property owners affected by flooding to identify measures that would, if necessary, substantially minimize or avoid any damages to existing structures that would occur as a result of increasing water elevations in the lagoon pursuant to the approved project. As appropriate and indicated in the BO, the Permittee shall continue to survey properties within the estuary's maximum water elevation in greater detail to more accurately and precisely determine the elevation of the structures potentially at risk; this information shall be kept on record by the Permittee and a copy shall be provided to each of the property owners. A detailed account of individual properties and development of these properties for each foot of estuary water surface elevations shall be	

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California Coastal Commission (continued)	provided. The range of options available to protect affected developments, other than breaching or controlling water levels in the estuary, including relocating, elevating, or reinforcing structures, shall be provided. At a minimum, and evaluation of the effects of flood levels at 4.5, 7, and 9 feet shall be so evaluated. b. **Habitat Monitoring.** Monitoring shall be conducted consistent with the BO to provide information on (1) the ways in which the project results in benefits to juvenile steelhead and/or adverse impacts to other salmonids, (2) whether a controlled outlet program can achieve optimal lagoon elevations, and (3) whether habitat improvements would result if no breaching occurred, water levels were allowed to be higher than current management, a larger estuary was formed, and low-lying development within the historic estuary footprint were flooded. A geotechnical study shall be conducted prior to December 31, 2014 to contribute to a determination as to what modifications to/removal of the jetty infrastructure would optimize seepage through the sand barrier and allow estuary levels to rise to a maximum elevation without the sand bar manipulation. An evaluation of the need for additional monitoring wells and frequency of water level data needed to adequately characterize seepage through the sand bar and jetty shall be conducted at the commencement of the geotechnical work so that reliable information is assured to be included in the study. c. **Water Quality Monitoring.** The water quality monitoring data collected for the 2008 BO, the Temporary Urgency Change Petition's surface water sampling program, and the Stipulated Judgment's sediment sampling requirement shall be integrated under the direction of an independent water quality professional. These data collection programs shall be linked and coordinated so that they provide a cohesive and useful data set that can be used to evaluate the low velocity lagoon outlet channel and whether or not it is successful in sustaining raised water elevations and improved water quality conditions in the estuary. At a minimum, the Plan shall specify the water quality analyses, sampling locations, sampling frequency, quality control and data reporting that will be used to assess water quality impacts of implementing the Russian River Estuary Management Program Adaptive Management Plan. In addition, the Water Quality Monitoring Plan shall include sampling for the following constituents, at a minimum, temperature, salinity, pH, nutrients, chlorophyll, and bacteria indicators used to assess human health impacts consistent with the most up-to date methods and standards required by the North Coast Regional Water Quality Control Board (NCRWQCB). Monitoring shall occur weekly during the Lagoon Management Period at the locations that are currently included in the Russian River Water Quality Summary for the Sonoma County Water Agency 2012 Temporary Urgency Change. Finally, the Plan shall include a contingency to increase sampling frequency to daily if the bacteria indicators exceed the operative standards required by the NCRWQCB and monitoring shall continue daily until measurements are below the operative standards. If the operative standards are exceeded, the Permittee will immediately inform the NCRWQCB and Sonoma County Public Health and seek direction on whether warning signs should be posted at the affected beaches regarding a potential health threat and consult with NCRWQCB and Sonoma County Public Health to determine if mechanical breaching is a recommended action to reduce the threat to public health.	

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California Coastal Commission (continued)	**d. Monitoring Reports.** The Monitoring Plan shall provide for submission of annual reports of monitoring results to the Executive Director for review and approval for as long as activities are authorized by this CDP, with the first annual monitoring report due on August 15, 2014, and subsequent reports due on August 15th of each year thereafter. Each monitoring report shall be cumulative and shall summarize all previous results. Each report shall clearly document conditions in the project area related to project implementation, including in narrative (with supporting monitoring data) and through photographs taken from the same fixed points in the same directions each year, all commencing from the project baseline. Each report shall include a performance evaluation section where information and results from the monitoring program are used to evaluate the effect of project implementation with respect to flooding, habitat, and water quality impacts, both beneficial and detrimental. To allow for an adaptive approach, each report shall also include a recommendations section to address changes that may be necessary in light of monitoring results and/or other information, including with respect to more current data and/or species information related to the habitat areas in question, if any. Actions necessary to implement the recommendations shall be implemented within 30 days of Executive Director approval of each Monitoring Report, unless the Executive Director identifies a different time frame for implementation. Minor adjustments to the above monitoring requirements may be allowed by the Executive Director in the approved Monitoring Plan if such adjustments: (1) are deemed reasonable and necessary; and (2) do not adversely impact coastal resources. All requirements above and all requirements of the approved Monitoring Plan shall be enforceable components of this CDP. The Permittee shall undertake development in accordance with the approved Monitoring Plan. 7. **Assumption of Risk.** By acceptance of this CDP, the Permittee acknowledges and agrees, on behalf of itself and all successors and assigns: a. **Coastal Hazards.** That the site is subject to coastal hazards including but not limited to episodic and long-term shoreline retreat and coastal erosion, high seas, ocean waves, storms, tsunami, tidal scour, coastal flooding, and the interaction of same; b. **Assume Risks.** To assume the risks to the Permittee and the property that is the subject of this permit of injury and damage from the above-identified coastal hazards in connection with this permitted development; c. **Waive Liability.** To unconditionally waive any claim of damage or liability against the Commission, its officers, agents, and employees for injury or damage from the above-identified hazards; d. **Indemnification.** To indemnify and hold harmless the Coastal Commission, its officers, agents, and employees with respect to the Commission's approval of the project against any and all liability, claims, demands, damages, costs (including costs and fees incurred in defense of such	

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California Coastal Commission (continued)	claims), expenses, and amounts paid in settlement arising from any injury or damage due to the above-identified coastal hazards. 8. **Sand Bar Breaching L imitation**. Except under conditions requiring immediate action to prevent or mitigate loss or damage to life, health, property, or essential public services, the sand bar breaching activities authorized by the CDP shall not be initiated on or within 36 hours prior to any weekend or State holiday. 9. **CD P Term**. Development authorized by this CDP is valid for three (3) years from the date of Commission approval (until August 15, 2016). One request for an additional three-year period of development authorization may be accepted, reviewed and approved by the Executive Director for a maximum total of six (6) years of development authorization, provided the request would not alter the project description and/or require modifications of conditions due to new information or other changed circumstances. The request for an additional three-year period of development authorization shall be made at least 120 days prior to August 15, 2016. If the request for an additional three-year authorization period would alter the project description and/or require modifications of conditions due to new information or other changed circumstances, an amendment to this CDP shall be necessary to authorize development beyond August 15, 2016. If the Permittee submits a request/application to continue estuary management (including breaching and other activities intended to control water elevations) beyond August 15, 2016, such request/application shall be accompanied by a project alternatives analysis that, at minimum, provides a survey of potential flooding risks to properties within the estuary up to a water elevation of 14 feet, or the maximum water elevation known to occur, whichever is higher, to precisely determine the elevation of the structures potentially at risk. In addition, the analysis shall include an evaluation of the range of options available to protect against identified flooding risks, other than breaching or controlling water levels in the estuary, including relocating, elevating, or reinforcing structures. Such analysis shall also include an evaluation of the range of options available to modify or remove the jetty to reduce or eliminate the need for breaching. 10. **Other Agency Approval.** PRIOR TO ISSUANCE OF THE COASTAL DEVELOPMENT PERMIT, the Permittee shall submit to the Executive Director written evidence that all necessary permits, permissions, approvals, and/or authorizations for the approved project have been granted by Sonoma County, the North Coast Regional Water Quality Control Board, California State Lands Commission, California Department of Parks and Recreation, California Department of Fish and Wildlife, National Marine Fisheries Service, U.S. Army Corps of Engineers, and the U.S. Fish and Wildlife Service or that no such permits or approvals are necessary. Any changes to the approved project required by these agencies shall be reported to the Executive Director. No changes to the approved project shall occur without a Commission amendment to this CDP unless the Executive Director determines that no amendment is necessary. 11. **Liability for Costs and Attorneys' Fees.** By acceptance of this CDP, the Applicant/Permittee agrees to reimburse the Coastal Commission in full for all Coastal Commission costs and attorneys'	

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California Coastal Commission (continued)	fees (including (1) those charged by the Office of the Attorney General, and (2) any court costs and attorneys' fees that the Coastal Commission may be required by a court to pay) that the Coastal Commission incurs in connection with the defense of any action brought by a party other than the Applicant/Permittee against the Coastal Commission, its officers, employees, agents, successors and assigns challenging the approval or issuance of this CDP. The Coastal Commission retains complete authority to conduct and direct the defense of any such action against the Coastal Commission.	

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US Army Corps of Engineers, San Francisco District Section 404 & Section 10, Individual Permit (285610N) - July 22, 2005 Permit Modification - October 5, 2009 Time Extension January 5, 2011 Time Extension December 8, 2011 Time Extension December 10, 2012 Time Extension December 10, 2013 Section 404 & Section 10, Individual Permit (2004- 285610N) – April 1, 2014 Expiration - December 31, 2023	SPECIAL CONDITIONS: 12. To remain exempt from the prohibitions of Section 9 of the Endangered Species Act, the non-discretionary Terms and Conditions for incidental take of federally-listed Species shall be fully implemented as stipulated in the Biological Opinion entitled, *"Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Conh·ol and Water Conservation Improvement District in the Russian River Watershed,"* also known as the Russian River Biological Opinion, (NMFS File No. 151422SWR2000SRl50) dated September 24, 2008. Project authorization under this permit is conditional upon compliance with the mandatory terms and conditions associated with incidental take. Failure to comply with the terms and conditions for incidental take, where a take of a federally-listed species occurs, would constitute an unauthorized take and non-compliance with the authorization for your project. The NMFS is, however, the authoritative federal agency for determining compliance with the incidental take statement and for initiating appropriate enforcement actions or penalties under the Endangered Species Act. 13. SCWA shall provide USACE a copy of the approved Estuary Monitoring Plan and all subsequent Annual Monitoring Reports required by the Biological Opinion. 14. Unless otherwise approved, authorized discharges of dredged material on the sandbar below the high tide line shall consist only of the native sand excavated from the pilot channel. 15. SCWA shall provide USACE a Breaching Activities Report by 31 March for each year of the ten-year permit authorization period. Each Breaching Activities Report shall present a tabulation of the breaching events that occurred during the preceding year, including the approximate estuary closure date, the approximate number of estuary closure days occurring before the breach event, the breaching event date, and the recorded estuary water level of the breaching event date. 5. The current Coastal Development Permit (CDP 2-12-004) issued by the California Coastal Commission expires on 15 August 2016. The current Section 401 water quality certification (WDID No. IB04001WNSO) issued by the Regional Water Quality Control Board expires on 31 December 2015. SCWA shall obtain requisite time extensions for the Coastal Development Permit and water quality certification prior to the commencement of any work to be performed during the remainder of the ten-year Department of the Army permit authorization period. SCWA shall provide USACE a copy of all requisite time extensions to ensure continuing project conformance with State coastal zone and water quality standards.	March 31: Annual Breaching Report

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California Environmental Quality Act Environmental Impact Report (EIR) Notice of Preparation – May 10, 2010 Notice of Completion – December 15, 2010 Notice of Determination – August 16, 2011	See EIR for Mitigation Measures.	None
California State Lands Commission General Lease, Public Agency Use (PRC 7918.1 R 08103) – June 29, 2004 Lagoon Outlet Channel Authorization – October 13, 2009 (Expiration - December 31, 2010) Monthly Extensions - January 1 to December 31, 2011 General Lease, Public Agency Use (PRC 7918.9) – January 1, 2012	**SECTION 2** **SPECIAL PROVISIONS** **BEFORE THE EXECUTION OF THIS LEASE, ITS PROVISIONS ARE AMENDED, REVISED OR SUPPLEMENTED AS FOLLOWS:** 1. Lessee agrees to be bound by and fully carry out, implement, and comply with all mitigation measures and reporting obligations identified as Lessee's, or Responsible Party's responsibility as set forth in the Mitigation Monitoring Program (MMP) attached hereto as Exhibit C and by this reference made a part of this Lease, or as modified by Lessor as permitted by law. 2. Lessee acknowledges that the land described in Exhibit A of this Lease is subject to the Public Trust and is presently available to members of the public for recreation, waterborne commerce, navigation, fisheries, open space, or other recognized Public Trust uses and that Lessee's proposed construction activities and use of the Lease Premises shall not interfere or limit the Public Trust rights of the public. At least 24 hours prior to and during the breaching activities, Lessee will contact the California Department of Parks and Recreation lifeguards and post signs and barriers to minimize potential hazards to the public. 3. Prior to the start of the initial freshwater lagoon construction on the Lease Premises, Lessee shall submit to Lessor copies of all permits and authorizations from agencies having jurisdiction over the construction of the authorized activities on the Lease Premises. Lessee shall maintain all regulatory permits and authorization required during the term of the lease.	No Date: Annual Water Quality Data Summary Reports; Annual Report for Russian River Estuary Management Activities Monitoring Plan

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California State Lands Commission (continued) Renewed General Lease, Public Agency Use (PRC 7918.9) – March 23, 2015 Expiration – December 31, 2023	4. All breaching activities shall be carried out in accordance with all applicable safety regulations, permits, and conditions of all other agencies. 5. During the term of the lease, Lessee shall provide Lessor with an annual report on frequency and timing of outlet channel construction and maintenance and breaching occurrences completed each calendar year, including number of days of closure of Goat Rock State Beach. The report should include narrative descriptions and evaluations of outlet channel and breaching events, including any adaptive management changes implemented. 6. Lessee shall submit to Lessor copies of the following: a. Adaptive estuarine water level and barrier beach management plans (as described in 2.1.1 of the Russian River Biological Opinion) after approval by the National Marine Fisheries (NMFS), the California Department of Fish and Wildlife, and the U.S. Army Corps of Engineers. b. Annual water quality data summary reports (as described in 2.2, Monitoring Estuarine Water Quality: Reporting and Review, of the Biological Opinion). c. Annual report, as specified in the "Russian River Estuary Management Activities Pinniped Monitoring Plan" and distributed to NMFS, the California Department of Parks and Recreation, and the Stewards of the Coasts and Redwoods, on pinnipeds' reaction to the proposed activities authorized in this Lease. 7. All personal property, tools, or equipment taken onto or placed upon the Lease Premises shall remain the property of the Lessee or its contractors. Such personal property shall be promptly removed by the Lessee, at its sole risk and expense upon the completion of the project. Lessor does not accept any responsibility for any damage, including damages to any personal property, including any equipment, tools, or machinery on the Lease Premises	

Agency / Permit / Expiration	Special Conditions	Report Due Date
California State Lands Commission (continued)	8. No refueling, repairs, or maintenance of vehicles or equipment will take place on the Lease Premises. 9. Lessee shall maintain a logbook on all work vessels during work within the Lease Premises utilized in operations conducted under this Lease to keep track of all debris created by objects of any kind that may fall into the water. The logbook should include the type of debris, date, time and location to facilitate identification and location of debris for recovery and site clearance verification. All debris shall be promptly removed from the Lease Premises. 10. Any equipment to be used on the Lease Premises is limited to that which is directly required to perform the authorized use and does not include any equipment that may cause damage to the Lease Premises. 11. Lessee acknowledges and agrees: a. The site may be subject to hazards from natural geophysical phenomena including, but not limited to waves, storm waves, tsunamis, earthquakes, flooding and erosion. b. To assume the risks to the Lessee and to the property that is the subject of any Coastal Development Permit (CDP) that is issued to Lessee for development on the leased property, of injury and damage from such hazards in connection with the permitted development and use. c. To unconditionally waive any claim or damage or liability against the State of California, its agencies, officers, agents, and employees for injury or damage from such hazards. d. To indemnify, hold harmless and, at the option of Lessor, defend the State of California, its agencies, officers, agents, and employees, against and for any and all liability, claims, demands, damages, injuries, or costs of any kind and from any cause (including costs and fees incurred in defense of such claims), expenses, and amounts paid in settlement arising from any alleged or actual injury, damage or claim due to site hazards or connected in any way with respect to the approval of any CDP that is issued to Lessee involving this property or issuance of this Lease, any new lease, renewal, amendment, or assignment by Lessor. 12. Lessor shall have the right to enter upon the property at reasonable times in order to monitor Lessee's compliance with and otherwise enforce the terms of the Lease. 13. Paragraph 10, Surety Bond, contained within Section 3 is hereby deleted from this Lease.	

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California Department of Parks and Recreation Temporary Use Permit – December 30, 2003 Permit Extension – September 14, 2009 Permit Extension – December 28, 2009 Expiration – June 30, 2010 Temporary Use Permit – May 15, 2011 Time Extension – February 20, 2013 Time Extension – December 18, 2013 Time Extension – February 2, 2015	**Now therefore**, the State by this Permit hereby grants to the Permittee permission to enter upon State's property, conditioned upon the agreement of the Parties that this Permit does not create or vest in Permittee any interest in the real property herein described or depicted, that the Permit is revocable and non-transferable, and that the Permit is further subject to the following terms and conditions: 1. **Project Description:** By this Permit, the State hereby grants to the Permittee permission to enter onto those lands depicted and described on Exhibit "A", Russian River Estuary Management Activities, and Exhibit "B", Russian River Estuary Outlet Channel: Excavation Cut and Fill Locations, attached hereto and herein incorporated by this reference, solely for the purpose of flood control and environmental monitoring. 2. **Permit Subject to Laws and Regulatory Agency Permits:** This Permit is expressly conditioned upon Permittee's obtaining any and all regulatory permits or approvals required by the relevant regulatory agencies for the Project and Permittee's use of the Property, and upon Permittee's compliance with all applicable municipal, state and federal laws, rules and regulations, including all State Park regulations. Prior to commencement of any work, Permittee shall obtain all such legally required permits or approvals and submit to the State full and complete copies of all permits and approvals, including documentation related to or referenced in such permits and approvals, along with the corresponding agency contact and telephone numbers, and related California Environmental Quality Act (CEQA) and/or National Environmental Policy Act (NEPA) documentation as applicable. 3. **Term of Permit:** This Permit shall only be for the period beginning on 11/15/2011, and ending on 12/31/2012, or as may be reasonably extended by written mutual agreement of the Parties. 4. **Consideration:** Permittee agrees to pay State the sum of One thousand five hundred and No/100 Dollars ($1,500.00) as consideration for the rights granted by this Permit. Payment is due upon execution of this Permit. 5. **Permit Subject to Existing Claims:** This Permit is subject to existing contracts, permits, licenses, encumbrances and claims which may affect the Property.	No Reporting Required for TUP

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Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Parks and Recreation (continued) Expiration – December 31, 2015 Renewal Requested – November 3, 2015	6. **Waiver of Claims and Indemnity:** Permittee waives all claims against State, its officers, age and/or employees, for loss, injury, death or damage caused by, arising out of, or in any way connected with the condition or use of the Property, the issuance, exercise, use or implemen of this Permit, and/or the rights herein granted. Permittee further agrees to protect, save, ho harmless, indemnify and defend State, its officers, agents and/or employees from any and a damage, claims, demands, costs and liability which may be suffered or incurred by State, its agents and/or employees from any cause whatsoever, arising out of, or in any way connecte this Permit, exercise by Permittee of the rights herein granted, Permittee's use of the Propert and/or the Project for which this Permit is granted, except those arising out of the sole active negligence or willful misconduct of State. Permittee will further cause such indemnification a waiver of claims in favor of State to be inserted in each contract that Permittee executes for t provision of services in connection with the Project for which this Permit is granted. 7. **Contractors:** Permittee shall incorporate the terms, conditions and requirements contained when contracting out all or any portion of the work permitted hereunder. Permittee shall be responsible for ensuring contractor/subcontractor compliance with the terms and conditions contained herein. Failure of Permittee's contractors to abide by State's terms and conditions constitute default by Permittee (see Paragraph 20) allowing State to terminate this Permit an all legal remedies. 8. **Insurance Requirements:** As a condition of this Permit and in connection with Permittee's indemnification and waiver of claims contained herein, Permittee shall maintain, and cause it contractors to maintain, a policy or policies of insurance as follows: Permittee shall maintain motor vehicle liability with limits of not less than $1,000,000 per a Such insurance shall cover liability arising out of a motor vehicle, including all owned, hire non-owned motor vehicles. Permittee shall maintain statutory Workers' Compensation and employer's liability insuran coverage in the amount of $1,000,000/employee/disease/each accident, for all its employ will be engaged in the performance of work on the Property, including special extensions applicable. Said policy shall include a waiver of subrogation in favor of State. If the Perm an individual or sole proprietor who is not required by law to have Workers' Compensatio insurance, Permittee shall provide State with a written confirmation that Permittee is not r to be, and has elected not to be, covered by Workers' Compensation. Permittee shall procure commercial general liability insurance at least as broad as the mo commonly available ISO policy form CG 0001 premises operations, products/completed operations, personal/advertising injury and contractual liability with limits not less than $1, per occurrence and $2,000,000 general aggregate. Said policy shall apply separately to insured against whom any claim is made or suit is brought subject to the Permittee limits liability.	

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Parks and Recreation (continued)	Each policy of insurance required by this provision shall: (a) be in a form, and written by an insurer, reasonably acceptable to State; (b) be maintained at Permittee's sole expense; and (c) require at least thirty (30) days written notice to State prior to any cancellation, non-renewal or material modification of insurance coverage. Insurance companies issuing such policies shall have a rating classification of "A-" or better and financial size category ratings of "VII" or better according to the latest edition of the A.M. Best Key Rating Guide. All Insurance companies issuing such policies shall be licensed to do business in the State of California. Such policies shall contain an endorsement naming the CALIFORNIA DEPARTMENT OF PARKS AND RECREATION as an additional insured at no cost to State. Permittee shall provide to State evidence that the insurance required to be carried by this Permit, including any endorsement affecting the additional insured status, is in full force and effect and that premiums therefore have been paid. Such evidence shall, at State's discretion, be in either the form of an ACORD Form (Certificate of Insurance) or DPR Form 169A (Certificate of Insurance for Concession Contracts/Special Events), or a certified copy of the original policy, including all endorsements. Permittee is responsible for any deductible or self-insured retention contained within the insurance program. Should Permittee fail to keep the specified insurance in effect at all times, Permittee shall be considered to be in default of this Permit, and State may, in addition to any other remedies it has, terminate this Permit.	

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California Department of Parks and Recreation (continued)	Permittee shall require and ensure that all contractors and subcontractors have adequate insurance meeting the coverage requirements in this provision. Any insurance required to be carried shall be primary and not excess to any other insurance carried by State. Coverage shall be in force for the complete term of this Permit, including any extension thereof, and for all work being done for which this Permit is required. 9. **Reservation of Rights:** State reserves the right to use the Property in any manner, provided such use does not unreasonably interfere with Permittee's rights herein. 10. **Access Limits and Conditions:** Access to the Property shall be limited to the access designated by State and is illustrated in Figure 2 of Exhibit "A" and as described below. The barrier beach would be accessed from the paved parking lot at Goat Rock State Beach, located at the end of Goat Rock Road off of Highway 1. Equipment would be off-loaded in the parking lot and driven north onto the beach via an existing access point within the parking lot. Additional detail is provided in the attached Russian River Estuary Management Activities. 11. **Notice of Work:** Any required notices to State shall be sent to the State authorities in charge of Sonoma Coast State Park named below. At least 24 hours prior to any entry upon the Property for any of the purposes hereinabove set forth, Permittee shall provide the State contact[s] named below with written notice of Permittee's intent to enter the Property. **STATE:** Contact: Brendan O'Neil Address: 25381 Steelhead Blvd. Duncans Mills, CA 95430 Tel: 707/865-2391 Fax: 707/865-2046 **PERMITTEE:** Contact: Jessica Martini-Lamb Address: 404 Aviation Blvd. Santa Rosa, CA 95403 Tel: 707/547-1903 Fax: 707/524-3782 12. **Limits of Work:** In no event shall this Permit authorize work in excess or contrary to the terms and conditions of any regulatory agency permit or approval. Under no circumstances, whether or not authorized by any regulatory agency, other permit or any person or entity other than State, shall work exceed that which is authorized by this Permit as described in the Exhibit B, Russian River Estuary Management Activities. 13. **Public Safety:** Permittee is responsible for public safety during and after the breaching operation until such time that water velocities and standing waves recede, the sandbar banks stabilize and cease to erode, cave and wash away and heavy equipment has been removed from State Park property. In the interest of public and Park visitor safety STATE reserves the right to require PERMITTEE to provide Peace Officers and/or Lifeguards, at no cost to STATE, to monitor and close the beach to the public for a distance of 750' on each side of the breach as recommended in the Russian River Estuary Study. In the interest of public safety, the preferred days for sandbar breaching are from Monday to Thursday (excluding holidays) when Park visitation is usually at a minimum. In the event of emergency situations, breaching may proceed immediately after notifying the State Park District Superintendent or their designee. 14. **Compliance with Monitoring and Mitigation Measures:** Resource monitoring and mitigation measures identified within the Russian River Estuary Management Project Final Environmental Impact Report, NMFS Biological Opinion, DFG Lake and Streambed Alteration Agreement, Regional Water Quality Control Board Section 401 Water Certification, California Coastal Commission Coastal Development Permit, US Army Corps of Engineers Section 404 and Section 10 Permit, and State Lands Commission General Lease shall be completed in accordance with and to the satisfaction of the District Superintendent or designee. Permittee's activities conducted under this Permit shall comply with all State and Federal environmental laws, including, but not limited to, the Endangered Species Act, CEQA, and Section 5024 of the Public Resources Code. Any of Permittee's archaeological consultants working within the boundaries of the Property shall obtain a permit from the California State Parks Archaeology, History & Museums Division prior to commencing any archaeological or cultural investigations of the Property.	

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California Department of Parks and Recreation (continued)	Permittee shall immediately advise State's contact person if any new site conditions are found during the course of permitted work. State will advise Permittee if any new historical resources (including archaeological sites), special status species, threatened/endangered species protocols, or other resource issues are identified within the Project site. Permittee shall abide by District Superintendent or designee's instructions to protect the resource(s) during the permitted work or risk revocation of the Permit. Permittee shall make all excavation activities on the Property available to the State Archaeologist for observation and monitoring. During excavation, the State archaeological monitor may observe and report to the State on all excavation activities. State archaeological monitor shall be empowered to stop any construction activities as necessary to protect significant cultural resources from being disturbed. In the event that previously unknown cultural resources, including, but not limited to, dark soil containing shell, bone, flaked stone, groundstone, or deposits of historic trash are encountered during Project construction by anyone, work will be suspended at that specific location, and the Permittee's work will be redirected to other tasks, until after a State-qualified archaeologist has evaluated the find and implemented appropriate treatment measures and disposition of artifacts, as appropriate, in compliance with all applicable laws and department resource directives. If human remains are discovered during the Project, work will be immediately suspended at that specific location and the District Superintendent or designee shall be notified by Permittee. The specific protocol, guidelines and channels of communication outlined by the California Native American Heritage Commission (NAHC), and/or contained in Health and Safety Code Section 7050.5 and Public Resources Code Sections 5097.9 et seq., will be followed. Those statutes will guide the potential Native American involvement in the event of discovery of human remains. Permittee shall provide a written work schedule to State so that the State archaeological monitor can arrange to be on site on the necessary days. Permittee shall provide reasonable advance notice of and invite the District Superintendent or designee to any preconstruction meetings with the prime contractor or subcontractors. **15. Restoration of Property:** Permittee shall complete the restoration, repair, and revegetation of the Property in consultation with, and to the satisfaction of the State Environmental Scientist should any damage result from permitted activities. Restoration, repair and/or revegetation is required within 30 days after damage or as determined by the State Environmental Scientist. This obligation shall survive the expiration or termination of this Permit. **16. Right to Halt Work:** The State reserves the right to halt work and demand mitigation measures at any time, with or without prior notice to Permittee, in the event the State determines that any provision contained herein has been violated, or in the event that cessation of work is necessary to prevent, avoid, mitigate or remediate any threat to the health and safety of the public or state park personnel, or to the natural or cultural resources of the state park. **17. Use Restrictions:** The use of the Property by Permittee, including its guests, invitees, employees, contractors and agents, shall be restricted to the daytime hours between sunrise and sunset on a day-by-day basis, unless otherwise approved in advance in writing by State. No person shall use or occupy the Property overnight. Activities on the Property shall be conducted only in a manner which will not interfere with the orderly operation of the state park. Permittee shall not engage in any disorderly conduct and shall not maintain, possess, store or allow any contraband on the Property. Contraband includes, but is not limited to: any illegal alcoholic beverages, drugs, firearms, explosives and weapons. Permittee shall not use or allow the Property to be used, either in whole or in part, for any purpose other than as set forth in this Permit, without the prior written consent of the State. **18. State's Right to Enter:** At all times during the term of this Permit and any extension thereof, there shall be and is hereby expressly reserved to State and to any of its agencies, contractors, agents, employees, representatives, invitees or licensees, the right at any and all times, and any and all places, to temporarily enter upon said Property to survey, inspect, or perform any other lawful State purposes. Permittee shall not interfere with State's right to enter. **19. Protection of Property:** Permittee shall protect the Property, including all improvements and all natural and cultural features thereon, including cultural and natural resources, at all times at Permittee's sole cost and expense, and Permittee shall strictly adhere to the following restrictions:	

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California Department of Parks and Recreation (continued)	(a) Permittee shall not place or dump garbage, trash or refuse anywhere upon or within the Property, except in self-contained trash receptacles that are maintained to State's satisfaction by Permittee. (b) Permittee shall not commit or create, or suffer to be committed or created, any waste, hazardous condition or nuisance in, on, under, above or adjacent to the Property. (c) Permittee shall not cut, prune or remove any vegetation upon the Property, except as identified in the Project description and herein permitted or subsequently approved in writing by the District Superintendent. (d) Permittee shall not disturb, move or remove any rocks or boulders upon the Property, except as identified in the Project description and herein permitted or subsequently approved in writing by the District Superintendent. (e) Permittee shall not grade or regrade, or alter in any way, the ground surface of the Property, except as herein permitted, or subsequently approved in writing by the District Superintendent. (f) Permittee shall not bait, poison, trap, hunt, pursue, catch, kill or engage in any other activity which results in the taking, maiming or injury of wildlife upon the Property, except as identified in the Project description and herein permitted or subsequently approved in writing by the District Superintendent. (g) Permittee shall not use, create, store, possess or dispose of hazardous substances (as defined in the California Hazardous Substances Act) on the Property except as herein permitted, or subsequently approved in writing by the District Superintendent. (h) Permittee shall exercise due diligence to protect the Property against damage or destruction by fire, vandalism and any other causes. **20. Default:** In the event of a default or breach by Permittee of any of the terms or conditions set forth in this Permit, State may at any time thereafter, without limiting State in the exercise of any right of remedy at law or in equity which State may have by reason of such default or breach: (a) Maintain this Permit in full force and effect and recover the consideration, if any, and other monetary charges as they become due, without terminating Permittee's right to use of the Property, regardless of whether Permittee has abandoned the Property; or (b) Immediately terminate this Permit upon giving written notice to Permittee, whereupon Permittee shall immediately surrender possession of the Property to State and remove all of Permittee's equipment and other personal property from the Property. In such event, State shall be entitled to recover from Permittee all damages incurred or suffered by State by reason of Permittee's default, including, but not limited to, the following: (i) any amount necessary to compensate State for all the detriment proximately caused by Permittee's failure to perform its obligations under this Permit, including, but not limited to, compensation for the cost of restoration, repair and revegetation of the Property, which shall be done at State's sole discretion and compensation for the detriment which in the ordinary course of events would be likely to result from the default; plus (ii) at State's election, such other amounts in addition to or in lieu of the foregoing as may be permitted from time to time by applicable law. **21. State's Right to Cure Permittee's Default:** At any time after Permittee is in default or in material breach of this Permit, State may, but shall not be required to, cure such default or breach at Permittee's cost. If State at any time, by reason of such default or breach, pays any sum or does any act that requires the payment of any sum, the sum paid by State shall be due immediately from Permittee to State at the time the sum is paid. The sum due from Permittee to State shall bear the maximum interest allowed by California law from the date the sum was paid by State until the date on which Permittee reimburses State. **22. Revocation of Permit:** The State shall have the absolute right to revoke this Permit for any reason upon ten (10) days written notice to Permittee. Written notice to Permittee may be accomplished by electronic or facsimile transmission, and the notice period set forth in this paragraph shall begin on the date of the electronic or facsimile transmission, or, if sent by mail, on the date of delivery. If Permittee is in breach of the Permit or owes money to the State pursuant to this Permit, any prepaid monies paid by Permittee to State shall be held and applied by the State as an offset toward	

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Parks and Recreation (continued)	damages and/or amounts owed. Nothing stated herein shall limit the State's exercise of its legal and equitable remedies. **23. Recovery of Legal Fees:** In any action brought to enforce or interpret any provisions of this Permit or to restrain the breach of any agreement contained herein, or for the recovery of possession of the Property, or to protect any rights given to the State against Permittee, and in any actions or proceedings under Title 11 of the United States Code, if the State shall prevail in such action on trial or appeal, the Permittee shall pay to the State such amount in attorney's fees in said action as the court shall determine to be reasonable, which shall be fixed by the court as part of the costs of said action. **24. Voluntary Execution and Independence of Counsel:** By their respective signatures below, each Party hereto affirms that they have read and understood this Permit and have received independent counsel and advice from their attorneys with respect to the advisability of executing this Permit. **25. Reliance on Investigations:** Permittee declares that it has made such investigation of the facts pertaining to this Permit, the Property and all the matters pertaining thereto as it deems necessary, and on that basis accepts the terms and conditions contained in this Permit. Permittee acknowledges that State has made, and makes, no representations or warranties as to the condition of the Property, and Permittee expressly agrees to accept the Property in its as-is condition for use as herein permitted. **26. Entire Agreement:** The Parties further declare and represent that no inducement, promise or agreement not herein expressed has been made to them and this Permit contains the entire agreement of the Parties, and that the terms of this agreement are contractual and not a mere recital. **27. Warranty of Authority:** The undersigned represents that they have the authority to, and do, bind the person or entity on whose behalf and for whom they are signing this Permit and the attendant documents provided for herein, and this Permit and said additional documents are, accordingly, binding on said person or entity. **28. Assignment:** This Permit shall not be assigned, mortgaged, hypothecated, or transferred by Permittee, whether voluntarily or involuntarily or by operation of law, nor shall Permittee let, sublet or grant any license or permit with respect to the use and occupancy of the Property or any portion thereof, without the prior written consent of State. **29. Choice of Law:** This Permit will be governed and construed by the laws of the State of California.	

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
California Department of Parks and Recreation (continued) Collections Permit – September 1, 2012 Collections Permit renewal – February 26, 2014 Collections Permit renewal – April 2, 2015 Expiration – April 2, 2017	PERMIT CONDITIONS: CONTACT UNIT PEACE OFFICER/RANGER PRIOR TO MAKING COLLECTIONS: 707/875-3483	No Reporting Required for Collectors Permit

Sonoma County Water Agency
Summary of Special Conditions of Permits for Russian River Estuary Management Activities

Agency / Permit / Expiration	Special Conditions	Report Due Date
US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service Incidental Harassment Authorization (IHA) - April 21, 2011 IHA (renewal) - April 21, 2012 IHA (renewal) - April 21, 2013 IHA (renewal) - April 21, 2014 IHA (renewal) - April 21, 2015 IHA (renewal) - April 21, 2016 Expiration – April 20, 2017	1. This Incidental Harassment Authorization (IHA) is valid from April 21, 2016 through April 20, 2017. 2. This IHA is valid only for activities associated with estuary management activities in the Russian River, Sonoma County, California, including: (a) Lagoon outlet channel management; (b) Artificial breaching of barrier beach; (c) Work associated with a jetty study; and (d) Physical and biological monitoring of the beach and estuary as required. 3. General Conditions (a) A copy of this IHA must be in the possession of SCWA, its designees, and work crew personnel operating under the authority of this IHA. (b) SCWA is hereby authorized to incidentally take, by Level B harassment only, 4,464 harbor seals *(Phoca vitulina richardii)*, 36 California sea lions *(Zalophus californianus californianus)*, and 36 northern elephant seals *(Mirounga angustirostris)*. (c) The taking by injury (Level A harassment), serious injury, or death of any of the species listed in condition 3(b) of the IHA or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA. (d) If SCWA observes a pup that may be abandoned, it shall contact the National Marine Fisheries Service (NMFS) West Coast Regional Stranding Coordinator immediately (562-980-3230; Justin.Viezbicke@noaa.gov) and also report the incident to NMFS Office of Protected Resources (301-427-8425; Benjamin.Laws@noaa.gov) within 48 hours. Observers shall not approach or move the pup. (e) If SCWA observes any fur seal on the beach, it shall contact the NMFS West Coast Regional Stranding Coordinator immediately and shall discontinue any ongoing activity. 4. Mitigation Measures The holder of this IHA is required to implement the following mitigation measures: (a) SCWA crews shall cautiously approach the haul-out ahead of heavy equipment to minimize the potential for sudden flushes, which may result in a stampede – a particular concern during pupping	January 20, 2015: Marine Mammal Monitoring Results Report

Agency / Permit / Expiration	Special Conditions	Report Due Date
	season. (b) SCWA staff shall avoid walking or driving equipment through the seal haul-out. (c) Crews on foot shall make an effort to be seen by seals from a distance, if possible, rather than appearing suddenly at the top of the sandbar, again preventing sudden flushes. (d) During breaching events, all monitoring shall be conducted from the overlook on the bluff along Highway 1 adjacent to the haul-out in order to minimize potential for harassment. (e) A water level management event may not occur for more than two consecutive days unless flooding threats cannot be controlled. (f) Equipment shall be driven slowly on the beach and care will be taken to minimize the number of shut-downs and start-ups when the equipment is on the beach. (g) All work shall be completed as efficiently as possible, with the smallest amount of heavy equipment possible, to minimize disturbance of seals at the haul-out. (h) Boats operating near river haul-outs during monitoring shall be kept within posted speed limits and driven as far from the haul-outs as safely possible to minimize flushing seals. In addition, SCWA shall implement the following mitigation measures during pupping season (March 15-June 30): (i) SCWA shall maintain a one week no-work period between water level management events (unless flooding is an immediate threat) to allow for an adequate disturbance recovery period. During the no-work period, equipment must be removed from the beach. (j) If a pup less than one week old is on the beach where heavy machinery will be used or on the path used to access the work location, the management action shall be delayed until the pup has left the site or the latest day possible to prevent flooding while still maintaining suitable fish rearing habitat. In the event that a pup remains present on the beach in the presence of flood risk, SCWA shall consult with NMFS and CDFW to determine the appropriate course of action. SCWA shall coordinate with the locally established seal monitoring program (Stewards of the Coast and Redwoods) to determine if pups less than one week old are on the beach prior to a breaching event. (k) Physical and biological monitoring shall not be conducted if a pup less than one week old is present at the monitoring site or on a path to the site. 5. Monitoring The holder of this IHA is required to conduct baseline monitoring and shall conduct additional	

Agency / Permit / Expiration	Special Conditions	Report Due Date
	monitoring as required during estuary management activities. Monitoring and reporting shall be conducted in accordance with the approved Pinniped Monitoring Plan. (a) Baseline monitoring shall be conducted each week, with two events per month occurring in the morning and two per month in the .afternoon. These censuses shall continue for four hours, weather permitting; the census days shall be chosen to ensure that monitoring encompasses a low and high tide each in the morning and afternoon. All seals hauled out on the beach shall be counted every 30 minutes from the overlook on the bluff along Highway 1 adjacent to the haul-out using high-powered spotting scopes. Observers shall indicate where groups of seals are hauled out on the sandbar and provide a total count for each group. If possible, adults and pups shall be counted separately. (b) In addition, peripheral coastal haul-outs shall be visited concurrently with baseline monitoring in the event that a lagoon outlet channel is implemented and maintained for a prolonged period (over 21 days). (c) During estuary management events, monitoring shall occur on all days that activity is occurring using the same protocols as described for baseline monitoring, with the difference that monitoring shall begin at least one hour prior to the crew and equipment accessing the beach work area and continue through the duration of the event, until at least one hour after the crew and equipment leave the beach. In addition, a one-day pre-event survey of the area shall be made within one to three days of the event and a one-day post-event survey shall be made after the event, weather permitting. (d) For all monitoring, the following information shall be recorded in 30-minute intervals: i Pinniped counts by species; ii Behavior; iv. Estimated distances between source of disturbance and pinnipeds; v. Weather conditions (e.g., temperature, percent cloud cover, and wind speed); and vi. Tide levels and estuary water surface elevation. (e) All monitoring during pupping season shall include records of any neonate pup observations. SCWA shall coordinate with the Stewards' monitoring program to determine if pups less than one week old are on the beach prior to a water level management event. 6. Reporting The holder of this IHA is required to: (a) Submit a report on all activities and marine mammal monitoring results to the Office of	

Expiration		Report Due Date
	Protected Resources, NMFS, and the West Coast Regional Administrator, NMFS, 90 days prior to the expiration of the IHA if a renewal is sought, or within 90 days of the expiration of the permit otherwise. This report must contain the following information: i. The number of seals taken, by species and age class (if possible); ii Behavior prior to and during water level management events; iii. Start and end time of activity; iv. Estimated distances between source and seals when disturbance occurs; v. Weather conditions (e.g., temperature, wind, etc.); vi. Haul-out reoccupation time of any seals based on post-activity monitoring; vii Tide levels and estuary water surface elevation; viii. Seal census from bi-monthly and nearby haul-out monitoring; and ix. Specific conclusions that may be drawn from the data in relation to the four questions of interest in SCWA's Pinniped Monitoring Plan, if possible. (b) Reporting injured or dead marine mammals: i. In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner prohibited by this IHA, such as an injury (Level A harassment), serious injury, or mortality, SCWA shall immediately cease the specified activities and report the incident to the Office of Protected Resources, NMFS, and the West Coast Regional Stranding Coordinator, NMFS. The report must include the following information: A. Time and date of the incident; B. Description of the incident; C. Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility); D. Description of all marine mammal observations in the 24 hours preceding the incident; E. Species identification or description of the animal(s) involved; F. Fate of the animal(s); and G. Photographs or video footage of the animal(s). Activities shall not resume until NMFS is able to review the circumstances of the prohibited take. NMFS will work with SCWA to determine what measures are necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. SCWA may not resume their activities until notified by NMFS.	

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	ii. In the event that SCWA discovers an injured or dead marine mammal, and the lead observer determines that the cause of the injury or death is unknown and the death is relatively recent (e.g., in less than a moderate state of decomposition), SCWA shall immediately report the incident to the Office of Protected Resources, NMFS, and the West Coast Regional Stranding Coordinator, NMFS. The report must include the same information identified in 6(b)(i) of this IHA. Activities may continue while NMFS reviews the circumstances of the incident. NMFS will work with SCWA to determine whether additional mitigation measures or modifications to the activities are appropriate. iii. In the event that SCWA discovers an injured or dead marine mammal, and the lead observer determines that the injury or death is not associated with or related to the activities authorized in the IHA (e.g., previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), SCWA shall report the incident to the Office of Protected Resources, NMFS, and the West Coast Regional Stranding Coordinator, NMFS, within 24 hours of the discovery. SCWA shall provide photographs or video footage or other documentation of the stranded animal sighting to NMFS. iv.Pursuant to sections 6(b)(ii-iii), SCWA may use discretion in determining what injuries (i.e., nature and severity) are appropriate for reporting. At minimum, SCWA must report those injuries considered to be serious (i.e., will likely result in death) or that are likely caused by human interaction (e.g., entanglement, gunshot). Also pursuant to sections 6(b)(ii-iii), SCWA may use discretion in determining the appropriate vantage point for obtaining photographs of injured/dead marine mammals. 7. Validity of this IHA is contingent upon compliance with all applicable statutes and permits, including NMFS' 2008 Biological Opinion for water management in the Russian River watershed. This IHA may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if NMFS determines that the authorized taking is having a more than a negligible impact on the species or stock of affected marine mammals.	

Attachment D. Russian River Barrier Beach and Estuary Water Surface Level Adaptive Management in Concert with Physical Processes

(from National Marine Fisheries Service)

Russian River Barrier Beach and Estuary Water Surface Level Adaptive Management in Concert with Physical Processes

John McKeon, National Marine Fisheries Service

To comply with NMFS' BO for adaptive management of the RR estuary, i.e., to manage the beach with the goal of conserving beach sand to allow formation of a stable low-flow season elevated outlet-channel and creating a brackish /freshwater lagoon with marine influence minimized, the Sonoma County Water Agency (SCWA) will need to balance multiple natural physical processes when carrying out flood control activities. The two primary processes to balance are: wave and longshore transport of sand into the channel, dependent on wave direction, height and steepness; and outlet channel river-flow scour determined by slope, depth and roughness. The amount of sand transported by either force is dependent on sand supply. As the channel is likely to be of sand only, the vertical elevation-controls of the outlet channel will be the sum of sand transport out of the channel at low tide by the river outflow, versus transport of sand into the channel on the incoming high tide by wave action and longshore current. As the tide lowers and rises, one of these two physical forces will predominate. Balancing the two transport mechanism rates over a 24 hr tidal cycle will be key to maintaining an over-all stable vertical outlet channel elevation and stable estuary water levels minimally influenced by tidal fluctuation. The wave-face between the low tide line and the top of the wave-face crest (height determined by wave height at high tide) will be the key area of scour and accretion during the cycle.

Calculation of scour in open flume channels is a well studied subject, with critical shear stress of when sediments are mobilized on the channel bottom a function of grain size, water velocity and depth. Velocity is determined by roughness and slope. Channel dimension, slope and roughness can be calculated for predicted flow ranges to minimize sheer stress, bed mobilization, scour, and incision of the channel. However, slope across the wave face will be determined by the beach profile where the river outflow meets the ocean. This is the likely point at which channel headcutting would begin, resulting in significant lowering of the outlet channel elevation and estuary water surface elevation (WSE). Because SCWA cannot influence the slope of the wave face beach profile, strategies to minimize scour potential are limited to: 1) choose a river channel outlet location across the wave face where the beach profile has the least slope between the low tide line and wave-face crest height, and 2) minimize depth with increased channel width across the crest of the wave face. This will both limit scour on the outgoing tide, and increase wave transport of sand into the mouth with a greater length of wave break pushing sand into the channel on high tides. Also, to limit propagation of any headcutting precipitated at low tide, the velocity in the channel above the wave face can be decreased with increased roughness and length, or the depth (and scour potential) decreased by increasing the outlet channel width. The beach size and configuration at the time of closure, and the jetty, will constrain, and in part determine, these three channel characteristics.

However, if flood threats and subsequent breaching actions are to be avoided, minimization of scour in the channel and across the wave face needs to be balanced against the ability of channel outflow to remove the predictable transport of sand into the channel by wave and longshore transport, both of which significantly increase during a beach building event and result in a channel closure event.

Transport of sand by waves on to a beach (and into the outlet channel) occurs when wave height compared to wave length reaches a critical point, which is called critical steepness, expressed as Critical H/L. JW Johnson determined critical steepness in the laboratory as = 0.03; waves with a lower H/L value moved sand offshore, those with a higher value moved sand onshore[2]. Wave length is directly proportional to wave period. Using the acceleration rate of gravity, 32/ft/sec/sec= g; and pi for rough approximation of wave form as sinusoidal, L = g/2pi* T^2 or $5.12T^2$ (*e.g.,* 13 ft waves, 9 second period; 9 squared*5.12= 414.72; 13/414.72= 0.0314, steep enough to accrete, or 9 ft waves, 7 second period; 7 squared*5.12= 250.88; 9/250.88= 0.0359).

Because of the coastal aspect of the RR beach and the presence of headlands to the north and south, wave direction is important in determining the height of waves which reach the beach. Wave direction and size also determine the strength of the longshore current, and thus the rate of channel infilling on an incoming tide. The larger the waves, and greater the angle of wave incidence away from perpendicular to the beach, the stronger the longshore current and amount of sand transport.

The incidence of the outlet channel to the wave-face crest will be critical in limiting channel infilling by wave action during a beach building event. When a beach building/closure event is occurring, at high tide waves will be delivering and depositing sand up and over the wave face crest into the mouth of the channel at a rate much greater than the ability of the relatively low flow of the channel to transport sand in opposition to the direction of wave transport. However, a channel behind the wave-face crest and close to perpendicular to the wave direction will be more capable of transporting the sand washed into it by wave action, as flow from the wave will be entrained in the flow of the outlet channel, with the added flow increasing the transport power of the outlet channel. Thus, by orienting the outlet channel near to perpendicular to wave run-up direction, the out-flow channel will be better at limiting or preventing accretion of sand in the channel mouth by successive waves than if the channel is parallel to the wave run-up direction. Strategies for minimizing accretion of sand in the lagoon outlet channel mouth during a beach building event, and limiting likelihood of outlet channel closure events will be: 1) choose a river channel outlet location where the beach profile has the least slope between the low tide line and wave-face crest height, as less slope will mean a greater distance for waves to expend their energy before topping the wave crest, and/or the lower wave-face crest would signify an area of reduced wave size and transport capacity; 2) align the channel from the lagoon outlet, and behind the wave-face crest, to be as near to perpendicular as possible to wave run-up direction in order to minimize sand accretion at the channel mouth during high tide.; 3) insure there is sufficient slope from the lagoon WSE to the point the channel crosses the wave-face crest sufficient to maintain flow across the wave-face crest when waves push the crest above the high tide line (~ 3.3 ft NGVD with a 6 foot high tide). This means planning for the outlet channel invert to be above the lowest point of the wave-face crest height.

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[2] Willard Bascom. 1980. *Waves and Beaches.* Anchor Books Edition. ISBN: 0-385-14844-5

Channel Planform and Slope

In addition to the above described means to balance scour and accretion in the channel mouth and across the wave face, the channel planform will be dictated by beach topography. The entire beach topography above the tide lines is determined by waves and longshore current that will continue to sculpt the beach once the outlet channel has been established. To avoid repetitive heavy equipment excursions on to the beach to reform the outlet channel, the beach topography should dictate both the channel planform and slope of the outlet channel. To determine the most natural channel planform and slope, *i.e.*, the planform location and slope that will most likely be maintained by wave and tidal action subsequent to formation of an outlet channel by SCWA, a detailed topographic survey of the beach will need to be prepared post lagoon-closure, and prior to beach and estuary WSE management actions.

Natural Analogues

When waves reach critical steepness and sand accretion occurs on the beach, the underwater sand bar just outside the wave break is moved onshore with the incoming tide. The beach increases in both width and height, which results in a lengthening of the outlet channel as it has a greater width of beach to cross, and behind the wave-face crest, flows longitudinally along the beach to the lowest point of the crest. The increased length of the channel results in more resiliency to scour and incision during low tide and allows for stabilized lagoon WSE, with tidal influence becoming muted. Lacking subsequent beach building events, the channels may scour back down below the high tide level within weeks, reintroducing tidal influence to the lagoon WSE. However, with continued or subsequent beach building events, the channel continues to elevate and lengthen, and with river inflows declining in spring/summer, the channel loses its ability to incise, and a closed of perched lagoon WSE eventually results.

A short duration event of critically steep waves and beach building occurred along the California Coast the week of May 27th to June 3, 2010. Attached are photos of these river mouth beaches and the channels that resulted from that short duration beach building event. A WSE stage monitor in the Carmel lagoon recorded the effect on lagoon WSE, in which subsequent to the event and the lengthening of the channel, the WSE of the lagoon was maintained above the high tide level and tidal influence became muted. Photos included are of Carmel, San Lorenzo, Scott, Waddell, Pamponio and Navarro river beaches. A plot of the Carmel lagoon WSE for June 2010 can be viewed at http://www.mpwmd.dst.ca.us/wrd/lagoon/webplots/2010/2010webplots.htm

CARMEL, 6/9/2010

San Lorenzo, 6/10/2010

Scott Creek, 6/10/2010

Waddell, 6/10/2010

Pamponio, 6/10/2010

Navarro, 6/6/2010

Navarro, 6/6/2010

Navarro, 6/6/2010 (high tide-/Lagoon WSE ~ 6-7 feet NGVD estimated)

Navarro, 6/6/2010

Attachment E. Implementation of the 2010 Outlet Channel Adaptive Management Plan!

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At the direction of NMFS, Sonoma Count/ !Water Agency (the Agency3has been tasked with creating an outlet cˆannel intended to)&prove salmonid habitat in the Russian River Estuary while &aintaining the current level of flood protection for properties adjacent to the estuary! (NMFS, 2008). The adaptive &˙˝˙gement plan, described in the!&ain bo(/ of this report, was developed by the Agency with assistance fro&!ESA PWA and the resource agency management team in 2009 ˙nd revised in 2010. Because of permit constraints, the Agency!5as onl/ able to)&plement the plan beginning in %°°˛!!This att˙ˆment documents the &anagement actions)˝! response to inlet closures that occurred during the 201°!lagoo˝!&anagement period.!

!

During the management period, Ma/ ! 5th to October 15th, Agency staff regularly!&onitored current and forecast estuar/ water levels, inlet state, river discharge, tides, and wave conditions to anticipate inlet closure. For the first mo˝th and a half, river ( )scharge was somewhat larger than historic dail/ !&edian conditions due to a wetter8than-average spring, but then receded to nearly replicate historic median flow rates. Average monthly wave ener1/ !)n 2010 was si&)˘˙r to historic averages for most of the m˙nagement period a˝(!ˆ)1 ˆer for!9une and October. Two periods of inlet closure occurred (Figure 1), leading the Agency to begin planning for management action to create an outlet channel, in accordance with the p˘˙˝: s communication protocol: !

!

- Starting in late June 2010,!pˆ/ sical conditions at the &outh of the Russian River Estuary! naturally established an outlet channel that persisted for a week!4efore wave action co&pletely closed the lagoon. In response to this closure, the Agency attempted to create an outlet channel for the first time. This m˙nagement action briefly re8established outlet channel conditions, but within a!ˆ˙ ˘*!(˙/.!5 ave a tion re8closed the outlet cˆanne˘˛!! Before the next scheduled management action could t˙ e place, the lagoon breached, returning the estuary to ti(al conditions.!!!
- The estuary closed twice more in the management period, during the third week of September and again at the start of October. Although action to create an outlet channel was initially!considered after the Septem4er closure, an extended period of large waves ˘)&ited beach access due to safety concerns. As a result, water levels continued to rise, heightening flood risk. Therefore, in consultation with the resource agency!&anagement team, the Agency decided to implement full breaching. Two attempts were required for each closure before the lagoon was successfully breached.

!

The next section of this attach&ent reviews the process for leading up to!˙˝(!(uring the Jul/ ! outlet channe˘!)&plementation. In the following section, the September and October closures are assessed. Although the September and October closures did not result in creation of an outlet channel, the planning process and physical processes are relevant to adaptive management. The last section summarizes lessons learned!from the 2010 m˙˝˙1 ement period to consider in subsequent years.

!

JUNE-JULY 2010 OUTLET CHANNEL EVOLUTION

!

In the second half of June, an outlet channel and perched lagoon were naturally established at the &outh of the Russian River. For about one week, this c˄˙ nnel conveyed e˝ oug˄ !5 ˙ ter to the ocean to sustain 4.5 to 5 ft!+@A7!water levels in the lagoon. Once waves closed the outlet channel and lagoon water levels began to rise, the Agency!)&plemented!˙!&˙ nagement action to create an outlet channel. In the face of strong waves, this outlet qui ly closed. Several days later, the lagoon was breached and tidal con()tions returned until September˛!!7etails of this channel evolutio˝!˙ re provided belo5˛!

NATURALLY ESTABLI- HED OUTLET CHAN+ EC!

!

Outlet channel conditions (defined as a nearly steady lagoon water levels above ocean water levels a˝(!& ˙ intained b/! u˝)&directional outflow in!˙! ˄˙ nnel passing through the beach berm3! naturally established over a week-long period in late June. The ph/ s) ˙˘! onditions associated with this evolution are described below.!

Water level !

Water levels in the lagoon, as observed at!the Jenner g˙ ge, exhibited a muted tide range, indicative of partial c˘osure, starting on June 20th as shown in Figure 2a. The tide range gradually! decreased from!about 1.5 ft until ti(˙˘!#˙ riations ceased early on the morning of June 27th˛!! Lagoon water levels then increased over the next!(˙ / !to just over 4 ft NGVD. Water levels were then fairly constant at about ?!ft NGVD for three d˙/ s˛ On June 3° th, the water levels started to decline, probably due to the drop in upstream!riverine discharge as co&pared to higher outlet channel d)scharge. Water levels declined to!˙!&)˝)&um o*!'!ft NGVD before the channel closed on Jul/ !?th˛!

Ocean waves and tides!

Significant w˙ ve height at CDIP's Point Reyes buo/!)ncreased above!%!&starting on June 24th as shown in Figure 2b. About the time that tidal influence disappeared from!lagoon water levels on June 27th, the significant wave height exceeded 3 m!and sta/ e(!˙ bove 3 m until Jul/ ! st. Peak! wave period during this ti&e period was approxim˙ tely 8 seconds and the peak direction was from!the northwest. Figure 3 illustrates the wave direction, perio(.!˙˝(!& agnitude fro&!June 16th! throug˄!9ul/! ? th. Astronomic tides were declining fro& pe˙ spring levels, with the hig˄ er h)1˄! water on June 2Eth of just over 3 ft NGVD as shown in Figure 2c.

Riverine discharge!

Riverine discharge in late June was higher than to median conditions because o*!late season precipitation and full reservoirs. Figure 2d illustrates how flow dropped rapid˘y from 325 ft'/s on June 2Eth to 225 ft'/s on!9une 30th˛!!,˘ow then continued to drop!&ore slowly ˙ t a!rate of less than 5 ft'/s per day for the next two weeks.

Planform!˙˘)1nment!

At the time of closure, the channel exited the northwest corner of the lagoon and ran along the foot of the bluff, landward of the berm crest, for approxim˙tely 550 ft. The channel then crossed the berm!˙nd exiting to the ocean. This alignment was similar to the alignment observed during 1998, an El Nino / ear (personal communication, C. Delaney). Several days be*ore the closure, the cˆannel was observed further south than its a˘)1˝&ent a˘ong the bluff once tˆe outlet cˆannel established. Unfortunately, the Agenc/ :s autom˙te(!camera d)(!˝ot collect pictures between 9une 23-29 due to!a power failure, precluding!˙!&ore detailed analysis of the channel's planform! evolution in the days preceding the establishment of the outlet cˆannel. !

Beach a˝(! hannel topograph/ !

The beach berm north of the outlet channel and the downstre˙& !end of the channel was surveyed 4/ Agenc/ staff o˝ Ju˘/ ! st (Figure 4). The presence of seals on the beach to the south o*the channel prevented additional survey data from being collected. On both sides of the channel's &outh, sand had deposited!such the intertidal beach protruded approxim˙tely 5°!feet into the ocean as compared to the beach align&ent further south (Figure 4 and Figure 5a). Just north of the outlet channel, the beach face that had been covered b/ !wave runup during the previous hi1ˆ! tide extended up to 8 ft N@A7¸!!˘hen the beach profile stepped up to a bench with elevations above 10 ft NGVD. South of the channe˘.!the berm crest elevation was esti&ated to approxim˙tel/ !Eft NGVD, but was not measured d)rectly. The outlet channel was approximately! 60 ft wide, with its bed elevation at 0-1 ft NGVD for last one hundred feet before it entered the ocean. The channel flowed around numerous large boulders along!&uch of its length. These boulders m˙/ have served as natural grade control inhibiting erosion.!

Channel discharge!

On June 30th.!the A1ency collected water depths a˝(! point #elocities in the outlet cˆannel.!5ˆ) ˆ! was approximately 60 ft wide. Water in the outlet channel flowed at depths up to 2.7 ft and velocities of at least 5.4 ft%/s. These velocities are in excess of per&issible scour criteria for beach sands, but not sufficient to scour the larger boulders found in the outlet cˆannel (Fischenich, 2001). Integrated water depth and point velocity measurements yielded an estimate the channel's discharge of 297 ft'/s (SCWA unpublished observations). As shown in Figure 2d, this (ischarge magnitude was observed upstream!at Guerneville approxim˙tely two days earlier and was larger than the concurrent Guerneville discharge. This is consistent with the dropping water levels in the lagoon (Figure 2a) and tributar/ !)˝*˘ows downstream!of Guerneville.

!

WAVE-INDUCED OUTLET CHANNEL CLOSURE

!

After the week of sustained outlet channel conditions, the wave energy briefly relaxed on July 2˝(.! and then returned to significant wave heights from the northwest exceeding 3.5 m!starting on July ' rd (Figure 2b). This increase in wave height was acco&panied by!˙˝ increase in northwest swell wave period to approximately!10 seconds. This increase in wave energy provided enough landward sand transport to close the outlet ch˙nnel. Riverine discharge had recently declined, reducing the hannel's a4)˘ity to clear s˙˝(!˙ nd remain ope˝˛!!This losure occurred during!˙!˝eap tide, when higher h)gh water levels just b˙rely exceeded 2 ft NGVD. !

!

Changes to the wave cli&ate continued for the next several d˙/ s, with the peak!(irection shifting to the south and the wave period lengthening to nearly 14 seconds!2Figure 3). Significant wave height dropped to less than 1.5 m. This long-period, ˘ow-steepness swell is likely to have built the beach berm!with onshore sand transport. This likely onshore transport changed the beach topography! hanged in two!5˙/ s. The protruding s˙nd deposits at!the channel's!&outh noticeably ()&inished in size between Ju˘/ !?th!˙˝(!9uly 5th.!˙˝(!5 ere essentially gone by Jul/ !Fth. In addit)on, the onshore transport proba4˘/ !4uilt the berm crest elevation from the estimated berm crest elevation of 7 ft NGVD on Ju˘/! st (C. Delaney3!˙˝d July!?th (J. Largier) to an elevation of 8.5 ft NGVD as surveyed on Jul/ !8th˛!!

!

Once the outlet channel closed, lagoon water levels began to rise at a rate of approxim˙tely 0.5 ft/day. The channel closure and rising water levels initiated the Agency's outlet channel management plan. !

!

MANAGEMENT ACTIO+!

!

Management action to create an outlet channel was scheduled for Jul/ !8th in consultation with the resource management team. Tˆe action was scheduled for Ju˘/ 8th because it was a Thursday, the last day that action could be taken before the State Parks permit restrictions on Friday8-unda/! operations went into effect. Given the observed rate of lagoon water level rise o*!°˛5 ft/da/ .! waiting until the following Monda/!5 as deemed to be too risky in ter&s of flood hazard a˝(! channel scour. To provide operational flexibilit/ !)n response to site conditions, two different management options were proposed during planning. Figure 4 shows the alignment of these options, botˆ!'°! ft wide, as laid on the topographic sur*ace collected on Jul/! st. This schemati ! design was used to discuss management plans with the resource agencies, to esti&ate volu&es o*! excavated &aterial, and to guide operations staff. Option A, the preferred option, followed the northwest alignment of the natural outlet channel prior closure. In the event that beach surveys indicated a low point in the!4er&!further south or if access to the Option A location was restricted 4/ waves, Option B was proposed just north of Ha/ st˙ Rock˛!!

!

Based an assessment of site conditions early on the morning of Jul/ !8th, Option A was selected for)&plementation. Excavation be1˙n at approxim˙tely E˙& on Jul/! 8th with a bulldozer a˝(! 4˙ hoe excavator. The lagoon water level at the time work began was 5.9 ft NGVD.

!

The excavated portion of the managed channel follo5 ed the alignment of the southern half of the naturally established outlet channel, as shown in Figure 5b. This alignment allowed the excavation equipment to ˙void roc s embedded in the berm. The backhoe remo#ed sand from!the landward portion of the berm.!adjacent to a large rock. The bulldozer pushed sand towards the ocean to form the lower portion of the channel. A s&˙˘˘!4erm!was preserved between the two pieces of equipment to prevent lagoon outflow before the channel was co&plete. After approxim˙tely two hours of work, wave runup associated with the rising tide started to enter the channel's mouth. Therefore, the middle ber&!5˙ s removed with the excavator at approxim˙te˘/ ! 9:30am.! ompleting the cˆ˙nnel. !

!

At the time of completion, the outlet channel was approxim˙tely!' °!ft wide and had an invert o*! approxim˙tely 4.5 ft NGVD. Water flowed in the channel at a depth of approximately 0.5 ft. Flow was t/ p) ˙˘˘/ uniformly seaward in the upstream portion of the newly ex ˙vated channel. However, in the downstream portion, wave runup periodically over5 helmed the outflow, c˙using the flow to switch direction to landward. The transition between the existing channel and the newly excavated portion created a h/ (raulic control across which water transitioned from! subcritical to supercritical, thereby explaining the channel's lower water level as compared to the lagoon. Bed erosion was observed starting from!this transition region and into the new portion. !

!

During the period when the outlet ˆ˙˝˝ e˘!5as ope˝.!5 ater levels in the lagoo˝!continued to increase at a s)&ilar rate to the rate before the &anagement action. This constant rate of water level increase indicates that flow in the outlet channel was relatively sm˙˘˘ co&pared to riverine inflow to the lagoon. !!

!

OUTLET CHANNEL CLOSURE!

!

As ocean tides increased water levels throughout Jul/ 8th, the w˙ve runup fro&!the south swell advanced up and over the beach face, as evidence(!4y the absence of equipment tracks on the beach in Ju˘/ 9th photo1raphs˛!!6y the e#ening of Jul/! 8th, this a(#˙˝)˝1!5 ave runup transporte(! enough s˙˝(!)˝ to the outlet channel that the channel once a1˙)˝! losed. Higher hi1ˆ!5 ater on the evening of Ju˘y 8th was above 3 ft NGVD, as tidal conditions were building towards large spring tides.

!

After reviewing lagoon a˝d be˙ ˆ! onditions on Ju˘/! 9th, the A1ency scheduled follow&up management for Monda/.! 9uly 12th, the first d˙/ !5ˆ) h the/ were allowed to operate on the beach under their St˙te Parks permit.

BREACD;+ G TO TIDAL!˘ ONDITIO+ -!

!

Lagoon water levels continued to rise at a rate of!˙pproxim˙tely 0.5 ft/da/ in the days followin1! closure. On the evening of!9ul/! th, the!lagoon breached in the vicinit/ !of Ha/ st˙ Rock. The lagoon water level at the time of the breach was 7!*t NGVD, which is approxim˙tely! ˛5 ft below the berm crest elevation surveyed on July 8th˛!!˜his difference suggests that the breach may!ˆ˙#e been caused 4/ !seepage through the ber&. Just before the breach, the water's edge extending towards the breach site, indicating that breach occurred at the low point in the beach berm:s crest elevation.

!

Because the estuary returned to ti(al conditions on Jul/! th, the m˙nagement action planned for! July 12th was cancelled. Tidal conditions persisted in the estuary until September.

!

SEPTEMBER-OCTOBER 2010 CLOSURES AND MANAGEMENT

!

In the end of August, coincident with ne˙p tides and increased wave heights, the estuary water levels became muted, diminishing to a ti(e range of less than one foot (Figure 6a). Shortl/! afterwards, starting o˝ Septem4er 4th.!5˙ve energy increased considerably fro&!the northwest (Figure 7b) to sustained wave heights exceed)˝1!'!& and peaking above 4 m!2Figure 6b). This! co&4ination of muted tides followed by large waves, would seem!to have been ideal conditions to prompt closure. However, the inlet stayed open throughout this high wave period. Several factors probabl/! ontributed to the inlet's persistent ope˝)˝ 1˛!Although lar1e in height, the w˙ves' period was relatively short (below 12 seconds) and fro&!the northwest. Because of the beach faces the! southwest, it may!4e partially sheltered from!waves out of the northwest. The tides were transitioning from neap to spring, so the increasing tidal prism!would have contributed to scouring the inlet's channel˛!0˙# e overtoppin1 also &˙/!ˆˆ ve contributed to!maintaining in˘et b/! adding water to the estuary that then flowed out the inlet, s our)˝1!the cˆannel. !!

!

After the &uted tides in early Septem4er,!full tide range returned to the lagoon, probabl/ assisted 4/ the arrival of larger spring tides. Around Septem4er 18th, during the month's!second neap tide, another wave event was observed with significant wave height less than 2 m, nearly half the magnitude of tˆe early Septe&4er event (Figure 6b). However, the wave period was longer, 16-18 seconds instead of 8-10 seconds, and waves were from!the south instead of the northwest. These conditions closed the estuary on September 21st˛!!!

!

After the inlet closed on Septem4er 21st, planning to establish an outlet channel began. Based on the most recent beach topography, tˆe projected rate of lagoon water level increase, ti(es, and wave forecasts, Septem4er 28th, was selected for an attempt at creati˝1!˙˝ outlet channel. Two options for the channel were proposed, o˝e extending to the nortˆwest fro&!the edge of the lagoon, and one just south of Haystack Rock where the inlet had been just before closure. Lagoon water levels were above 6 ft NGVD b/ the 28th, as anticipated, in part due to wave overwash. Although water levels were rising, runup fro& large waves &˙(e beach access unsafe and operations were postponed to September 29th. Unsafe wave conditions persisted on the 29th.!˙1˙)˝! preventing beach access. Si˝ce wave forecasts predicted o˝˘/ a brief lull on the next da/ before large waves returned and weekend access restrictions loomed, the Agency, in consultation witˆ! the resource agency management team, decided on tˆe evening of!0 ednesday, September 29th, to switch fro& attempting to create an outlet channel to attempting a full breach.

!

Wave and tide conditions on the &orning of September 30th allowed for beach access an(!˙!*u˘˘! breach was i&p˘emented. However, waves carried o˝!the rising tide re-closed the inlet that afternoon and lagoon water levels continued to rise. A second attempt at breaching the afternoon of the 30th was cancelled because of unsafe wave conditions on the beach. Because of the)&pending flood risk!29 ft water levels were projected by Sunday, October 3rd), the Agency! sought and received permission from State Parks to access the beach Frida/ , October 1st. The

breach on October 1st was successful, helped b/ !extensive scour coinciding with tides dropping to lower low water during the night. Estuary water levels dropped to 1 ft NGVD on October 2˝(˛!!
!
After a brief lull, wave conditions once again intensified and the)˝˘et closed again on October 4th˛! Although still within the management period, the proximity to the end of the m˙˝ agement season, as well as continuing forecasts for high waves, led the Agency to propose and receive permission from!the resource agency management team for a full breach. Breaching was attempted on October 1 th, when lagoon water levels had exceeded E!*t NGVD. This attempt failed as waves pushed sand into the breach before it could enlarge and lower lagoon water levels. A seco˝(! breach attempt was &˙de on the afternoon o* October 12th, successfully creating a sustained breach that lowered estuary water levels to tidal conditions. A third closure occurred o˝ October %st and self breached on October 24th, p˙rtly!)n response to high r)#er discharge. Although this third event was outside the outlet channel &˙nagement period, it was indicative of the extended period of large!5aves during Septem4er and October 2010˛!
!

LESSONS LEARNED AND RECOMMENDATIONS

!
Based on observations of the estuary, associated physical processes, and the July 8th outlet channel m˙nagement action, we note the following lessons about i&plementing the outlet cˆannel management plan.!

CONCEPTBAL MODEL!

- All four closures discussed above occurred coincident with noticeable wave ener1/ ! associated with periods greater than 12 seconds. In fact, a long period, but relatively!˘o5! wave height (less than 2&) event closed the inlet in the third week of Septem4er even though a larger wave heigˆt, but shorter!period wave event two weeks earlier did not close the inlet. In all but!one case, the long period waves which caused closure originated from!the south or west.
- When wave runup started to progress into the outlet channel and force operations to end, it was decided to favor a deeper outlet channel o#er a wider outlet channel. Channel depth was sought to facilitate!&ore discharge from!the lagoon to counter incom)˝1! waves. We recommend continuing to observe channel/ocean dynamics in subsequent outlet cˆannels to inform!tradeoff decisions of this nature.!

!
FEASIBILIT"!

- ;˝!ˆ)˝ (sight, a better opportunit/ !*or establisˆ)˝1!˙ ˝ !outlet cˆannel!)˝!9ul/!!&ay have been Jul/! ° th or the morning of Jul/! th.!5ˆ en!the lon1!perio(!south!swell ˆ˙(!su4sided! but before the breach occurred. However, based on available information (wave forecasts and no nowledge of the breach) tˆe &˙nage&ent action was enacted earlier, on July 8th.! because the following days were Friday through Sunday when State Parks restricts beach access. Future outlet channel management opportunities are likely!to face si&)˘˙rly! constrained time windows: too soon after closure, the wave conditions which caused closure &˙/ !prevent safe beach access ˙˝(! lagoon water levels wi˘˘!4e less than the BO targets; too late after closure and water levels &˙/ cause flooding or overtopping the beach ber&. In addition to the State Parks weekend access constraints, operations are constrained b/ IHA rules, particularly!4efore June 15th when pupping season ends.

- If the rocks em4edded in the beach are essential for stabilizing against failure by scour, then the elevation of the roc s will largely determine the outlet channel bed elevation and lagoon water level. During the naturall/! established outlet channel which occurred from! June 27th through July 3rd, the channel's bed elevation just before the beach face was 0-1 ft NGVD (9uly 1st Agency survey) and the lagoon water level was between 4.5 and 5 ft! NGVD. Under these conditions, the outlet channel was able to convey approxim˙tely! 300 ft' /s.
- If an outlet channel had been in p˘ace at the start o* the September-O tober large wave period, it quite likely woul(have closed since waves frequentl/ overtopped the beach berm and even some full breaches were quick˘/ closed. If the lagoon water level was close to or at the BO target!Eft NGVD 5ˆ en the closure occurred an(!4each access was ˘)&ited by wave conditions for multiple days, e.g. the five day period from Septem4er %Fth to Septem4er 3°th, the lagoon woul(!˘) el/ !have reached flood stage.
- Management actions attempting full bre˙ ˆ)″1.!5ˆ) ˆ!˙)& !to convert the inlet between two of its stable modes (breached and closed)!˙″(!5ˆ ich are informed b/ decades o*! management experience, st)˘˘!*˙)˘quite regularly. For e<˙&ple, in 2010, two of four breach attempts were unsuccessful and historically, one out of every three attempts have been unsuccessful (Behrens et al., in prep). We anticipate that the failure rate of efforts to create an outlet channel, a less common and less stable transitional state, to be at least as frequent, if not more frequent, than the failure rate for full breaches.

!

COMMUNICATION

- Continue the practice of developing!˙″(! communicating a!4˙ up p˘an for the outlet channel management action in the event that surf conditions were unsafe at the preferred channel location. Communicating this b˙ up plan ahead of time allowed time for discussion a&ong the resource m˙nagement team. reducing the potential for last minute disagreement if this opt)on had to be e″˙ cted.
- Agency, NMFS, and ESA PWA staff consulted as to the specifics of the outlet channel)&plementation immediately before and during the excavation. This discussion was necessary!because of uncertaint/ about the actual beach topography, the excavation progress relative to the tides.!and the overall development of outlet cˆ ˙nnel strategy for this initial implementation. It enabled real-t)&e adaptation to on-site constraints. For instance, the excavation's location was shifted slightly south of the prior cˆannel:s location to avoid large rocks known to be!ˆ)dden within the berm. After following this alignment beyond the rocks, the excavation was guided nortˆward so that the mouth of the outlet channel would be as close as possible to the prior location. !
- After each &anagement action, we suggest ask)ng State Parks staff if operations had gone)″!˙ccordance with their e<pectations with regard to park)″1!˘ot use, public safety, s˙″(! placement, etc.

!

STAFFING!

- The A1ency's engineer on site had broad k˝owledge of the project objectives a˝(! operational constraints, e˝˙ 4˘)˝1!ˆ)& !to engage in dis ussion with the other on-site personnel (particularly the NMFS representative), observe physical conditions, and m˙ e real-time decisions about the outlet channel configurat)on. This presence and decision-&˙ ing authority was essential since the management action was onl/ defined ahead of time as a strate1/ .!˝ot construction-grade drawings.
- Develop capacity of other Agency staff to m˙˝˙1 e outlet channel operation so availability! of informed decision-m˙ ers does not hinder m˙nagement operations.!
- Although equipment operators were new to the site, they adeptly executed outlet channel design as directed by Agency staff. Encourage the contractor to provide staff familiar with the project whenever possible.
  !

EQUIPMENT AND OPERATIONS!

- The backhoe excavator was &ore adept at operations adjacent to rock, the bulldozer was faster for areas with open sand. Particularly!)f operations occur o#er two d˙/ s, consider choice of equipment. For e<˙&ple, on the first da/. ! hoose two bulldozers for speed in excavating a larger channel and replace one bulldozer with an excavator on the seco˝(! (˙/ !for more precise operat)ons.!
- Tides, day˘)ght, and permits all restrict the time available for operations. To m˙<)&ize time available for implementing m˙˝˙1 e&ent actions.! onsider the following procedures:!
  - When possible, have key resource &˙˝˙1 e&ent team mem4ers discuss the operations pl˙n ahead of time, ideally on-site the day before, or by phone if on-site is not practical.
  - Clarify staging procedure between equipment operators and engineering staff to reduce waitin1!!
  - Consider the use of lights to enable equipment to oper˙te under low8light conditions.
- Because rocks limit the outlet channel's alignment; having survey staff on-hand to stake locations of rocks covered b/ !the sand was useful. Agency surve/ s should continue to &onitor rock locations duri˝1!&onthly surve/ s. !
- Equipment operators demonstrated good coordi˝˙ tion between the pieces of equipment, with neither piece idle for an extended period. The two pieces smoothl/ switched the two primary!tasks o*! ˆannel excavation an(!*eathering excavated &aterial o˝ to the beach face.!
- Sand cleared from!the outlet channel was left as a temporar/ !berm!˙t the &outh of the outlet cˆannel to impede wave runup into the outlet ˆannel. This berm was re-shaped just before finishing to open the outlet channel while still providing some protection from! south swell.

!

MONITOR;+@!

- Because the IHA li&its the d˙/ s available to p˘ace people on the beach to collect data, use the full two days allotted for outlet ˆ˙ nnel creation to collect additional dat˙. For instance, consider having the survey team return at 12-hr intervals to take photographs and surve/ channel b˙thy&etry!˙˝(!( )scharge.
- Consider an alternate automated ˙& era placement to capture!the northern portion of the beach.

!

!

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!

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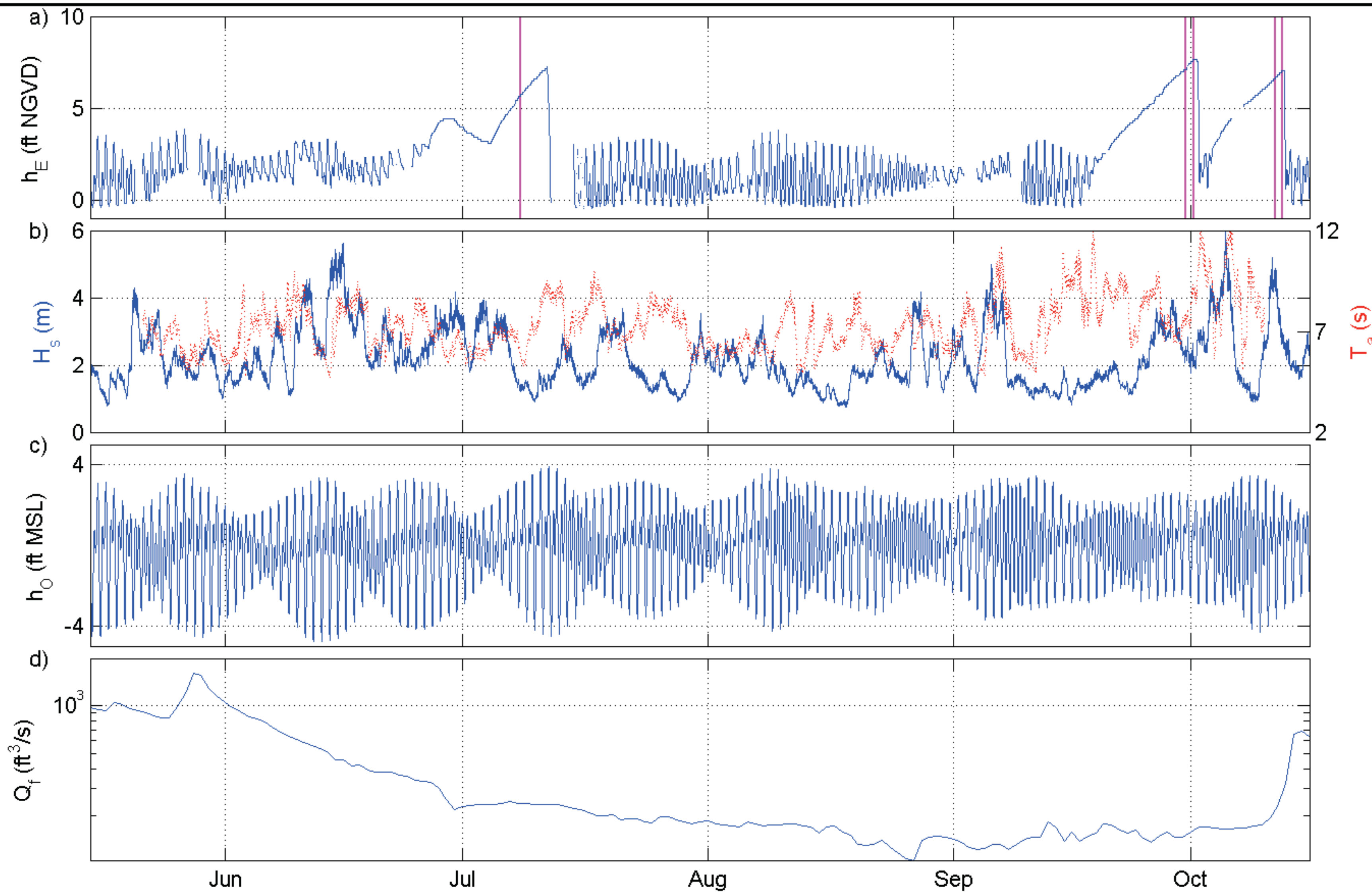

Sources:
a) h_E=estuary water level (SCWA); pink bar = mmgt action
b) H_s=sig. wave height; T_a=avg. wave period (CDIP, Pt. Reyes, #029)
c) h_O=ocean water level (NOAA, Pt. Reyes #9415020)
d) Q_f=river discharge (USGS, Guerneville #11467000)

Figure 1
Russian River Estuary Outlet Channel Management Plan

Estuary and Ocean Conditions, May 15 - October 15 2010

PWA Ref# 1958.01

ESA PWA

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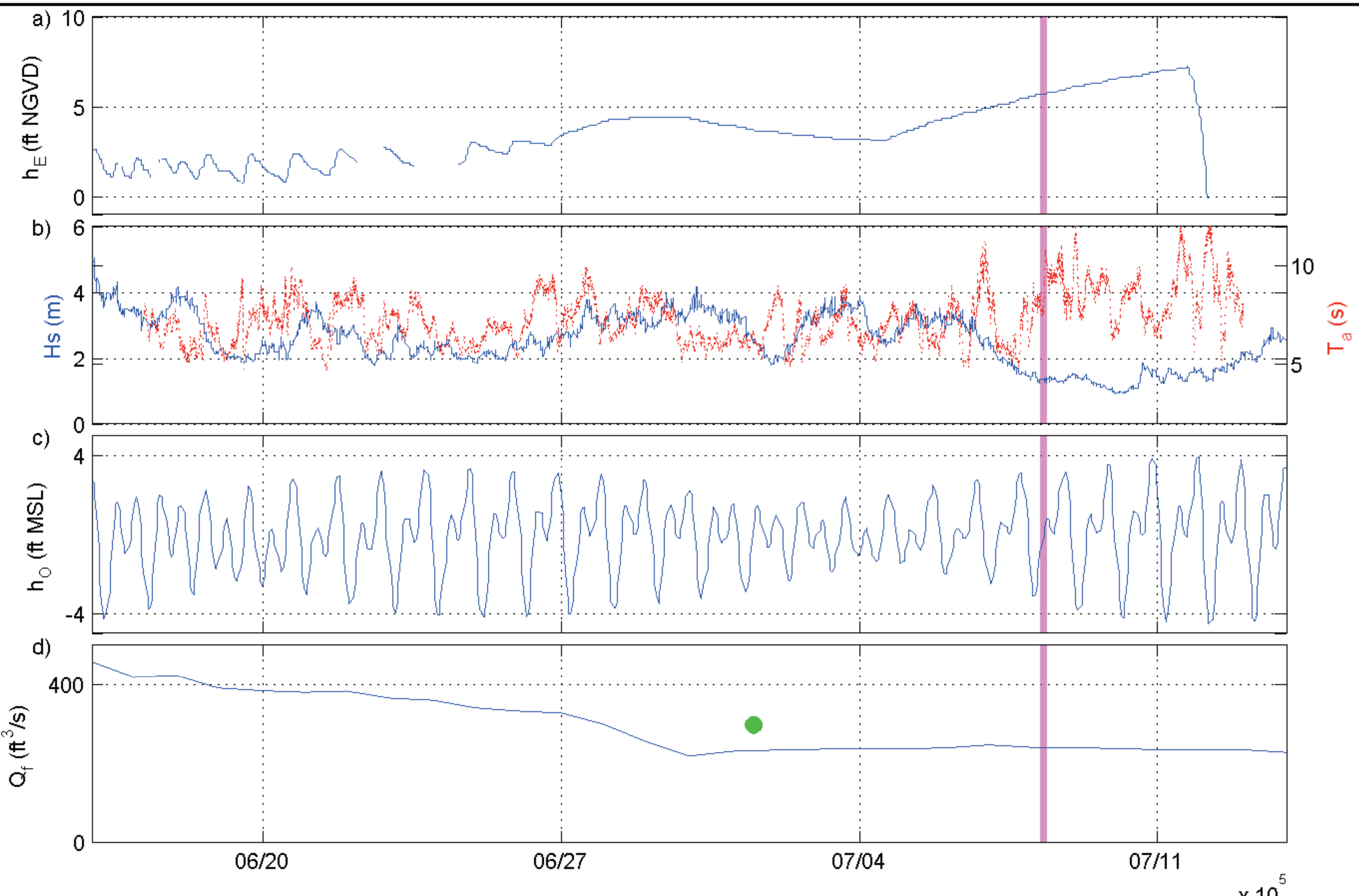

Sources:
a) h_E=estuary water level (SCWA); pink bar = mmgt action
b) H_s=sig. wave height; T_a=avg. wave period (CDIP, Pt. Reyes, #029)
c) h_O=ocean water level (NOAA, Pt. Reyes #9415020)
d) Q_f=river discharge (USGS, Guerneville #11467000)

Figure 2
Russian River Estuary Outlet Channel Management Plan

Estuary and Ocean Conditions, June - July 2010

PWA Ref# 1958.01

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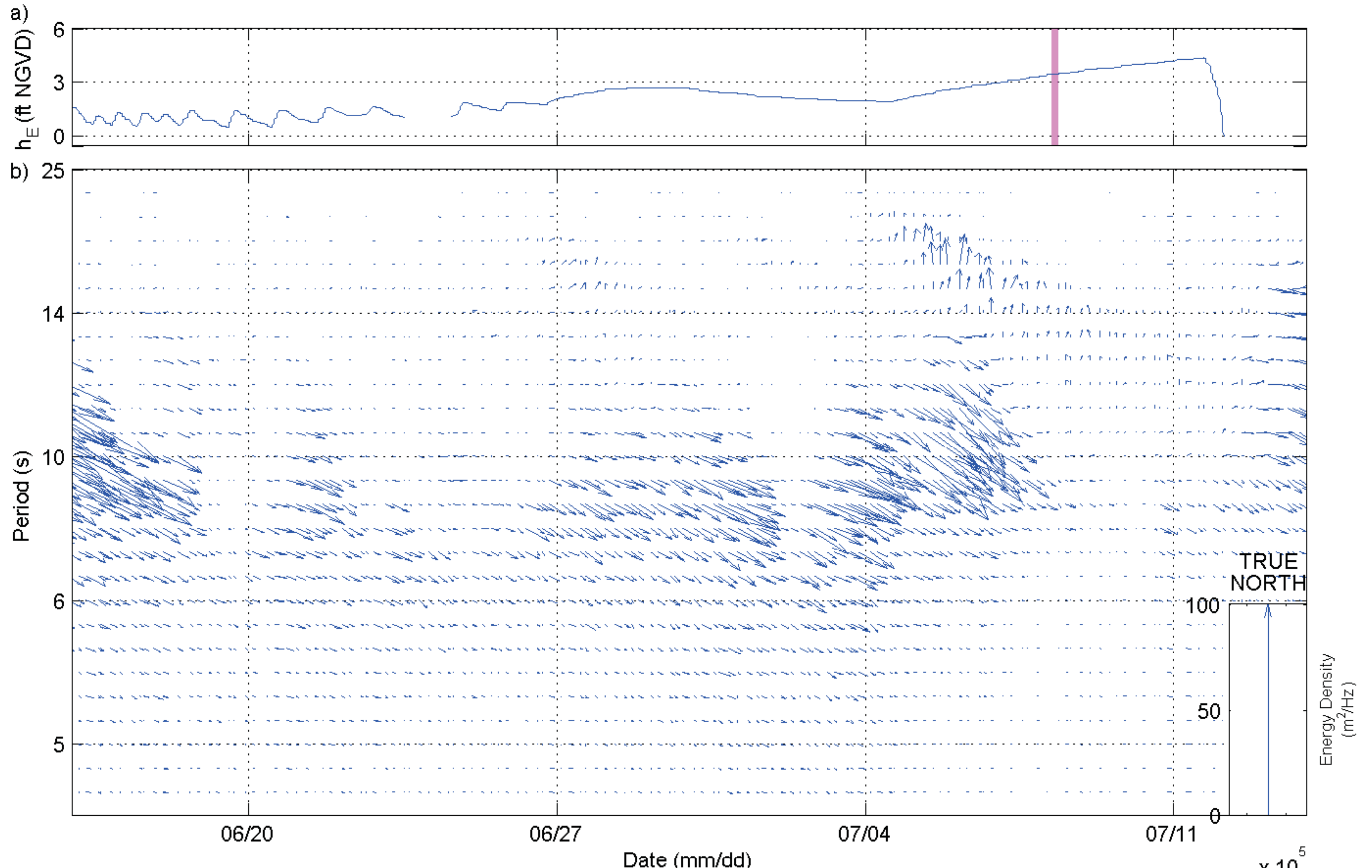

Sources:
a) h_E=estuary water level (SCWA); pink bar = mmgt action
b) Wave magnitude and direction (CDIP, Pt. Reyes, #029)

Figure 3
Russian River Estuary Outlet Channel Management Plan

Estuary Water Level and Wave Energy/Direction Spectrum
JUNE-JULY 2010

PWA Ref# 1958.01

ESA PWA

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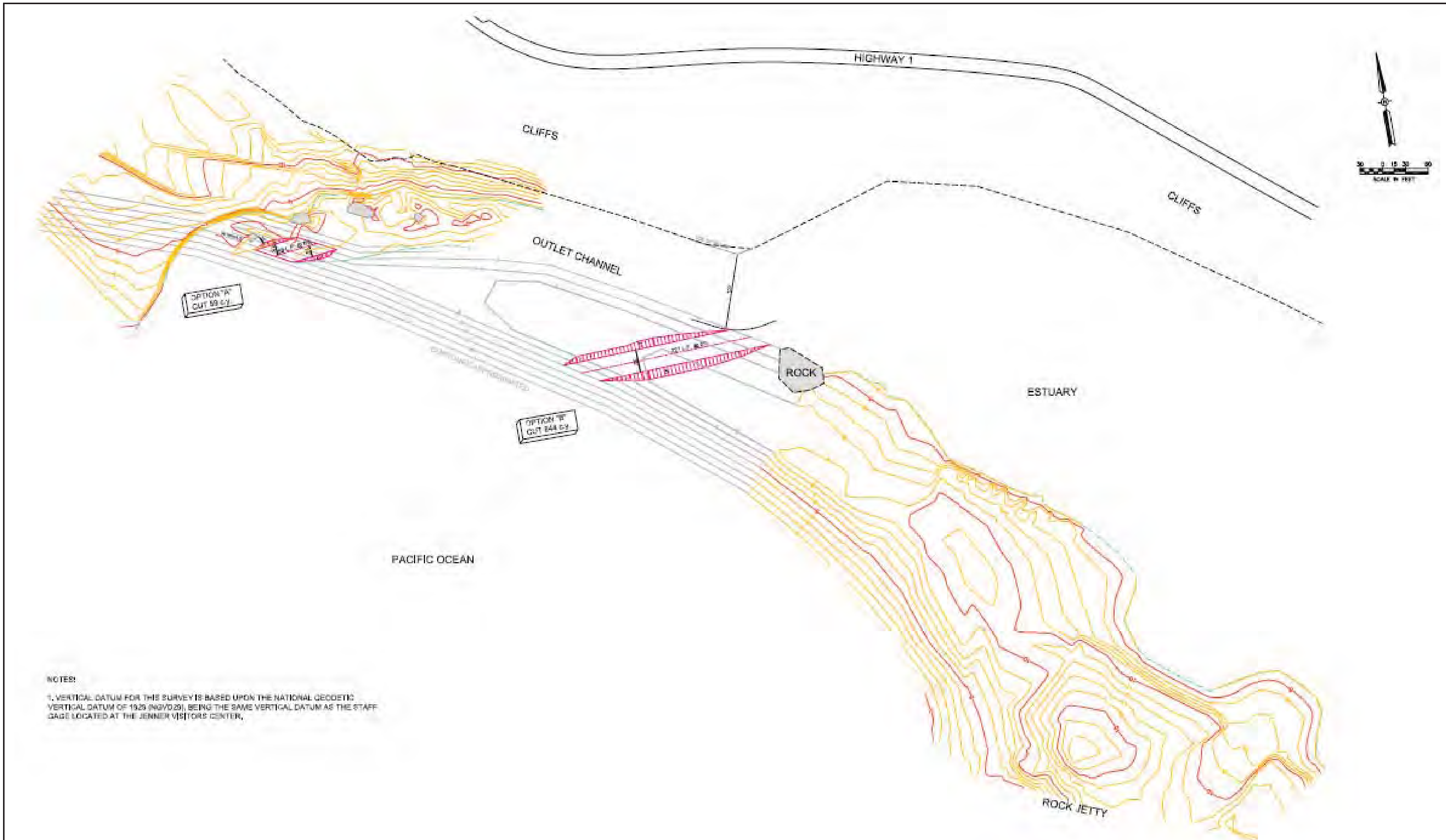


Source: SCWA

figure **4**

Russian River Outlet Channel Adaptive Management Plan

Beach Topography and Management Options, June 2010

PWA Ref# 1958.01

ESA PWA

a)

b)

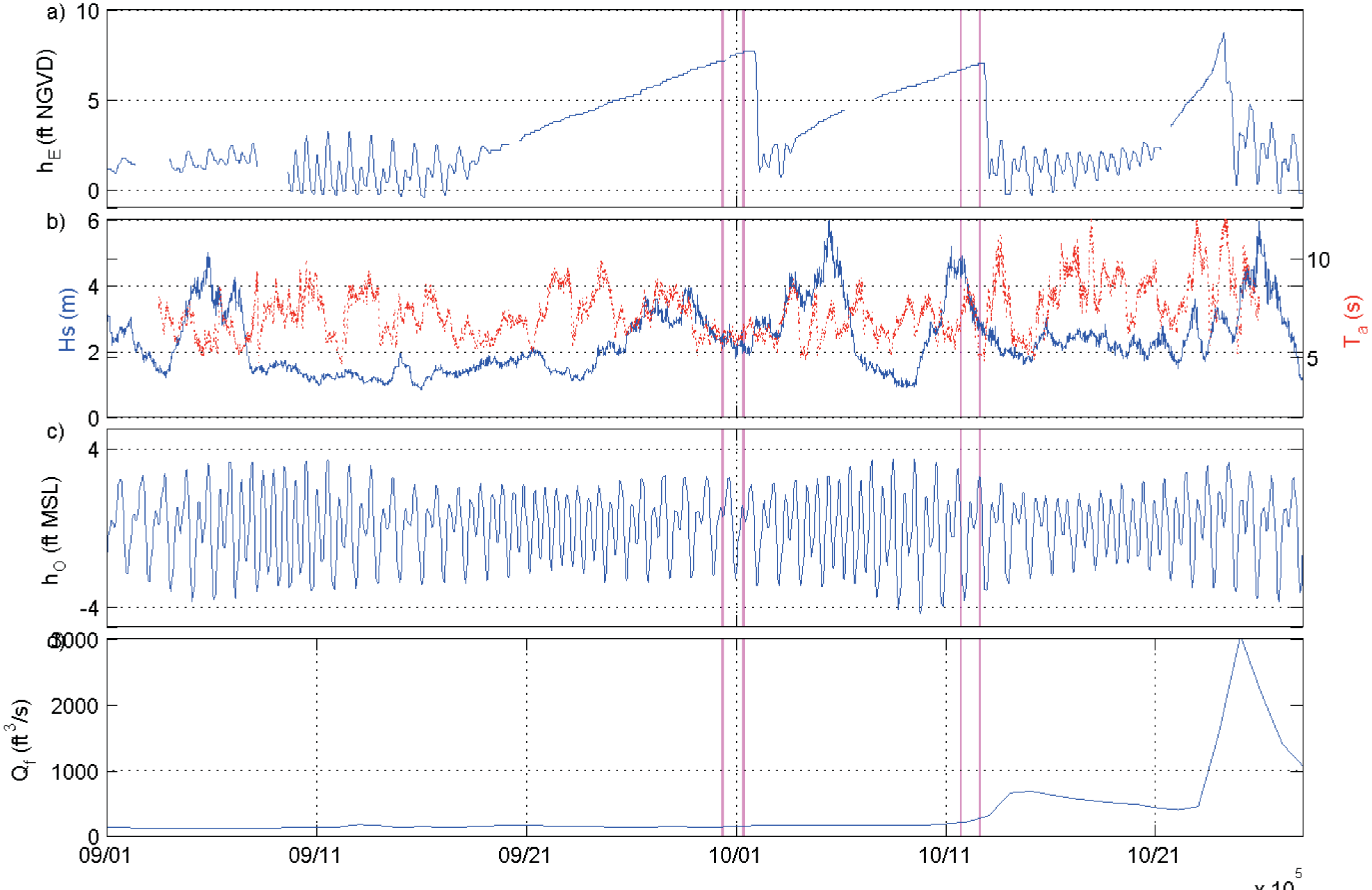
Source: C. Delaney, SCWA

figure 5

Russian River Outlet Channel Adaptive Management Plan

Natural and Managed Outlet Channels

PWA Ref# 1958.01



Sources:

a) h_E=estuary water level (SCWA); pink bar = mmgt action
b) H_s=sig. wave height; T_a=avg. wave period (CDIP, Pt. Reyes, #029)
c) h_O=ocean water level (NOAA, Pt. Reyes #9415020)
d) Q_f=river discharge (USGS, Guerneville #11467000)

Figure 6

Russian River Estuary Outlet Channel Management Plan

Estuary and Ocean Conditions, September - October 2010

PWA Ref# 1958.01

ESA PWA

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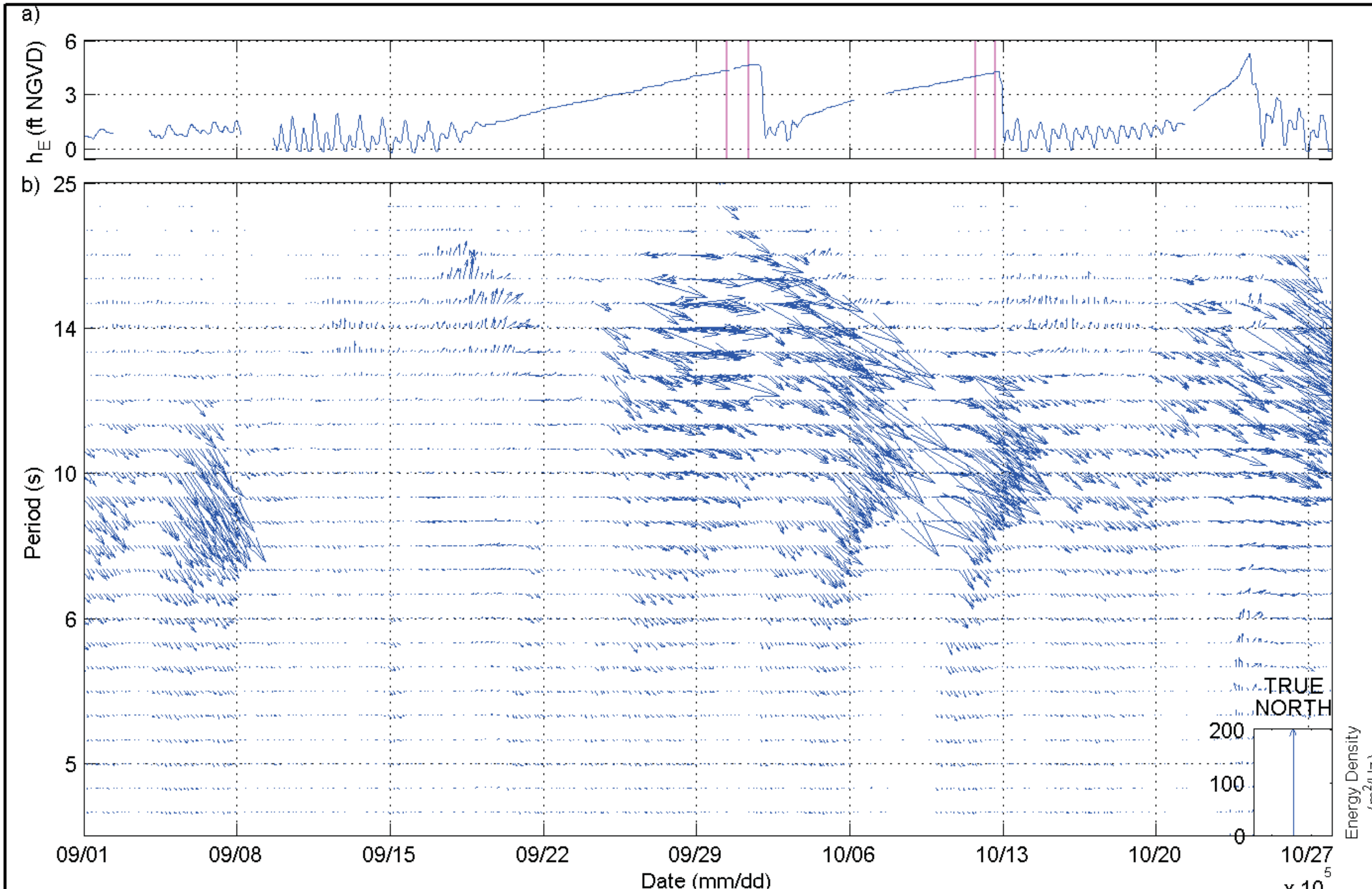

Sources:
a) h_E=estuary water level (SCWA); pink bar = mmgt action
b) Wave magnitude and direction (CDIP, Pt. Reyes, #029)

Figure 7
Russian River Estuary Outlet Channel Management Plan

Estuary Water Level and Wave Energy/Direction Spectrum
September-October 2010

PWA Ref# 1958.01

ESA PWA

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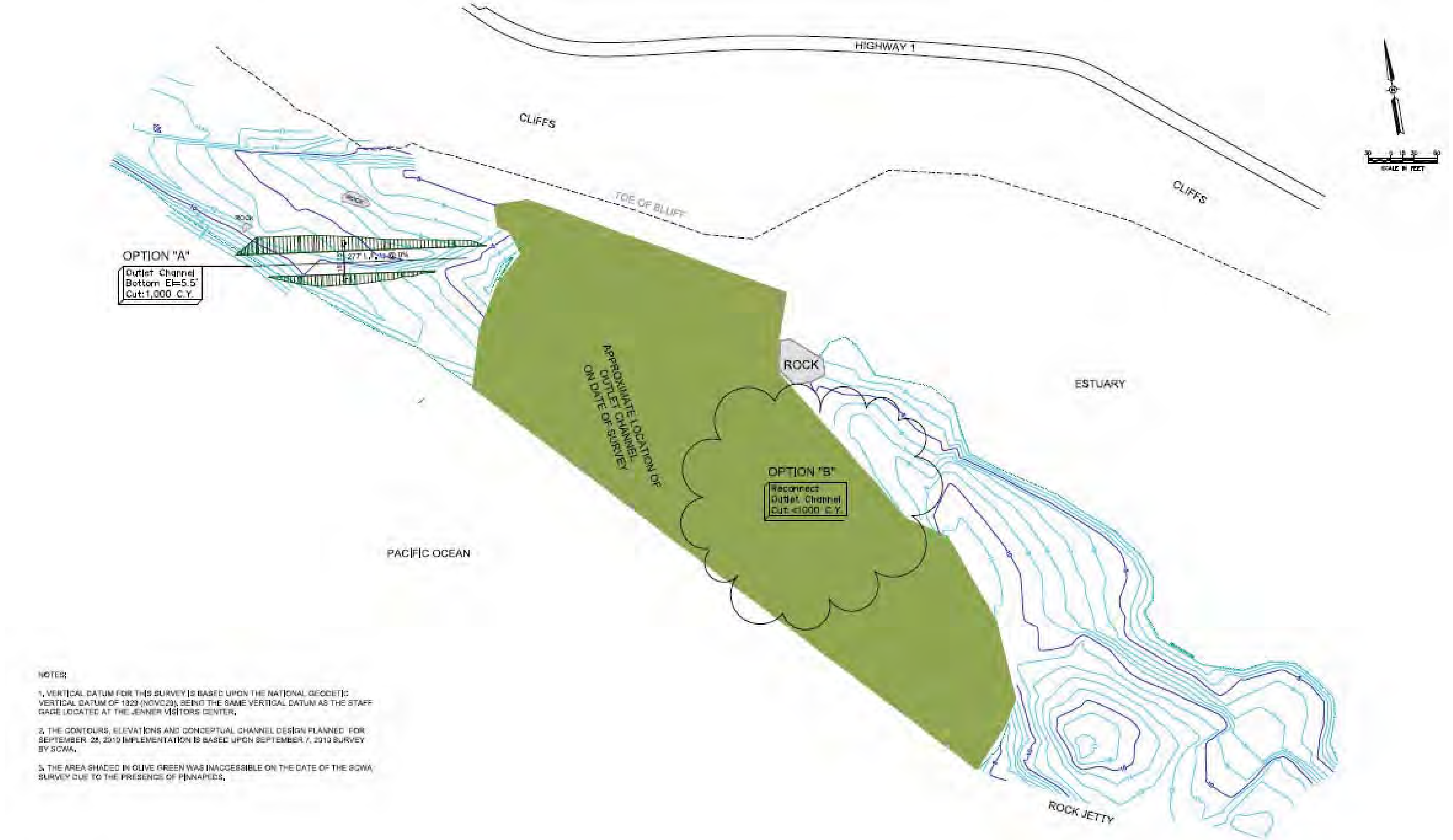

Source: SCWA

figure 8

Russian River Outlet Channel Adaptive Management Plan

Beach Topography and Management Options, September 2010

PWA Ref# 1958.01

ESA PWA

Attachment F. Physical Processes During the 2011 Management Period!

!

As required by the Russian River Biological Opinion, - onoma County Water Agency (0 ater Agency) has been tasked with managing a summer lagoon i˝ tended to improve s˙˘&onid habitat in the Russian River Estuary!4/ !creating an outlet channel while maintaining the current level of flood protection for properties adjacent to the estuary!2NMFS, 2008). The adaptive &˙nagement plan, described in the main body of this report, was developed by the Water Agen / with assistance fro&!ESA PWA and the resource agency management team in 2009 and revised in %° °!˙˝(!%011. Because of permit constraints, the Water Agency was onl/ able to implement the plan begin˝)˝ 1!)˝!%° ˛!ˆˆ e revised plan was in effect for 20 .! but no opportunities for management action occurred during the management period.!!

!

During the 2° !& ˙nagement period, May 15th to October 15th, Water Agency staff regularly &onitored current and forecasted estuary water levels, inlet state, river discharge, tides, and wave conditions to anticipate changes to the inlet's state. High river discharge in the first two &onths of the m˙nagement period followe(!4/ !the typical low wave energy!conditions during the summer contributed to!the inlet staying open for the first four!&onths of the management period. Starti˝1! in late Septem4er, the inlet went through a successio˝ of perche(!˘agoon onditions and self breaches, during which the Water Agency closely!&onitored estuary conditions and considered management options. The perched episodes were short-lived, lasting no more than a week.!˙˝(! included a small outlet channel flowing along and sometimes through gaps in tˆe jetty. The perched episodes ended when lagoon water levels increased, overtopped the beach berm.!˙˝(! scoured a new tidal channel. Since the perched lagoon episodes did not evolve to the point tˆat management action was warranted, the Water Agency did not take!˙˝/!& ˙˝ agement actions to encourage formation of!˙˝!outlet channe˘˛!!

!

Even though no management a tions were!)&plemented to inform!the a(aptive m˙nagement process, the ph/ sical conditions and inlet response during the m˙˝˙1 ement period are reviewed in this attachment to contribute to site understandi˝1!˙˝(to inform!future management a tions.!

!

METHODOLOGY

This review of the 2011 outlet channel management period ex˙&ined water levels, ocean wave conditions, ocean water levels, riverine discharge, beach topography, as well as inlet size and location. The sources for these parameters are listed in Table 1. These data were supplemented with personal observations and discussion with staff from the Water Agency, NMFS, DFG, and the Bodega Marine Laboratory.!!

!!

Table 1. Data Sources

Parameter	Source
Estuary water level (h_E3!	Water Agency Jenner g˙ge[J]!
Wave height (D_s), period (T˙3.!˙nd direction !	ˇ DIP Point Reyes buo/!K°%0!
Ocean water level (h_O3!!	NOAA Point Reyes #9415020
Russian River discharge (Q*3!	USGS Guerneville # ?FE°°°!
Beach topography, ft NGVD	Water Agency monthly surveys!
Inlet size and location	Water Agency and Bodega Marine Laboratory! autonomous c˙&eras

[J]Gage faile(!˝ ear the end of Juˇ/ .!˙˝ d was replaced 4/ early Septem4er.!

!

INLET STABILITY PARAMETER AND CLOSBRE RISK PROBABILIT" !

In addition to considering individual parameters, researchers at the 6 odega Marine Laboratory have developed a co&4ined parameter to evaluate the stability of the inlet's state, with the aim!of predicting closure risk. (Note that the inlet stability parameter does not differentiate between full closure and the perched conditions with a small outlet channel that formed in fall 2010. When discussing this parameter, both states are referre(! to as a 'closure'.) The inlet stability!parameter presented by Behrens et al. (in pu4lication) quantifies the risk of inlet closure based on a sediment balance in the inlet. It considers the daily balance between wave-dri#en sediment import to the inlet and sediment export dr)#en b/ !tidal fluctuations. The former is estimated from!wave measurements and the latter is esti&ated fro&!tide g˙1 e data within the estuary and a stage-storage relation derived from the available batˆ/ &etry. Using daily-average values of the stabilit/ ! parameter witˆ in the period 1999-2008, Behrens et al.!(in publication) showed that high-percentile values of the parameter are closely!ˇ)˝ ed to the risk of the inlet closing within five (˙/ s. As the percentile of the stability parameter increases, the risk of inlet closure witˆ in five (˙/ s increases exponentially, from!risks of roughl/ !*)ve percent when the parameter is at the 50th percentile to a risk of 80 percent when it is measured at the 99th percentile.!!

!

FALL PERCHED EPISODES AND SELF BREACHES

!

ˇ) &e series of estuary water levels, as well as the key forcing factors (waves, ti(es, and riverine discharge), are shown in Figure 1 for the entire &˙˝˙1 e&ent period. Prior to Septe&4er, no inlet closures occurred, so lagoon water levels fluctuated in concert with ocean tides 2Figure 1a). As shown in Figure 1d, discharge remained high for the first two months of the m˙˝ agement period as a result of a wet spring, including pre ipitation in the start of June. River discharge did not drop beˇo5!? 00 ft'/s until after June 15th and below 200 ft'/s until after July 15th. This elevated discharge probably reduced the l) elihood of inlet closure during tˆ e first two months of the management season even though so&e sizeable wave events occurred during these &onths (Figure 1b). In late July and particularly in August, wave energy was at the annual &)˝) &u&.!so tidal exchange was sufficient to m˙ intain an open inlet. As typically occurs on the California coast, wave energy!increased starting in September,!5 hich eventually caused the estuary to perch! six times, starting in late September and into Novem4er.

!

All six inlet perched lagoon episodes in fall 2011 lasted a week or less, ending when the estuary! water levels reached 4-5 ft NGVD, overtopped the beach berm. and scoured a new tidal channel. Conditions during the perched lagoon episodes (Septem4er 22-29, October 3-8, October 10-14, Novem4er 3-8, Novem4er °8 %.!˙˝(!+ ovem4er 17-20) are shown in Figure 2. Although the management period ends on October 15th, conditions up through the end of Novem4er were reviewed since they were consistent with the inlet beˆavior that started in late Septem4er. Six instances of perched lagoon conditions are slightly!ˆ)gher than the average nu&ber of closures, ?¸F.!)n Septem4er through Nove&4er (ESA, 2011). However, a series of repeated perched episodes and self breaching is not com&on; since 1996, this pattern has onl/ !been observed onl/! one other time, in 20°F¸!

!

Consistent with the existin1! onceptual &odel described in Section 4 of!the Management Plan, perched lagoon conditions t/ p) ˙˜˜/ occurred when both wave energy increased and tidal exchange decreased. All perched episodes occurred when the mean wave period was greater tˆ˙˝! 10 seconds and five perched episodes occurred when significant wave heights were greater th˙˝! 12 ft. Tˆe O tober 10th episode coincided with wave heights of only 8 ft, but since these waves had long, 1F8second periods and originated from!the southwest, they still conveyed significant wave energy to the beach. Five of the 2011 episodes occurred during neap tides when the tide range was reduced to less than 5 ft (Figure 2c). When the tide range is less, tidal scour in the inlet is also less, &˙ ing the inlet more susceptible to infill with sand. Onl/ !the Nove&4er 10-12 episode occurred when the oceanic tide range was greater than 6 ft. All but the first episode occurred with riverine discharge elevated above 250 ft'/s and the three Novem4er episodes occurred when riverine dis ˆ˙ rge was approxim˙tely 400 ft'/s.

!

PERCHED LAGOON A+ D NATURAC BREACH 7"+ AMICS!!

As an ex˙&ple of a perched lagoon-breach cycle, Figure 3 shows a sequence of photos of the inlet before, during, and after the October 3-8 episode. As was the case for almost ˙ll of the management period, the i˝˘et was located next to!the jetty. Shortl/! before the episode, on September 30 (Figure 3a), the inlet had narrowed in width to approxim˙tely!"°!*eet.

!

The estuarine water level became &uted starting o˝ October 3 with the arrival of so&e larger, longer-period waves (Figure 2a and b). B/ October 5, a tidal signal was absent from!the estuary and water levels began to rise. The inlet transformed into a small outlet channel running)&&ediately adjacent to and among the rocks at the toe of the jett/ (Figure 3b; Figure 4a). The! outlet channel was narrow, with a width of approxi&˙tely ten feet. When the channel reached the portion of the jetty wˆ) ˆ!ˆ ad been damaged, the cˆ˙˝ nel turned south a˝(!*˘owed through the gap in the jetty (Figure 4b).

!

The jetty and rocks which had been a part of the jetty!&˙/ have stabilized the outlet channel, both in sheltering the outlet cˆannel from!5aves a˝(!4 y providin1!4˙˝ !˙nd bed stabil)zation that &)˝)&ized ch˙nnel scour. Sheltering by the jett/ probably reduced 4erm build-up at the inlet's

location, leaving a low point in the beach berm that was the site for subsequent overtopping and self breaching. This sm˙˘˘!outlet channel, present from the start of the episode, contrasts with other historic closures that were &ore extensive. For these extensive closures, al&ost the entire inlet was filled with sand, 5 ith onl/ a small indentation on the!4˙ side of the berm providing ˙˝/ !indication of the inlet's prior location, and no outlet channel was present. All the 2011 episodes were less extensi#e, which left the beach berm!more susceptible to self breaching.
!
Self breaching probabl/ occurred when the estuary water level had risen sufficiently high that it overtopped the beach berm!)n the vicinit/ of the outlet channel. This overtopping increased the flow rate through the outlet channe˘!˙˝(.!)n spite of a˝/!4˙ ˝ sta4)˘)zation provi(e(!4y the jett/ ! and associated rocks, the increased flow rate scoured sand from!the channel bed and ba˝ s. The enlarged channel was then su**))ently deep to allow tides and salt water to return to the estuary˛! Shortly!after self breaching, the tidal channel was approxim˙tely 50 feet wide (Figure 3c), wider than it had been in the da/ s preceding the episode. This channel enlargement is consistent with the self breaching mechanis& as the higher flow, induced by the elevated estuar/ water levels during episode, scoured the channel.
!
CLOSURE R;SK PROBABILITY !
!
The 5-da/ closure risk probability.!˙!(erivative of the inlet stability!parameter described above, was hindcast *or 2011 according to the method described in Behrens et al. (in publication). Tˆ is hindcast provides an indication of the utilit/ of the stabilit/ parameter as a prediction tool for &onitoring inlet conditions and pla˝˝) ng management action. This parameter integrates wave an(! ocean forcing conditions, as well as estuary water levels, to provide greater pred)ctive skill than just waves or ocean tides on their own. The stability parameter co&4ines these factors, and the corresponding five-da/ closure risk time series exceeded 50 percent before each 2011 event (Figure 2a). - ome 2011 episodes occurred quick˘/ , tra˝sitioning from fully tidal to perched lagoon withi˝ !˙!(˙/ , so the risk time series did not provide much forewarning in these cases. However the risk was elevated &ore than two d˙/ s be*ore the episodes on Septem4er 22, Novem4er 3, and Novem4er 17.!
!
TOPOGRAPD;˘!˘D ANGE
The Water Agency has conducted monthl/ !surve/ s o* Goat Rock State Beach that cover a region starting from!the jetty a˝(! extending approxim˙tely! ,500 feet to tˆ e north. Typically, the sur#eys do not include bathy&etry within the inlet because flow conditions in the inlet prevent safe access. Also, the survey extent is often li&ited by the Water Agency's comp˘)˙˝ ce with its &arine mammal incidental harassment authorization, wˆ) ˆ !prohibits the survey rew from disturbing the marine mammals hauled out on the beach. Water Agency sur#e/ staff collected spot elevations! using RTK-GPS and then assem4led these elevations into a set of contour!˘)˝es at 1 ft intervals˛! The survey elevations are reported in the!+@A7%9 vertical datu&, the working datu&!for estuary! &onitoring a˝(!& anagement. !
!
To characterize beach berm!topographic conditions, ESA PWA assessed data from!the Water Agency's 2010 (Jul/ to Septe&4er) and 2011 (Ma/ !to!October) surveys. The locations of five

transects selected for analysis are shown!in Figure 5. The locations include two transects backed 4/ cliff (Figure 6 and Figure 7), two transects whic˜! extend into the estuary!2Figure 8 and Figure 9), and a transect just north of the jetty (Figure 10).
!
This review focuses on the 2° surve/ s!5ˆ en the surveys capture(!˙! ˘ earer picture o*!4each evolution. However, the 2010 surve/ s are included in the transect plots for conte<t. In general the crest elevations in 2°10 were lower than 2° ˛ The cause of the lower crest elevations is not nown, but may the result of inter-annu˙˘!#˙riations in wave e˝er1/!˙ nd littoral sediment suppl/˛!
In addition, the inlet exhibited greater variation in its location in %010, extendi˝1!*ar to the north)˝!9uly before!&oving south later by August. As the inlet opened a˝(! losed or changed location, it resulted in large changes in beach topography. For example, at Transect 4, the inlet's closure in early Jul/ !%°10 is readil/ apparent as substantial increase in the berm:s size between the 7/1/2010 and 7/8/2010 transect (Figure 6). The inlet's migration south is evident at Transect 3 (Figure 7) when the crest elevation drops from!its 7/8/2010 profile to less than 4 ft NGVD on 8/3/2010. The inlet migration and gaps i˝! the survey data yield little inform˙tion for evaluating crest elevation evolution at most transects. However, there is sufficient data at Transect 4 to show a trend of increasing crest elevation during summer 201°˛!!
!
The crest elevations of Transects 2.!' .!˙˝ (!? steadily!increased over the 2011 m˙˝˙ gement per)od. This trend is consistent with seasonal patterns on m˙˝/ California beaches. After so&e initial increase from May!to June, when wave energy was at the annual m)˝)&u&!)n July and August, transect ch˙˝ ges were &)˝)&˙l. Then ber&!4uilding accelerated in the fall with the concurrent increase in w˙ve energy (Figure 1), as i˝() cated by the change between the August 15th survey and the Septem4er 19th survey˛ The largest change occurre(!4etween the Septem4er and October surveys, the period that also experienced the largest wave energy. Over the course of the management period, the crest &oved landward at Transect 3!˙˝ d Transect 4, witˆ the exception o*! the October surve/ , when the crest &oved seaward at Transect 3. This landward movement is opposite to the typical crest movement at other California beaches (Weigel, 1992) and m˙/ !be indicative of additional processes affecting these transects, such as suppl/8˘)&ited alongshore transport. At Transects 1 and 2, the crest moved seaward as it built upwards, consistent with typical summer-ti&e response.
!
Transect 0.!5ˆich is located just north of an(! p˙rallel to the jetty.!ˆ˙(!˝ oticeably different elevations and evolution than the other transects. Compared to the other transects, crest elevations were highest at this transect for botˆ!%° °!˙˝(!% ° ˛!; n addition, Tr˙nsect 0 di(!˝ ot evolve duri˝1! the management periods, as was observed at the other transects. The o˝˘/ significant change occurred during the winter between the 2010 a˝(!%°11 management periods. These two characteristics, the higher crest an(!˘˙ of m˙nagement period variabilit/ , suggest that the jetty shelters this portion of the beach fro&!small to &oderate waves that occur during the management period. Only the larger waves associated 5 ith winter storms m˙/ be sufficient to re-shape the beach ber&!˝ear the jetty. !
!
The changes to the beach ber& at Transect 1 were inter&ediate between the &o˝thly! ˆ anges that occurred to the north (Transects 2-4) and the negligi4˘e! hange in berm!elevation adjacent to the

jetty (Transect 0). Crest elevations at Transect 1 o˝˜/ !increased between the Septem4er an(! October survey, tˆ e portion of the management period with the strongest wave e˝ ergy.!This! suggests that the jetty m˙/ alter wave conditions over so&e distance fro&!its location: Transect 1 is approxim˙ tely 200 ft north of the jett/!˙ nd outside of the area occupied by the!)nlet durin1!&ost of the 20 !& anagement period.!

!

LESSONS LEARNED AND RECOMMENDATIONS

Based on o4servations of the estuary, associated pˆ/ sical processes, and the Water Agency's planning for outlet cˆ anne˘!&˙ nagement, we note the following lessons about implementing the! outlet cˆ anne˘!&˙ nagement plan.!

!

CONCEPTBAL MODEL!

- Elevated discharge in the late spring and early summer (greater th˙ n 400 ft'/s until June 15th; greater than 200 ft'/s until July 15th) reduced the likelihood for inlet closure at that time. However, multiple perched lagoon episodes occurred in the fall when riverine discharged exceeded 250 ft'/s. This is consistent with Behrens et al. (in publication) that although discharge affects probability of closure, the threshold that prevents closure is ˘) ely in excess o*!%000 ft'/s. A likely contribut)˝1!*˙ctor to the fall perched episodes was the higher wave energ/¸!
- The inlet moved south ear˘/!)n the management period, reaching the jetty!)˝!˘˙te May or early June, a˝ d remained there throughout the 201 !& ˙˝ agement period and tˆ e following wi˝ ter. This inlet alignment is not common, but has been observed in past / ears (Behrens et al., 2009)¸!!
- During the management period, steady growth of the beach berm!was observed north of! the jetty, consistent with typical beach 4er& building that occurs during tˆ e summer. However, the rate of berm growth appeared to decrease approxim˙ tely!200 ft north of the jetty and was negligible immediately adjacent to the jetty.!
- Although autumn wave events were large enough to reate perched lagoon conditions.! the beach berm remained at low elevations, approxim˙ tely 5 ft NGVD. The inlet then self breached when rising estuary water levels overtopped the berm!˙ t this low point a˝(! scoured a new tidal channel.

!

OUTLET CHANNEL FEASIBILITY!

- The jetty!&ay shelter the inlet, making closure less likely!and also limiting berm growth, which then maintains a low point for self breaching. When the lagoon self breaches, management actions cannot be!)&plemented.!
- Even if the inlet being near the jett/ !ˆ)nders formation of sustained lagoon and outlet channel conditions.!&˙ nagement opportunities for re-locating the outlet channel are ˘)&ited a˝(! onstrained. At ˙!&)˝)&um.!creating an outlet cˆ˙ nnel further north!from the jetty requires a full natural losure, absence of a low point in the beach berm near the jetty.!˙˝ d equipment access to the area north of the jetty. !
- A small outlet channel formed during the fall perched lagoon episodes. However, it did not conve/ enough discharge to prevent!lagoon water levels fro& rising at 0.8 ft/(˙/¸!!

- The outlet cˆ ˙nnel that formed during the perched ˘agoon episodes!flowed along the jett/! ˙˝(!˙& ong the disaggregated roc at the damaged end of the jett/ . This rock from!the jetty!&˙/ have provided channel stabilization for the outlet channel, increasing the channel's resilience to scour.
- Once outlet channel discharge increased due to rising lagoon water levels, the discharge scoured a new channel, breaching the estuary to the tides. This behavior highlights the susceptibility of a sand bed outlet channel to scour, li&iting conve/ ˙nce capacity.!
- The mere occurrence of a perched lagoon is not sufficient to provide an opportunity for outlet cˆanne˘!&˙nagement; other factors m˙y not permit m˙nagement!˙ction. Th)s point is highlighted by both the 2011 self breachings and the early fall closures in 2010, when continuing ocean swell precluded outlet channel m˙nagement action. Over the first two / ears of effort to implement the outlet channel adaptive &˙nagement plan, only!o˝e closure (July 20103!ˆ˙s been suited for outlet cˆ ˙nne˘!&˙nagement action. !

!

OPERATIO+-!

- When equipment operators visited the beach to plan a possible management action, the/ ! noted that the channel had incised a steep!4˙˝ !)˝!the ber& adjacent to the jetty (Figure 3.!5ˆ) ˆ!5 ould have made equipment access to any areas north of the jetty infeasible. !

COMMUNICATIONS!

- Although the perched lagoon episodes did not evolve to!the point tˆ at management action was warranted, the Water Agency began pla˝˝) ˝1!&anagement actions as soon as the episodes occurred. Planning included heightened observations of!)˝˘et conditions!4/! Water Agency staff, em˙il updates to infor&!the resource management group, and pre-)&plementation meetings at the project site to refine plans for management actio˝˛!! !

!

MONITOR;+@!

- The Water Agency's upgrades to monitoring the estuary (water levels and photo1raphs available in real-time via the Internet) enhance both management planning and the abilit/ ! to observe inlet processes.

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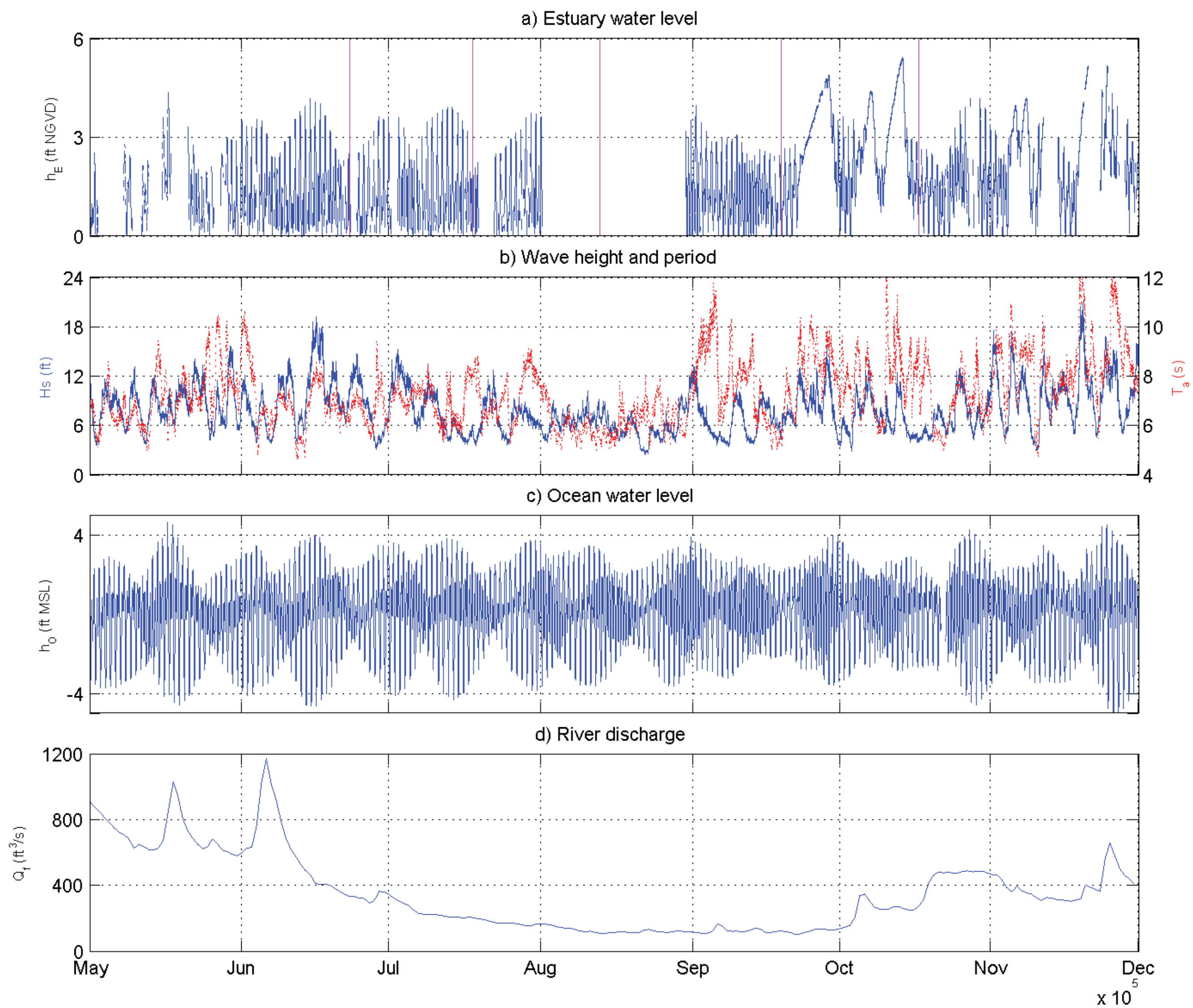


SOURCE:

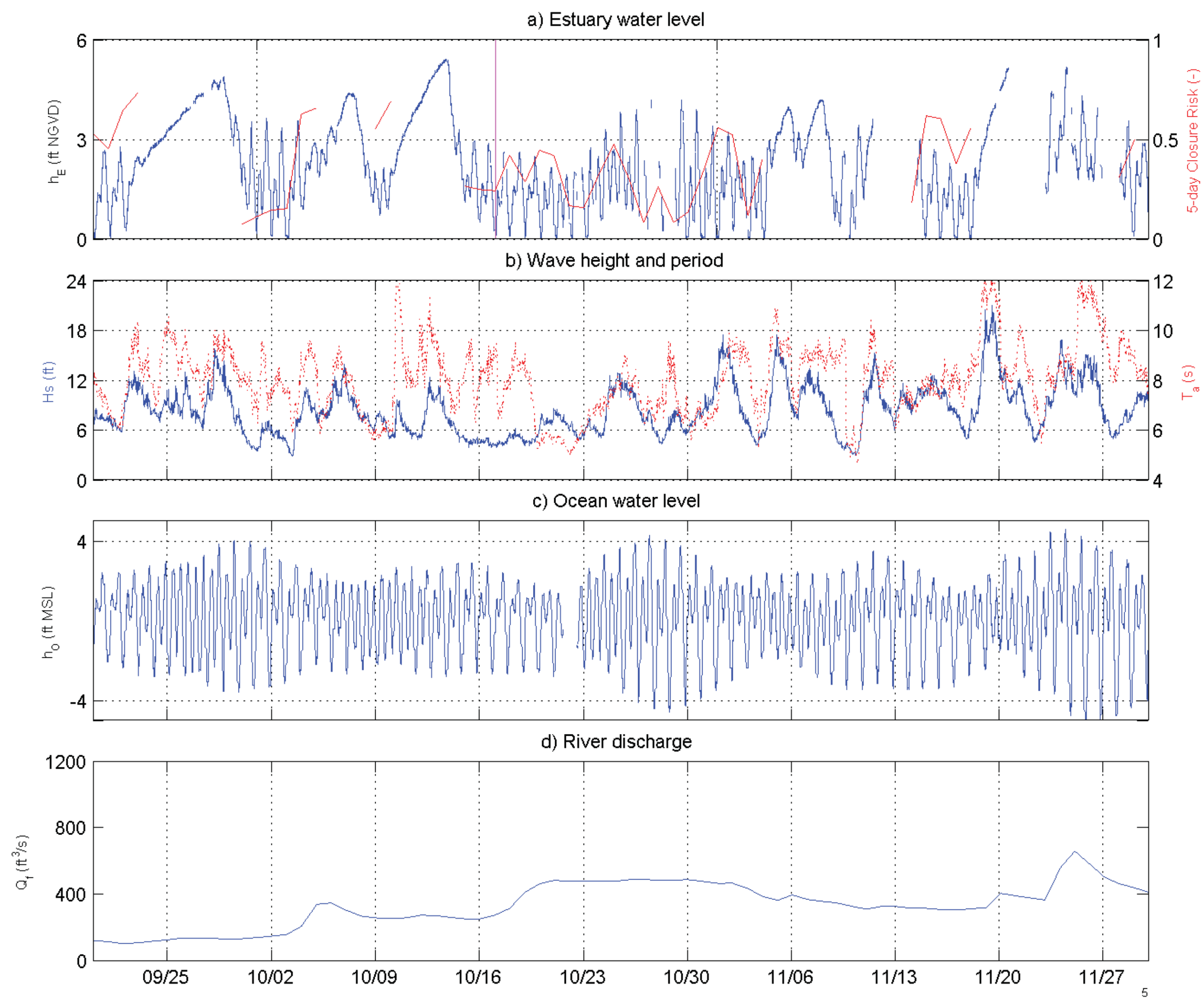
a) h_E=estuary water level (SCWA); pink bar = beach survey

b) H_s=sig. wave height; T_a=avg. wave period (CDIP, Pt. Reyes, #029)

c) h_O=ocean water level (NOAA, Pt. Reyes #9415020)

d) Q_f=river discharge (USGS, Guerneville #11467000)

Figure 1
Estuary, Ocean, and River Conditions
May - November 2011



SOURCE:

a) h_E=estuary water level (SCWA); pink bar = beach survey

b) H_s=sig. wave height; T_a=avg. wave period (CDIP, Pt. Reyes, #029)

c) h_O=ocean water level (NOAA, Pt. Reyes #9415020)

d) Q_f=river discharge (USGS, Guerneville #11467000)

Figure 2
Estuary, Ocean, and River Conditions
September - November 2011

a)

b)

c)

SOURCE: Bodega Marine Lab

Figure 3
Inlet State, September 30, October 6, and October 9, 2011

a) b)

SOURCE: Sonoma County Water Agency

Figure 4
Outlet Channel Along and Through Jetty, September 26, 2011

Source: Sonoma County Water Agency survey data

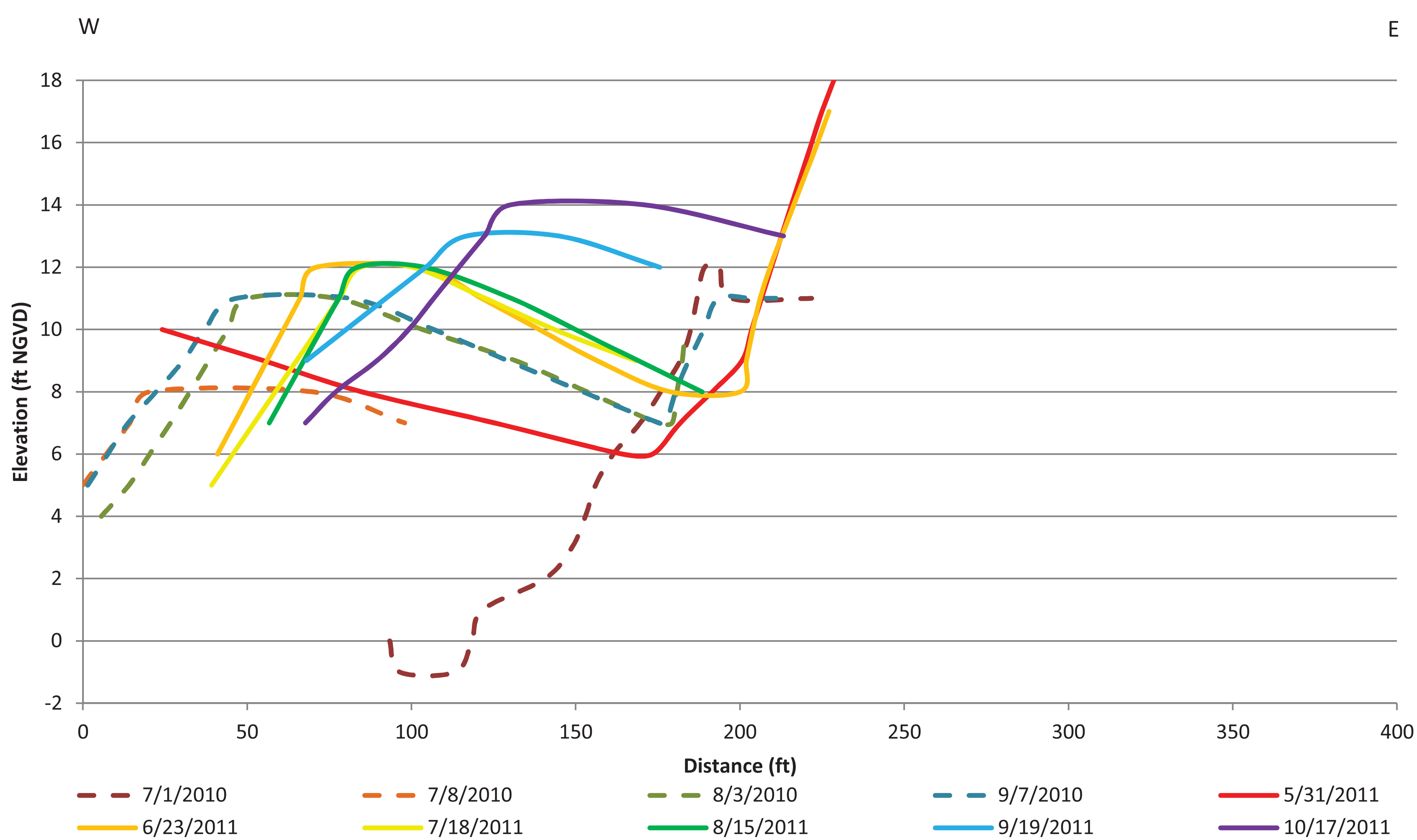
N

figure 5
Russian River Outlet
Channel Management Plan

Beach Topography Transect Locations

ESA PWA Ref# - DW01958

Beach_topo.mxd



Source: Sonoma County Water Agency survey data

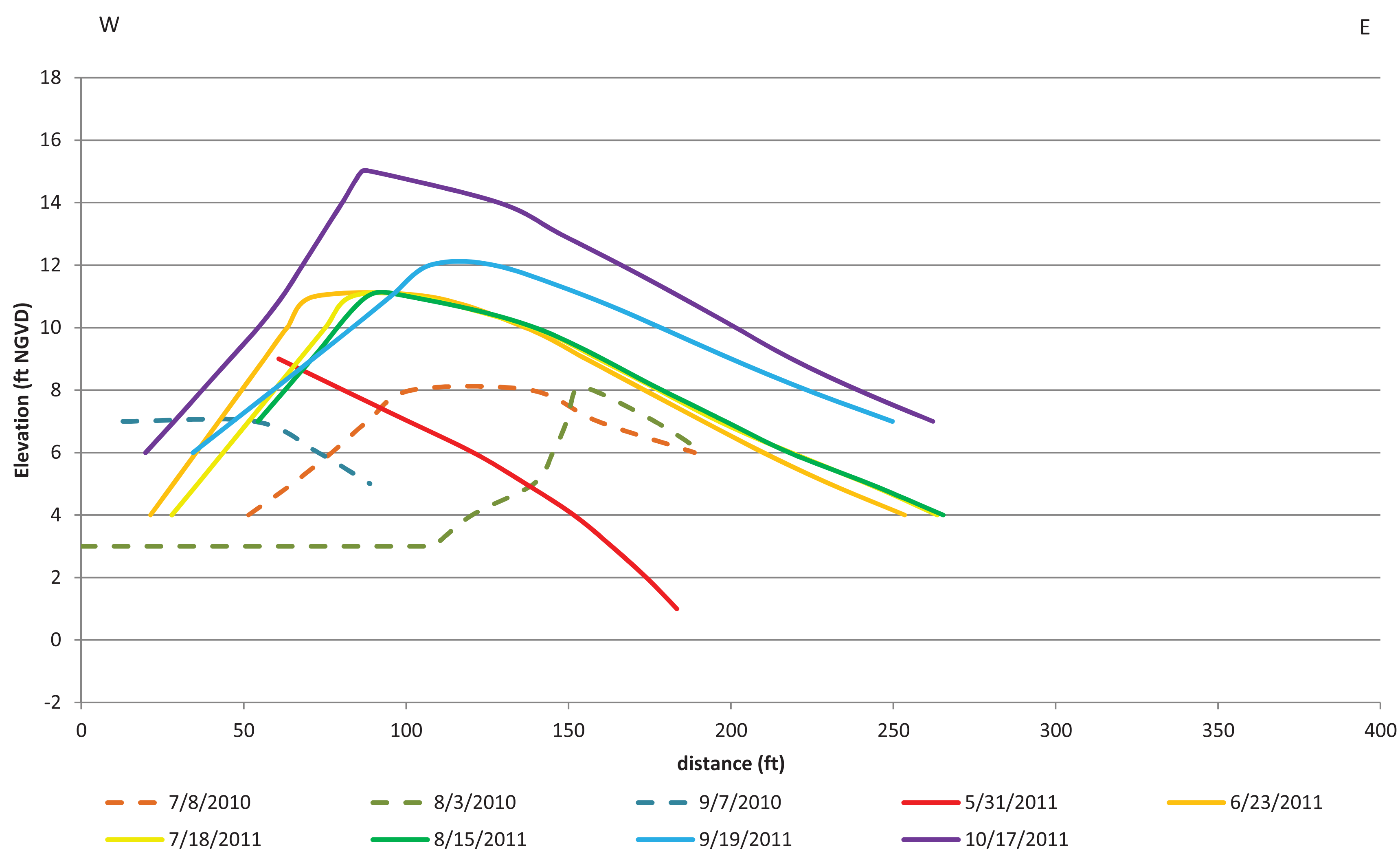
figure **6**

Russian River Outlet Channel Management Plan

Beach Transect 4

ESA PWA Ref #: DW01958

Bathy_transects.xlsx / Transect4



Source: Sonoma County Water Agency survey data

figure ***7***

Russian River Outlet Channel Management Plan

Beach Transect 3

ESA PWA Ref #: DW01958

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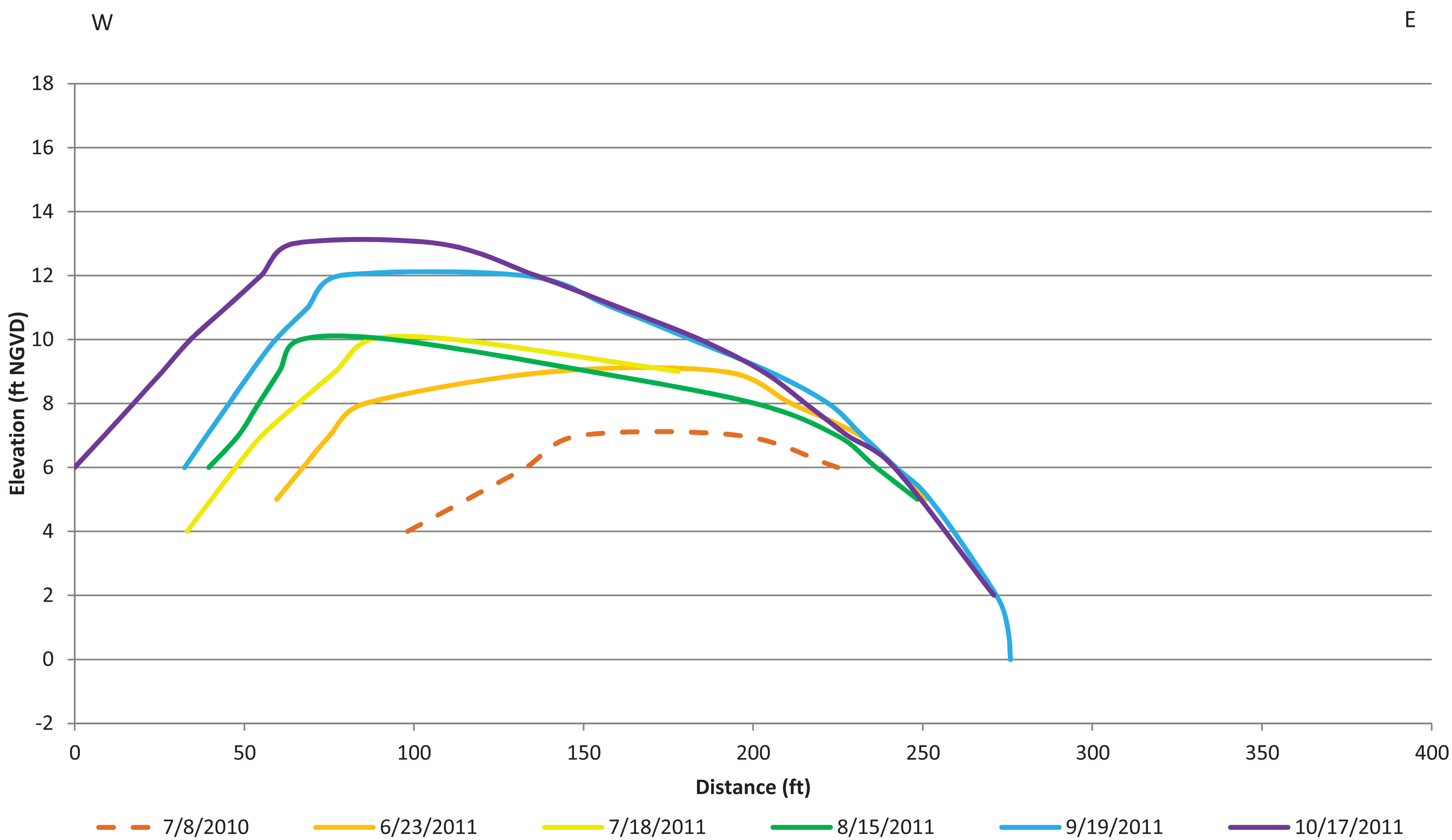


Source: Sonoma County Water Agency survey data

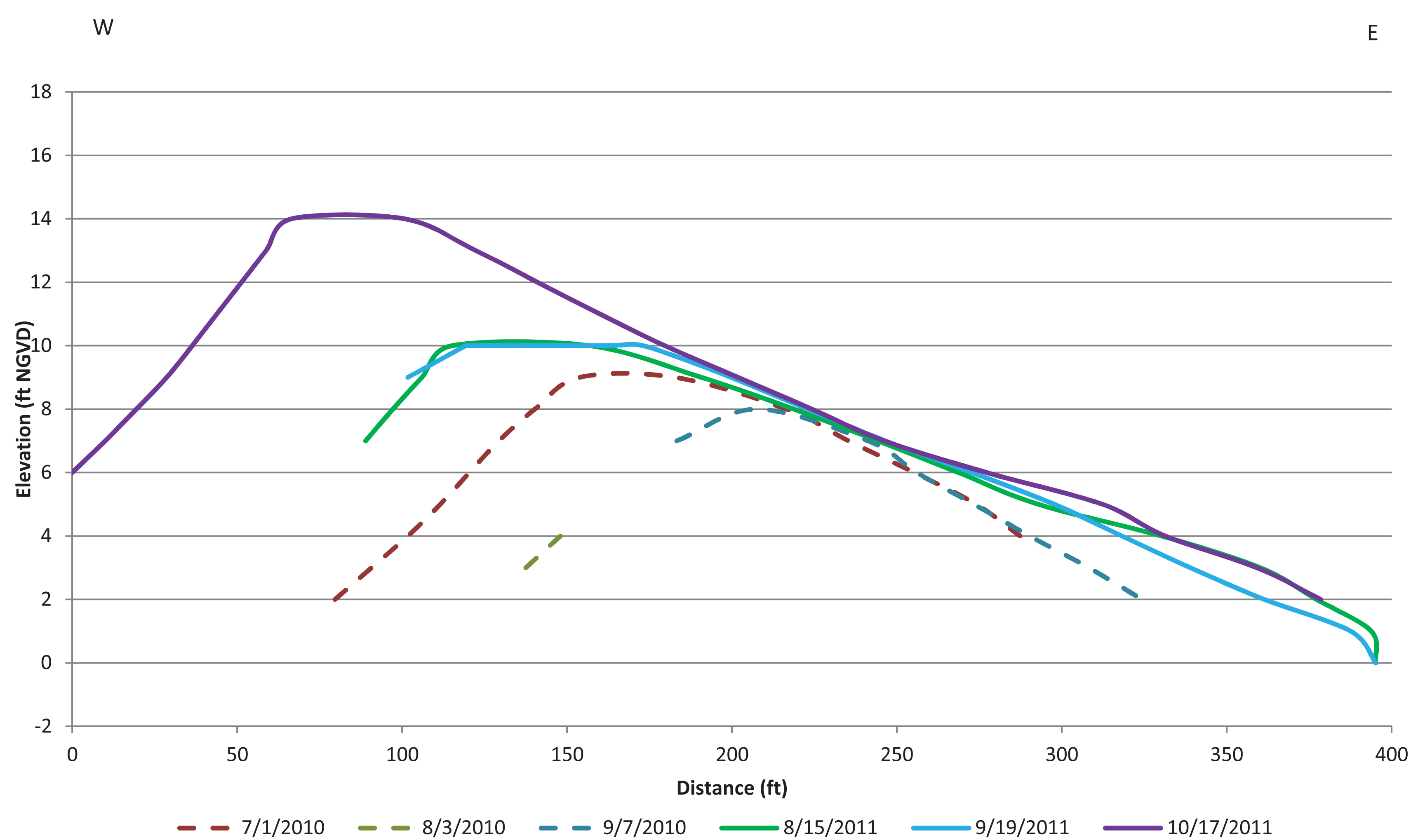
figure **8**

Russian River Outlet Channel Management Plan

Beach Transect 2

ESA PWA Ref #: DW01958

Bathy_transects.xlsx / Transect2



Source: Sonoma County Water Agency survey data

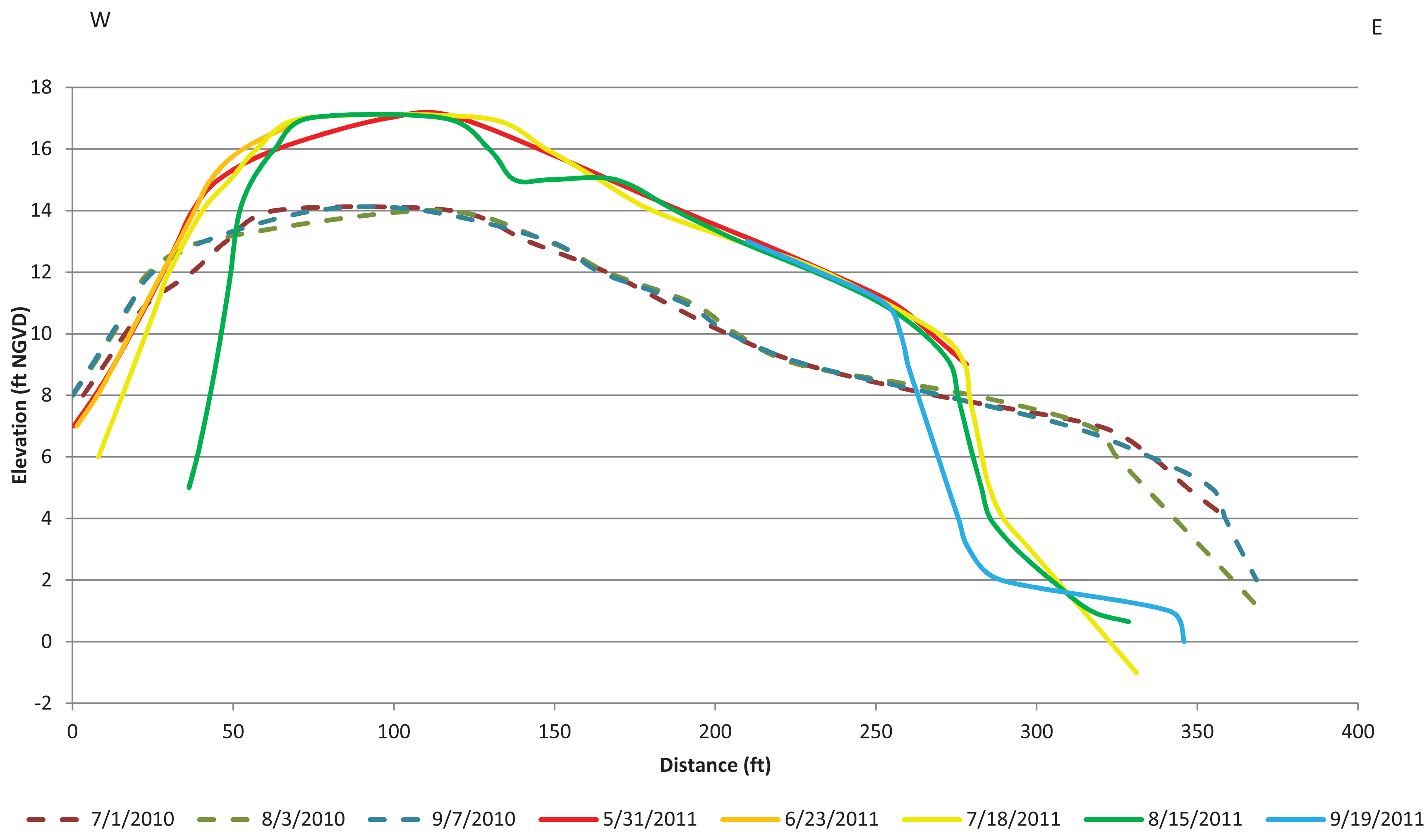
figure **9**

Russian River Outlet Channel Management Plan

Beach Transect 1

ESA PWA Ref #: DW01958

Bathy_transects.xlsx / Transect1



Source: Sonoma County Water Agency survey data

figure **10**

Russian River Outlet Channel Management Plan

Beach Transect 0

ESA PWA Ref #: DW01958

Bathy_transects.xlsx / Transect0

SOURCE: Sonoma County Water Agency

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 11

Steep Berm Limiting Beach Access, September 26, 2011

Attachment G. Physical Processes During the 2012 Management Period!

!

As required by the Russian River Biological Opinion, Sono&˙ County!Water Agency (Water Agency) has been tasked with m˙˝˙1)˝1!˙ summer lagoon i˝te˝(ed to improve s˙˘&onid habitat in the Russian River Estuary!4/ !creating an outlet channel while maintaining the current level of! *lood protection for properties adjacent to the estuary (NMFS, 2008). The adaptive &˙nage&e˝t plan, described in the main body of this report, was developed 4/ the Water Agen / with assistance *ro& ESA PWA and the resource agency &anagement team in 2009 and revised annually in 2010-2013. Because o*!permit constraints, the Water Agency was only able to)&ple&ent the plan beginning in %° °¸!˜ˆ e revised plan was in effect *or 2012, but no opportunities for m˙˝˙gement action occurred during the manageme˝t period.!!

!

During the 2° %!&˙nage&ent period, May 15th to October 15th, Water Agency!staff regularl/ ! &onitored current and forecasted estuary!water levels, inlet state, river discharge, tides, and wave conditions to anticipate changes to the inlet's state. Although the inlet experienced several closures, none resulted in water levels above 5.5 ft NGVD prior to self8breaching. For much of! June and July, the inlet was either closed or o˝˘/ allow)˝1!ˆeavily!&uted tides (tide range < 1 ft3.! but the lagoon water sur*ace never surpassed 5 ft +@VD. During this ti&e, each closure ended when lagoon water levels increased, overtopped the beach berm.!˙˝d scoured a new tidal channel. Since these episodes did not evolve to the point that m˙nage&ent action was warranted, the Water Agency did not take a˝/ !management actions to encourage form˙tion of!˙˝!outlet channel. For! the remainder!of Jul/ , all of August, and the first hal*!of Septem4er, the estuar/ !was full/ tidal. Then the inlet closed twice between Septe&4er 2°th!˙˝(October 10th. Both closures were short-lived, lasting less than one week. and again the inlet self8breached, precluding any Water Agency! &˙nage&ent action. The highest lagoon water level of the 201%!&nagement period, 5¸25 *t! NGVD, occurred at the end of the October closure.

!

Even though no m˙nage&ent actions were implemented to infor&!the a(aptive m˙nage&ent process, the physical conditions and inlet response during the m˙˝˙1 ement period are reviewed in this attachment to contribute to site understandi˝1!˙˝(to inform!*uture manage&ent a tions.!

!

METHODOLOGY

This review of the 2012 outlet channel management period ex˙&ined water levels, ocean wave conditions, ocean water levels, riverine discharge, beach topography, as well as inlet size and location. The sources for these parameters are listed in Table 1. These data were supplemented with personal observations and discussion with staff from the Water Agency, NMFS, DFG, and the Bodega Marine Laboratory.!!

!!

Table 1. Data Sources

Parameter	Source
Estuary!5 ˙ter level (h_E3!	Water Agency!Jenner g˙ge[J]!
0 ˙ve height (H_s), period (˜ ·3.!˙nd direction !	ˇ DIP Point Reyes buoy #029!
Ocean water level (h_O3!!	NOAA Point Reyes #9415°%°!
Russian River discharge (Q*3!	USGS Guerneville #114FE°°° !
Beach topography.!*t!+@A7 !	0 ater Agency!&onthly!surveys
Inlet size and location	Water Agen / and Bodega Marine Laboratory! autono&ous ca&er˙s

[J]Data transmission f˙ilure due to cellular networ issues occurred for several 1-5 day periods throughout the!&anage&ent period.!

!

INLET STABILITY PARAMETER AND CLOSBRE RISK PROBABILIT" !

In addition to considering individual parameters, researchers at the 6odega Marine Laboratory! have developed a co&bined parameter to evaluate the stability of the inlet's state, with the aim!o*! predicting closure risk (Behrens et al., 2013). (Note tˆat the inlet stability parameter does not differentiate!4etween *ull closure and the perched conditions with a s&˙ll outlet channel. When discussing this parameter, both states are referred to as a 'closure' in that tides are prevented fro&! propagating i˝to the estuary¸3The inlet stability parameter presented!4/ !6ehrens et al. (2013) quantifies the risk of inlet closure based on a sed)&ent b˙lance in the inlet. It considers the d˙)˘/ ! balance between wave-driven sediment import to the inlet and sediment export driven by tidal fluctuations. The wave-driven import is assessed usin1 nearshore wave est)&ates derived fro&!˙! transfor&˙tio˝!&˙trix and offshore buoy data (ESA PWA!%° %3and the latter is estimated fro&! tide gage data within the estuar/ !˙˝ d a stage-storage relation derived fro& the available bathymetr/¸!Using daily8˙verage values of the stability para&eter 5 ithin the period 1999-2008, Behrens et al.!2%° '3 showed that high-percentile values of!the parameter ˙re closely!˘)˝ ed to the risk of the inlet closing within five days. As the percentile of the stability par˙&eter increases, the risk of!inlet closure within five days increases exponent)˙˘˘/.!*ro&!risks of roughly five percent when the parameter is at the 50th percentile to a ris of 80 percent when it is &easured at the 99th percentile.

!

SUMMER AND FALL CLOSURES AND SELF-BREACHES!

˜) &e series of estuar/ !5 ˙ter levels, as well as the key!*orcing factors (waves, ti(es, and riverine discharge), are shown in Figure 1 for the entire &˙˝˙ 1e&ent period. The lagoon water level time series (Figure 1a) su&&arizes the observed &uted conditions in earl/ su&&er and short-lived closure events that occurred at the end of the &˙˝˙gement period. As shown in Figure 1d, discharge remained high for the first two months of the manageme˝t period.!River discharge did not drop belo5!%°°!*t˙/s until after June 10th, at which time the estu˙ry had already!begun its &uted tidal phase, leading up to four short-lived closures. This elevated discharge probably! reduced the likelihood of inlet closure during the first ' °8?° !(˙/ s o*!the management period (Figure 1d), despite the occurrence of energetic wave conditions in May!(Figure 1b). Wave energ/ reached a &)")&um in August and early!- eptem4er, but was weaker throughout the 2012 &˙nage&ent period than i" !%° 1. The hourly!significant wave height was less than 8 ft for the &˙jority o* this period. !

!

The conditions leading to inlet closure were consistent with the existing conceptu˙˘!&odel described in Section 4 of the Management Plan. All closure events coincided with either &oder˙tel/ !^)1^!5˙# es (H_s!O!F!t*) having periods greater than 10 s, or with neap oceanic tide ranges of less than approximately 5 ft¸ !Moderate˘/ !^)1^!5˙# es coincided with the closure events in June, July, Septem4er an(October. The first closure observed in June!˙"(!4 oth July closures coincided with neap tide conditions, although long-period swells occurred prior to the former of! the two. Closure events that occurred in June a"(!9 uly!˙re e<˙&)"ed in more detail in Figure %.! while Figure 3 su&&arizes conditions that occurred later in September8Novem4er.

!

All closure events occurred with the inlet located!˙(jacent to the jett/ ¸!˘^) s positioni"1! &ay have prevented perched conditions fro&!arising by shielding this area of the beach fro&!the wave-driven sediment deposition that caused closure, preventing the be˙ ^!* ro&!accreting to a sufficient height to allow the desired outlet channel elevations!*rom be)"1!˙ttained. The low point in the be˙ ^!4 erm!that was subsequently overtopped and self8breached also persisted immediately! adjacent to the jett/ ¸!

!

PERCHED LAGOON AND SELF-BREACH DYNAMICS !

During the June and July!closures (Figure 2), as well as the late Septem4er closure (Figure 3), the lagoon water level only!increased at approxim˙tely!°¸'!*t/day. This slower increase probably! occurred because a small outlet c^annel that flowed over the beach berm!˙nd through!˙!1˙p in!the jetty!partially balanced i"*lowing river discharge.

!

As an example of one of!the several inlet closure events that resulted in self8breaching prior to target outlet channel elevations, Figure 4 shows a sequence of!photos of!the inlet before, during, and after an episode fro&!October 8-15. As was the case for all o* the &anageme" t period, the inlet was located next to the jetty. Prior to closure, the inlet had allowed only!&uted tides, resulting from!a partial breach on October 2"(that did not restore full tidal action. Neap oceanic tides co&pounded this, and 7-ft high nearshore waves having a do&inant period above 20 seconds closed the inlet on October 8th!2Figure 3b,c). !

!

After the onset of closure, the estuary water levels began to rise.!, or the first two days of closure, the water level increased at approxim˙tel/ !°.5 ft/day!fro&!' !to 4!ft NGV7.!4 ut this decreased to less than 0.3 ft/day!˙*terwards (lagoon sta1e above 4 ft NGVD). Waves deposited sediment adjacent to the gap in the jetty structure, block)"1!out*lows *ro& the lagoon that had occurred in prior closures (Figure 4b).!This partially8*ormed barrier ber&!was overtopped when the lagoo"! reached approxim˙tely 5.25 ft on October 15th!(Figure 4c). The outlet channel was narrow, with a width of less than ten feet. This overtopping event coincided with a spring phase of!the oceanic tides, which generated a large head difference between the estuar/ !˙nd ocean waters. This head ()**erence presu&˙4˘/ contributed to channel flow velocities exceeding the threshold for scouring the beach sand, since the spring lower-low tide on October 16th resulted in the s&all channel eroding the barrier and creating a new inlet (Figure 4d). After the initial breach, the increased *low rate scoured sand from!the channel bed and 4˙˝ s, and the channel increased to &ore than %°!*eet in width (Figure 4(3¸!!

!

The jetty and rocks which had been a part of the jetty appeared to have a significant influence on the geomorphic evolution!o*!the channel. At ti&es, the jett/ ele&ents!&˙/!ˆ ave stabilized the outlet cˆ annel, both!in sheltering the outlet cˆ anne˘!*rom waves a˝ (!4/ providin1!4˙˝ !˙˝ d be(! stabilization that &)˝)&)>ed channel scour. Wave!sheltering by the jett/ probably!reduced ber&! build-up at the inlet’s location, leaving a low point in the beach berm that was the site *or subsequent overtopping and self8breaching. Of!the six closure events that occurred within the &˙ nage&ent period, all experienced a si&ilar breaching pattern, self8scouring a tidal inlet before estuar/ !water levels reached 5.5 ft NGV7¸!˜ˆ) s was also true of the two closure events wh) ˆ! occurred in Novem4er, following the!&anagement period 2,)1 ure 3). At times, the outlet channel *lowed through notch in the jetty (Figure 5), such that the rocks probably provided stabilization that prevented bed scour. The jett/ also!ˆalted lateral scour to the south. However, o˝ ce later˙˘! scour is halted, the channel &˙ / !then m˙ intain its cross-sectional area b/ scouring downward where it runs parallel to the jetty¸!!

!

!

CLOSURE R;SK PROBABILITY !

The 5-day closure risk probability.!˙!(eri#ative of the inlet stability!parameter described above, was hindcast *or 2012 according to the method described in Behrens et al. 22013). This hi˝(ast provides an indication of the utility of the stability parameter as a prediction tool for monitoring inlet conditions and planni˝1! &˙ nage&ent action.!˜ˆ) s parameter integrates wave and ocean *orcing conditions, as well as estuary water levels, to provide greater predictive skill than just! waves or ocean tides on their own. The stabilit/ !parameter co&4)˝es these factors, and the corresponding five-day closure risk time series exceeded 50 percent!be*ore each 2012 event (Figure 1e, Figure 2e, and Figure 3e). The closure event initiated on July! st occurred quick˘/ .! transitioning *rom!*ully tidal to fully! losed within a!(˙/ , so the risk time series did not provide &uch forewarning in this case. This was also true of!two closure events occurring outside of!the &˙ nage&ent period, in!+ o#ember 2012. However, for all other events observed fro&!9une to Novem4er, the predicted probability of! losure exceeded 50% 2-5 d˙/ s in advance of each closure. There were no instances during the &˙ nagement period when the predicted probability of! closure e<ceeded 50%!˙˝(! ˙! ˘osure did not occur w)tˆ in 5 (˙/ s.

!

TOPOGRAPD;˘!˘D ANGE

The W˙ ter Agency!ˆ˙ s conducted monthly!surveys of!@oat Rock State Beach that cover a!region starting from!the jetty!˙nd extending approxim˙ te˘/ 1,500 feet to the north. Typically, the surveys do not include bathymetry within the inlet because f˘o5 conditions!in the inlet prevent safe! access. Also, the survey extent can be limited b/ the Water Agency’s co&p˘)˙˝ ce with its &arine &˙ &&˙˘!)˝) dental harassment authorization, which sets guidelines for the survey! rew’s disturbance to marine m˙ mmals!ˆ˙ uled out on the be˙ ˆ ¸!0 ˙ ter Agency survey staff collected spot elevations using RTK-GPS and then asse&4led these elevations into a set of contour li˝ es at

1 ft intervals. The survey elevations are reported in the!+@A7%9 vertical datu&, tˆe work)˝1! datum!*or estuary!&onitoring a˝(!& anagement.

!

To characterize beach berm!topographic conditions, ESA PWA assessed data fro&!the Water Agency's 2010 (July to Septem4er), 2011 (May!to October), a˝(!%° 12 (May!to October) surveys. Surveys *ro& Novem4er 2011 to May 2012 were also co&pared, to assess winter-time changes of! beach shape. Survey transects *ro&!the 2011 analysis were reused (Figure 6), and include two transects b˙ ed b/ ! ˘)**!2Figure 7 and Figure 8), one transect which extends into the estuar/ ! (Figure 9), and two transects just north of the jett/ !2,)gure 10).

!

This review focuses on the 201%!surveys, although the!%° °!˙˝(!%° 11 surveys are included for context. Compared with both 20 °!˙ ˝(!%011, the 20 % topographic data indicate that the be˙ ˆ! ber&!5˙ s less variable in shape than in previous years. This is especiall/ true of the northern two transects (Figures 7 and 8), and to a lesser extent at Transect 2 (Figure 9). Because of inlet an(! seal haulout locations, topographic data were not collected in the vicinity o*!Transect 1!)˝!%°%.! so this is not included in the analysis. Adjacent to the jetty!groin, Transect 0 showed little &onthly! ˆ˙˝ ge in topogr˙ phy, but extensive inter-annual variabilit/ ˛!!!

!

During the &anagement period in 2012, the beach berm!˙ long transects 2, 3, and ? showed little variability.! ˆ ˙˝1)˝1!4/ less than two feet. The profile along Transect 2 (Figure 9) showed a slight aggradation trend over the course of the &˙˝˙1 ement period, but at Transects 3 and 4, the change in shape fluctuated only!slightly!2,) gures 7 and 8). In contrast, between M˙/ !%° !˙˝(! October 2011, the beach berm!at these transects built in size b/ !&ore than 6 feet. The difference)˝!&onthly variability!˙ t the northern transects between the 20 !˙˝(!%° %!&˙ nagement periods ˙˝!˘) ely be tied to the dif*erence in the extent of inlet &igration. In 2011, the inlet &igrated north o*!D˙/ stack Rock during the winter, and returned to the jetty in late spring or early summer. This &igration resulted in a lower beach profile at all transects. Over the course of the &˙ nage&ent period, the 4each gradually built up to!˙ !typical summer profile. Even during the peak!5 inter and sprin1!*lows of 2012, the inlet never m)grated north of!D˙/ stack Rock, leavi˝1!˙! largel/ -intact 4each ber&!˝orth o*!D˙/ st˙ Roc !˙˝ (!˙!˘ower terrace between H˙/ st˙ Rock! and the jetty!1roin. Since these northern transects started at a &u ˆ!ˆ)gher elevation at the start o*! the &˙ nagement period, the vertical growth o*!the beach profiles at these locations were sever˙ ˘! feet less than during the previous year i˝ the sa&e locations.

!

Transect 0, which is located just north of and parallel to the jetty, had noticeably different elevations and evolution than the other transects!during the 20 %!&anagement period. Co&pared to the other transects, crest elevations were highest at this transect for both 2° °!˙˝(!% ° ˛ !This was not the case in 2012, when the nortˆ ern&ost two!transects were the highest.!The crest elevation at Transect 0 did not evolve during the &anagement periods!)˝!%°°!˙˝(!%° 11, but was observed to erode between August a˝(! October in 20 %˛!;&˙ ges from the BML stationary! ˙&era indicate that this was the result of the inlet shi*ting fro&!˙ sinuous align&ent (resulting fro&! southward m)gration) to a straight alignment running nearly parallel to the jetty. The only! significant changes occurred during the winter between each of!the &anagement periods. The ˘˙ of!&˙˝˙gement period variability!o*!this region suggests that the jetty shelters this portion of!

the beach fro&!small to &oderate waves that occur during the &anagement period. Only!the larger waves associated with winter storms m˙/! 4e su**))ent to re-shape the beach ber&!˝ ear the jetty¸!!

!

0 ˙ter A1ency surveys taken during the &onths preceding the 201%!&˙ nagement period (Novem4er 2011 to April 2012, Figure 11) show more variability!in beach berm height and width than was observed for the 2012!&˙˝ agement period (Figure 9). Tˆ e highest be˙ ˆ! rests observed during the 128&onth period from!+ovem4er 2011 to!October 2012 oc urred in Novem4er a˝(! Dece&4er 2011, peak)˝1!4etween 14 and 15 ft NAVD88 at Transect 2 (Figure 11). This is consistent with the co&bination of!ˆ)1ˆ8energ/ . long-period swell waves and generally!low *uvial flows during!the late fall. By the February 2012 survey. erosion s)1˝)*)cantly!reduced the beach crest elevation. This erosion is likely!due to fluvial flows through the inlet at Transect 2¸! Farther north, at Transect 3, there was less influence fro&!the inlet,!˙˝ d there appeared to be less erosion duri˝ g winter 2011-12 (Figure 12). The ber&!crest was highest in late spring (March and May profiles) and in Nove&4er 2012, peaking between 16 a˝(! E!* t NAVD88. The difference between the evolution of!˜ ransects 2 a˝ (!'!& ˙/ be!˙ !result of the inlet's lack of!&igration in 2012, or possibly!˙!()**erence in the amount of!wave exposure between locations.!

!

Water Agency!surveys were also used to assess the beach width at Transect 3. We *ocus o˝! Transect 3.!4ecause the influence of the)nlet caused the beach to be consistentl/ lower at other transects, so&eti&es as low as the intertidal zone, where survey!(ata were not consistently! collected. The Transect 3!4each width was as the horizontal distance between a particular elevation on the ocean and estuary!sides of the beach *ace, respectively. Fro& Novem4er 2011 to June 2012, the beach width at the 12 ft NAVD88 elevation varied fro& 110 to 145 feet, showing signs of both narrowing a˝ (!5 idening (uring the winter and spring!2,)gure 13).!, rom!9une to August 20 %. the be˙ ˆ!5 idth grew steadily!*rom!about 11°!*t to 145 ft a˝(!˙ ppeared to rem˙)˝!˙ t this width though Novem4er 2012. At an elevation of! ?!*t NAVD88, the widtˆ !*ollowed the same pattern, but had larger!*uctuations, vary)˝1!*rom!roughly 30 to! °!* t and grew steadily! *ro&!9une 2012 onward. These observations underscore the typ) ˙˜! pattern of beach buildi˝1!)˝! su&&er, but also indicate that waves in winter can build the beach between destructive events.!

!

LESSONS LEARNED AND RECOMMENDATIONS

Based on observations of the estuary, associated physical processes, and the Water Agency:s planning for outlet channe˜!&˙ nageme˝ t, we note the following lessons about implementing the outlet cˆ anne˜!&˙ nagement plan.!

!

CONCEPTBAL MODEL!

- Elevated discharge in the late spring (greater than 200 ft˙/s until June 10th3!&˙ /! ˆ ˙#e! reduced the likelihood for inlet closure in May, although the wave climate at this time! was also significantly weaker than during the previous / ear. !
- Several short-lived closure events occurred, but waves never built up the m)˝)&u& crest height (the li&iting height for closure) beyond 5.5 ft +@A7.!˙ ˝(!˙ ll e#ents ended with

self-breaches below this elevation. This prevented &˙˝˙gement actions fro&!4eing taken during the 2012 season.

- The inlet never migrated north of!D˙/ stack Rock during pe˙ !5inter f˘oods, and returned to the jetty in earl/ !spring, mu h earlier tˆ˙˝!)˝! &ost / ears. This inlet align&ent is not co&&on, but ˆas been observed in past years (Behrens et al., 2009). !
- During the management period, most of!the beach north of!D˙/ stack Rock underwent little topographic change. A transect adjacent to Haystack Rock aggraded slightl/ .! consistent with typical beach berm building that occurs during tˆe su&&er. Adjacent to the jetty. the berm did not ˙ggrade, but rather rem˙ined large˘/ unchanged for most of the season and then later eroded between August and October as a result of a sh)*t in the inlet ˙˘)1˝&ent.
- The wave clim˙te remained weak throughout!&uch of the su&&er and f˘˘.!5ˆ) ˆ!& ˙/! have stunted the growth of the beach crest in the vicinity o* the jetty!(the location of the inlet throughout the 2° %!season), preventing lagoon water levels *ro& reaching levels conducive of the planned outlet cˆannel.!
- When an outlet channel is present, oceanic tide conditions can encourage scouring and *ormation of a new tidal inlet. During the spring phase of the tide, the lower-low tide creates a large head dif*erence between the lagoon and ocean, likel/ !increasing the flow velocit/ in the channel.

!

OUTLET CHANNEL FEASIBILITY

- The jetty!&˙y shelter the inlet, &˙ ing closure less likely and also limiting berm growth, which then m˙intains a low point for self-breaching. When the inlet is)˝!˙!*ully or &uted tidal condition, options for management beco&e considerably!&ore diff)cult to)&pleme˝t.
- An outlet channel that was intermittently observed during the 2012 closures conveye(!˙! portion of the inflowing river discharge, slowing the rise in lagoon water levels to approxim˙tely 0.3 ft/day¸!˘ˆ is channel f˘owed through a!1˙p in the jetty.!5hose large rocks likely!provided some degree of channel stabilization against scour. However, this condition changed with lagoon levels, as described below.!
- Once outlet channel discharge increased due to rising lagoon water levels or low oceanic tides, the discharge scoured a new channel, 4reaching the estuar/ to!the tides. This behavior highlights the susceptibility of!˙!sand bed outlet channel to scour, lim)ting conveyance capacit/¸!
- Even if the inlet being near the jetty!ˆ)nders!*orm˙tion of sustained lagoon a˝(outlet channel conditions.!&˙nagement opportunities *or re-locating the outlet channel are ˘)&)ted a˝(! onstrained. At ˙!&)˝)&u&.! reating an outlet cˆannel!*urther north *rom!the jetty requires a full natural closure, absence of a low point i˝!the beach berm near the jett/ .!˙˝d equip&ent access to the area north of the jett/¸!!
- Over the first three years of e**ort to imple&ent the outlet cˆannel a(aptive m˙˝˙gement plan, only one closure (July 2010), has been suited for outlet channel &˙nagement action. !

!

COMMUNICATIONS!

- Although the perched lagoon episodes did not evolve to the point tˆat management action was warranted, the Water Agency began p˘˙˝˝) ˝1!&anagement actions as soon as the episodes occurred. Planning included heightened observations of inlet conditions!4/ ! 0 ˙ter Agency staff, email updates to inform!the resource &˙nagement group, ˙˝(pre-)&ple&entation &eetings at the project site to refine plans for &˙˝ agement actio˝˛!!

MONITOR;+@!

- The Agency's month survey!&ethods should be!&odif)ed to collect specif)ed contours, such as the beach ber&!ridge line, wetted edge (beach side3.!˙˝d water edge (estuar/ ! side).

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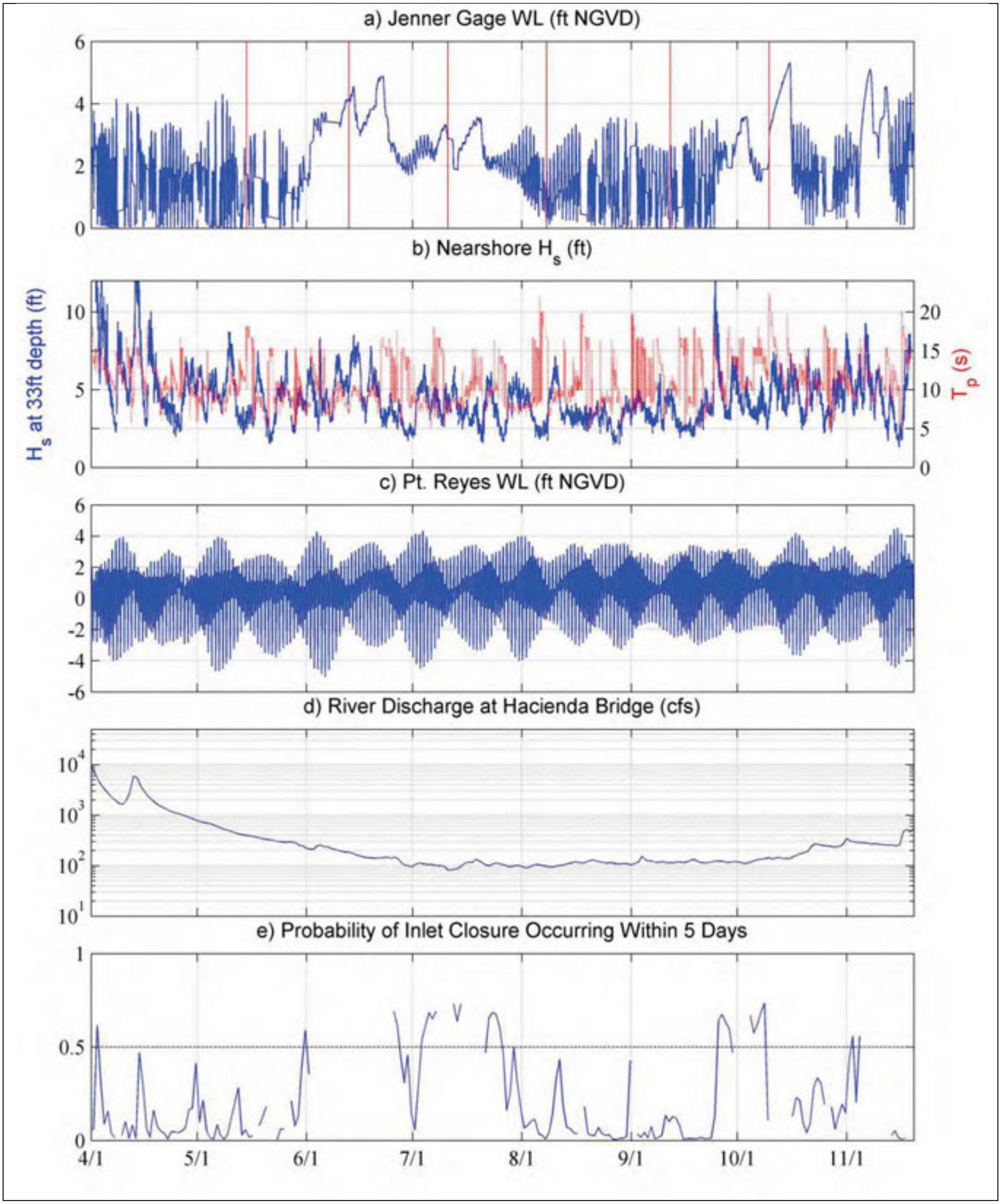
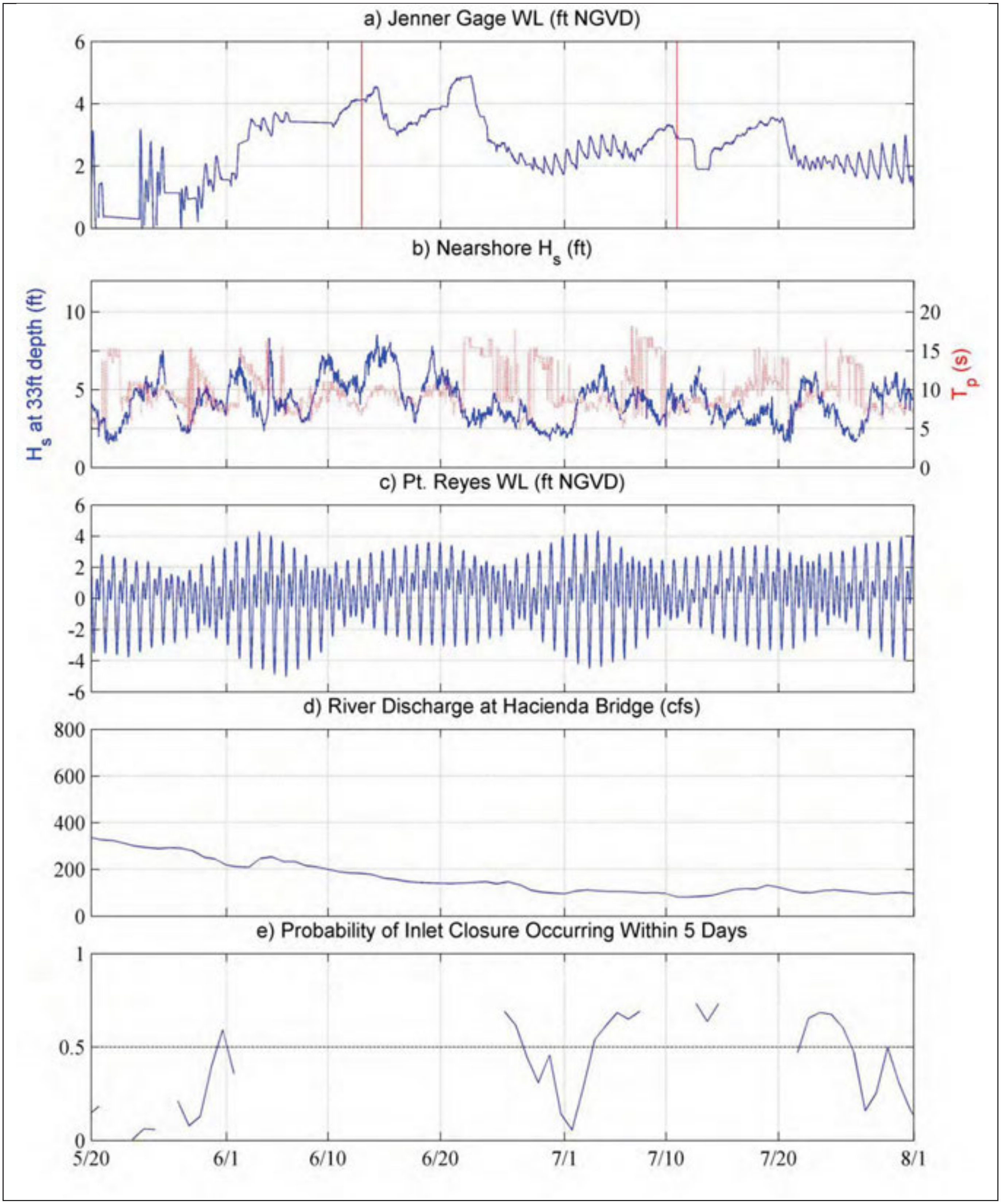


SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

Figure 1

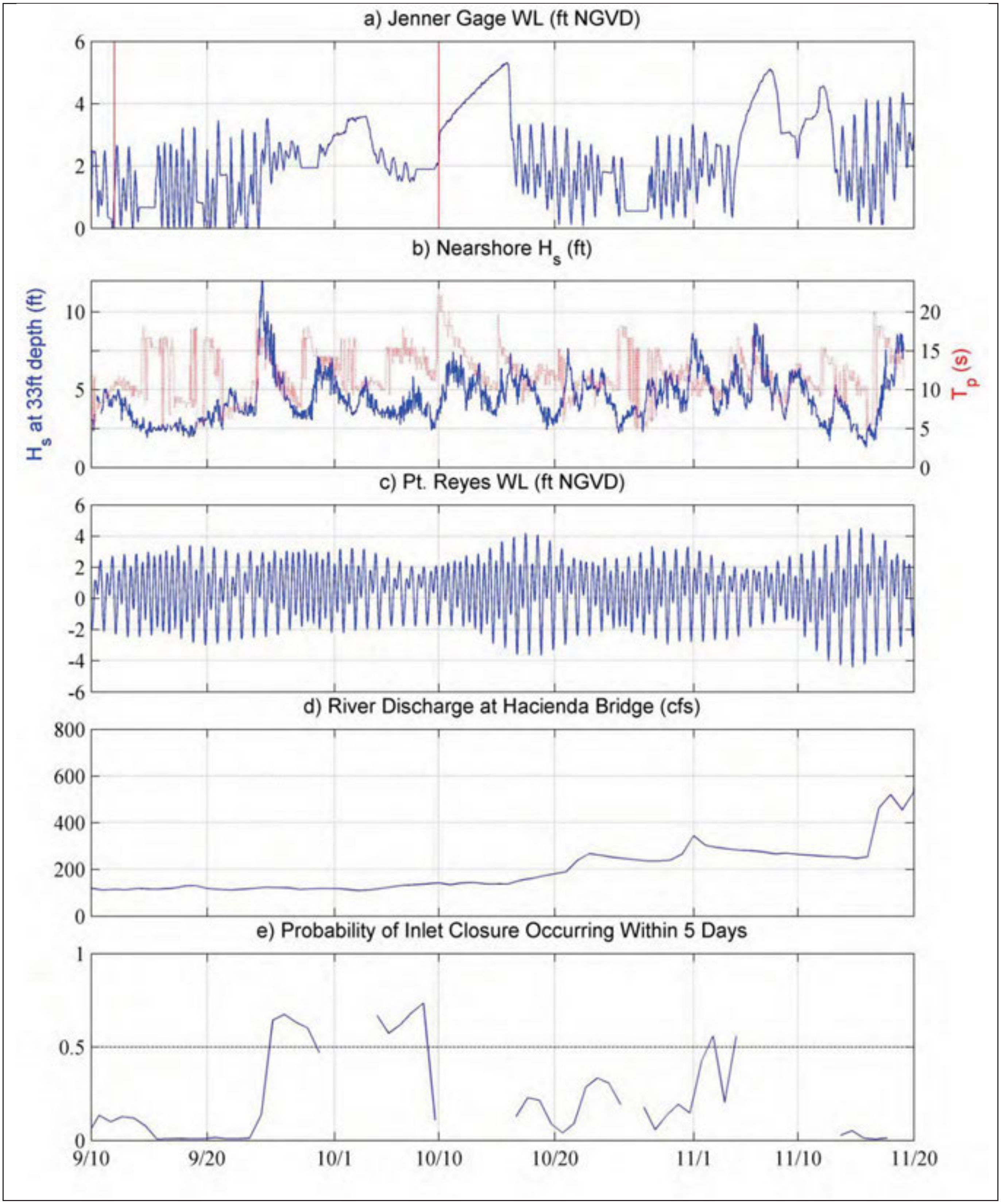
Estuary, Ocean, and River Conditions Compared with Closure Probability: September – November 2012



SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; T_p=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

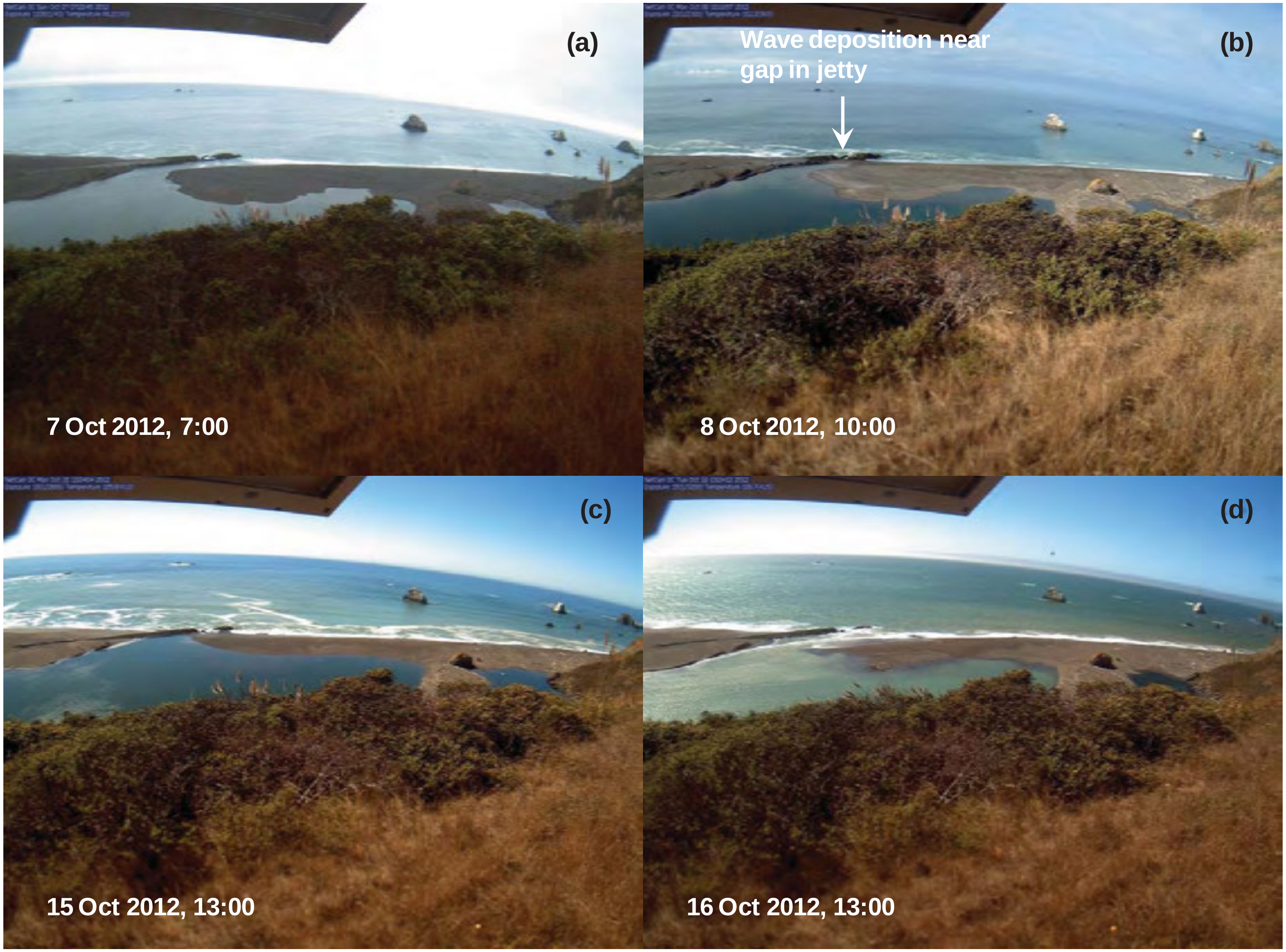
Figure 2
Estuary, Ocean, and River Conditions Compared with Closure Probability: May 20 – August 1, 2012



SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; T_p=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

Figure 3
Estuary, Ocean, and River Conditions Compared with Closure Probability: September 10 – November 20, 2012



SOURCE: Russian River stationary observation camera (BML)

Figure 4
Inlet Closure and Self-Breach in October 2012

Source: Sonoma County Water Agency

figure 5
Project Name

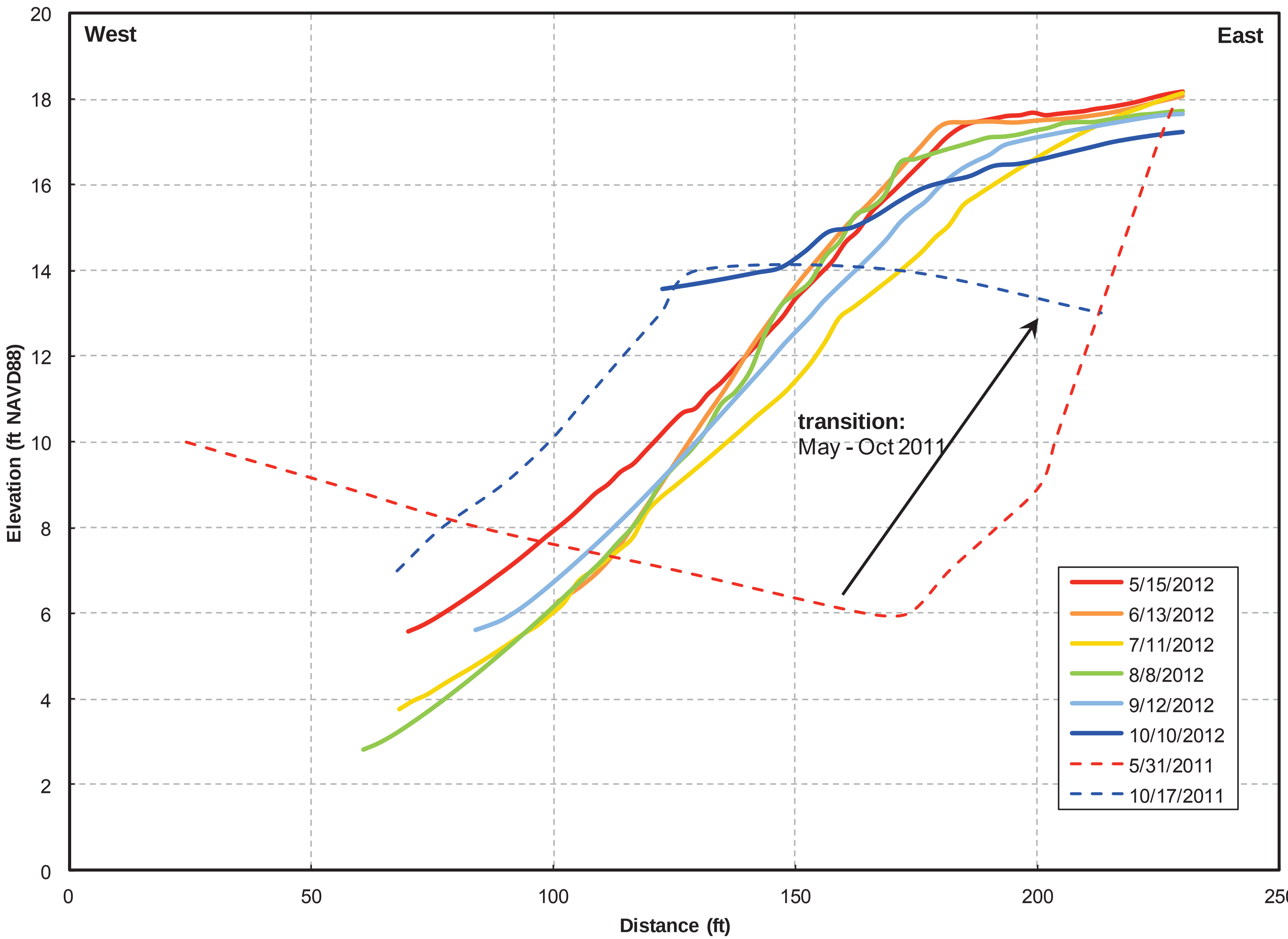
Outlet Channel Flow Through Jetty Notch

ESA PWA Ref# DW01958.02

ESA PWA

SOURCE: image from USDA NAIP

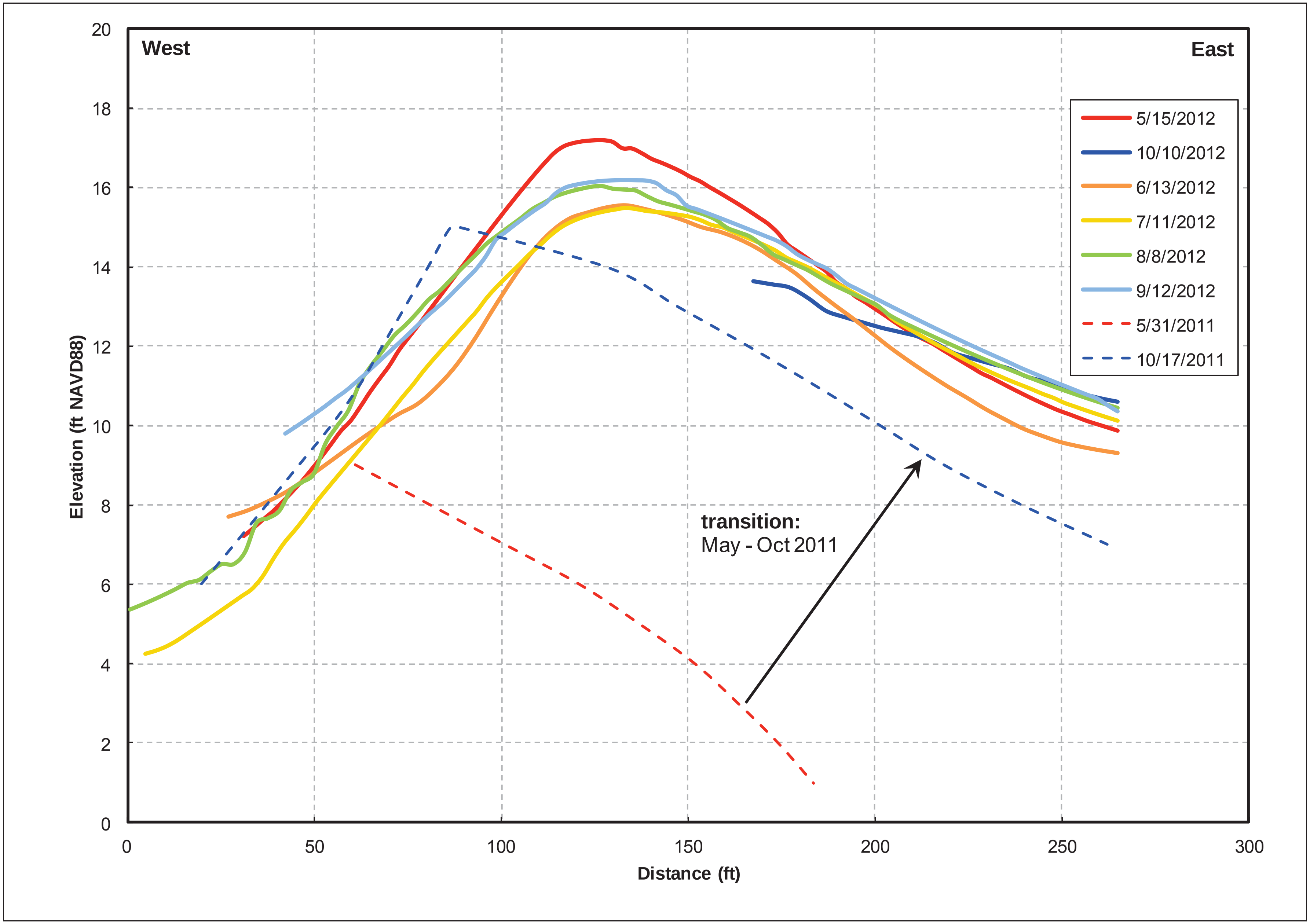
Figure 6
Beach Transect Locations



SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

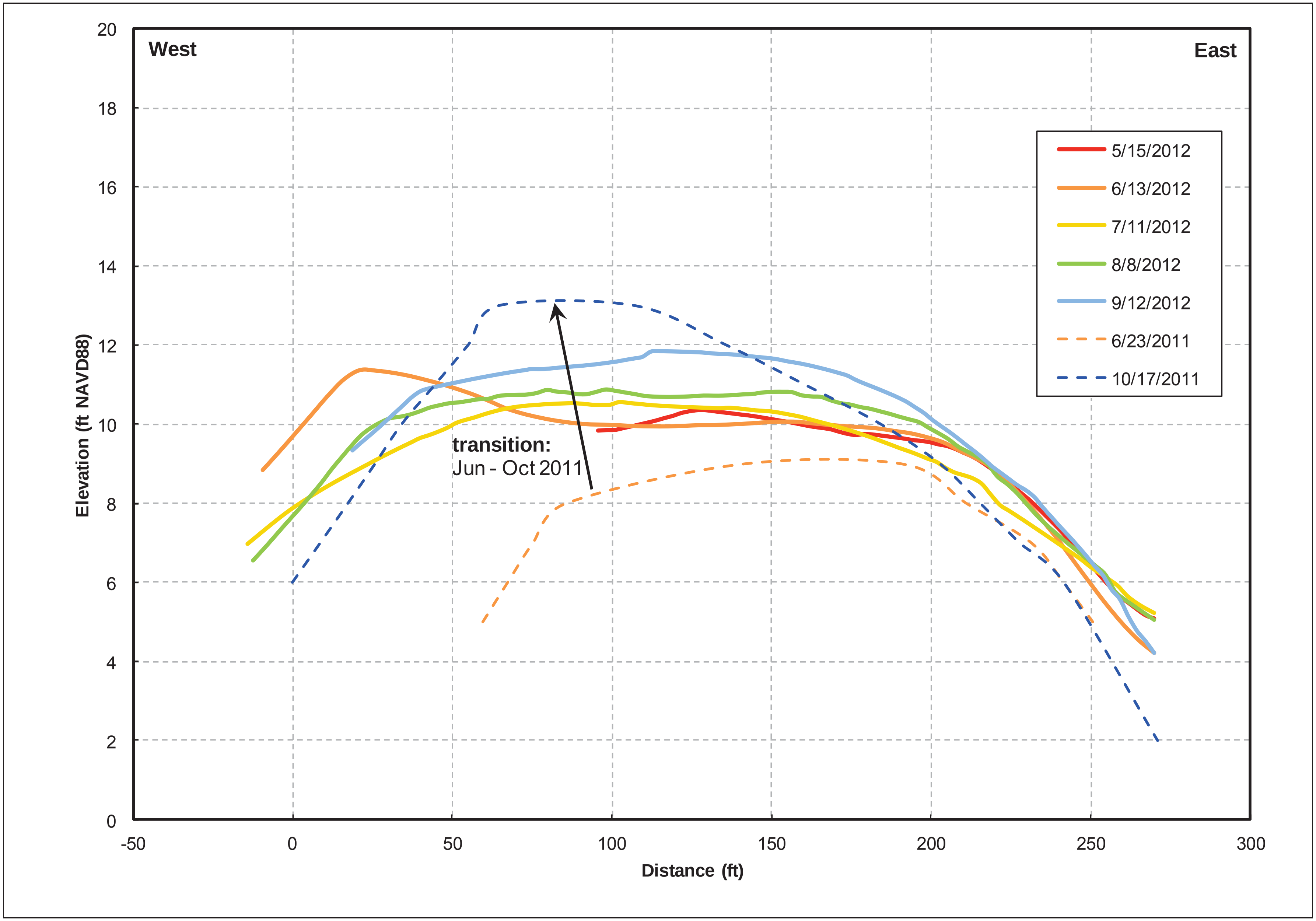
Figure 7
Beach Transect 4



SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

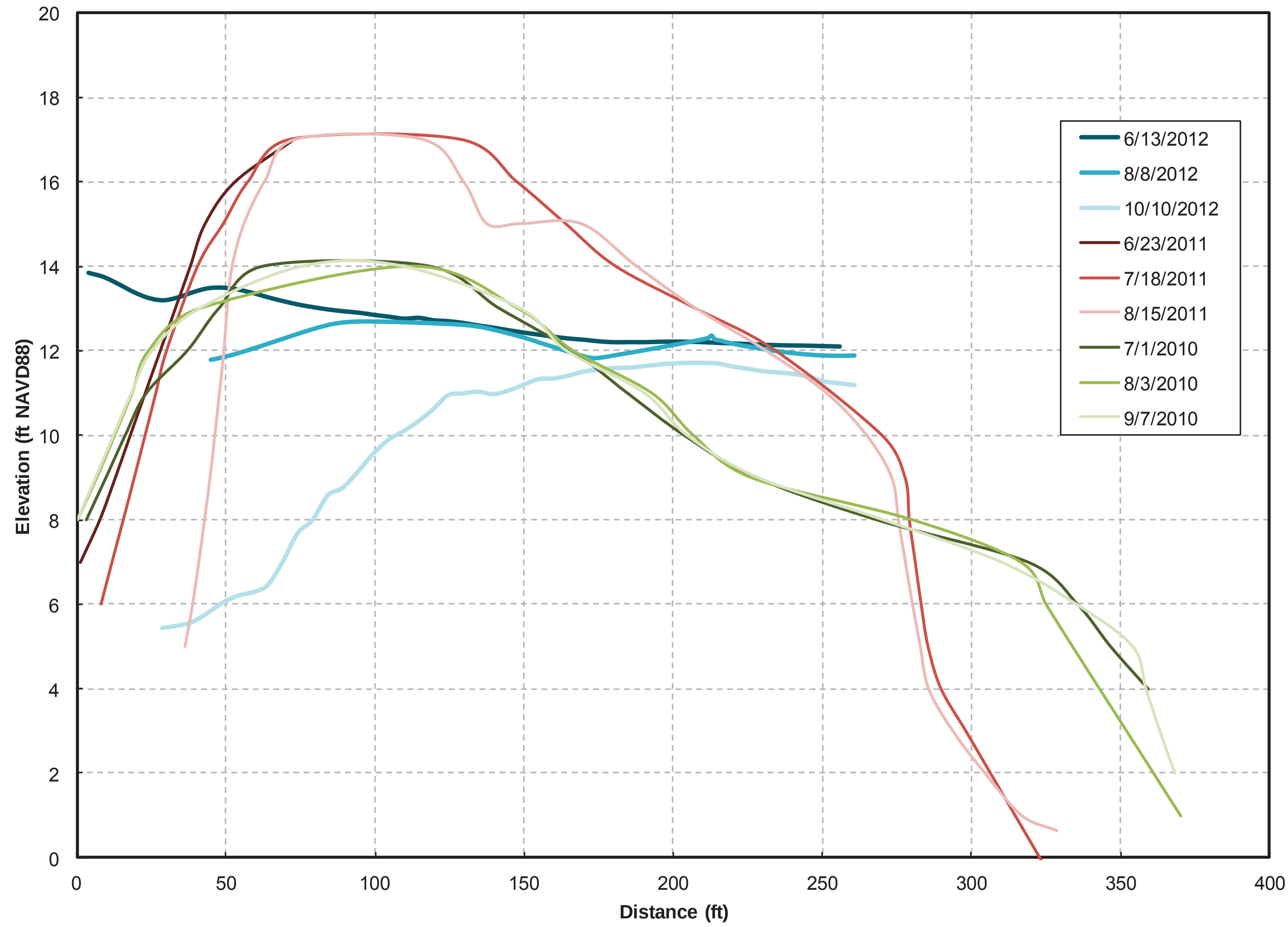
Figure 8
Beach Transect 3



SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

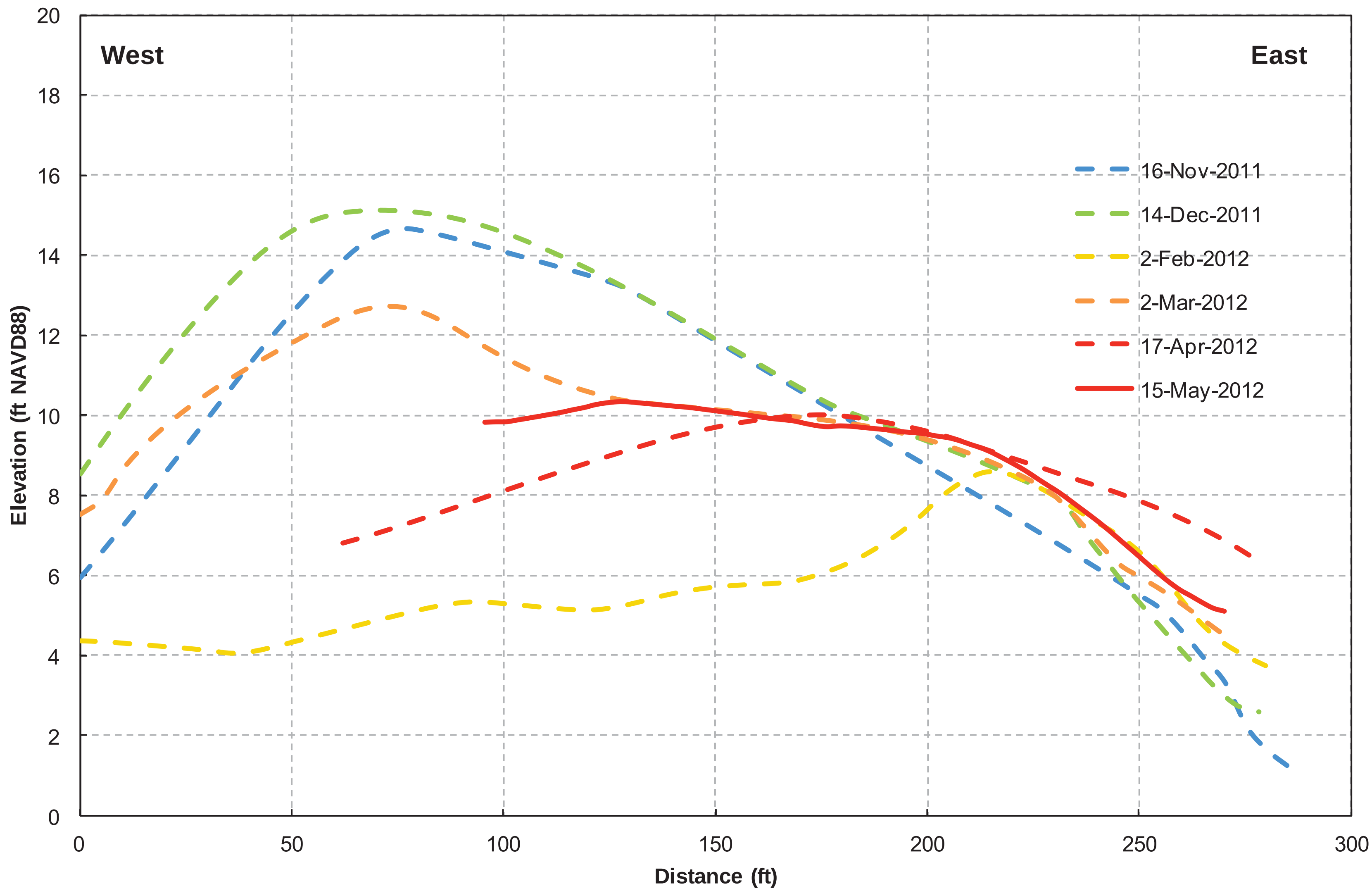
Figure 9
Beach Transect 2



SOURCE: SCWA survey data

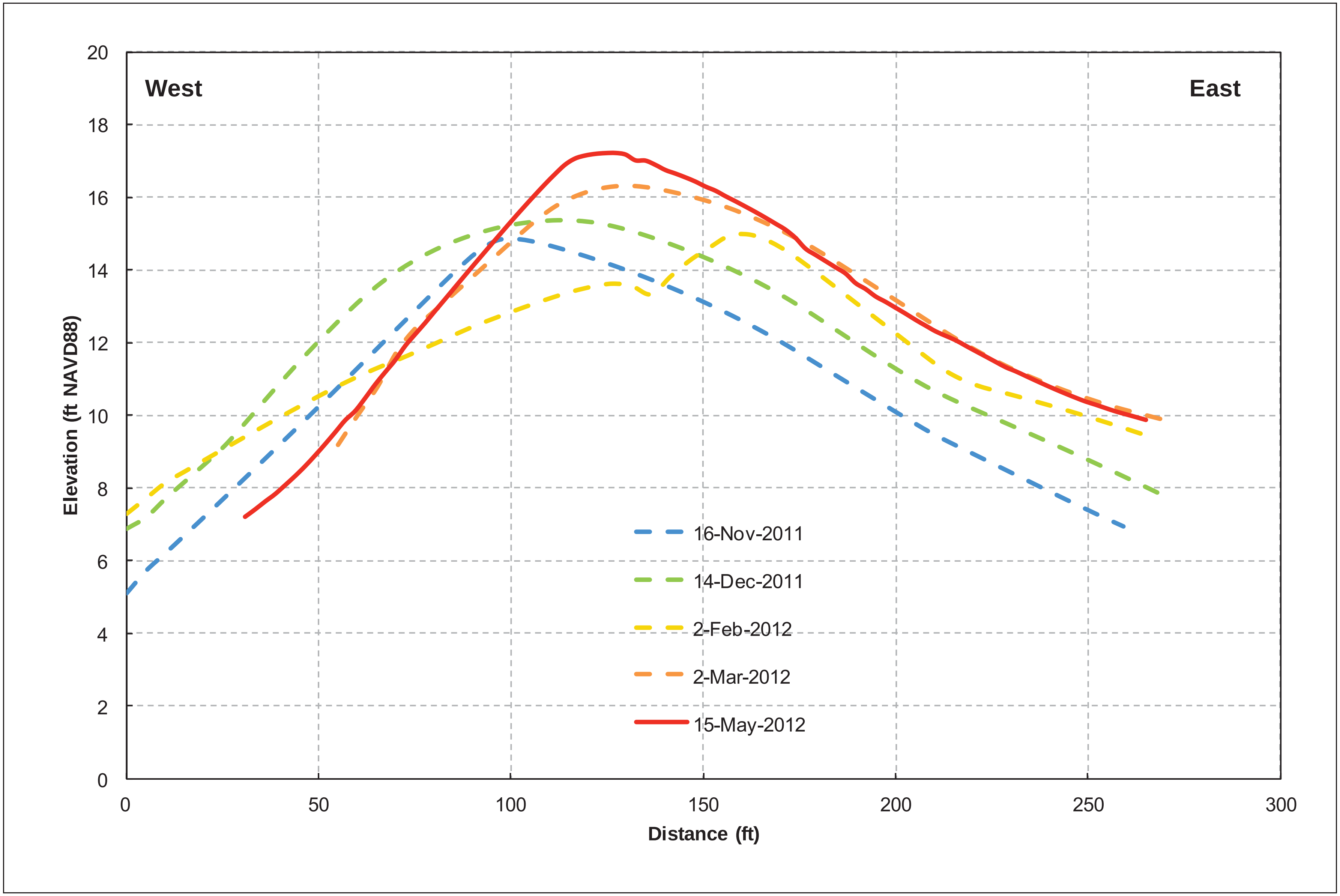
Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 10
Beach Transect 0



SOURCE: SCWA survey data

Figure 11
Nov 2011 to May 2012 topographic change at Beach Transect 2

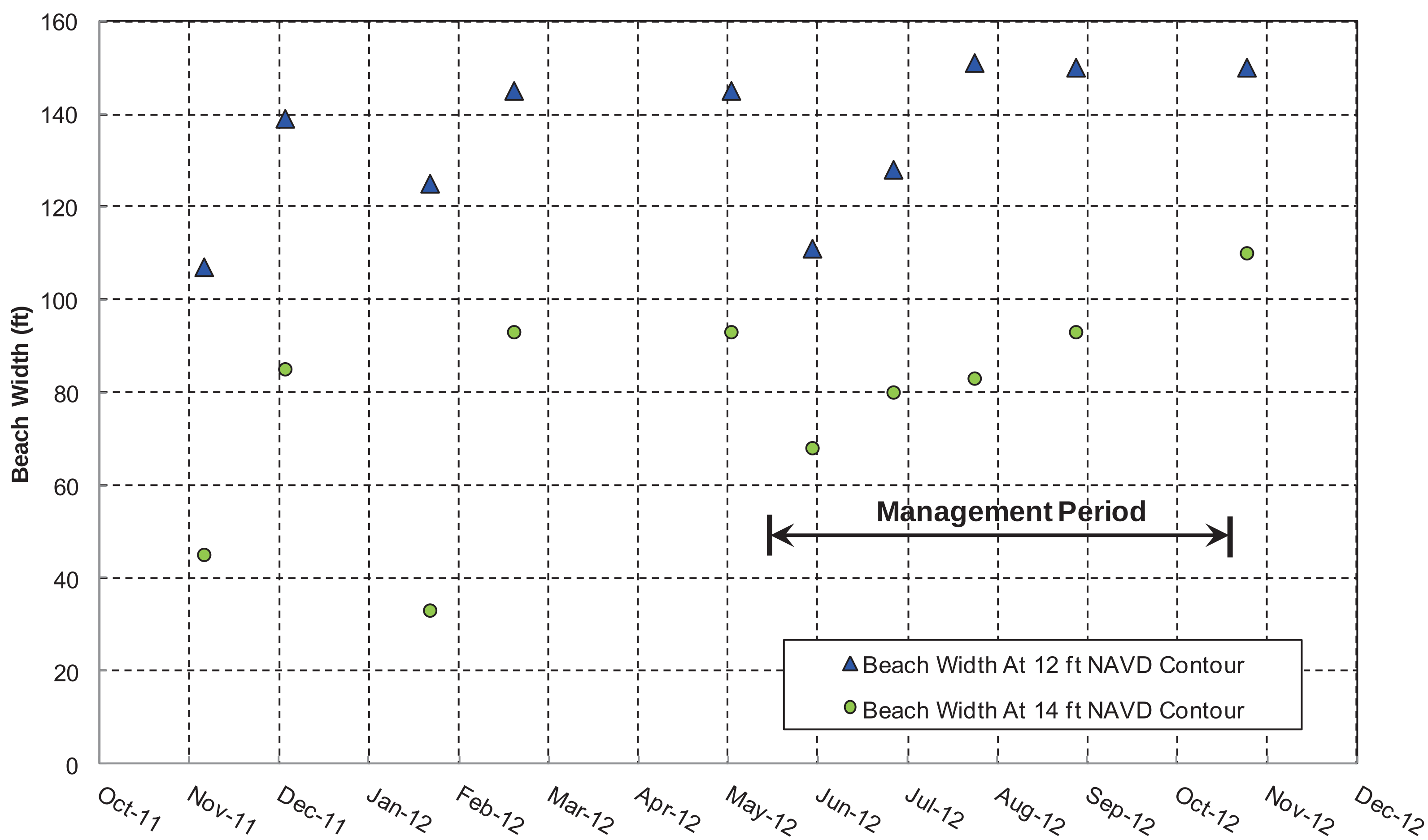


SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 12

Nov 2011 to May 2012 topographic change at Beach Transect 3



SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . D120709.00

Figure 13
Beach Width at Beach Transect 3.

!

Attachment H. Physical Processes During the 2013 Management Period!

!

As required by the Russian River Biological Opinion, the Sonoma County!0 ˙ter A1ency (Water Agency) has been tasked with &anaging a su&&er lagoon intended to improve salmonid habitat in the Russian River Estuary!4/ creating an outlet channel while maintaining the! urrent level of! *lood protection for properties adjacent to the estuary (NMFS, 2008). The adaptive m˙nage&e˝t! plan, described in the main body of this report, was develope(!4/ the Water Agency!5 ith assistance *ro& ESA PWA and the resource agency &anagement team in 2009 and revised annually!*ro& 2010 to 2014. Because of per&it constraints, the Water Agency!was only!able to)&ple&ent the plan be1)˝˝)˝1!)˝!%° °¸!˜ he revised plan was in effect for 2013,!but no opportunities *or m˙˝˙gement action occurred during the manageme˝t period.!!

!

During the 2° '!& ˙nage&ent period, May 15th to October 15th, Water Agency!staff regularl/ ! &onitored current and forecasted estuar/ !water levels, inlet state, river discharge, tides, and wave conditions to anticipate changes to the inlet's state. Although the inlet experienced several closures, an outlet channel was not i&p˘e&ented. The inlet was closed for the &ajorit/ !o* the *irst two &onths of the &˙˝agement period as a result o* two closure events. During this ti&e, each! closure ended when lagoon water levels increased, overtopped the beach berm.!˙˝d scoured a new tidal channel. The first event self8breached in ear˘/ June before water levels reached 7 ft NGV7.! while the second event resulted in lagoon stage above 7 ft NGVD but self8breached in early Ju˘/ ! before an outlet cˆannel could be!)&plemented. The estuary!remained fully tidal until it! losed again in late September. This Septem4er-October event was ended with a &˙nual breach on the last day o*!the manage&ent period to provide a path5˙/ !*or m)grating s˙˘&onids and to reduce water levels in advance of potential fall precipitation. !

!

Even though no m˙nage&ent actions were implemented to inform!the a(aptive m˙nage&ent process, the physical conditions and inlet response during the m˙˝agement period are reviewed in this attachment to contribute to site understandi˝1!˙˝(to inform!*uture manage&ent a tions.!

!

METHODOLOGY

This review of the 2013 outlet channel management period ex˙&ined water levels, ocean wave conditions, o ean water levels, riverine discharge, beach topography, as well as inlet size and location. The sources for these parameters are listed in Table 1. These data were supplemented with personal observations and discussion with staff from the Water Agency, NMFS, CDFW, and the Bodega Marine Laboratory.!!

Table 1. Data Sources

Parameter	Source
Estuary!5 ˙ter level (h_E3!	Water Agency!Jenner g˙ge[J]!
0 ˙ve height (H_s), period (˜ ·3.!˙nd direction !	ˇ DIP Point Reyes buoy #029!
Ocean water level (h_O3!!	NOAA Point Reyes #9415°%°!
Russian River discharge (Q_*3!	USGS Guerneville #114FE°°°!
Beach topography.!*t!+@A7!	0 ater Agency!&onthly surveys
Inlet size and location	Water Agen / !˙nd Bodega Marine Laborator/ ! autono&ous ca&er˙s

[J]Data transm)ssion failure due to cellular network issues occurred for several periods throughout the m˙nagement period.!

!

INLET STABILITY PARAMETER AND CLOSURE RISK PROBABILITY!

In addition to considering individual par˙&eters, researchers at the Bodega Marine Laboratory! have developed a co&4ined parameter to evaluate the stabilit/ !of tˆe inlet's state, with the aim!o*! predicting closure risk (Behrens et al., 2013). (Note tˆat the inlet stability parameter does not differentiate!4etween *ull closure and the perched conditions with a s&˙ll outlet channel. When discussing this parameter, both states are referre(! to as a 'closure' in that tides are prevented fro&! propagating i˝to the estuary˛3 The inlet stability parameter presented!4/ !6ehrens et al. (2013) quantifies the risk of inlet closure based on a sed)&ent b˙lance in the inlet. It considers the d˙)˘/ ! balance between wave-driven sediment import to the inlet and sed)&ent export driven by tidal fluctuations. The wave-driven i&port is assessed usin1!˝earshore wave esti&ates derived fro&!˙! transfor&˙tion m˙trix and offshore buoy!(˙ta (ESA PWA.!%° %3!nd the latter is estimated from! tide gage data within the estuar/ !˙˝ d a stage-storage relation derived fro& the available bathymetry. Using daily-average values of the stability para&eter within the per)od 1999-2008, Behrens et al.!2%° '3 showed that high-percentile values of!the par˙&eter ˙re closely!˘)˝ ed to the risk of the inlet closing within five days. As the percentile of the stability par˙&eter increases, the risk of inlet closure within five days increases exponent)˙˘˘/ .!*ro&!risks of roughly five percent when the parameter is at the 50th percentile to a ris of 80 percent when it is!&easured at the 99th percentile.

!

SUMMER AND FALL CLOSURES AND SELF-BREACHES!

˘) &e series of estuar/ !5 ˙ter levels, as well as tˆe key!*orcing factors (waves, ti(es, and riverine discharge), are shown in Figure 1 for the entire &˙˝˙ 1e&ent period. The lagoon water level time series (Figure 1a) su&&arizes the closure events at the beginning of the &˙˝˙gement period, as well as the subsequent tidal conditions and later closure events in fall. As shown in Figure 1d, discharge was low for &ost of the &˙˝ agement period, dropping below 100 ft'/s at the onset of June and not!rising ba s)1˝)*)cantly! °°!* t'/s until September, with the exception of!˙ short rise in response to a late June rainfall. Flows as low as 85 ft'/s during the closure in m)(8June allowed

!

the lagoon sta1e to rem˙in stead/ !at approxim˙tely 5 *t NGVD *or over a week˛!;mmediately! *ollowing this steady period, a late-season rainstorm brief˘/ increased flows into the lagoon to &ore than 20°!*t'/s, causing the lagoon stage to approach 8 ft NGA7!˙˝ d eventuall/ sel*-breach. As in prior years, wave e˝ergy!)n the subsequent months of!9uly8September was m)˝)&al (Figure 1b). The hour˘/ s)1˝)*)cant wave height only! onsistently surpassed 8 ft in late Septem4er, a! ˘) ely!cause of the last closure event o* the &anageme˝t period. !

!

The conditions leading to inlet closure were consistent with the existing conceptual &odel described in Section 4 of the Management Plan. All closure events coincided with either &oder˙tel/ !ˆ)1ˆ!5˙# es (H_s!O!F!*t) having periods greater than 10 s, or with neap oceanic tide ranges of less than approximately 5!ft. Moderate˘/ !ˆ)1ˆ!5˙# es coincided with the closure events in May, June, and October. All closure events also occurred during or shortly!˙*ter neap tidal periods. Closure e#ents that occurred in May!˙˝(!9une are e<˙&)ne(!)˝!&ore detail in Figure 2˛!

!

All closure events occurred with the inlet located adjacent to the jetty˛!;˝!%° 2, this positioni˝1! &˙/ !ˆ˙#e prevented perched conditions fro&!aris)˝1!4/ !shielding this area of the beach fro&!the wave-driven sediment deposition that c˙used closure, preventing the beach fro&!accreting to a sufficient height to allow the desired outlet channel elevations from!4e)˝1 attai˝ed. This appeared to be the case for the first closure event of the 2013 m˙˝˙1 ement season (Figure 2), which self-breached on June 3rd at a stage of!roughl/ !6.5 *t NGVD. The low point in the beach berm!that was subsequently overtopped and self8breached also persisted i&&ediately adjacent to the jetty˛! However, the same late-June rain storm!that increased lagoon stage during the subsequent closure event also coincided with several days of!long period swell w˙ves (Hs ~ 5 ft, Tp ~ 15 s) that built up the beach in this location, allowing tˆe lagoon stage to rise to almost 8 ft NGVD (Figure 2) before self-breaching in earl/ Ju˘/. Closure events that occurred later in fall (Figure 3) were breached at or below a lagoon stage of!8 ft NGV7˛!

!

CLOSURE AND SELF-BREACH DYNAMICS !

Of the three closure events that occurred within the &anagement period, the second closure event (lasting approxi&atel/ !fro&!9une 7th until July!?th) provided the best opportunit/ !*or outlet channel i&plementation. This event also indicated that water levels ˙˝(closures can be persistent)*!*lows drop below a &)˝)&u& level.

!

To better illustrate both the lagoon stage and beacˆ!&orphology during this ti&e, Figure 4 shows a sequence of photos of the inlet before and during this closure event. As was the case for all o*! the m˙nagement period, tˆe inlet was located next to the jetty. Five days prior to losure, on Ju˝e ' rd, the barrier beach sel*84reached. Since this self8breach occurred during a period of neap oceanic tides, tidal scour probably enlarged the inlet at a reduced rate, leaving it more susceptible to closure. Figure 4a depicts the inlet when it was located next to the jett/ sever˙˘!(˙/ s before closure, indicating a!5idth o*!less than roughly!?°!*t. Nearshore w˙ves having s)1˝)*)cant heights of!F8E!*t and periods of 9-12 seconds coincided with closure (Figure 2b, Figure 4b), and subsequently!raised the berm!near the jett/ !2Figure 4c). As discussed later, these waves built the berm higher next to the jetty than in pre#ious years, which allowed the closure event to persist.!

ESA PWA !

!

During the first week o*!closure, inflows (,) gure 2d) were &easured at 100 – 115 ft' /s, and the increase in stage was roughly!°¸%!M!°¸?!/d˙/ ¸!As inf˜ows dropped to 80 -! °°!* t' /s over the next several weeks, the water level increase slowed until the lagoon reached a balance between inflows and the co&4ined ˜osses fro&!4each seepage and evaporation (Figure 2a). Su&&er dams constructed during this ti&e downstream of the H˙) enda Bridge gage further reduced inflows to the estuar/ ¸!˜ˆ is &arkedl/ !slower water ˜evel increase is evidenced b/ !the lack o*!&ove&ent o*! the water line (emphasized with red dashed line) over the twelve days between Figure 4c an(! Figure 4d. Rainstor&8derived inflows and possible wave overwash fro&!June 25th!8%th caused the water level to rise at roughly!°¸?!*t/day. Fro& June 28th until the self8breach event on July!' rd.! the water level increase slowed to less than 0¸2ft/day¸!The low point of the beach (where breaching typ) ˙˜˜/ occurs) was at the jetty (Figure 4e).

!

B˝˜) e the 20 %!&˙nage&ent period, no natural outlet channels were for&ed near the jetty!)˝! 2013. However, as with 2012 and other previous years, the lowest portion of the beach was consistentl/ !˜ocated at the jett/ . This persistent low portion is probably! ˙used b/!5˙# e shelteri˝1! 4/ the jetty, which m˙/ !have reduced berm build-up at the inlet's location, leaving a low point in the beach berm!that was the site *or subsequent overtopping and self8breaching.

!

The first event (lasting from M˙/ !%rd until June 3rd) and last event (lasting fro& Septem4er 2?th! until October 15th) of the 2° '!& anagement period were ˙˜so unsuitable for implementing a˝! outlet channel. The first event self-breached before the lagoon stage reached the E ft NGVD target stage. The second event just reached the target elevation at the end of the &˙˝˙1 ement period. Then, o˝ the last d˙/ of the &anagement!period, the Water Agency!˙rti*))˙˜˜/! breached the beach to pro#ide a!p˙thway!*or migrating s˙˜&onids and to reduce w˙ter levels!)˝!˙dvance of potential *˙ll precipitation. !

!

Four &ore closures occurred after the end of the &˙˝ agement period in OctoberMDece&4er 2013 (Figure 3). These events coincided with typical late-fall energetic swell waves, and each persisted for o#er a week, since inflows remained lower than 300 ft' /s through the e˝(of!7ece&4er. In consultation with the resource agencies, the Water Agency conducted its October and Novem4er artificial breaches to the north of Haystack Rock. The intent of this alignment was to discourage the inlet from re-establishi˝1!˝ext to the jett/ . However, after the inlet closed twice north o*! Haystack Rock, the December artifi)˙˜!breach was i&p˜e&ented loser to the jett/ . This Dece&4er breach location was selected to encourage tˆ e inlet to stay open longer for &)grating sal&onids and to ensure that the breaching stayed witˆ in the Water Agency's per&itted excavation limits of! .°°°! / (' ¸!!

!

CLOSURE R;SK PROBABILITY !

The 5-day closure risk probability, a derivative of the inlet stability!parameter described above, was hindcast *or 2013 according to the method described in Behrens et al. (2013). This hi˝(ast provides an indication of the utility of the stability parameter as a prediction tool for monitoring inlet conditions and pl˙˝˝) ˝1!&˙nage&ent action. This parameter integrates wave and ocean

!

forcing conditions, as well as estuar/ !5 ater levels, to provide greater predictive skill than just waves or ocean tides on their own. The stabilit/ !parameter co&4)˝es these factors, and the corresponding five-day closure risk time series exceeded 70 percent!before each 2013 event (Figure 1e, Figure 2e, and Figure 3e). Data gaps in the Jenner gage record prevented closure risk! predictions prior to the first closure event. Otherwise, the predicted probability of closure exceeded 70% 2-5 days in advance of each closure. In previous years, a prediction threshold of! 50% was used, but there were several instances exceeding 50% in April and Jul/ of 2013 that!()(! not result in closures.

!

TOPOGRAPD;˘!˘D ANGE

The Water Agency!has conducted &ont˘˘/ surveys o* Goat Rock!State Beach that cover a region starting from!the jetty!˙nd extending approxim˙te˘/ 1,500 feet to the north. Typically, the surveys do not include bathymetr/ !5 ithin the inlet because flow conditions in the inlet prevent safe access. Also, the survey extent can!4e limited b/ !the Water Agency’s co&p˘)˙˝ce with its &arine &˙&&˙˘!)˝) (ental h˙rassment authorization,!5ˆ ich sets guidelines for the survey! rew’s approach to marine &˙&&als hauled out o˝ the beach. Water Agency survey st˙**!collected spot elevations using RTK-GPS and then assembled these elevations into a set o* contour lines at 1 ft intervals, as well as profiles along the beach berm!crest, the ocean wetted edge, and the estuary! water line. The survey elevations are reported in the NGVD29 vertical datu&˛!

!

To characterize beach berm!topographic conditions, ESA PWA assessed data fro&!the 0 ater Agency’s 2010 (July to Septem4er), 2011 (May!to October), 20 %!2May!to October), and 201'! (May to Octo4er) surveys. Survey!transects *ro& the 2012 analysis were reused (Figure 5), and include two transects b˙ ed b/ ! ˘)ff (Figure 6 and Figure 7), two transects which extend into the estuary (Figure 8 and Figure 93.!˙˝(two variations on a transect just north of the jetty!2Figure 9).

!

This review focuses on the 2013 surveys.!˙lthough the!%° 1 surveys!˙re included for context. The 2013 topographic data were similar to those of!%° %5 hen little morphologic change occurred throughout the &anage&ent season. In contrast, surveys taken in 20 °!˙˝(! %° !)ndicated that beach erosion and accretion occurred during the!&anagement period. The erosion was associated with inlet &igration and subsequent accretion of the beach was associated with long-period swell waves. During the 20 %!˙˝ (!%°'!& ˙˝˙ gement seasons, the inlet rem˙)ned at the jetty and did not &igrate north. Adjacent to the jetty groin, Transect 0 showed little!&onthly! ˆ˙˝ ge in topography.! but extensive inter-annual variability (Figure 10).

!

During the &anagement period in 2013, the beach berm!˙long Transects 1- ? showed little variability.! ˆ ˙˝1)˝1! 4/ less than one!*oot. This was particularly true during the &onths of May!M September at Transects 1-2!(Figures 8-9) and Transect 4 (Figure 6). At each of these profiles, the change in beach profile fro&!- eptember to October was greater than for the rest of!the &˙nage&ent season. The only!transect to experience more than one foot of! hange in elevation was Transect ' (Figure 7), whose crest ˙ggraded b/ ! ˛5 feet between the May!' °th!˙˝(!9 u˝e 13th! surveys. The ()**erence in monthly variability!˙t each transect between 2013 and prior years can ˘) ely be tied to the dif*erence in the extent of!)˝let migration. As an example, in 2011, the inlet

&)grated north of!D˙/ stack Rock durin1!the w)nter, and returned to the jetty in late spring or earl/ !su&&er˛ This &)gration resulted in a lower!4each profile at all transects. Then, over the course of the manage&ent period, the 4each gradually built up to!˙ !typical summer profile. In contrast, the inlet never m)grated north o*!D˙/ stack Rock!)˝!%°' , e#en durin1!peak!5 inter a˝(! spring flows. As i˝!%012, this left the beach ber&!largel/ !intact north o*!D˙ystack Rock!˙˝ (!˙! lower terrace 4etween Haystack Rock!˙nd the jetty!1roin. Since these northern transects started at ˙!&u ˆ!ˆ igher elevation at the start o*the &˙˝ age&ent period, the vertical growth o*the beach profiles at these locations were several *eet less than during 20 !) n the same locations.

!

Transect 0, which is located just nortˆ of and parallel to the jetty, was slightly lower than the other transects &easured during the 2° '! &˙˝˙1 e&e˝t period. Its crest was &easured at roughl/ ! 15 ft N@VD both at tˆe be1)˝˝)˝ 1 and end of the management period, co&pared with crest elevations of!15-17 ft NGVD &easured at the other transects. Figure 10 shows that this location is typically stable throughout the management period but varies from!/ear to year, likely!as a result of inlet m)gration, flood erosion, a˝(berm buildi˝1!4/ !winter waves. Compared with prior years, the berm at this location is lower than in %° , but!ˆ)1ˆer tha˝!)˝!%°°!˙ ˝(! %° %˛As we!ˆ˙ve noted during previous reports, the lack of!&˙˝˙1 e&ent period varia4)lity o*this region suggests that the jetty shelters this portion of the be˙ ˆ!* ro&!small to moderate waves that occur during the &˙nage&ent period. On˘/ the larger waves associated 5 ith winter stor&s!&˙/!4 e sufficient to re-shape the beach ber&!˝ear the jett/ ˛!!

!

Beach ber&!crest profiles were collected b/ !the Water Agency!*or the first ti&e)˝!%013. These data &˙ e it possible to discern important changes in beach shape along the length of the berm *ro& the northern beach access point to the jetty. Along-beach trends in crest elevation generally! indicate along-beach trends in wave energy!˙nd the influence of inlet &igration and breaching.

!

Figure 11 shows that the same!&)˝)&al change in crest elevation was apparent throughout the length of the beach north o*!Transect 1. Although the crest elevation changed by as &uch as 2 ft in so&e!˙reas, there was a distinct pattern in the along&shore crest height that rem˙ined roughly the same throughout the management period. The beach crest was lowest south of Transect 1, where the inlet resided. At Transects 1!˙˝(! % a set o*!ridges rem˙)˝ed in p˘ace with peak! elevations at 17-18 ft NGVD, wh)˘e the crest was generall/ lower (14-17 ft NGVD) an(!ˆ ˙d less of a consistent shape north of!Transect 2. Wave runup genera˘˘/ has less influence for higher beach profiles, since it beco&es less likel/ !that a given wave wi˘˘!overtop the crest. The higher variability north of Transect 2 is probably a reflection of the fact that the beach was lower in this area, and was!&ore suscept)ble to change fro&!the li&ited su&&er an(!*˙˘˘!5˙# es.

!

Changes to the beach shape were much larger after the end of the 2013 management period, as shown in Figure 12. This is probably!attributable to greater wave energy!and relocation of the inlet. W˙ve energy!increased dr˙&atically!)˝!+ovem4er a˝(!7 ecember, both!)˝!ˆeight and period. Although changes to the crest height were still &inor during these months, by January! F[th]!% ?.! the crest had been built as high as 19-20 ft NGVD north of Transect 4. At Transects 1 and 2, the crest ridges shifted in the along-beach direction, but the peak heights rem˙)˝ed similar to August.

!

Manual breaching of the inlet north of!D˙/ stack Rock on October allowed the inlet to carve a! 400-500 wide swath within the beach, centered roughl/ !at Transect '˛ The inlet then closed again and later breached at the jett/ ˛!6/ !7 ecember 1%th, waves had rebuilt the crest to a height of 10- %! *eet within the swath. By January! .!%° 4, this se1&ent of the be˙ h that the inlet had occupie(!)˝! October and Novem4er was indistinguishable fro&!tˆ e rest of!the 4each crest prof)˜e˛!!

!

BEACH WI7 ˜D !

To provide additional information about the beach morphology. ESA PWA assessed the beach width us)˝1!tˆ e W˙ter A1ency survey data. Figure 13 shows the evolution of the be˙ ˆ!5 idth at Transect 3 during both the 2012!˙˝(!%° '! &˙ ˝˙1 e&e˝ t periods. Dur)˝1!5 inter &onths, the beach was often ero(ed at Transect 3 to the point that the be˙ ˆ crest was below 12 ft NGVD, so that the width was effectivel/ !zero. Apart fro&!this seasonal erosion, there was no &˙ rked trend in the beach width. In 2013, the width at 12 ft NGVD varied between 80 ˙˝(! %° !*t, and was generally! less than 65 ft wide at the 14 ft NGVD contour˛!˜ˆ is was s&aller than in 2012, when it varied *ro& 110-150 ft NGVD at the 12 ft contour and was less than 110 ft at the! ?!*t contour. This interannual di**erence &˙/! be attributable to di**erences in fall&spring wave energy (and thus beach building), or possibl/ !to differences in inlet position.!

!

!

LESSONS LEARNED AND RECOMMENDATIONS

Based o˝!%°13 observations of the estuar/ .!asso)ated physical processes, and the Water Agency's planning for outlet channel &˙˝˙ gement, we note the following lessons about)&ple&enting the outlet cˆ˙nnel m˙nagement plan.!

!

CONCEPTBAL MODEL!

- The beach north of the inlet saw little change fro&!the 16-18 ft NGVD elevations! established in 2°12. Near the jett/ , the ber&!5 as lowered b/ !inlet &igration while! undergoi˝1!4each building.
- The inf˜uence of inlet breaching or migration north o*!the jetty! an lead to erosion of!˙! wide swath of beach, several times larger than the width of the channel. An erosion swath of 400-500!5as observed following the Agency breach on October 15th˛!
- -)&)lar to the winter of!%° 8 %. the inlet never m)grated north of!D˙/ stack Rock duri˝1! winter 2012- '.!˙ nd retur˝ed to the jetty in early spring, much earlier than in most years. This inlet align&ent is not co&&on, but has been observed in past years (Behrens et al., 2009).!!
- Peak annual river discharge has rem˙ined below 40,°°°!*t'/s for 8 consecutive years, a streak un&˙tched in the 70-year *low record. This may have a connection to the recent ˘˙ of inlet migration to the north.!
- The beach width in 2013 at Transect 3 (near Haystack!Rock) was smaller than in 201%˛! The interannual decline was larger than changes to beach width at this location within the %°'! &˙˝˙1 ement season alone. This &˙/ suggest that beach width is &ore closely!tied to seasonal changes in inlet behavior and offshore waves than to shorter-term! ˆ anges.

!

OUTLET CHANNEL FEASIBILITY

- The jetty!&˙y shelter the inlet, &˙ ing closure less likely and also limiting berm!1rowth, which then &˙intains a low point for self8breaching. When the inlet is!)˝!˙!*ully or &uted tidal conditio˝, options for management become! onsiderably!&ore difficult to)&pleme˝t.
- Late June closure included a 1°8(˙/ !period when lagoon water levels were nearl/ ! constant at approxi&˙tel/ 5 ft NGA7!4ecause low *lows &easured at Hacienda Bridge (80-10°!*t'/s) a˝(! onstruction of summer dams reduced flows into the estuary to the point that the/ !were balanced b/ seepage. An unusual earl/ su&&er rain then boosted discharge to more than 20°!*t'/s, causing self8breach ˙t approxi&˙te˘/ 8 ft N@A7˛!!
- Once lagoon water levels reach the low point of!the beach crest elevation, the lagoon self8 breached. This behavior highlights the susceptibility!o*!a sand bed outlet channel to scour, li&iting convey˙nce capacit/˛!
- Post-&anagement period, the Water Agency!4reached the inlet north o*!D˙ystack Rock˛! This align&ent was not continued because repeated closure threatened Chinook!&igration and the enlarged beach berm restricted breaching to within the permitted excavation volume.

- Over the first three years of e**ort to imple&ent the outlet cˆannel a(aptive m˙nagement plan, only one closure (July!%° °3.!ˆ˙s been suited for outlet cˆ˙˝ nel m˙nagement action. !

!

COMMUN;CATIONSAND PROTOCOLS!

- Since full set of per&its 5 as not in effect, the Water Agency!5˙ s required to seek! authorization for each breaching event, which occasionally caused delayed operations.
- Although the perched lagoon episodes d)d not e#olve to the point tˆat management a tion was warranted, the W˙ter Agency began p˘˙˝˝) ˝1!&anagement actions as soon as the episodes occurred. Plannin1!)ncluded heightened observations of inlet conditions!4/! 0 ˙ter A1ency staff, email updates to infor&!the resource m˙nagement group, a˝d pre8)&ple&entation &eetings at the project site to refine plans for &˙˝ agement!actio˝˛!!

! !

MONITOR;+@!

- The W˙ter Agency:s &onthly!survey methods were modif)ed to collect specif)ed profiles, such as the beach ber&!ridge line, wetted edge (beach side3.!˙˝d water edge (estuar/ ! side).

!

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Behrens, Dane K., Fabián A. Bo&4˙rdelli, John C˛!Largier, and Elinor Twohy. 2013. "Episodic Closure of the Tidal Inlet at the Mouth o*!the Russian River — A Small Bar-Built Estuary!)˝!˘˙˘)* ornia." *Geomorphology*!189 (May3: 66–80˛! doi:10˛° 16/j˛geomorph.20 '˛° ˛° E˛!!

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ESA PWA. 2012. Feasibility of alternatives to the Goat Rock State Beach jetty for managing lagoon water surf˘ce elevations: Draft existing condit)ons report. Su4&itted to Sono&˙! County!0 ˙ter A1ency˛!

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National Marine Fisheries Service (NMFS). 2008. Biological Opinion for W˙ter Supply, Flood Control Operations, and Channel Maintenance!conducted by the U.S. Arm/ Corps of! Engineers, the Sonom˙ County!0 ˙ter Agenc/ .!˙nd the Mendocino ˘ ounty!Russian River Flood Co˝tro˘!˙˝(!0 ater Conservation I&prove&ent District in the Russian River watershed.!

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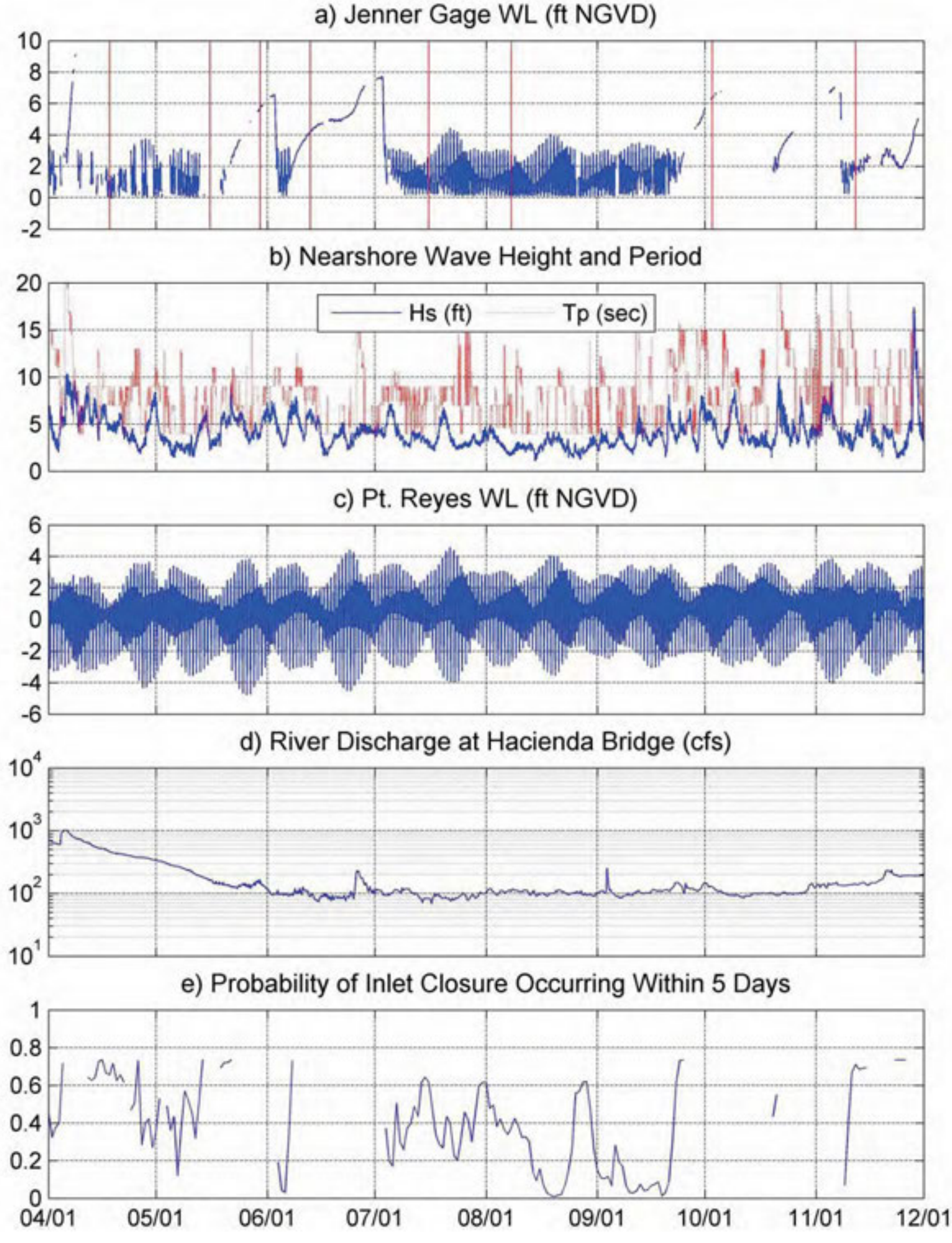
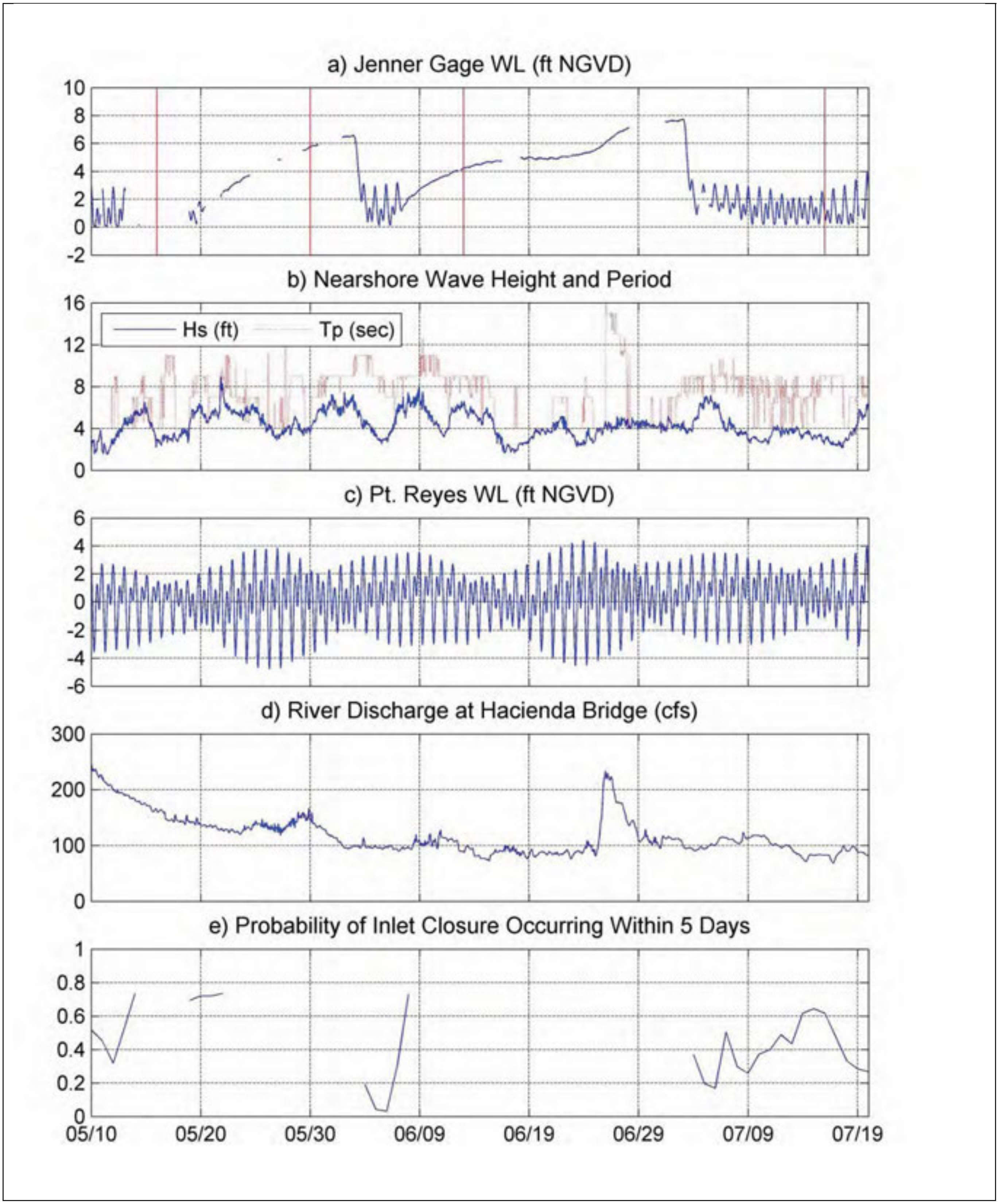


SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

Figure 1
Estuary, Ocean, and River Conditions Compared with Closure Probability: April – November 2013

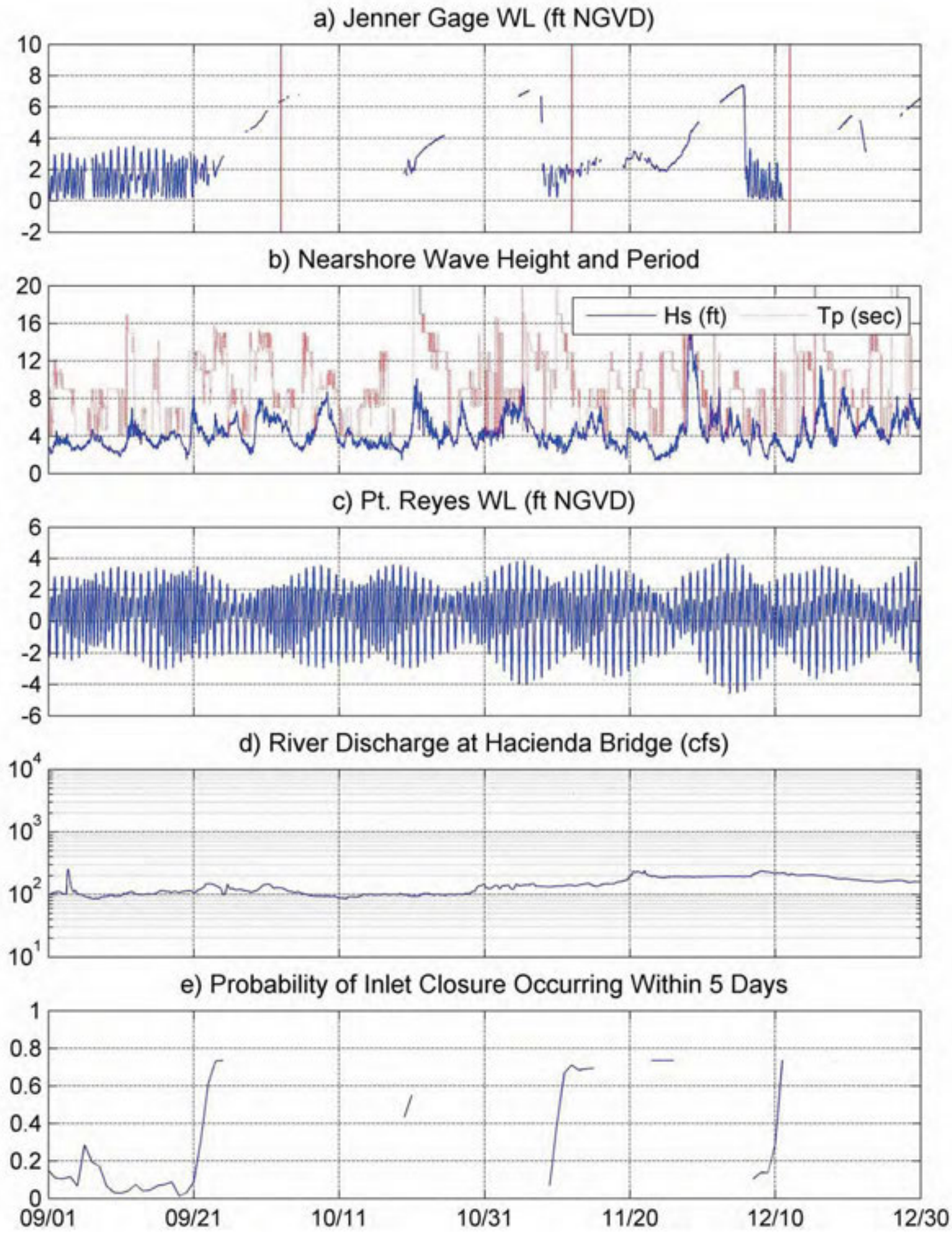


SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

Figure 2

Estuary, Ocean, and River Conditions Compared with Closure Probability: May – July 2013

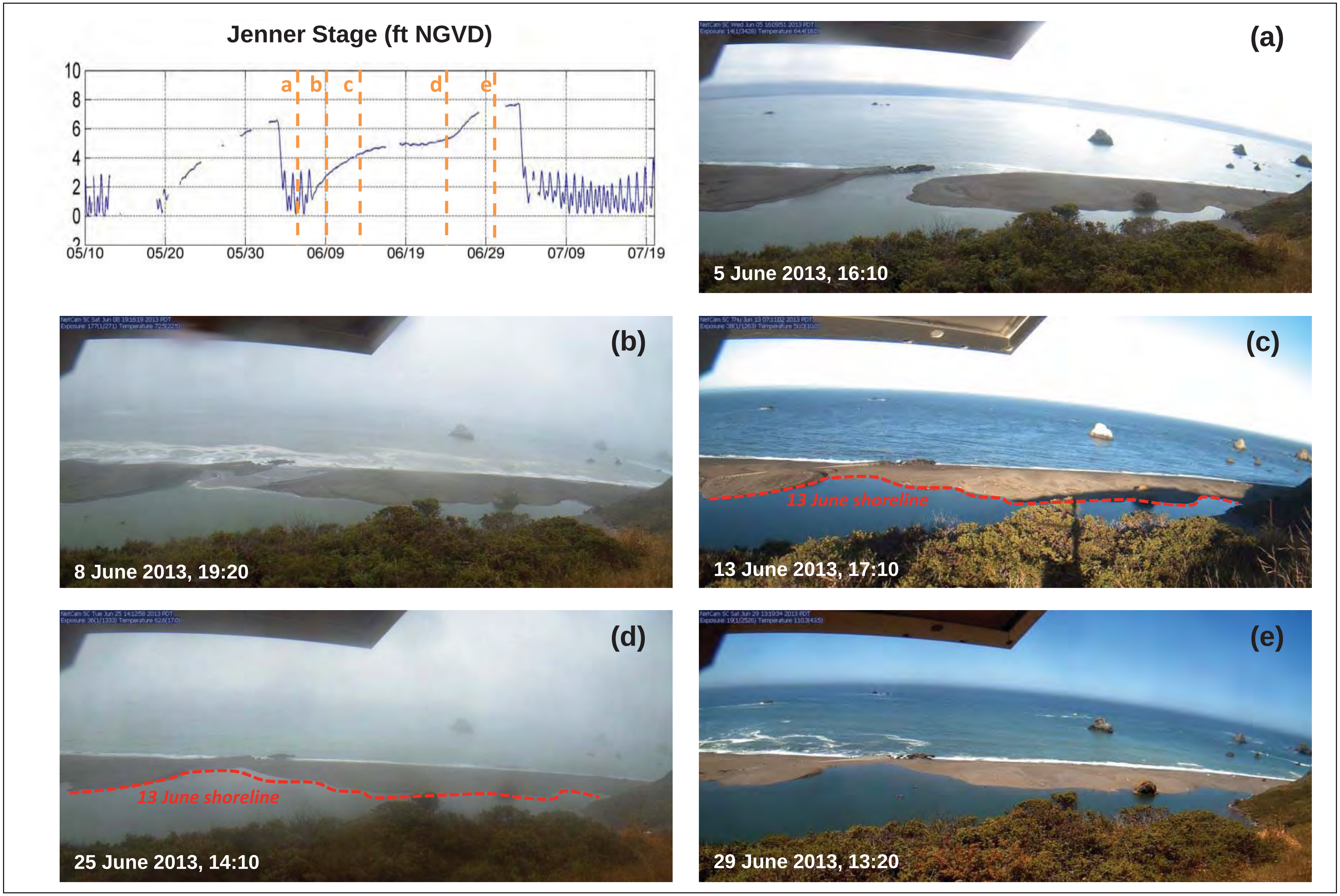


SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

Figure 3

Estuary, Ocean, and River Conditions Compared with Closure Probability: September – December 2013



SOURCE: Russian River stationary observation camera (BML)

Russian River Estuary Outlet Channel Management Plan . DW01958

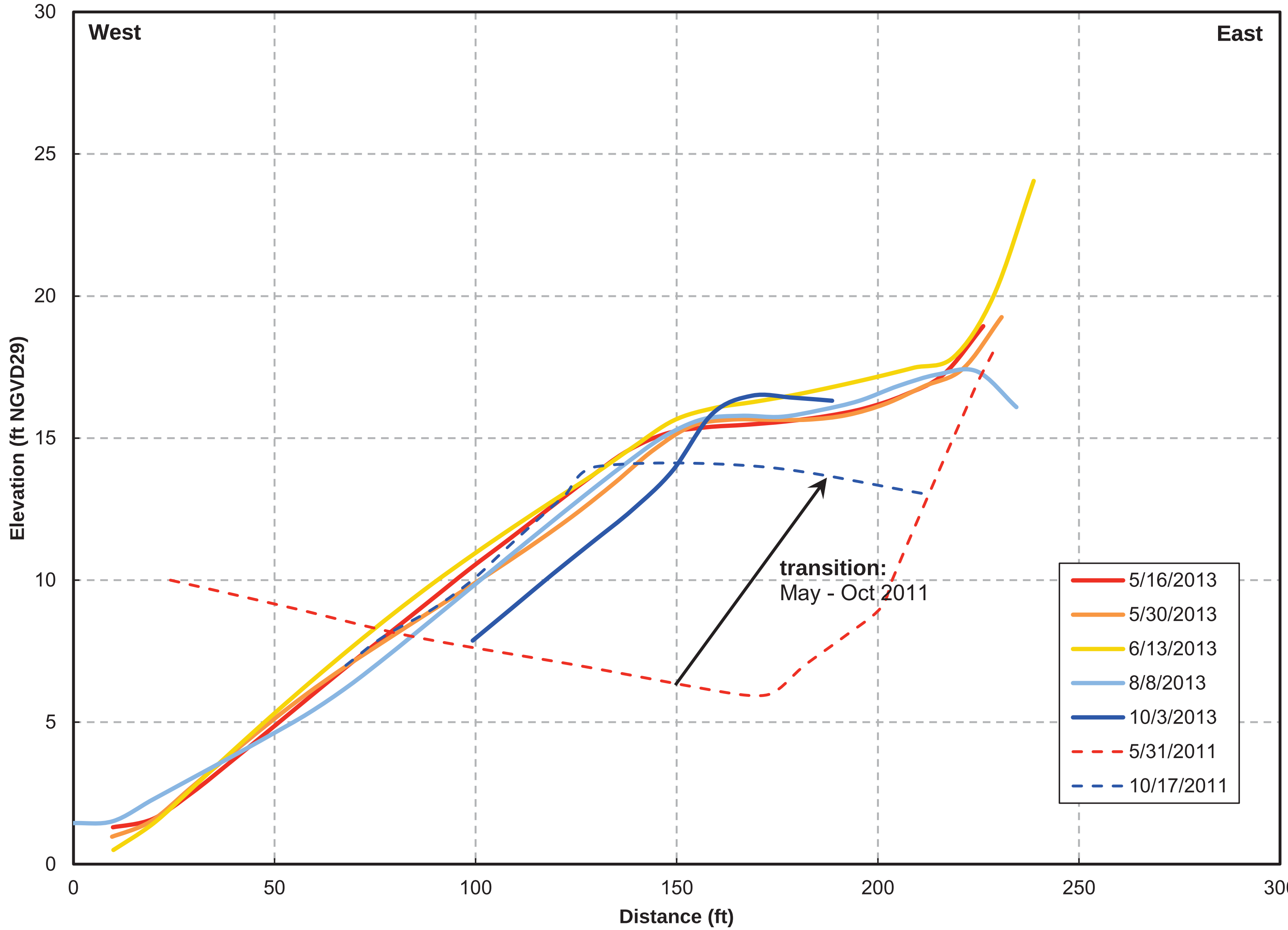
Figure 4
Inlet Closure Event in June-July 2013

SOURCE: image from USDA NAIP

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 5

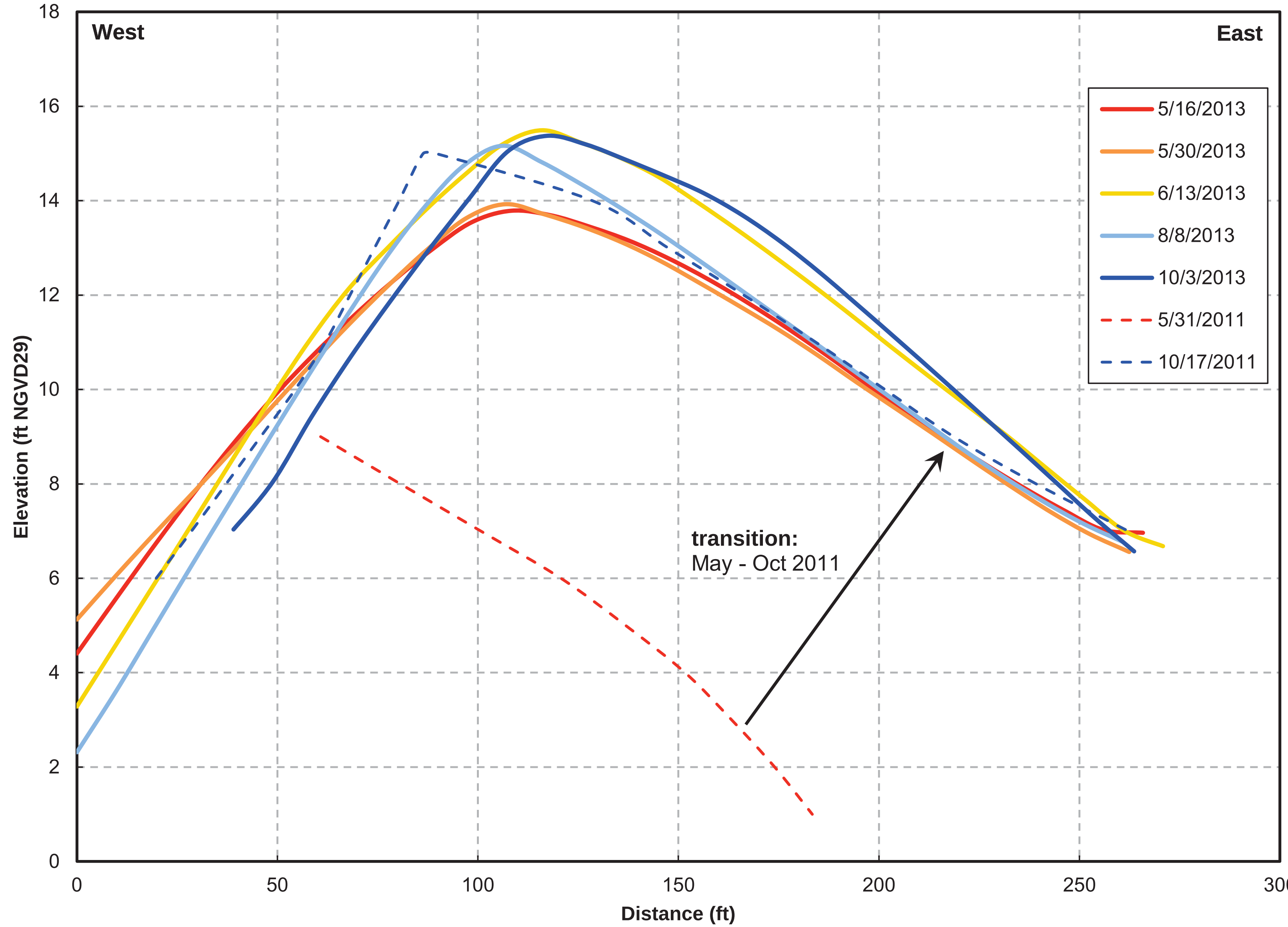
Beach Transect Locations



SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

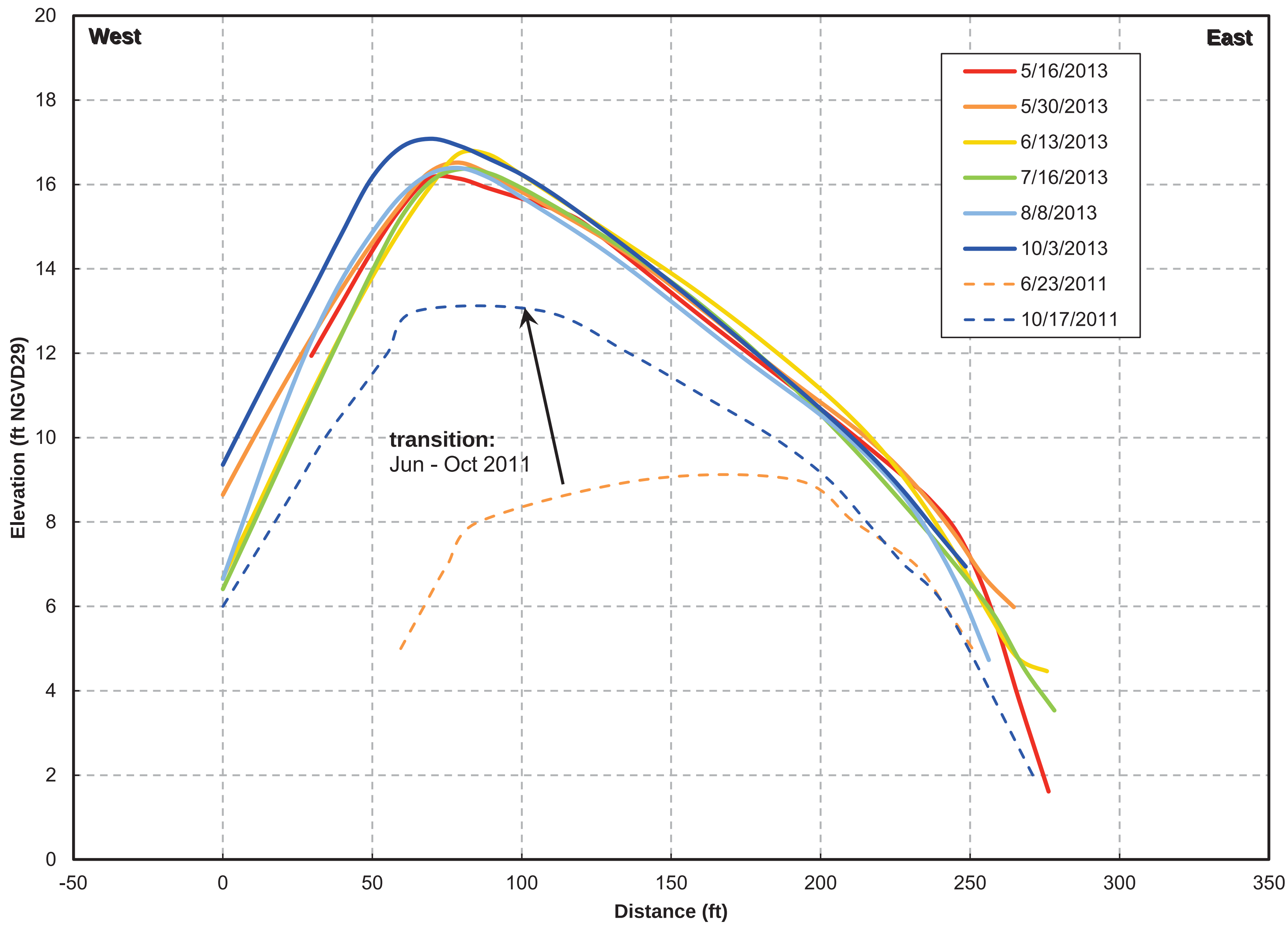
Figure 6
Beach Transect #4



SOURCE: Russian River stationary observation camera (BML)

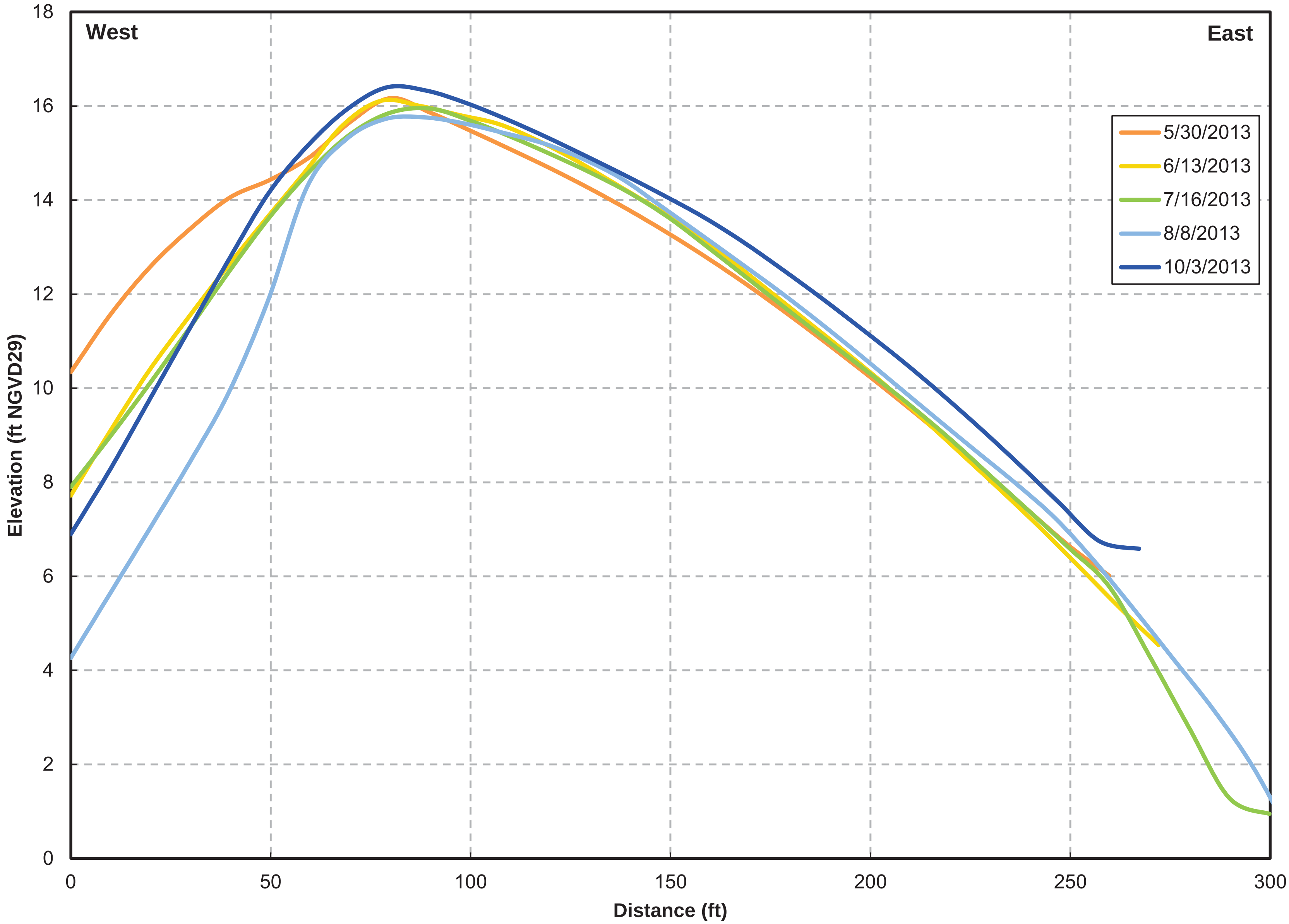
Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 7
Beach Transect #3



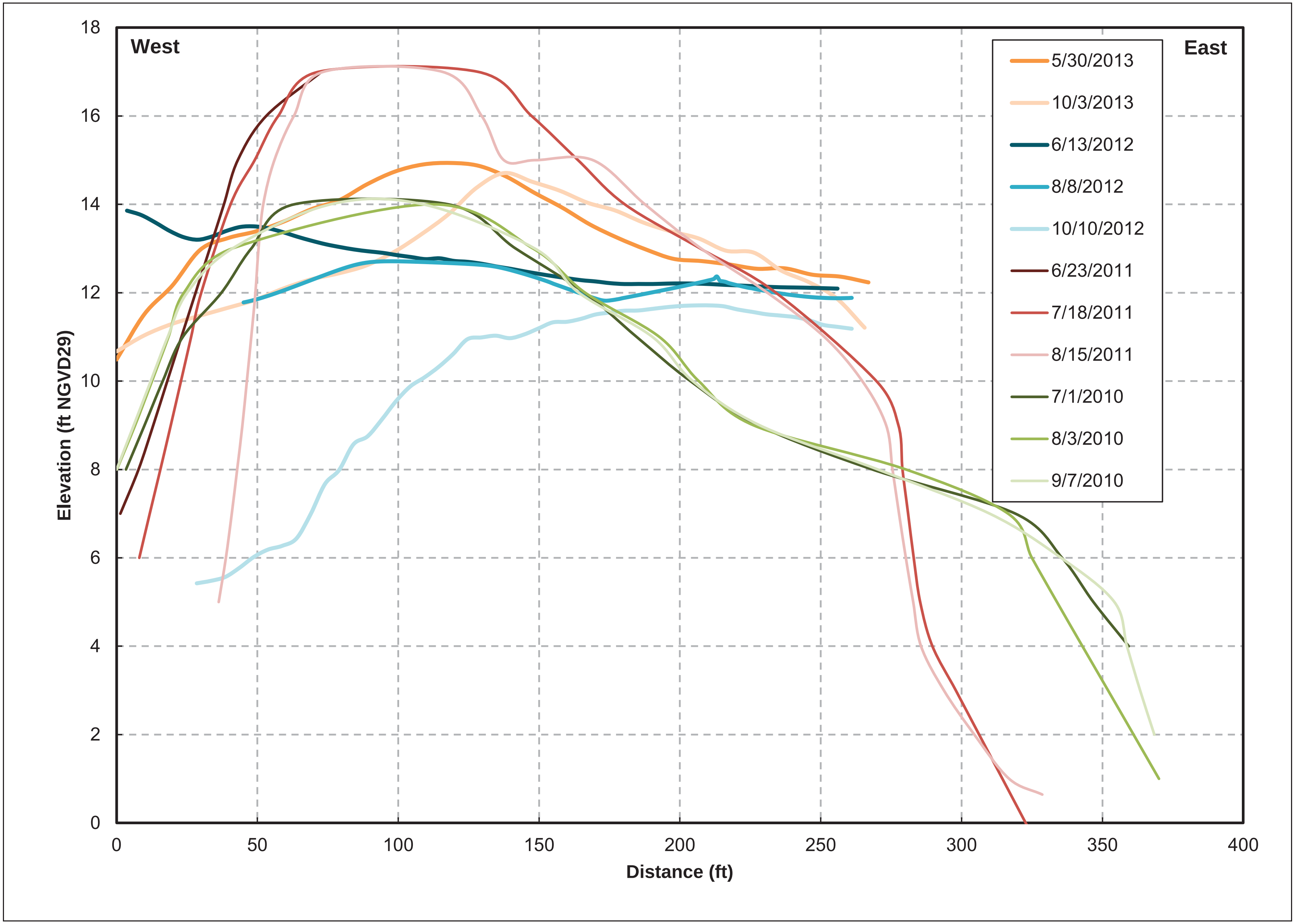
SOURCE: Russian River stationary observation camera (BML)

Figure 8
Beach Transect #2



SOURCE: Russian River stationary observation camera (BML)

Figure 9
Beach Transect #1

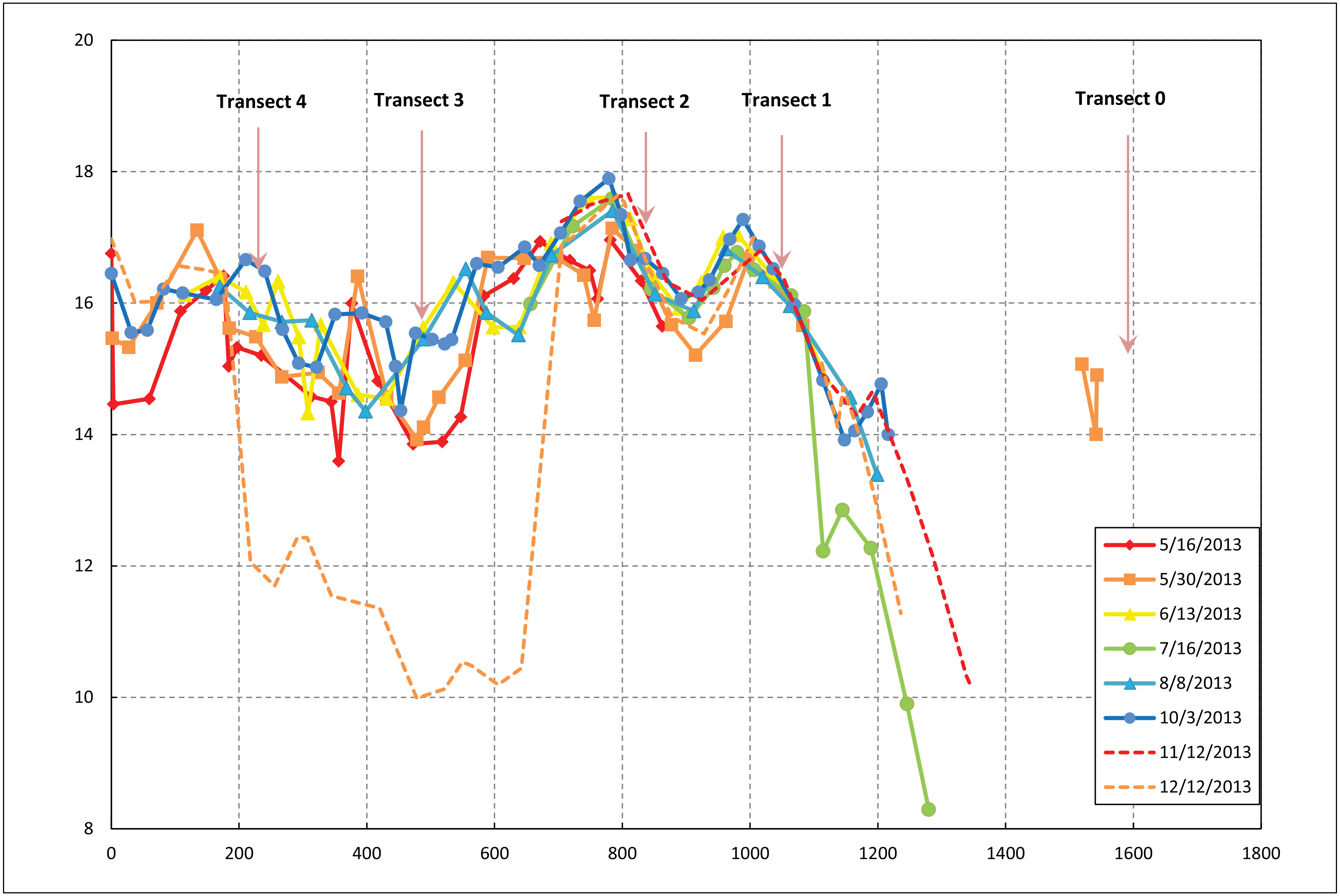


SOURCE: Russian River stationary observation camera (BML)

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 10

Beach Transect #0

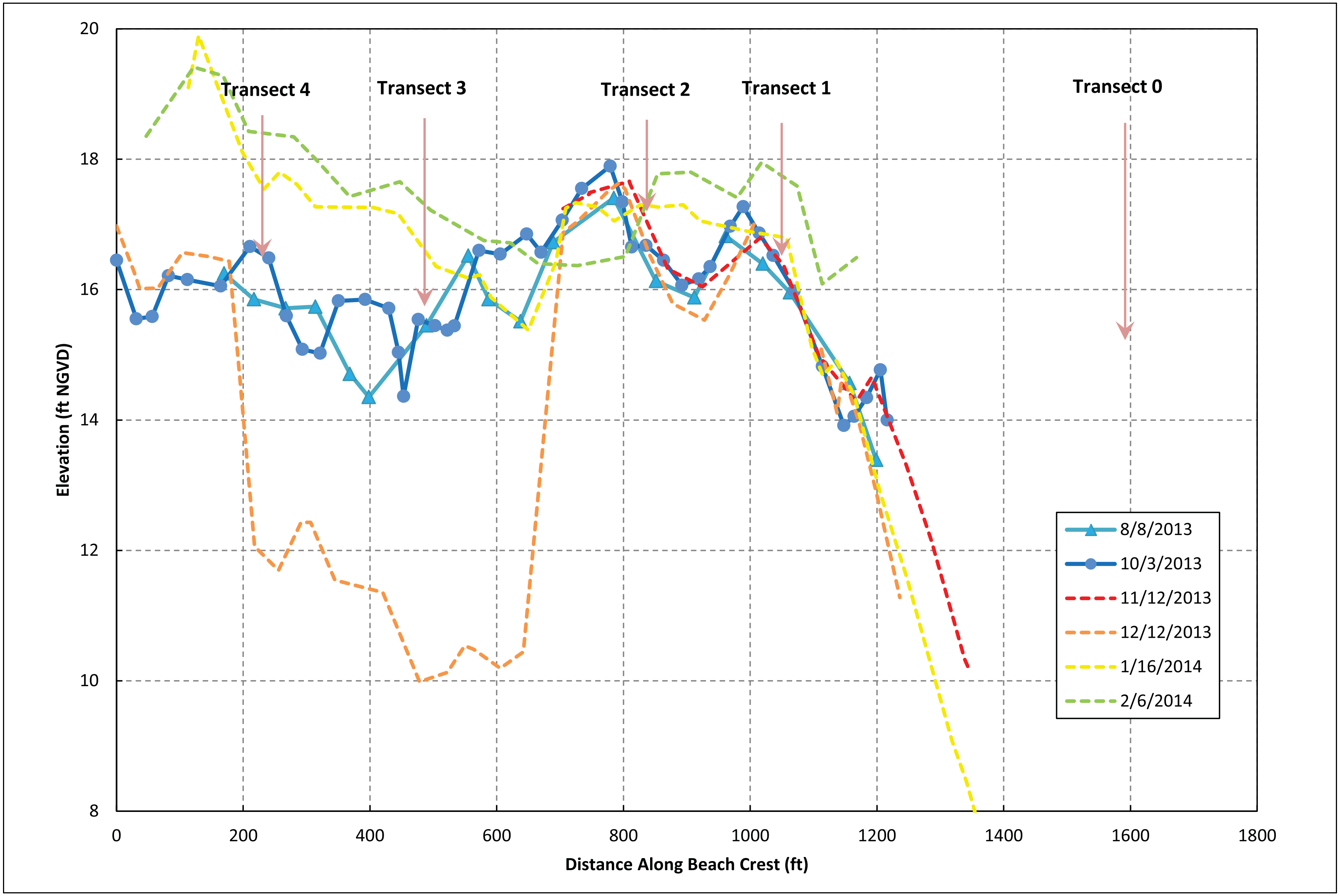


SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 11

Beach Crest Profiles During the 2013 Management Period.

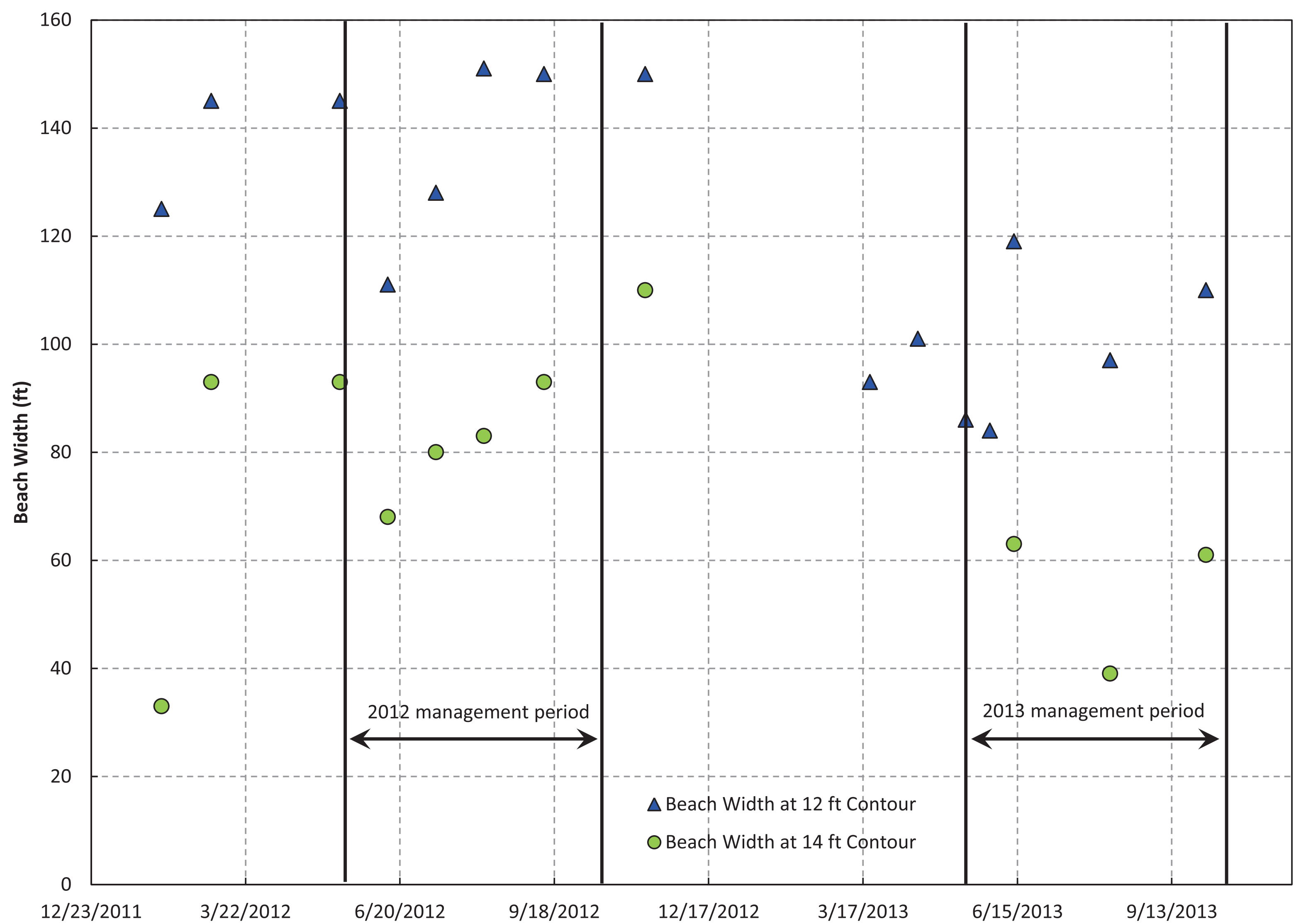


SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 12

Beach Crest Profiles From August 2013 to February 2014.



SOURCE: SCWA survey data

Figure 13
Beach Width During 2012 and 2013 Management Periods.

Attachment I. Physical Processes During the 2014 Management Period

As required by the Russian River Biological Opinion, the Sonoma County Water Agency (Water Agency) has been tasked with managing the Russian River Estuary to facilitate summer lagoon conditions to improve salmonid habitat. The goal is to meet this need by creating an outlet channel while also maintaining the current level of flood protection for properties adjacent to the estuary (NMFS, 2008). The adaptive management plan, described in the main body of this report, was developed by the Water Agency with assistance from ESA PWA and the resource agency management team in 2009 and revised annually from 2010 to 2015. Because of permit constraints, the Water Agency was only able to implement the plan beginning in 2010. The revised plan was in effect for 2014, but no opportunities for management action occurred during the management period.

During the 2014 management period, May 15th to October 15th, Water Agency staff regularly monitored current and forecasted estuary water levels, inlet state, river discharge, tides, and wave conditions to anticipate changes to the inlet's state. Although several short-lived closure events occurred throughout late April and early May, the first four months of the management period experienced only tidal conditions. An extended closure event began on September 17th. Because of reduced inflows, the lagoon's stage rose slowly and did not reach an appropriate level for enacting the outlet channel until the end of the management period. Except for a few days immediately after artificial breaches, the lagoon remained closed from late September through late November.

Even though no management actions were implemented to inform the adaptive management process, the physical conditions and inlet response during the management period are reviewed in this attachment to contribute to site understanding and to inform future management actions.

METHODOLOGY

This review of the 2014 outlet channel management period examines water levels, ocean wave conditions, ocean water levels, riverine discharge, and beach topography, as well as inlet size and location. The sources for these parameters are listed in Table 1. These data were supplemented with personal observations and discussion with staff from the Water Agency, NMFS, CDFW, and the Bodega Marine Laboratory.

Table 1. Data Sources

Parameter	Source
Estuary water level (h_E)	Water Agency Jenner gage*
Wave height (H_s), period (T_a), and direction	CDIP Point Reyes buoy #029
Ocean water level (h_O)	NOAA Point Reyes #9415020
Russian River discharge (Q_f)	USGS Guerneville #11467000
Beach topography, ft NGVD	Water Agency monthly surveys
Inlet size and location	Water Agency and Bodega Marine Laboratory autonomous cameras

*Data transmission failure due to cellular network issues occurred for several periods throughout the management period.

INLET STABILITY PARAMETER AND CLOSURE RISK PROBABILITY

In addition to considering individual parameters, researchers at the Bodega Marine Laboratory have developed a combined parameter to evaluate the stability of the inlet's state, with the aim of predicting closure risk (Behrens et al., 2013). (Note that the inlet stability parameter does not differentiate between full closure and the perched conditions with a small outlet channel. When discussing this parameter, both states are referred to as a 'closure' in that tides are prevented from propagating into the estuary.) The inlet stability parameter presented by Behrens et al. (2013) quantifies the risk of inlet closure based on a sediment balance in the inlet. It considers the daily balance between wave-driven sediment import to the inlet and sediment export driven by tidal fluctuations. The wave-driven import is assessed using nearshore wave estimates derived from a transformation matrix and offshore buoy data (ESA PWA, 2012) and the latter is estimated from tide gage data within the estuary and a stage-storage relation derived from the available bathymetry. Using daily-average values of the stability parameter within the period 1999-2008, Behrens et al. (2013) showed that high-percentile values of the parameter are closely linked to the risk of the inlet closing within five days. As the percentile of the stability parameter increases, the risk of inlet closure within five days increases exponentially, from risks of roughly five percent when the parameter is at the 50th percentile to a risk of 80 percent when it is measured at the 99th percentile.

SUMMER AND FALL CONDITIONS

Time series of estuary water levels, as well as the key forcing factors (waves, tides, and riverine discharge), are shown in Figure 1 for the entire management period. The lagoon water level time series (Figure 1a) summarizes the closure events at the beginning of the management period, as well as the subsequent tidal conditions and later closure events in fall. As shown in Figure 1d, discharge was low for most of the management period, dropping from 7,000 ft^3/s on April 2nd to below 100 ft^3/s on May 21st. In mid-July, flows briefly reached 200 ft^3/s and remained above 100 ft^3/s for about a week. Afterwards, flows slowly declined until they reached a minimum of 55 ft^3/s on October 7th. As in prior years, wave energy was minimal in much of the management period. A late season swell event ($H_s > 8$ ft, $T_p > 14$s) occurred in late June, and may have led to the subsequent week of muted tides in the lagoon, but did not lead to full inlet closure. A gap in Pt Reyes wave buoy data for the dominant period (T_p) for parts of September and October prevented nearshore transformation of waves during this time. At the end of the management season, high wave events overtopped the beach berm, delivering enough water to the lagoon to increase the daily rises in lagoon stage to 0.4-0.8 ft during the late-season closure event. Overtopping is visible in photographs taken by the river mouth overlook camera. These large waves also prevented breaching equipment from accessing the beach.

The conditions leading to inlet closure were consistent with the existing conceptual model described in Section 4 of the Management Plan. All closure events coincided with either moderately high waves ($H_s > 6$ ft) having periods greater than 10 s, or with neap oceanic tide ranges of less than approximately 5 ft, with the exception of the September closure event, when nearshore waves could not be estimated. Moderately high waves coincided with the closure events in April and May. The September closure event occurred during a neap tide. The artificial breach events that occurred on October 22nd and November 17th were coincident with neap tides and large to moderate waves, and were followed by closure within less than one day. The artificial breach event on November 26th happened during a spring tide, and was not followed by closure. The persistent closure conditions from September through November are examined in more detail in Figure 2.

As in 2012 and 2013, all closure events occurred when the inlet was adjacent to the jetty. In former years, this positioning may have prevented perched conditions from arising by shielding this area of the beach from the wave-driven sediment deposition that caused closure, preventing the beach from accreting to a sufficient height to allow the desired outlet channel elevations from being attained. This may have been the case for the September closure event in 2014 as well. Wave overwash in mid-October did appear to provide enough volume to raise the lagoon stage to a level requiring artificial breaching, but the same wave overwash also made work on the beach impossible, and occurred too late in the management season for a channel to be created.

LATE-SEASON CLOSURE EVENT

The only event that would have provided an opportunity for implementing the outlet channel occurred on September 17th. Inflows generally were below 100 ft^3/s throughout the event, allowing the stage to remain lower than 7 ft NGVD for almost a month of closure. The largest increases in stage happened on September 25th and October 12th due to wave overwash. The overwash raised the stage by about three quarters of a foot. Otherwise the weak inflows allowed the stage to rise at a very slow pace; the stage increased from roughly 5.0 ft NGVD on September 26th to approximately 6.8 ft NGVD on October 11th, and average increase of about 0.1 feet per day. Flows during this time were less than 85 ft^3/s and dipped to as low as 55 ft^3/s.

To better illustrate both the lagoon stage and beach morphology during this time, Figure 3 shows a sequence of photos of the inlet before and during this closure event. As was the case for all of the management period, the inlet was located next to the jetty. Figure 3a depicts the inlet when it was located next to the jetty several days before closure, indicating a width of less than roughly

40 ft. Nearshore waves could not be estimated for the week of closure, but are likely to have played a role, since waves generally begin to increase in energy in September. Neap tide conditions were present during the week of closure, with the oceanic tide range measured at approximately 4 feet (Figure 2c). Figure 3d shows extensive wave overwash surging over the beach berm and into the lagoon.

Unlike the 2012 management period, no natural outlet channels were formed near the jetty in 2014. However, as with 2012 and other previous years, the lowest portion of the beach was consistently located at the jetty. This persistent low portion is probably caused by wave sheltering by the jetty, which may have reduced berm build-up at the inlet's location, leaving a low point in the beach berm that was the site for subsequent overtopping and natural breaching.

CLOSURE RISK PROBABILITY

The 5-day closure risk probability, a derivative of the inlet stability parameter described above, was hindcast for 2014 according to the method described in Behrens et al. (2013). This hindcast provides an indication of the utility of the stability parameter as a prediction tool for monitoring inlet conditions and planning management action. This parameter integrates wave and ocean forcing conditions, as well as estuary water levels, to provide greater predictive skill than just waves or ocean tides on their own. The stability parameter combines these factors, and the corresponding five-day closure risk time series exceeded 50 percent before most 2014 events (Figure 1e). The gap in nearshore wave estimates in September was filled with offshore wave heights and periods, which are a poorer estimate of nearshore conditions. Since at least one day of tidal conditions are needed to predict closure, many of the closure events could not be predicted, since they occurred less than one day after breaching. Otherwise, the predicted probability of closure exceeded 50% 2-5 days in advance of most other closures.

TOPOGRAPHIC CHANGE

The Water Agency has conducted monthly surveys of Goat Rock State Beach that cover a region starting from the jetty and extending approximately 1,500 feet to the north. Typically, the surveys do not include bathymetry within the inlet because flow conditions in the inlet prevent safe access. Also, the survey extent can be limited by the Water Agency's compliance with its marine mammal incidental harassment authorization, which sets guidelines for the survey crew's approach to marine mammals hauled out on the beach. Water Agency survey staff collected spot elevations using RTK-GPS and then assembled these elevations into a set of contour lines at 1 ft intervals, as well as profiles along the beach berm crest, the ocean wetted edge, and the estuary water line. The survey elevations are reported in the NGVD29 vertical datum.

To characterize beach berm topographic conditions, ESA PWA assessed data from the Water Agency's 2010 (July to September), 2011 (May to October), 2012 (May to October), 2013 (May to October), and 2014 (May to October) surveys. Profiles include two transects backed by cliff (Figure 5 and Figure 6), two transects which extend into the estuary (Figure 7 and Figure 8), and two variations on a transect just north of the jetty (Figure 9 and Figure 10).

This review focuses on the 2014 surveys, although the 2011 surveys are included for context in some figures. The 2014 topographic data were similar to those of 2012 and 2013 in that the northernmost profiles underwent little morphologic change during the management season. However, in 2014 the southernmost profiles underwent more morphologic change than in those years, similar to the results from the 2010 and 2011 management seasons.

At profiles 3 and 4, the beach is backed by cliff, and undergoes morphologic changes when the inlet migrates north during floods and returns south to the jetty in spring or summer. In 2010 and 2011, migration in this area led to a sequence of erosion and accretion at these sites during the management period. The erosion seen in those years was associated with inlet migration and subsequent accretion of the beach was associated with long-period swell waves. During the 2012-2014 management seasons, the inlet remained at the jetty and did not migrate north, leading to an especially stable profile at Profile 4 (Figure 5). Profile 3 was also stable, but steepening in October led to changes in elevation on the order of 1-2 feet at the crest and along the beach face (Figure 6).

Compared with 2012 and 2013, Profiles 1 and 2 were much more variable. At Transect 2 (nearest to Haystack Rock), the beach profile was stable from May through August, and then grew vertically and moved landward in September (Figure 7). The largest change was between the September and October surveys, when the crest grew by roughly 2 feet. This type of seasonal growth is apparent in previous years, and is expected as wave energy increases seasonally. While Transect 1 underwent similar changes, it was more strongly influenced by proximity to the inlet throughout the summer. It was lowest in July and August, when the inlet was fully tidal. It extended seaward along the beach face from August to September and added an additional 1-2 feet vertically throughout the entire profile between September and October, reflecting the closure event.

Transect 0, which is located parallel to the jetty, was slightly higher than transect 1 in 2014, and showed a large shift in morphology at the end of summer (Figure 9). In previous years, it was more typical to see limited change throughout the management season at this transect, but large interannual variability (Figure 10). In 2014, it was mostly stable until August, and then grew seaward by over 50 feet between August and September. Its crest remained at roughly 14.5-15.0 ft NGVD despite this shift. This seaward growth is likely related to an abundance of northwesterly swell (Figure 2) that arrived during this month. Further growth between September and October was probably made possible by the combined waves and extended closure event.

Beach berm crest profiles were collected by the Water Agency for the first time in 2013 and collected again in 2014. These data make it possible to discern important changes in beach shape along the length of the berm from the northern beach access point to the jetty. Along-beach trends in crest elevation generally indicate along-beach trends in wave energy and the influence of inlet migration and breaching.

Figure 11 shows that through September, the change in crest elevation was minimal throughout the length of the beach north of Transect 1. By October, the crest elevation increased by as much as 3 ft in some areas. The beach crest was lowest south of Transect 1, where the inlet resided. At Transects 1-4, the crest profile shape remained essentially the same from May to September, with the dominant ridge pattern not shifting laterally. The along-crest ridge pattern also shifted laterally, with the new peak (18.0 ft NGVD) located along Transect 3. The beach was highest between Transects 3 and 4, peaking at 16-18 ft NGVD and minimum of 12.5-14.0 ft NGVD, north of Transect 4.

BEACH WIDTH

To provide additional information about the beach morphology, ESA PWA assessed the beach width using the Water Agency survey data. Figure 12 shows the evolution of the beach width at Transect 3 during the 2012-2014 management periods. In previous years during winter months, the beach was often eroded at Transect 3 to the point that the beach crest was below 12 ft NGVD, so that the width was effectively zero. In 2012 and 2013, apart from this seasonal erosion, there was no marked trend in the beach width. In 2014, the beach was wider than the previous two years, with peak width at the beginning of the management season (Figure 12). The width steadily decreased from 198 at 12 ft NGVD and 130 at 14 ft NGVD in May to 170 and 111 ft NGVD, respectively, in October. The shift appeared to be a result of beach face steepening, a typical summer process.

JENNER STAGE EXCEEDANCE

The Biological Opinion (NMFS, 2008) sets a target for estuary water levels "a daily minimum water surface elevation of 3.2 feet [NGVD] during 70% of the year." To facilitate this target, the Biological Opion notes "Absent river flood flows and historic mechanical breaching practices, NMFS expects cross shore transport of sand by wave action will be sufficient to maintain the bar at this elevation."

In 2014, the daily minimum water surface elevation exceed 3.2 ft NGVD roughly 33% of the year (Figure 13). For comparison, Figure 13 also includes hourly lagoon stage (exceeded 3.2 ft NGVD for roughly 46% of the year) and hourly Point Reyes stage (exceeded 3.2 ft NGVD for roughly 4% of the year). Data gaps at the Jenner Gage influence the exceedance curve, but BML camera photographs suggest an open mouth during most of the periods when stage data were missing, so the exceedance curves for the estuary are likely biased high, meaning that stage exceeded 3.2 ft NGVD for less of the year. This low amount of perched conditions results from the inlet maintaining open conditions throughout the summer of 2014. As with several of the years since 2010, lack of closure in June or July led to prolonged open conditions, as July and August waves were too small to cause closure. As explained in previous annual updates, if the inlet does not close in late spring, it is likely that open-inlet conditions will persist as a result of the seasonally weak waves. Since no closures occurred in late spring in 2014, an outlet channel could not be made, which would have presumably had the intended effect of causing prolonged perched conditions.

LESSONS LEARNED AND RECOMMENDATIONS

Based on 2014 observations of the estuary, associated physical processes, and the Water Agency's planning for outlet channel management, we note the following lessons about implementing the outlet channel management plan.

CONCEPTUAL MODEL

- The beach north of the inlet saw little change from the 16-18 ft NGVD elevations established in 2013. Near the jetty, the berm was lowered by inlet migration while undergoing beach building.
- Similar to the winters of 2011-12 and 2012-2013, the inlet never migrated north of Haystack Rock during winter 2013-14, and returned to the jetty in early spring, much earlier than in most years. This inlet alignment is not common, but has been observed in past years (Behrens et al., 2009).
- Peak annual river discharge has remained below 40,000 ft^3/s for 9 consecutive years, a streak unmatched in the 70-year flow record. This may have a connection to the recent lack of inlet migration to the north.
- The beach width in 2014 at Transect 3 (near Haystack Rock) was larger than in 2013. This may suggest that beach width is closely tied to inlet migration – the lack of migration north of Haystack Rock for several years has allowed the beach to grow at this end of the littoral cell.

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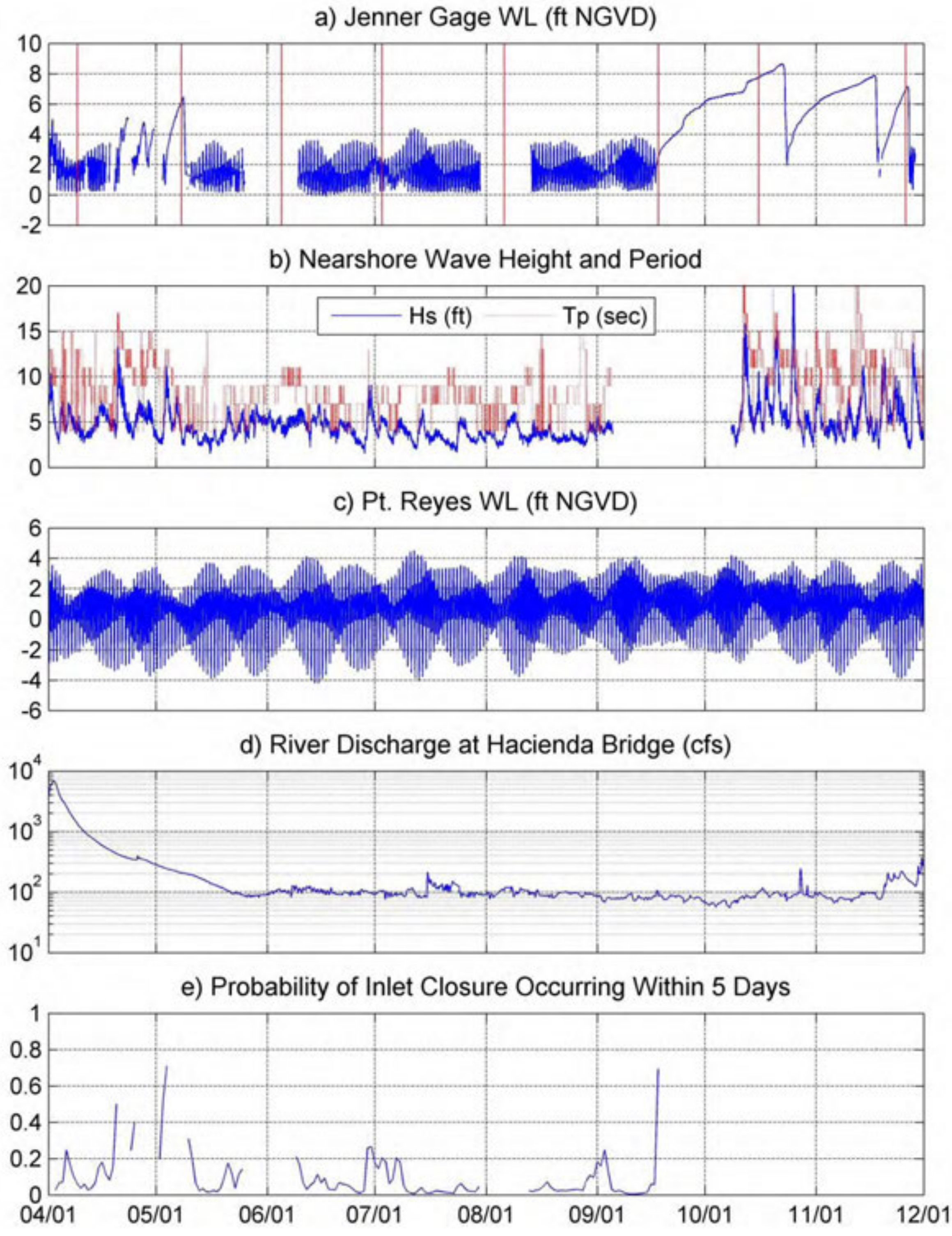

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c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

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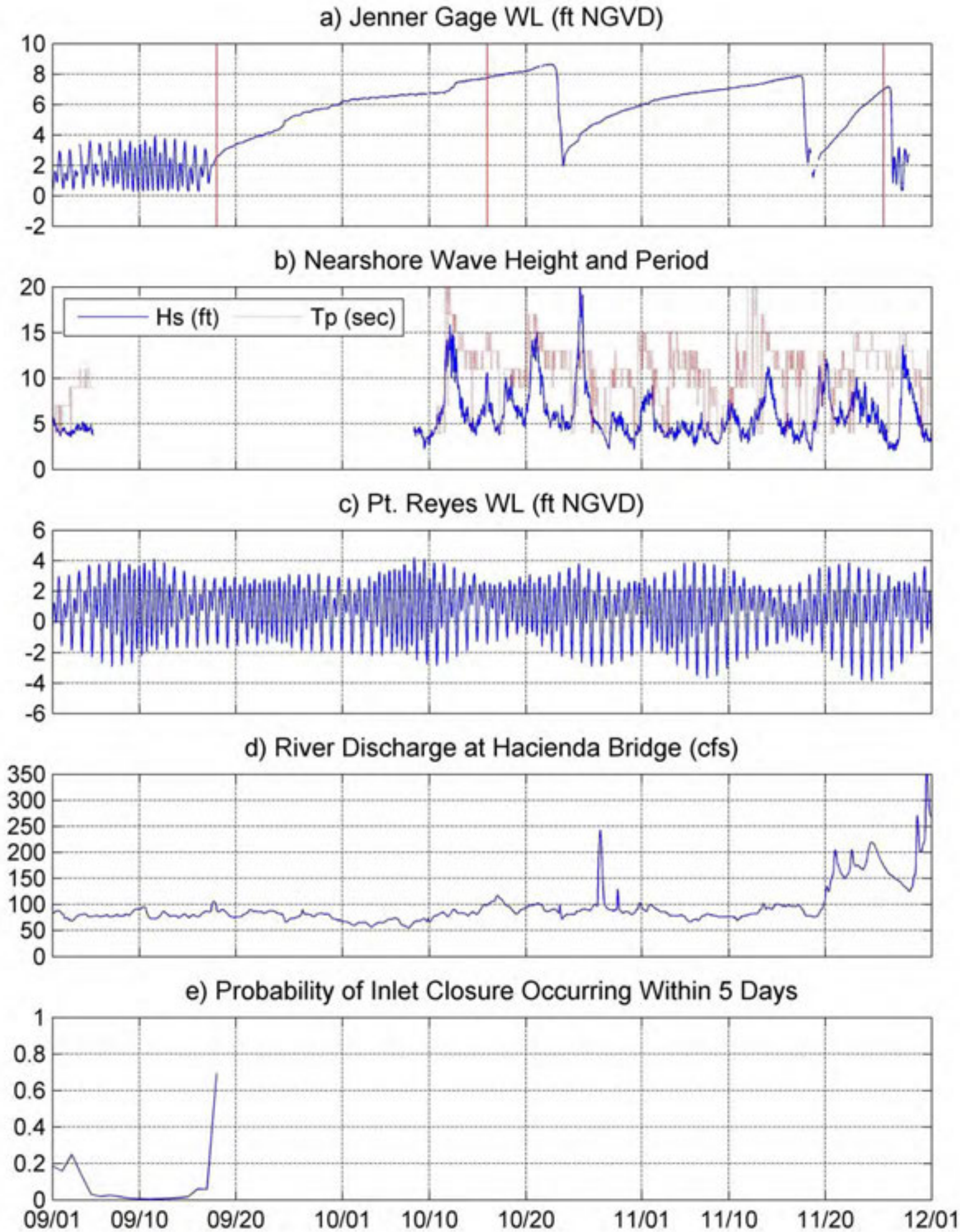
Figure 1

Estuary, Ocean, and River Conditions Compared with Closure Probability: April – November 2014

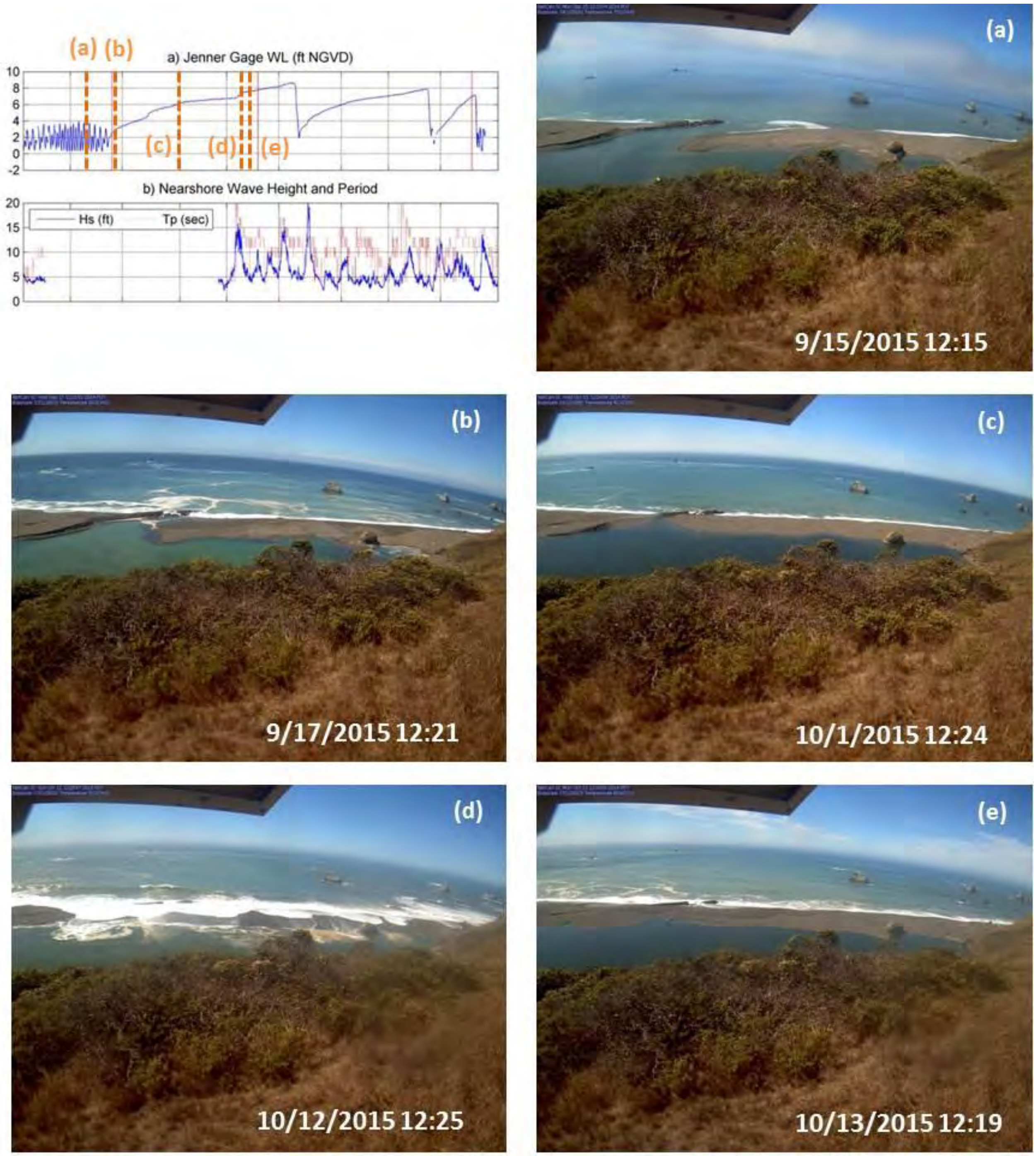


SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

Figure 2

Estuary, Ocean, and River Conditions Compared with Closure Probability: September – November 2014



SOURCE: SCWA camera

Figure 3
Russian River camera photographs showing some of the key morphologic influences during the September-October 2014 closure event.

SOURCE: image from USDA NAIP

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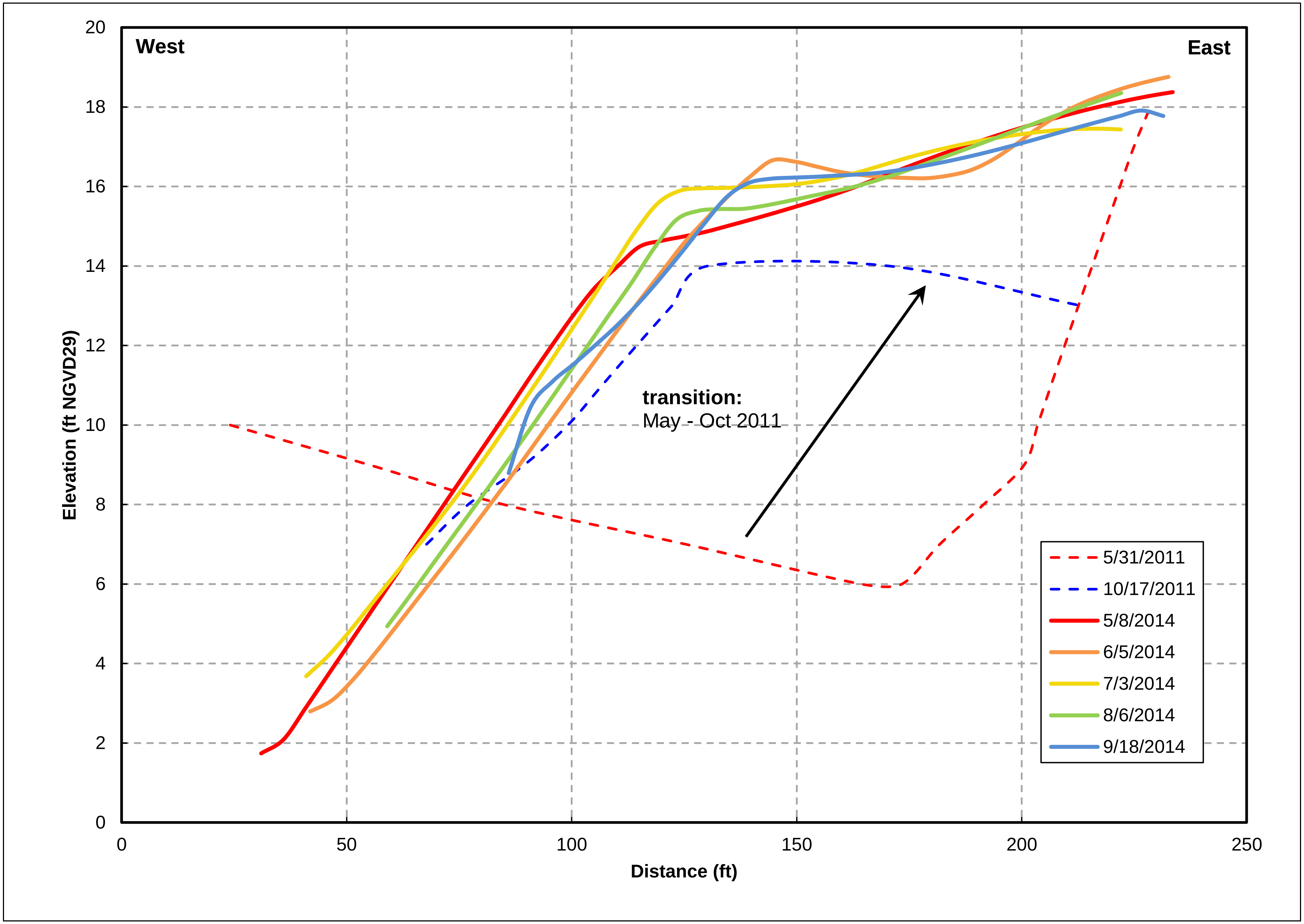
Figure 4
Beach Transect Locations



SOURCE: SCWA survey data

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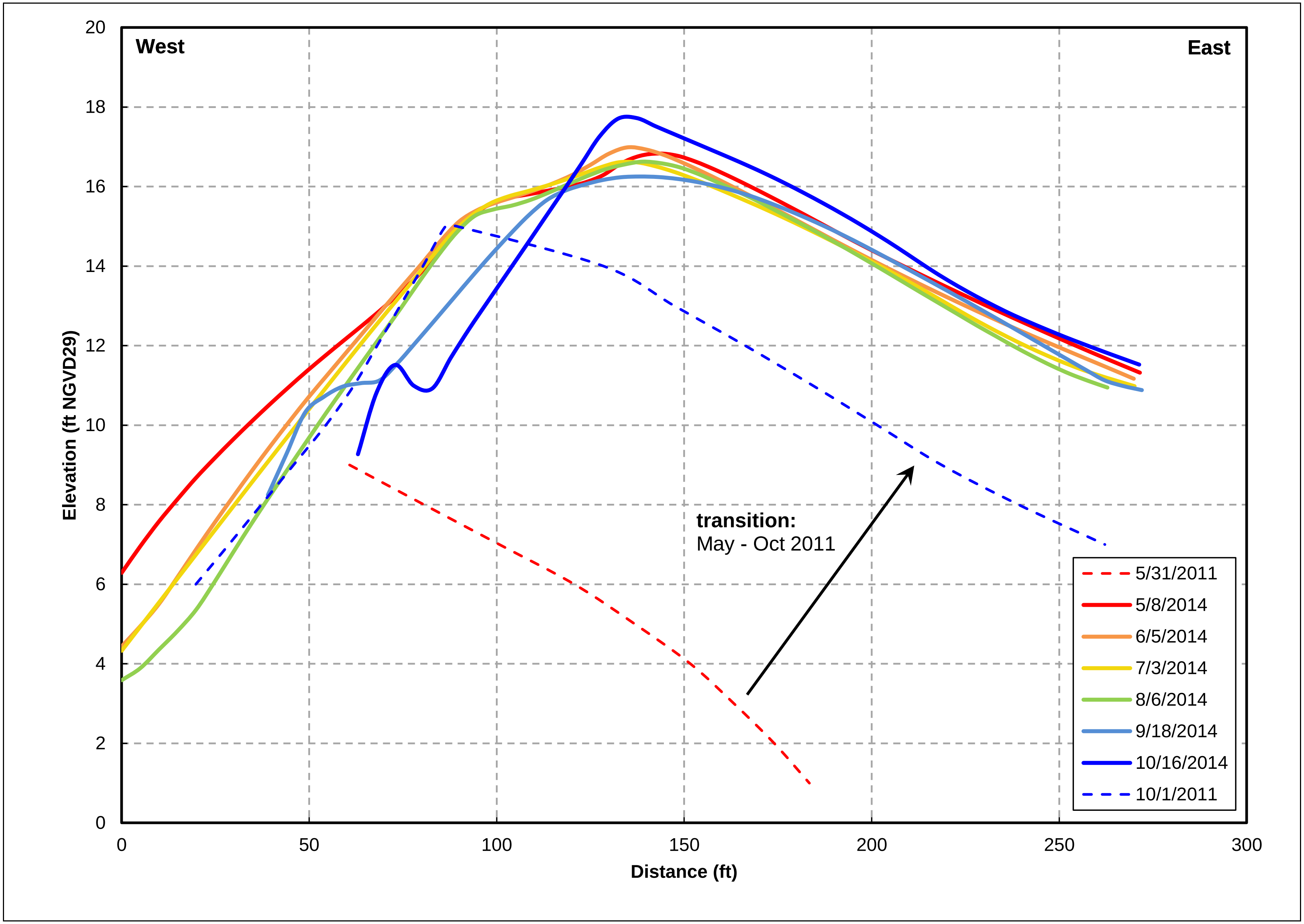
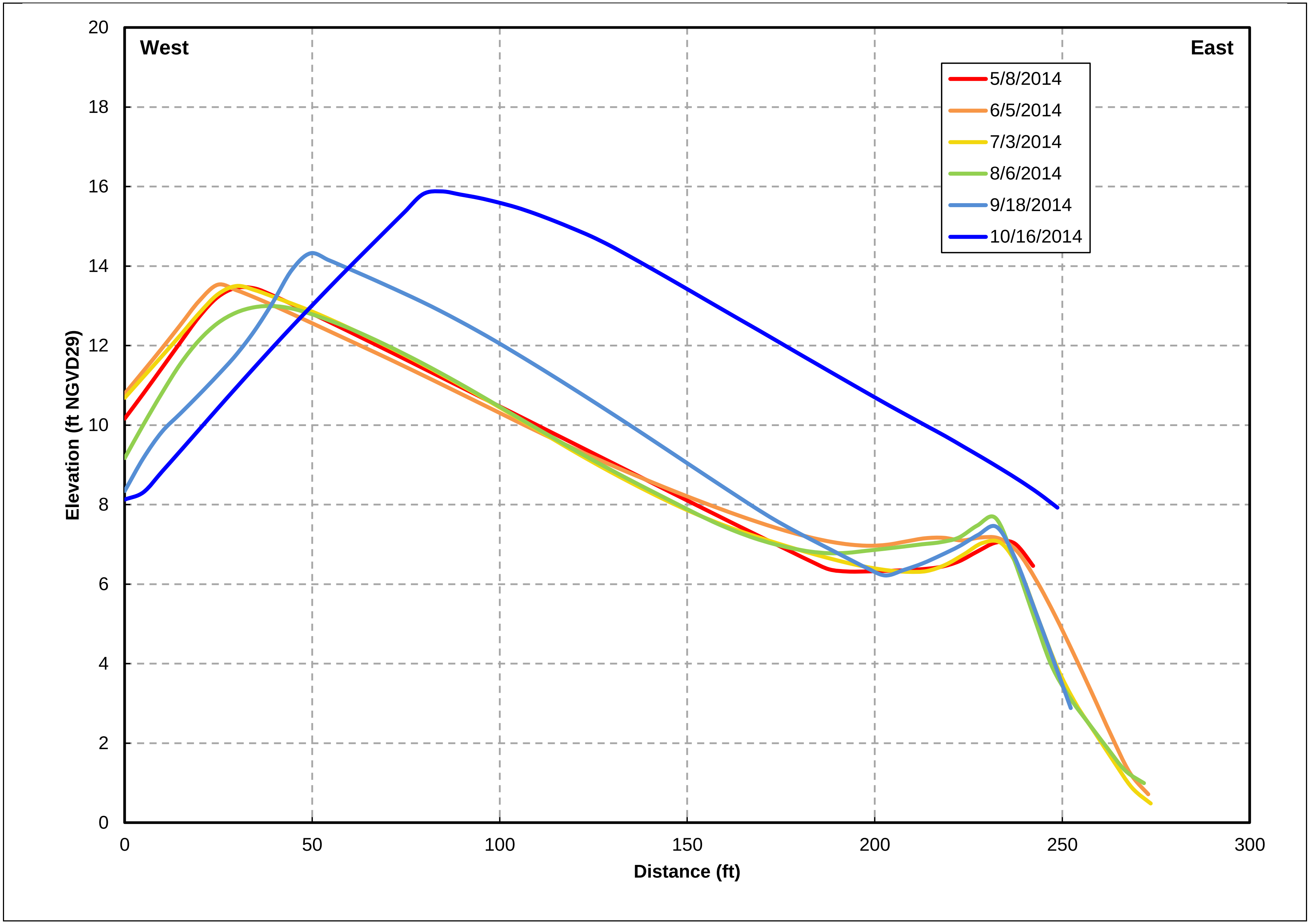
Figure 5
Beach Transect #4



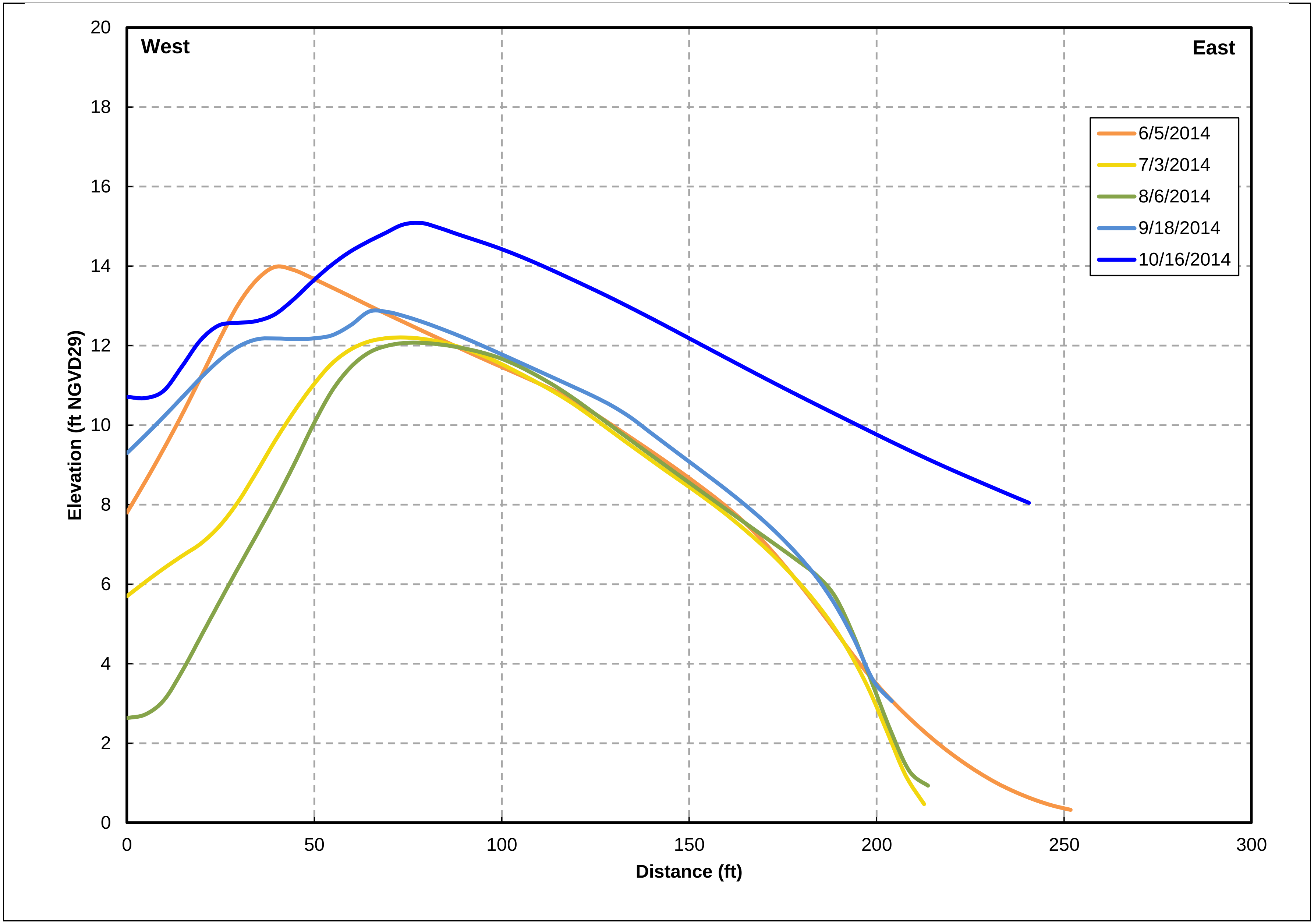
SOURCE: SCWA survey data

Figure 6
Beach Transect #3



SOURCE: SCWA survey data

Figure 7
Beach Transect #2



SOURCE: SCWA survey data

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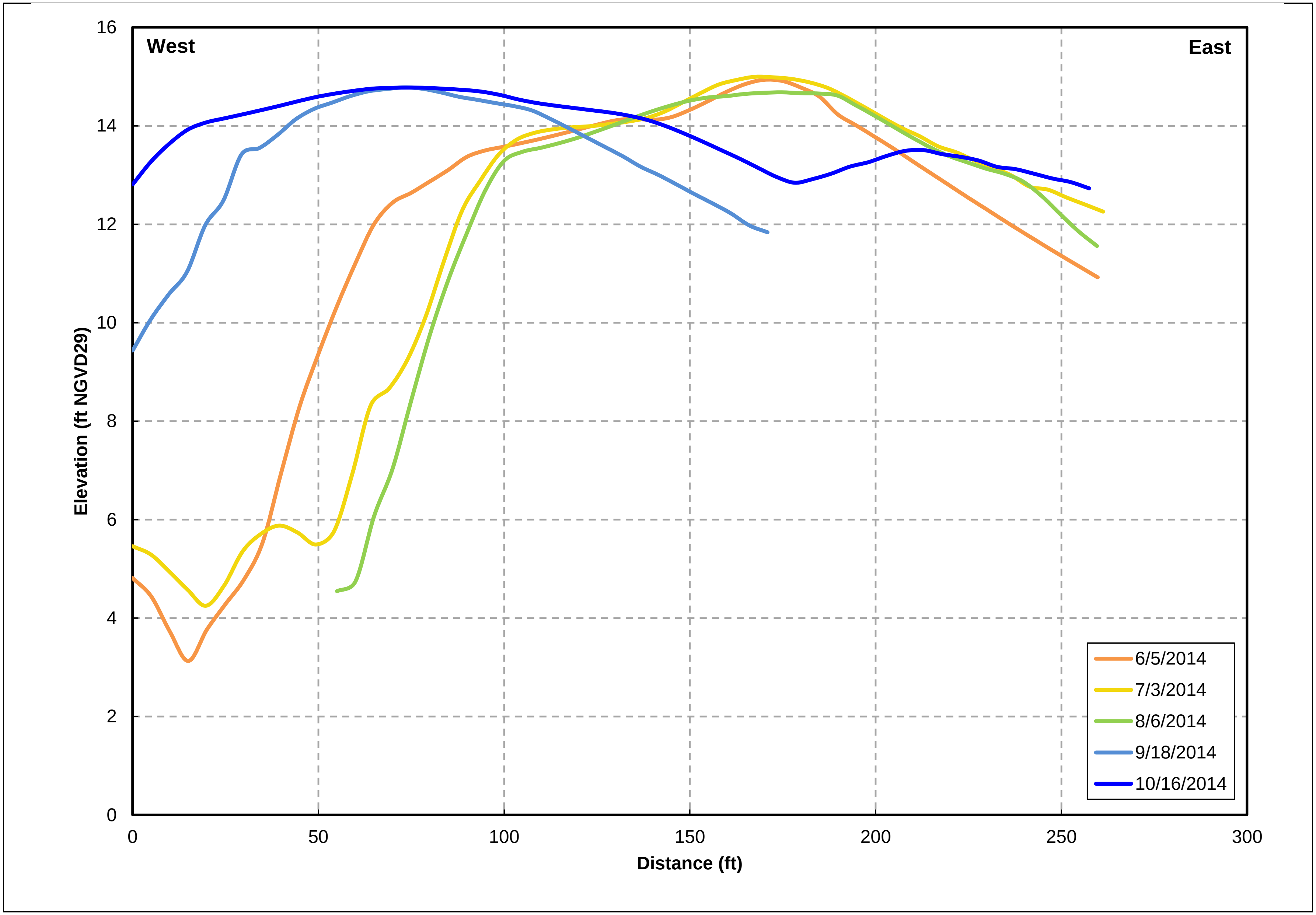
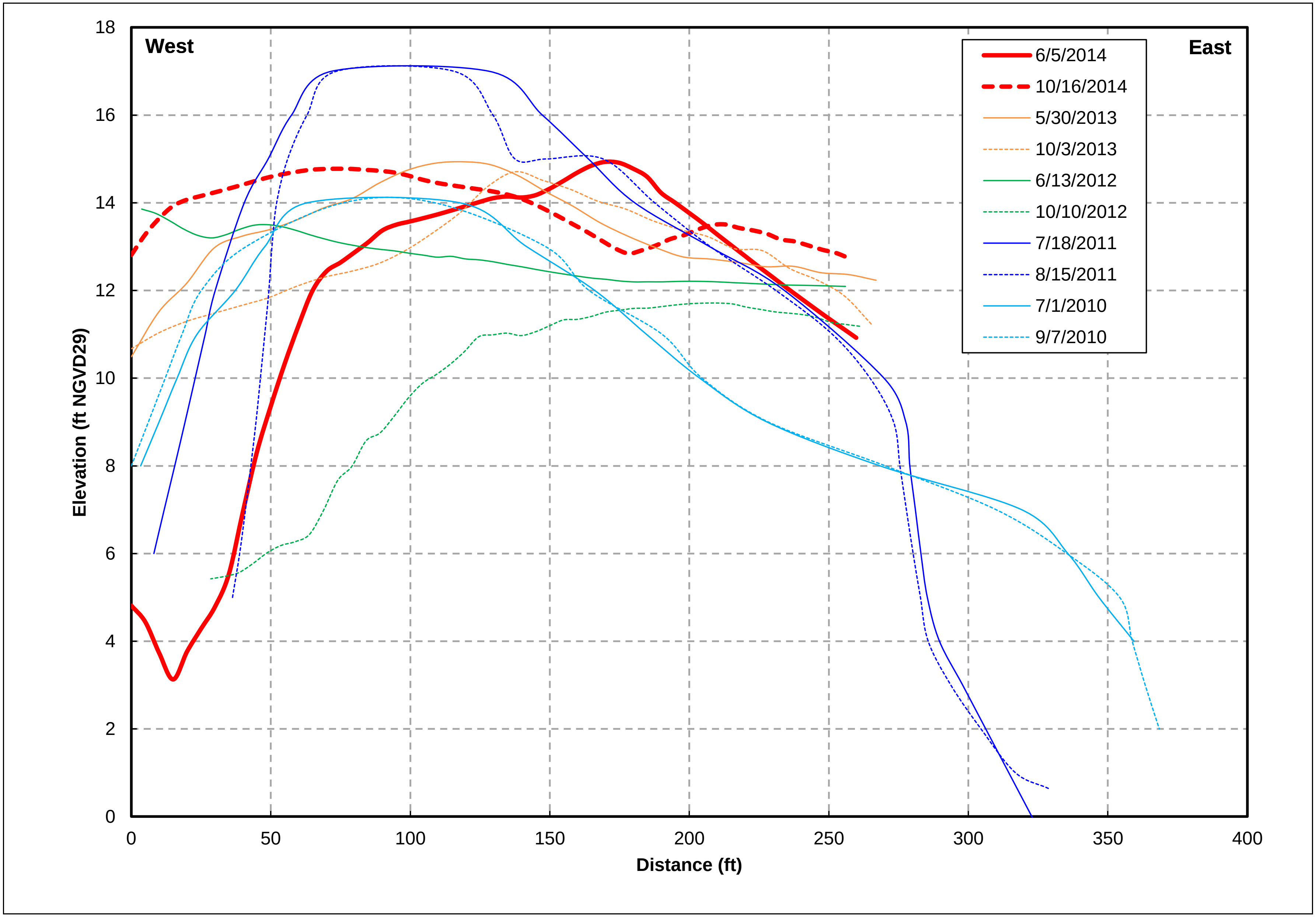
Figure 8
Beach Transect #1



SOURCE: SCWA survey data

Figure 9
Beach Transect #0 from 2014 management period.



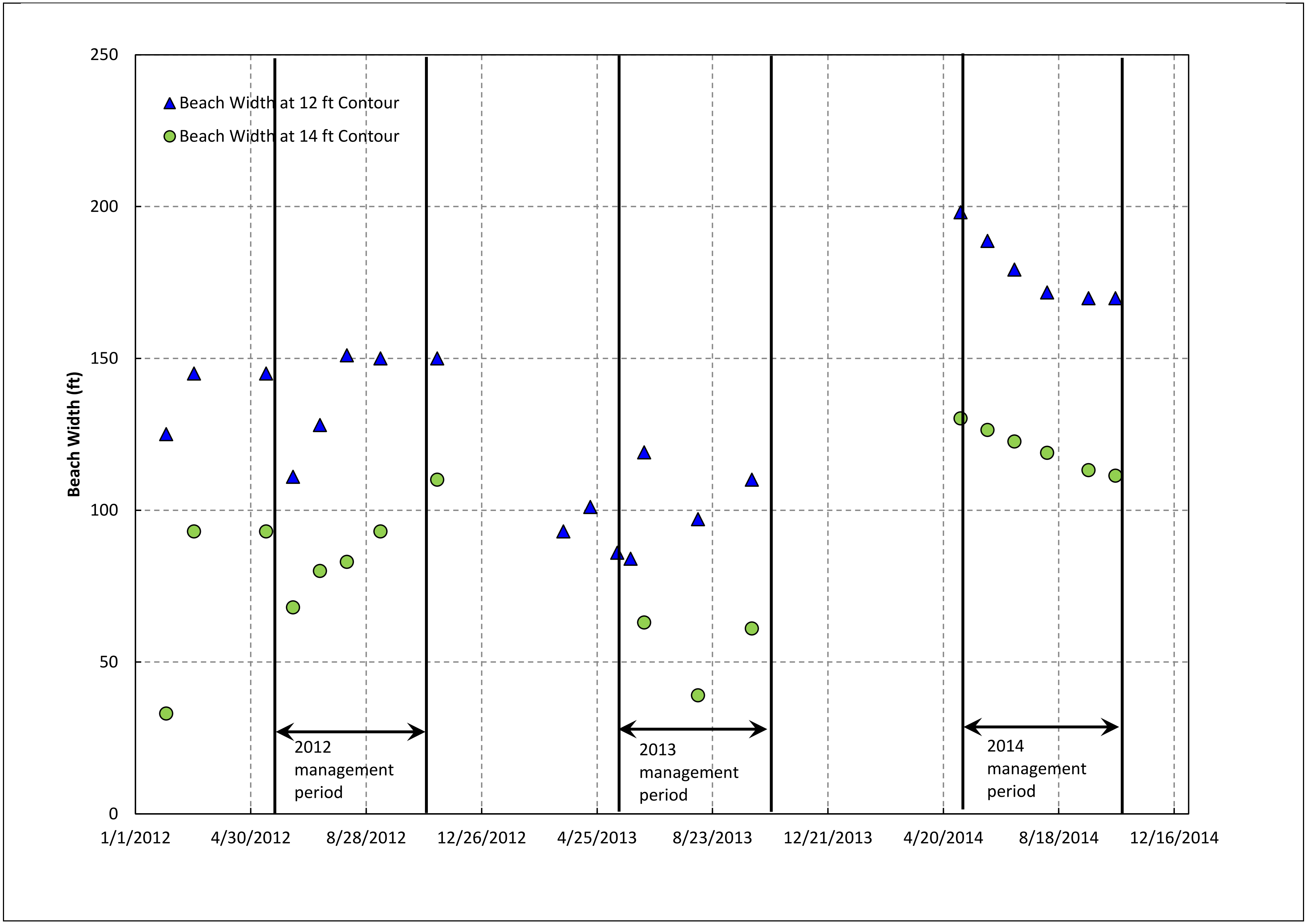
SOURCE: SCWA survey data

Figure 10

Beach Transect #0 from 2010-2014 management periods.

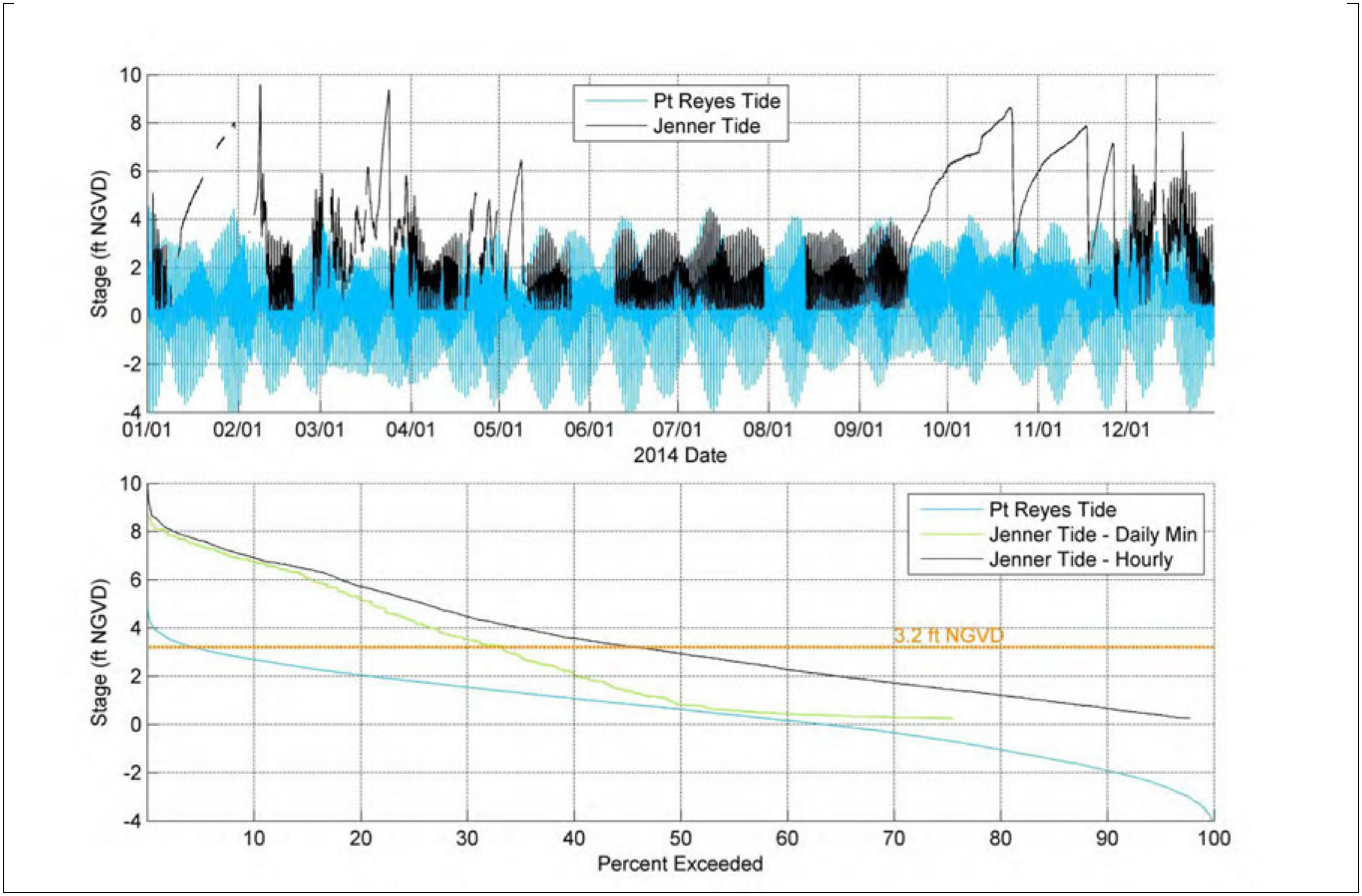
SOURCE: SCWA survey data

Figure 11
Beach Crest Profiles During the 2014 Management Period.



SOURCE: SCWA survey data

Figure 12
Beach Width During 2012-2014 Management Periods.



SOURCE: SCWA Jenner Gage and NOAA Pt Reyes tide data

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 13

Russian River Estuary stage exceedance for 2014.

Attachment J. Five-Year Review of Physical Processes Affecting the Russian River Estuary

1 Introduction

As required by the Russian River Biological Opinion (Biological Opinion) (NMFS 2008), the Sonoma County Water Agency (Water Agency) has been tasked with managing the Russian River Estuary (RRE) to facilitate summer lagoon conditions to improve salmonid habitat. Because of permit constraints, the Water Agency was only able to implement the Russian River Estuary Outlet Channel Adaptive Management Plan (RREAMP) beginning in 2010, and the Plan has continued for six years.

ESA has been asked to conduct a five-year review of the physical processes related to the RREAMP for the years 2010-2014. The goals of this review are to examine the physical processes that influenced the mouth from 2010 to 2014, to compare these conditions to prior years, and to communicate findings for refining the management plan.

To meet these goals, our approach includes the following steps:

- **Compile Data:**
    - Collect gaged and previously reported data
    - Process digital photographs from the Water Agency's time lapse camera operated by the Bodega Marine Laboratory (BML)
- **Analyze with existing methods:**
    - Model the lagoon mouth with the statistical closure probability model of Behrens et al. (2013)
    - Model the lagoon mouth using the lagoon quantified conceptual model (QCM) (ESA 2016, Behrens et al. 2015)
- **Development of new methods:**
    - Obtain mouth morphology data from the BML camera and incorporate into modeling.
    - Use the lagoon QCM to determine whether the mouth position and shape influence its state (open, closed, or perched).
    - Use statistical methods to identify which external conditions may have prevented successful implementation of the outlet channel.

Within this memorandum, these steps are organized into sections on data compilation (Section 2), data comparison of pre- and post-2010 conditions (Section 3), model comparison of pre- and post-2010 conditions (Section 4), and key findings (Section 5).

2 Data Compilation

Comparison of pre- and post-2010 conditions in the Russian River Estuary is possible because of the relative wealth of data at the site. Decades of gaged oceanographic and watershed runoff conditions are available, alongside an extensive record of mouth condition. More recently, the Water Agency has conducted topographic beach measurements since 2010. This section summarizes the data sources and describes the collection of data from the BML camera installed in 2011.

2.1 Inventory

Figure 1 summarizes the data available after 2010 and Table 1 lists the data sources. Gaged river flow, wave, and tide conditions are readily available both before and after 2010. The time series of wave conditions at Point Reyes was translated to a time series of nearshore wave conditions using wave transformation matrices derived from a numerical wave model (ESA 2016). Inside the estuary, the Jenner water level gage has operated continuously since 1999, with the exception of several gaps during periods of gage maintenance. In addition to continuous gage measurements, monthly beach topographical surveys have been collected regularly by the Water Agency since the summer of 2010. A time lapse camera installed in 2011 has complemented the survey data, providing images of the mouth twice each hour. As described in Section 2.2, the camera's photographs can be used to estimate mouth shape and position to compare directly with beach survey data. Mouth shape and position are also intermittently available prior to 2010, derived from near-daily photographs taken since 1991 (Behrens et al. 2013). Daily mouth conditions ('open' or 'closed') have been measured continuously since 1974 by Jenner residents and the Water Agency.

Table 1. Data Sources

Parameter	Source
Estuary water level	Water Agency Jenner gage
Wave height, period, direction, and power	CDIP Point Reyes buoy #027
Ocean water level	NOAA Point Reyes #9415020
Russian River discharge near Guerneville	USGS Hacienda Br Gage #11467000
Beach topography	Water Agency monthly surveys
Mouth size and location	• 2000-2011: BML • 2011-2014: Water Agency and Bodega Marine Laboratory autonomous cameras

2.2 Image analysis for inlet morphology

Prior to 2010, daily photographs were taken manually by a Jenner resident at the overlook point east of the mouth. Although the pictures were taken at slightly different times and locations each day, they were used to estimate basic dimensions of the mouth, such as its width, length, and position north of the groin (Behrens et al. 2013). This was possible because several landmarks (e.g. the jetty groin and Haystack Rock) are visible in every photograph, and their locations are fixed, and can be used to roughly scale the inlet size. The Biological Opinion requires that a fixed camera at the mouth for monitoring purposes. To fulfill this requirement, the Water Agency installed a camera at the mouth and later contracted with BML in 2011 to operate the camera on the hillside above the estuary, which now takes images twice an hour during daylight hours, enabling a more automated approach.

Using the Matlab image processing toolbox, a routine was developed to generate time series of inlet dimensions (Figure 2). This process involves (1) performing a geometric transformation of each image using fixed landmarks, to translate the original oblique images to plan view, (2) extracting a series of transects parallel to the beach on the plan view image, and (3) detecting the size and position of the inlet based on the intensity of the blue pixels along each transect. Inlet dimensions derived from this approach are discussed in Section 3.

3 Data Comparison of Pre- and Post-2010 conditions

This section discusses differences in physical processes before and after the Biological Opinion was adopted in 2009, based on gaged data, topographical survey data, and mouth morphology data derived from the Estuary camera. Table 2 provides summary statistics of many of these data. These data provide context for the management conditions for implementing the outlet channel after 2010 by comparing pre- and post- 2010 conditions.

Table 2. Summary of data and model outputs from 2000 to 2014.

Year	Jenner Stage (ft NGVD)		Mean Wave Power at Groin (lbf*ft/ft*s x 1000)	Watershed Runoff		Mouth Closure			Mouth Position	Lagoon QCM Predictions
	Mean	% exceeding 3.2 ft		Total Inflow per Water Year (Acre-feet x 1000)	Peak Winter Flow (ft^3/s)	No. of Closure Events	No. of Days Closed	Mean 5-day Closure Risk	% of Time Spent Next to Groin	Predicted Number of Perched Overflow Days
2000	2.52	30	70	714	37,900	15	63	0.18	33	0
2001	3.12	43	78	1287	24,700	10	62	0.16	50	0
2002	2.56	32	58	1564	44,000	9	35	0.10	28	1
2003	2.04	19	57	2084	57,600	3	17	0.11	45	0
2004	2.28	22	49	1167	63,400	7	47	0.14	66	1
2005	2.32	26	69	2944	21,900	5	32	0.11	44	0
2006	1.92	19	69	1305	86,000	5	11	0.09	50	12
2007	2.03	20	64	987	29,800	10	47	0.17	44	0
2008	2.44	29	60	570	36,600	11	77	0.20	4	5
2009	2.32	25	59	1095	22,400	8	61	0.15	18	0
2010	2.31	30	88	2039	37,900	3	37	0.16	--	14
2011	1.63	13	65	586	37,300	7	22	0.16	78	2
2012	2.23	21	71	1100	26,800	13	54	0.25	77	0
2013	2.53	28	45	365	38,400	12	110	0.13	73	0
2014	3.29	44	83	496	18,900	8	133	0.13	76	0
Mean: 2000-2014										
	2.37	27	66	1220	38,900	8	54	0.15	49	2.3
Mean: 2000-2009										
	2.35	27	63	1370	42,430	8	45	0.14	38	1.9
Mean: 2010-2014										
	2.40	27	70	917	31,860	9	71	0.17	76	3.2

3.1 Coastal and Fluvial Conditions

Oceanic tide conditions (not shown in Table 2) were the least variable of the gaged data at the site since these are largely a function of astronomic variables and only minimally affected by climatic variations. The tidal water levels varied only slightly from year to year. Figures 3 and 4 show ocean tides during the periods 2000-2014 and 2010-2014, respectively.

Wave conditions in 30 ft depth adjacent to the groin were more variable. The mean wave power from 2000 to 2014 near the groin was roughly 65,000 lbf*ft/ft*s. The strongest waves occurred in 2010 and 2014, with 134 and 127 percent of the 2000-2014 mean, respectively. Wave power was lowest in 2004 and 2013 at 69 and 75 percent of the 2000-2014 mean, respectively (Table 2). Mean wave power was about 10 percent higher in 2010-2014 than in the period from 2000 to 2009.

Watershed runoff at Guerneville was the most variable of the gaged data. Average total inflows from 2000 to 2014 were roughly 1.2 million acre-feet per water year (Oct. 1 – Sep. 30) at the USGS Guerneville gage. Three of the four driest years after 2000 occurred after the Biological Opinion was issued, in the 2011, 2013, and 2014 water years. Total inflows during these years were 30 to 50 percent of the post-2000 average. Most of the wettest years after 2000 happened before the Biological Opinion, with the 2003 and 2005 water years having 170 and 240 percent of the post-2000 average, respectively. Overall, the 2010-2014 mean of annual inflows is about 33 percent lower than for the period 2000-2009.

3.2 Estuary Stage

In contrast to ocean tides, tides within the Russian River Estuary vary significantly from year to year. As pointed out by NMFS (2008), persistence of water levels above the typical tidal range (usually during mouth closure events or brief one-way overflow) are thought to improve estuarine salmonid rearing habitat by creating a perched, fresh or brackish lagoon. Managing the mouth as an overflow channel in summer is intended to facilitate or prolong periods of these high water levels. The Biological Opinion (NMFS 2008) set a goal of maintaining a daily minimum of at least 3.2 ft NGVD (roughly oceanic MHHW) within the estuary for at least 70 percent of the year.

To understand the year to year variability, and to test whether the estuary stage met the goals of the Biological Opinion, we collected water levels from the SCWA Jenner gage from 2000 to 2014 and summarized the data using annual exceedance curves (Figure 5). On average, water levels were slightly higher in 2010-2014 than in 2000-2009. There were no years when water levels exceeded the level of 3.2 ft NGVD for more than 70 percent of the year. Across all years, the percent exceedance of 3.2 ft NGVD varied between 13 and 44 percent. Years with higher average water levels corresponded to higher number of closure days. Higher water levels also typically corresponded to low watershed runoff and/or and higher wave power (Table 2).

These summary statistics of the lagoon stage are affected by: (1) sensor data gaps and (2) sensor cutoff of low tides. Gaps in the stage data due to sensor maintenance or poor cellular service connectivity occur in most years and sometimes last several weeks. Since the timing of these gaps is unrelated to the mouth state, we assume that these do not have a large impact on the summary statistics. However, sensor cutoff introduces a bias in the exceedance curves. The Jenner gage does not collect tide data below -0.5 ft NGVD because of its fixed location on a pier.

BML water level measurements in 2010 and 2011 confirm that the estuary stage drops several feet below this level during open-mouth conditions (Largier and Behrens 2010). Although measurements taken when the Jenner gage was cutoff were excluded from this analysis, the lack of the lower stage data mean that the exceedance curves in Figure 5 are biased upwards, so that the estuary stage actually spends less than the reported 13-44 percent of the year above 3.2 ft NGVD.

3.3 Beach morphology

The monthly Water Agency beach topographic surveys were combined with the image analysis described in Section 2.2 to compare beach and mouth conditions side by side. We use them here to understand the beach conditions relevant for implementing an outlet channel after 2009.

The available camera and survey data show that the beach normally erodes in winter, when watershed runoff is highest and the mouth widens to cover most of the beach between the groin and the bluffs, a mouth width of about 1,000 ft. When peak runoff surpasses a threshold of roughly 40,000-50,000 cfs, most of the beach is eroded, providing a 'reset' to the system and pushing sediment offshore. When flows recede after these large events, the beach re-forms, and the mouth is usually located at the north end of the beach. In most years, it then migrates south to the groin during the spring or, more rarely, summer (Behrens et al. 2009; ESA 2016). Once the mouth reaches the groin, the beach begins to re-build further under spring swell waves. The monthly surveys show that the beach crest remains fairly stable in summer when wave power declines, and then increases again in fall when waves once again become more energetic. Eventually the berm crest reaches an equilibrium height set by waves, and further growth is limited (ESA 2016).

Prior to the Biological Opinion, this seasonal beach erosion and building cycle happened almost every year, but monthly survey data were not available to examine it in detail. After the Biological Opinion, this cycle was only observed in the 2011 management season, as described by ESA (2016). Peak annual flows have been less than 43,000 ft^3/s at Guerneville since 2007, which is an unprecedented length of time in the historical record. When winter floods remain below this level, some of the beach remains intact, and erosion of the beach depends on how extensively the mouth migrates in response to waves. The effect of these reduced peak floods has been more limited seasonal beach erosion and migration extent.

Figures 6 to 9 compare the beach crest, width, and mouth position since 2010 at four transects along the beach. At the transect nearest to the groin (Figure 6), the data indicate that the mouth's frequent location near the groin has at times limited berm growth. Away from the mouth, at the northern end of the beach (Figures 8-9), the berm crest and width have grown steadily since 2011, punctuated by brief periods of erosion when the mouth migrated briefly toward the north during the weak winter floods in recent years.

The location of the mouth near the groin after 2010 from the years before 2010. Table 2 indicates the percent of the year that the mouth spent at the groin since 2000. Since 2010, the mouth has been located at the groin for more than 75 percent of the year on average, compared with less than 40 percent prior to 2010. This increase in time spent at the groin is in spite of the Water Agency efforts to conduct its artificial breaches further north when feasible. Although survey data are not available for the earlier period, it can be inferred that an impact of this change has been less beach building adjacent to the groin. This location was usually the lowest part of the berm crest during the management season, and the preferential location for mouth self-breaches.

4 Model Comparison of Pre- and Post-2010 conditions

4.1 Closure Risk Index

Since wave and river conditions vary inter-annually, the timing of closure events also differs from year to year. This is especially apparent when examining conditions early in the management period, in May and June. In most years, a few short-lived closure events occur in May and June, after which tides alone are sufficient to maintain an open inlet throughout the summer as wave power has dropped off. Although wave power dips in the months of June-August, strong swell events occasionally arrive at Goat Rock State Beach (GRSB) in June and early July and encourage mouth closure events. Depending on the fluvial discharge, these closure events may be brief, or they may last several weeks, as in 2010 and 2014.

The inclination toward inlet closure can be estimated and compared for different years. In the short-term (e.g. less than 5-7 days), the chance of inlet closure can be estimated with good confidence based on daily estimates of the tidal prism in the estuary and the mean daily wave power in the nearshore zone (Behrens et al. 2013). The tidal prism and wave power are compared in a way that produces a dimensionless “closure likelihood” index that forecasts the chance of closure occurring within five days. As the index increases (i.e. as the influence of waves begins to dominate over the influence of tides), the risk of the inlet closing increases. Since this does not account for freshwater runoff, it can be interpreted as a tool for measuring the short-term inclination toward closure, but is not intended to forecast the length of closure events or the number of closure days per year.

Figure 10 (upper panel) shows that this approach is a good measure of closure risk in the short-term. Values of the index lower than the 50th percentile from 2000 to 2014 had risks of closure well below 10 percent, and values higher than the 99th percentile carried risks of 70-80 percent. It is difficult to predict closure above this accuracy without accounting for other factors that are difficult to measure, such as inlet shape and inlet sheltering from the groin.

Applying this model to the period from 2000 to 2014, we find that the risk of closure was slightly higher after 2010 than before (Figure 10: lower panel). The difference is small: for a given day of the year, the chance of closing within five days is 14.6 percent before 2010, and 17.9 percent after 2010. Within the management period, the chances of closure are smaller due to the weaker waves, at 11.6 percent and 16.4 percent for a given day, respectively. The higher risk of closure after 2010 reflects a difference in the wave climate: nearshore wave power was about seven percent higher from 2010 to 2014 than from 2000 to 2010.

4.2 Lagoon Quantified Conceptual Model

One of the difficulties in studying outlet channel conditions in the Russian River Estuary is that managed outflow conditions do not have a precedent in the recent historical record. The goal of implementing the outlet channel is to provide freshwater habitat for salmonids by limiting tidal exchange in the lagoon and perching the lagoon above ocean levels by facilitating outflow over the beach after the mouth has closed. Despite the lack of experiential data of this type of approach, naturally perched conditions provide a natural analogue, although they are rare.

The data summarized in Section 3 show how environmental conditions have differed in the Russian River Estuary before and after the Biological Opinion, but it is difficult to look at perched conditions directly from the data, for a few reasons:

- None of the individual data sources can explain on their own whether a persistent outlet channel was any more or less likely after 2010 (Table 2).
- It is difficult to find natural perched overflow conditions in the historical record when using only the lagoon stage and photographs as a guide.
- For outflow conditions lasting only a day or two, velocity measurements in the channel or a model of the lagoon mouth are needed to assess whether the channel is experiencing perched outflow.

To account for the last point, we built a lagoon model that accounts for the interconnected lagoon hydrology and mouth morphology. This model can be used to assess how likely the mouth was to be perched before and after 2010. This lagoon 'quantified conceptual model ' (lagoon QCM) was previously developed and tested by ESA (2013, 2015) at a number of sites, including the Russian River Estuary. It is described in more detail by Behrens et al. (2015). The model is a time-series water balance that uses watershed runoff and nearshore tides and waves as boundary conditions. Using these inputs, the model predicts a time series of lagoon stage and mouth/beach elevation, allowing the system to cycle through tidal, closed, and perched overflow conditions in response to the boundary conditions. The lagoon QCM also includes the process of mouth migration, empirically relating the migration rate to the alongshore wave power vector. Migration is important to include because it encourages closed or perched conditions by lengthening the channel, slowing velocities, and exposing the mouth to more deposition from waves. Migration is thought to be one natural precursor to perched and closed conditions (Behrens et al. 2009).

To test the model accuracy, we ran the lagoon QCM for the years 2000-2014 and compared the modeled mouth condition, lagoon stage, and mouth position time series against observations. The model predicted an average of 59 closure days per year from 2000 to 2014 compared to the 54 observed by the Water Agency (Figure 11). The seasonality of mouth closures (less closure in winter and summer, more closure in spring and fall) is well captured by the model (Figure 11). The model also performs well when using the lagoon stage frequency as a test (Figure 11). Modeled stage frequency above 5 ft NGVD is biased slightly upward since the model over-predicted closure conditions. The seasonal migration cycle described in Section 3.3 is reproduced in most years (Figure 12), although the model sometimes predicted that the mouth would return south to the groin earlier than was observed in some years.

Perched overflow is identified in the model when the following conditions are met:

- Only outflow (seaward-directed) flows occur for at least 24 hours
- The lagoon stage perched higher than oceanic MHHW for at least 24 hours

Using these rules, we observed perched conditions in the model results for about half of the years from 2000 to 2014 (Table 2). Perched conditions normally happened in the week immediately before closure, and did not persist for more than several days at a time, as was previously interpreted from the water level data (see RREAMP, Section 5). The years with the most perched conditions were 2006 (12 days), 2008 (5 days) and 2010 (14 days). This is supported by the RREAMP's Table 3 (ESA PWA, 2016), which describes perched conditions in 2006 and 2008, suggesting that more favorable conditions were present in those years. On average, the model predicted slightly more perching (3.2 days per year) after 2010 than before (1.9 days per year), with no days of perched conditions predicted in the years 2012-2014 (Table 1). This difference is insignificant when considering that perched conditions usually accounted for less than two percent of the time series in an average year.

5 Summary and Findings

To provide context for the results outlined above, it is important to summarize the conceptual model for the implementing the outlet channel, which is also discussed in the main body of the RREAMP. In order for the outlet channel to be successfully implemented, a number of conditions need to be met:

(1) A natural closure must occur within the management season of May 15-October 15,
(2) The beach must build high enough that water levels can rise to perched levels,
(3) Water levels must reach 5.5 feet NGVD29 or higher,
(4) The beach must be accessible to construction equipment,
(5) The channel must be constructed within an excavation allotment of 2000 yd^3,
(6) Once the channel is constructed, flows exiting through the channel must be slow enough to prevent scouring,
(7) Wave power adjacent to the mouth must be low enough that the channel does not close.

Since 2010, channel implementation has been prevented most often by conditions 1, 2, 4, and 7. In 2010, the outlet channel was implemented briefly in July, and was subsequently closed off due to wave action. In 2011, closure did not occur until the end of the management season. More recently, closures have occurred early in the management season, but beach conditions have prevented implementation, since the lowest elevation of the beach crest was sometimes below 7 feet NGVD29. This has been especially clear in both the 2014, and more recently, 2015 management seasons (see Attachments and I and K to ESA PWA, 2016), when the mouth repeatedly self-breached before beach management could take place. Unsafe beach conditions for construction has also prevented implementation in most years since 2010.

In dry years (e.g. 2014), when river inflows have been less, closures have lasted a month or more because of the reduced inflows. However, the lagoon water levels continually increase even in dry years, and may receive pulses of wave overwash that boost the rate of rise. This trend of continually increasing water levels during closure suggest that, in the absence of an outlet channel, the inflow into the estuary always exceeds the outflow, such that the estuary will eventual self-breach or require artificial breaching.

5.1 Findings

Key findings from pre- (2000-2009) and post-(2010-2014) Biological Opinion conditions include the following:

Jenner Stage:

- The water level has not been perched above 3.2 ft NGVD29 more than 44 percent in any year since 2000.
- The average percent of time above 3.2 ft NGVD29 is 27 percent, both before and after 2010.

(Note: these percentages are biased high because the Jenner gage's observations are cutoff for low water levels.)

Data comparison:

- Conditions have been more favorable for closure within the management season since 2010: Wave power has been about 10 percent higher, and the number of days closed throughout the year was about 60 percent higher than prior to 2010.
- Watershed runoff has been favorable since 2010 for encouraging closure and for outlet channel flows: Flows from 2011-2014 were dramatically lower than in prior years.
- Peak winter flows have been 25 percent lower after 2010 than before, and peak flows have not exceeded 43,000 ft^3/s since 2006.
- The mouth has spent more than 75 percent of the year adjacent to the groin since 2010, compared with less than 40 percent before. This may be partly caused by the weak winter floods. We infer that this has resulted in a lower minimum beach crest elevation near the groin, which then serves as the location for self-breaching.

Model comparison:

- Mouth closure has been only slightly more likely after 2010 than from 2000 to 2009. The July 2010 managed outlet channel ended in a natural mouth closure.
- The lagoon QCM model suggests that perched conditions were slightly more likely after 2010 than before.

Overall, coastal and watershed conditions have been more favorable for implementing an outlet channel after 2010. However since mouth migration appears to have been limited by weak winter floods, the mouth has frequently occupied the segment of beach immediately adjacent to the groin. The consequence of this has been weaker beach building at this location and a lower beach crest elevation as a result. This has made self-breaching prevalent throughout the management season, especially preventing implementation of the outlet channel in recent years.

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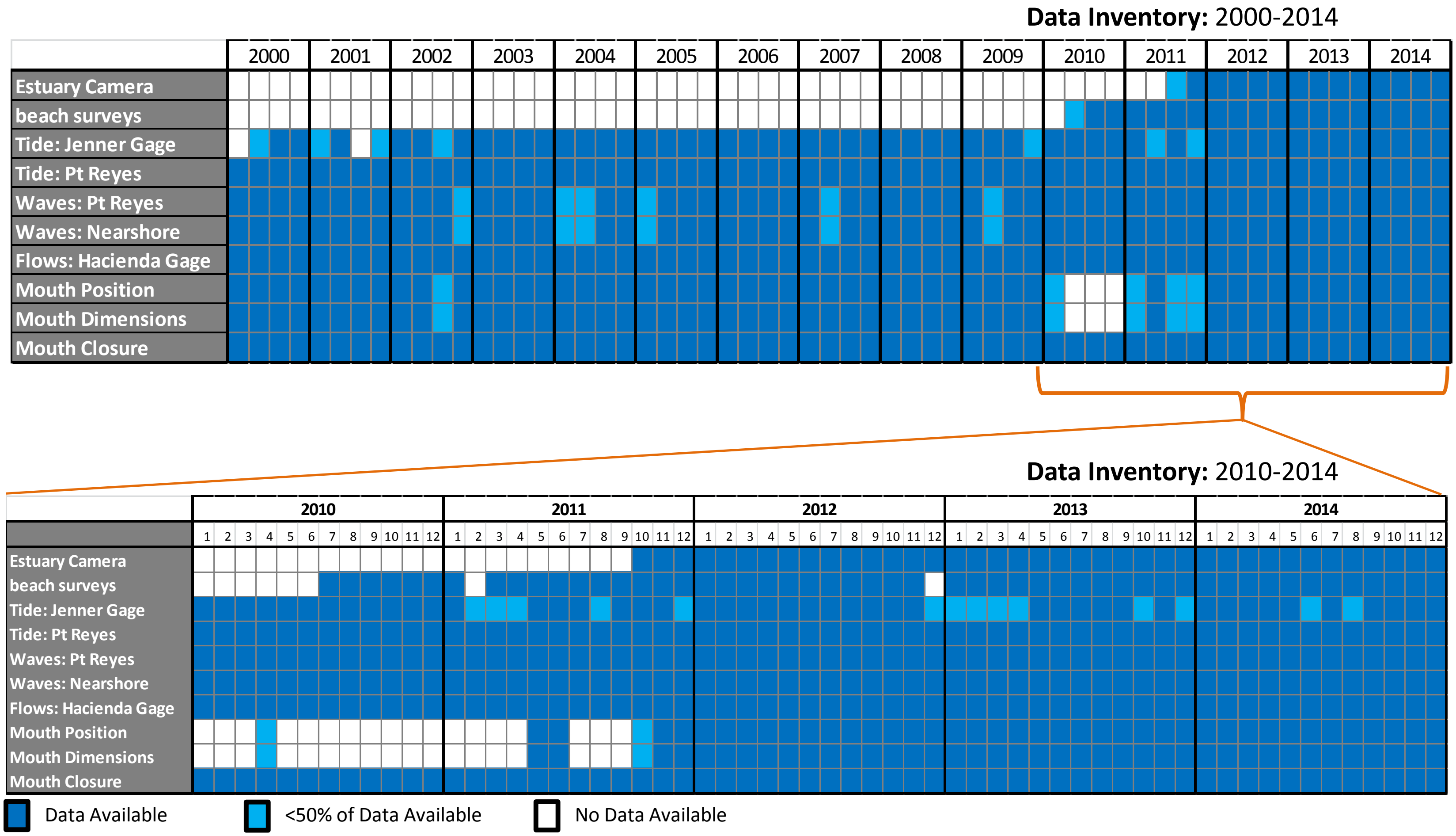
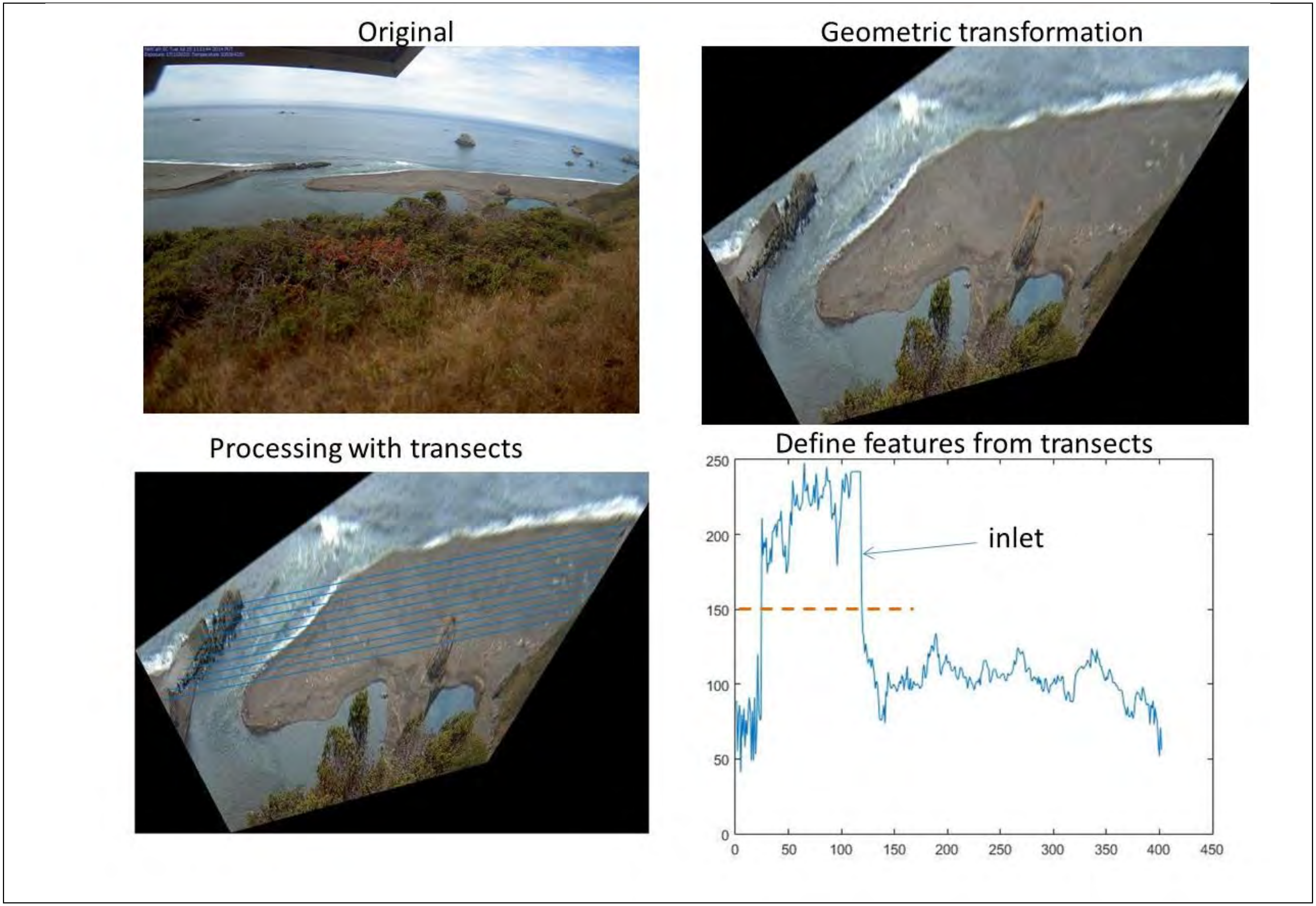
National Marine Fisheries Service (NMFS). 2008. Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River watershed.



NOTE: See Table 1 for data sources

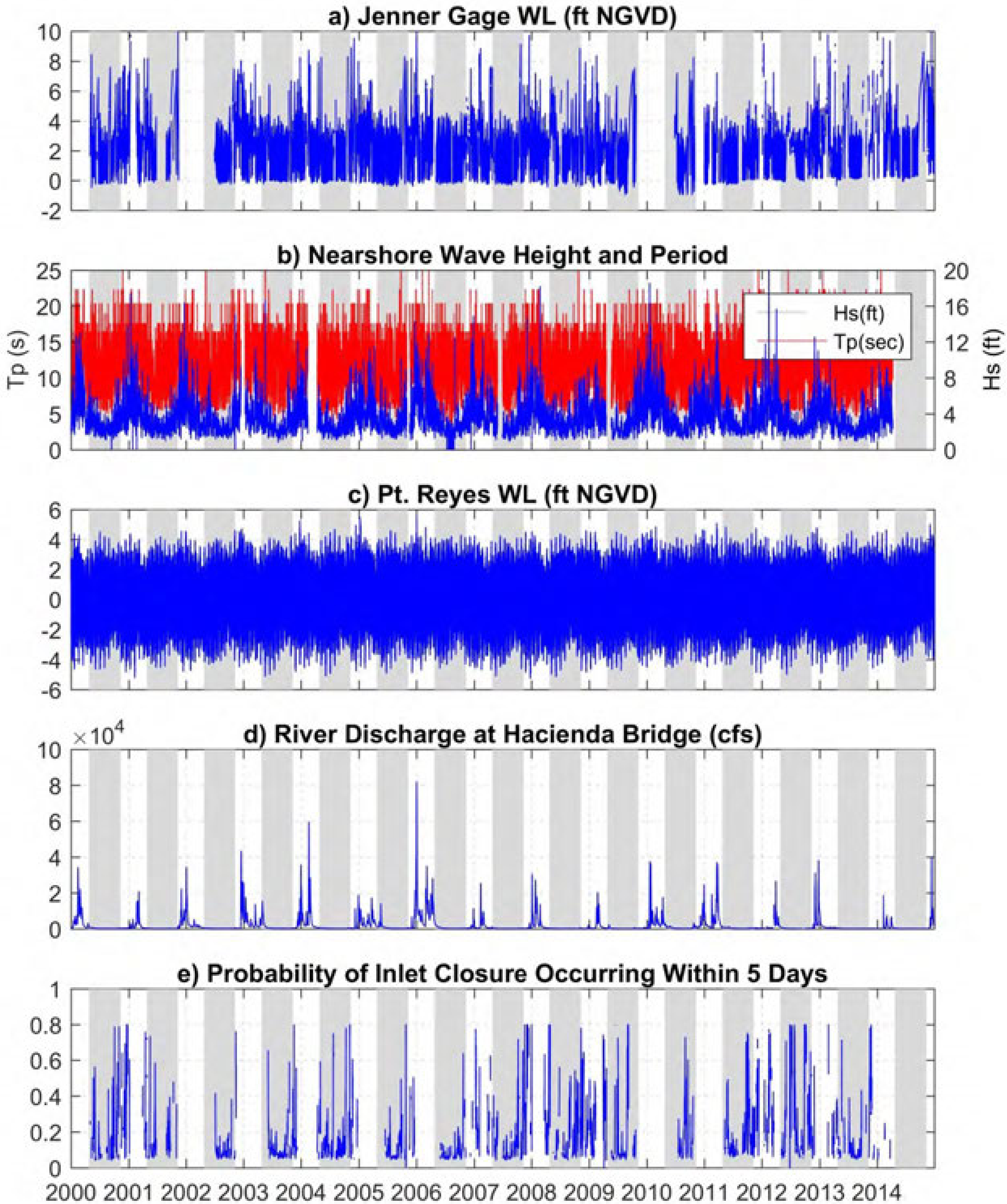
Figure 1

Data inventory for the Russian River Estuary for **(top)** 2000-2014 and **(bottom)** 2010-2014.



NOTE: Image source: BML

Figure 2
Summary of processing technique to obtain mouth morphologic data from the BML camera.

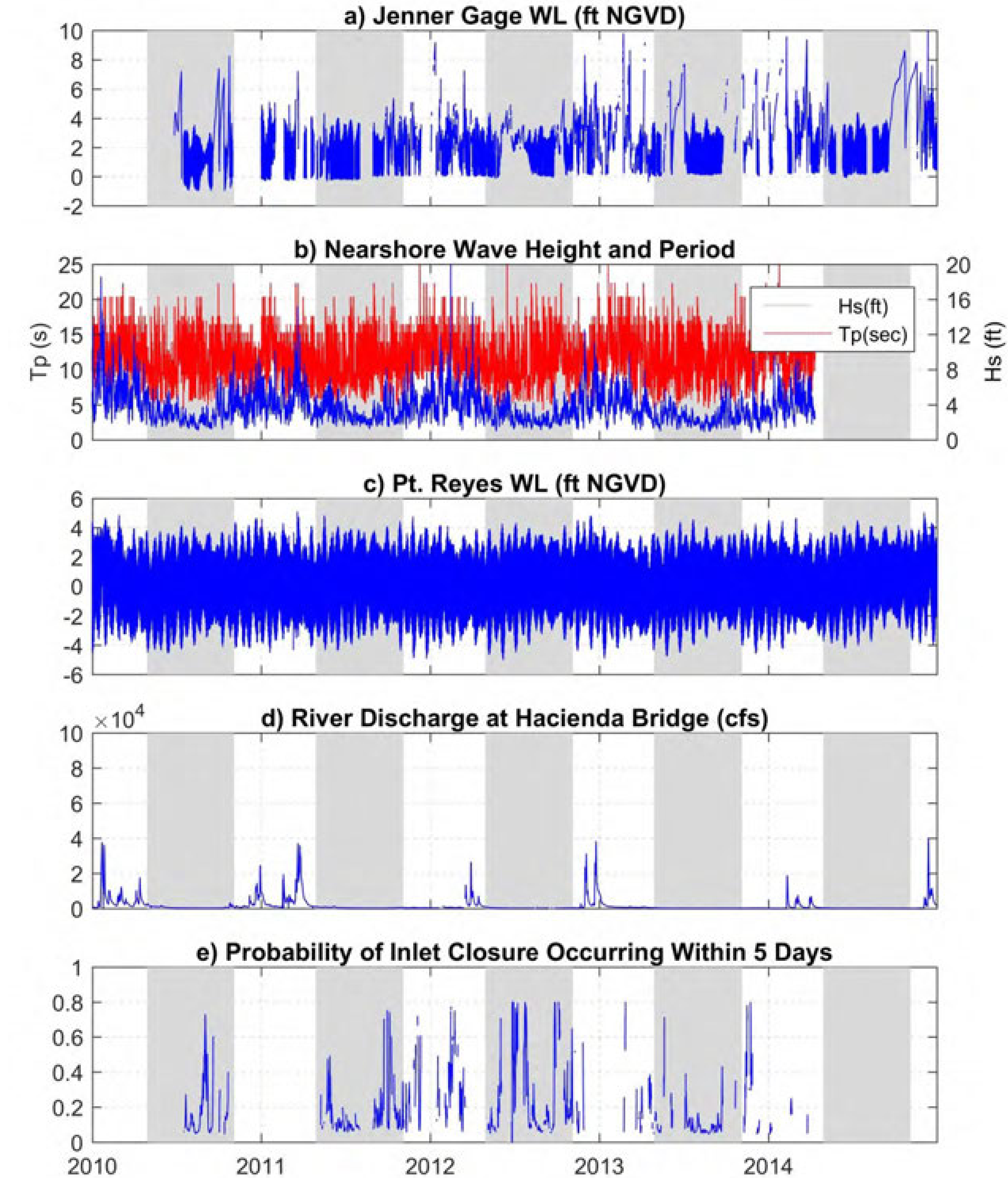


SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

NOTE: grey bands represent management period of May 15-October 15

Figure 3
Estuary, Ocean, and River Conditions Compared with Closure Probability: 2000-2014.



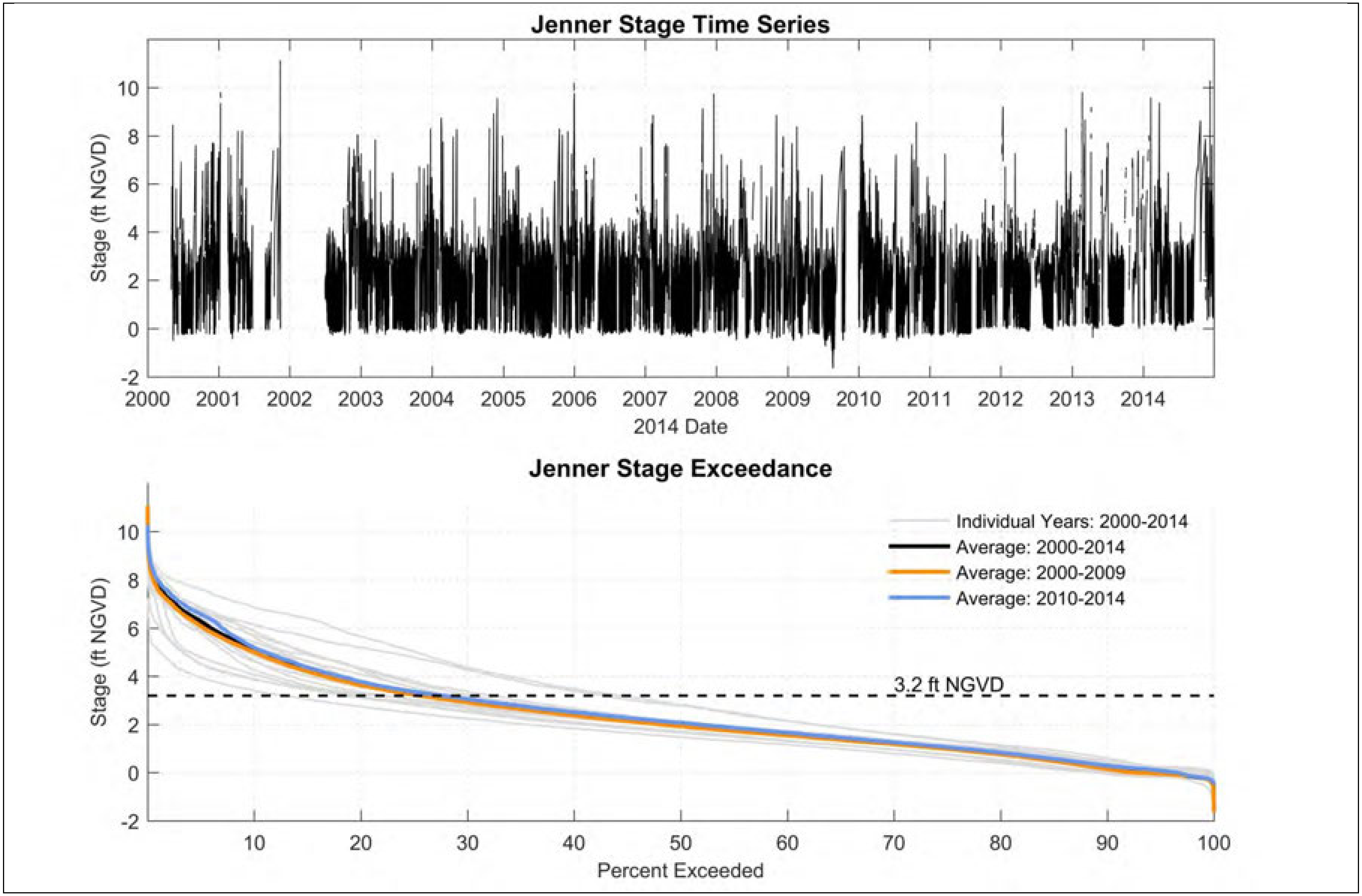
SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

NOTE: grey bands represent management period of May 15-October 15

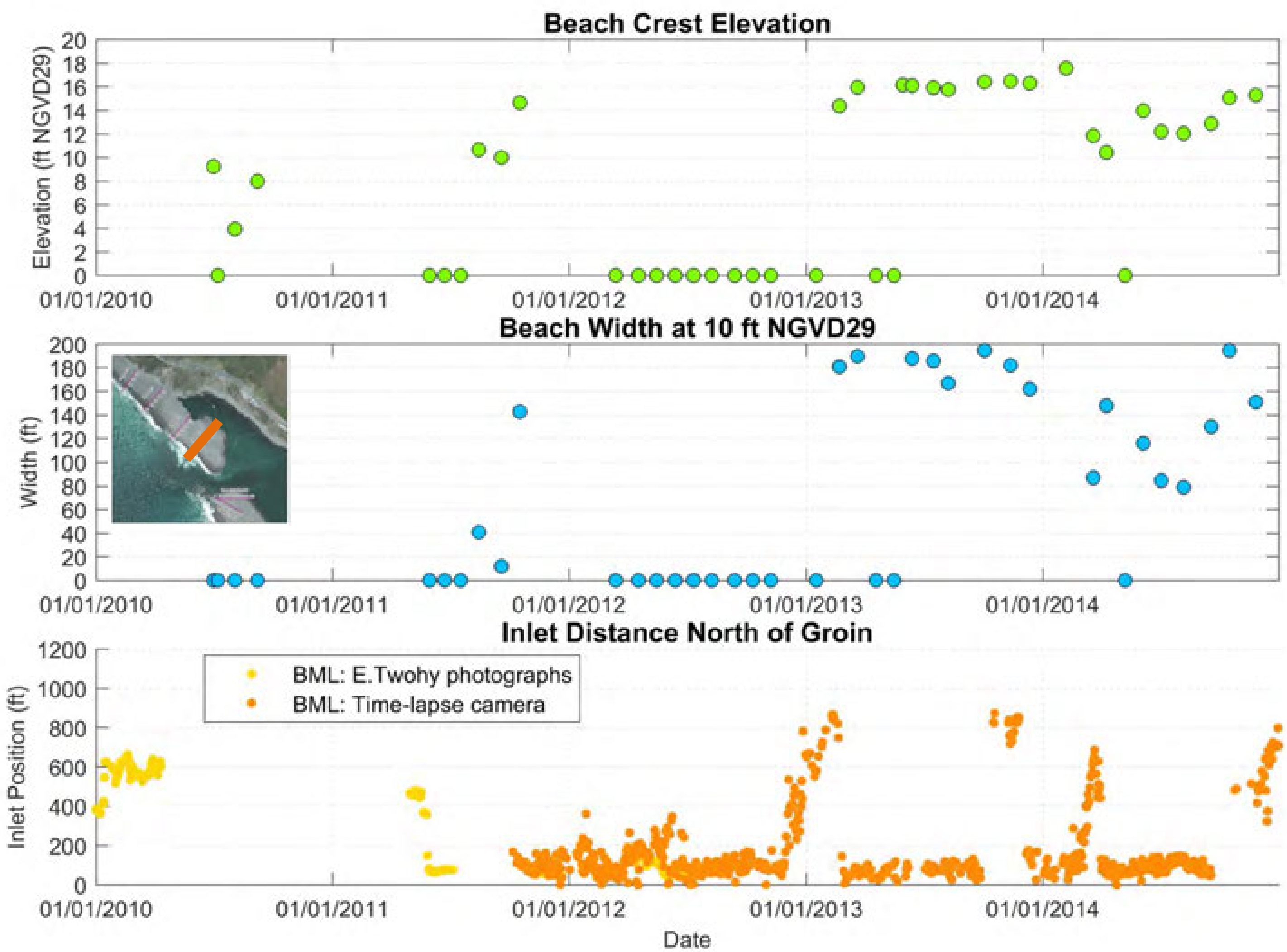
Figure 4

Estuary, Ocean, and River Conditions Compared with Closure Probability: 2010-2014



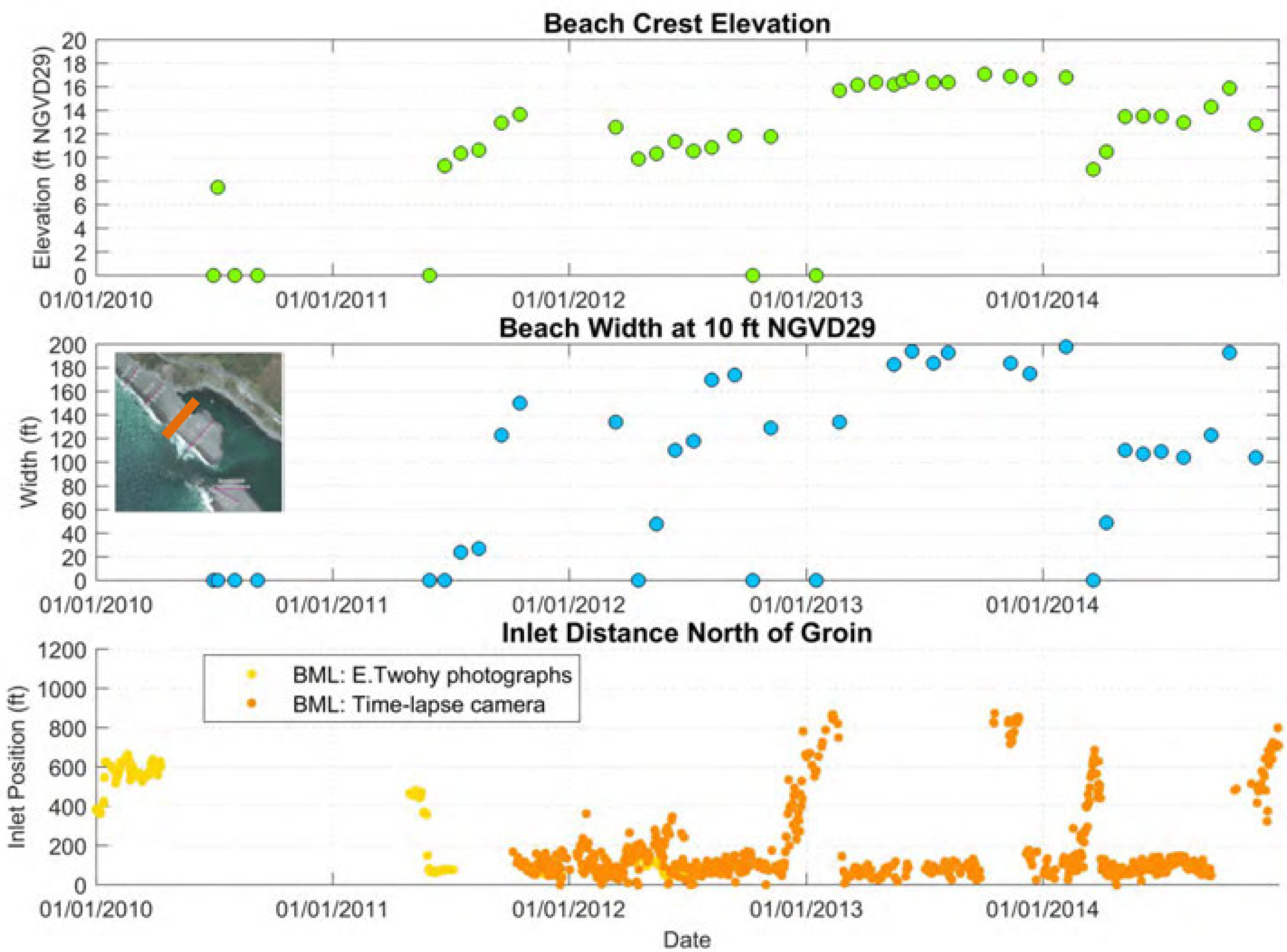
Source: Water Agency Jenner Gage

Figure 5
Russian River Estuary stage **(top)** time series and **(bottom)** exceedance curves.



SOURCE: Water Agency Topographic Surveys, ESA processing of BML camera

Figure 6
Summary of **(top)** monthly beach crest and **(middle)** beach width at Transect 1, measured from Water Agency surveys, compared with **(bottom)** Mouth position.



SOURCE: Water Agency Surveys, ESA processing of BML camera

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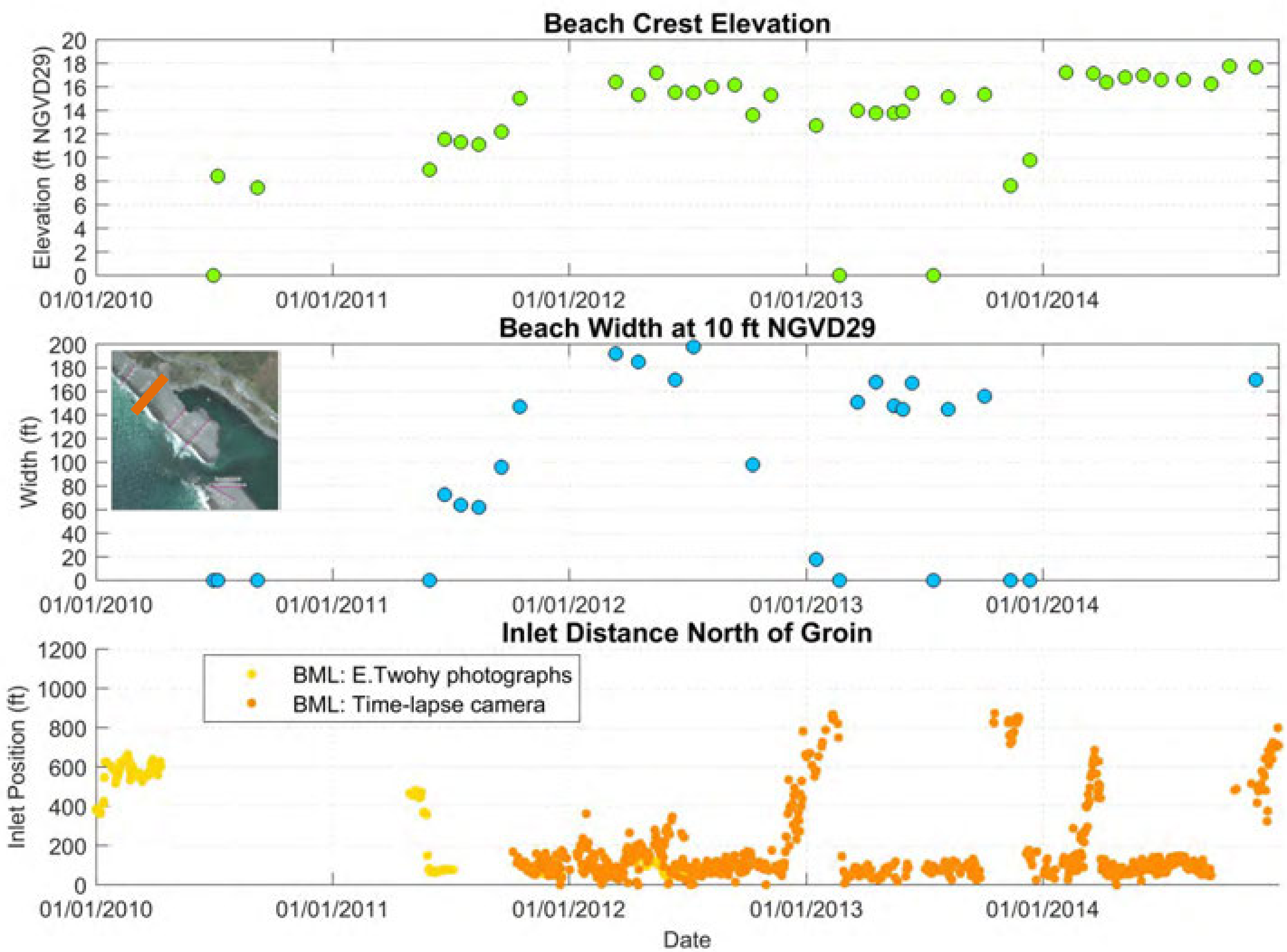
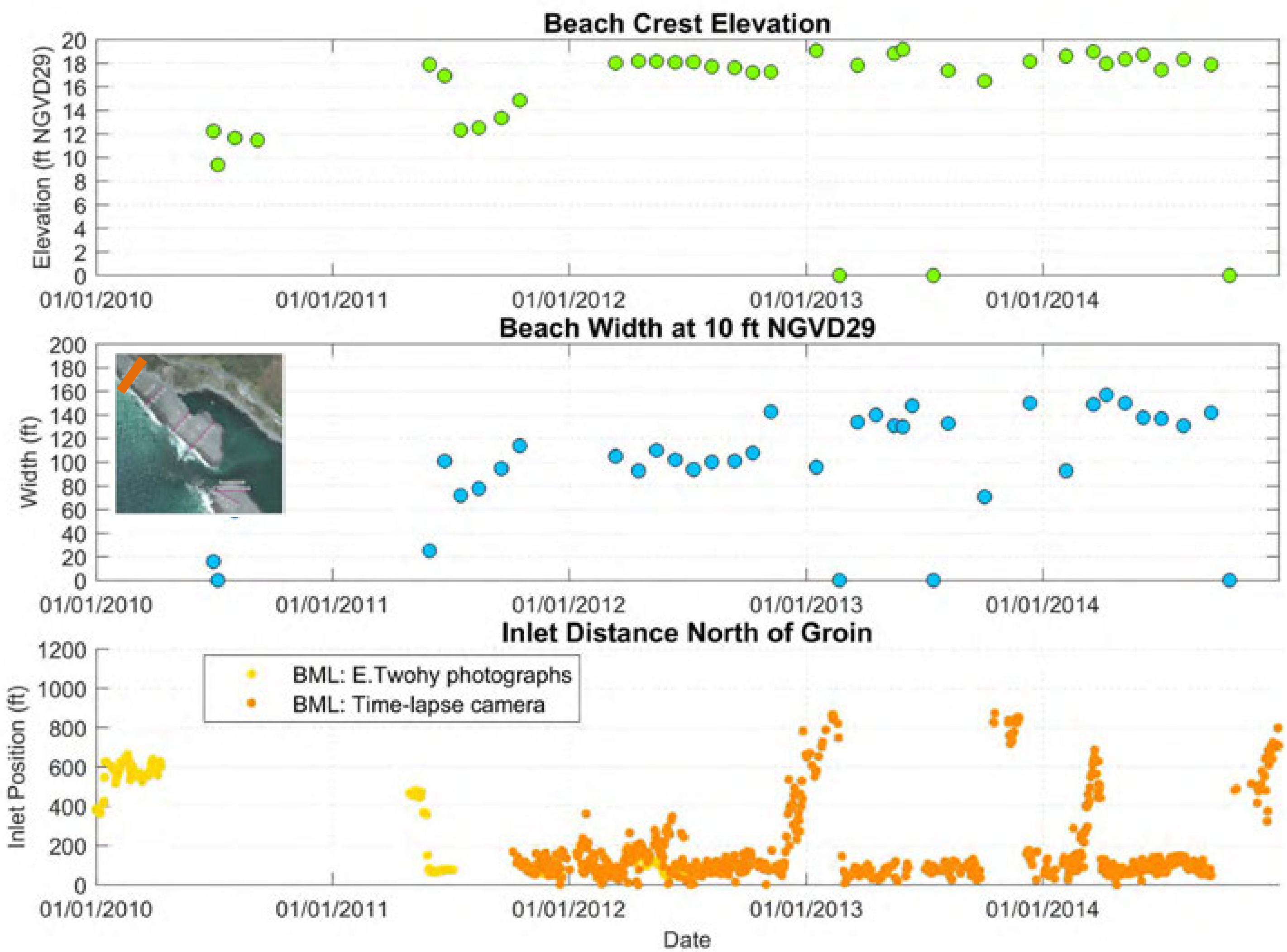
Figure 7
Summary of **(top)** monthly beach crest and **(middle)** beach width at Transect 2, measured from Water Agency surveys, compared with **(bottom)** Mouth position.



SOURCE: Water Agency Topographic Surveys, ESA processing of BML camera

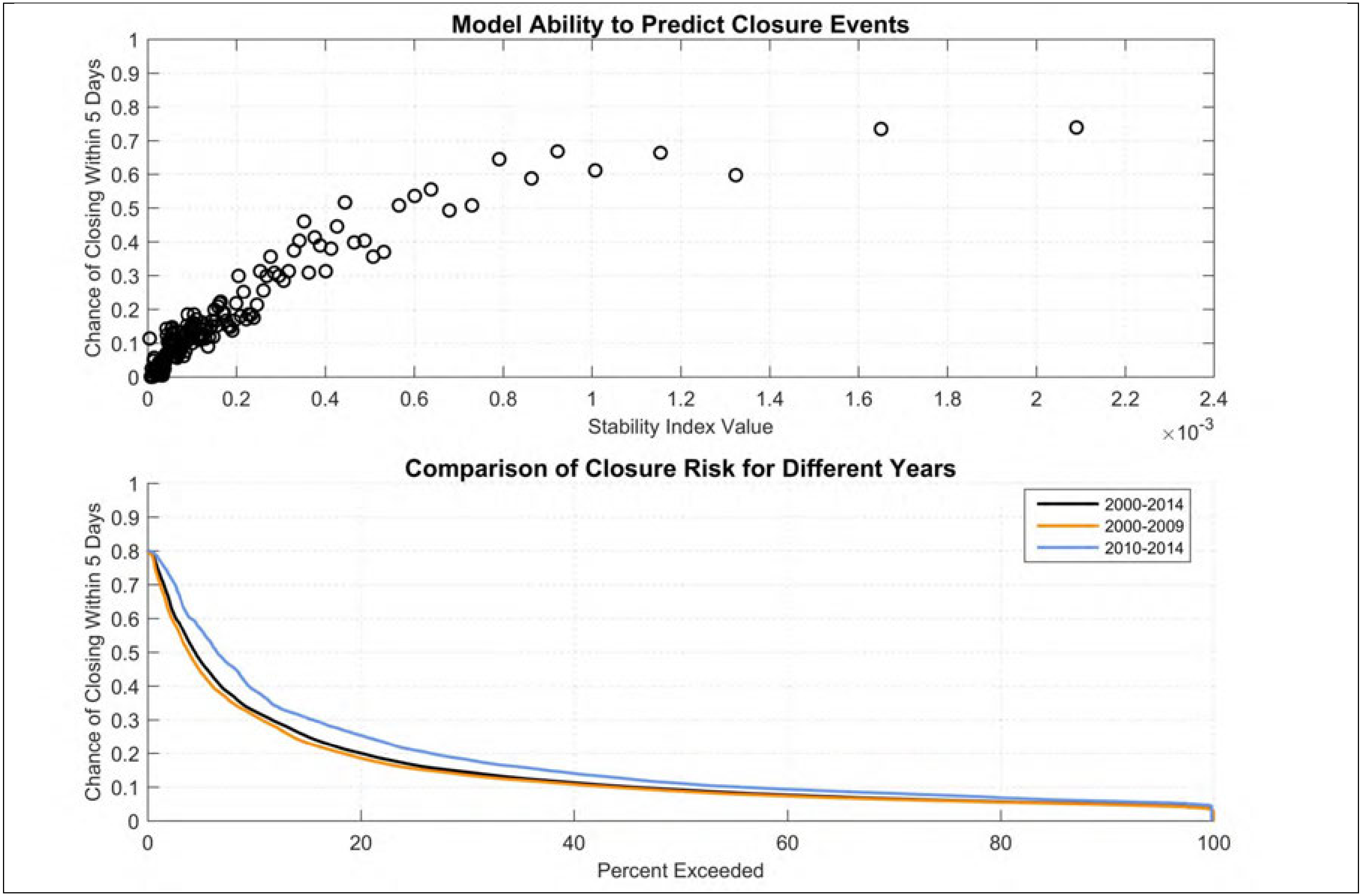
Figure 8

Summary of **(top)** monthly beach crest and **(middle)** beach width at Transect 3, measured from Water Agency surveys, compared with **(bottom)** Mouth position.



SOURCE: Water Agency Topographic Surveys, ESA processing of BML camera

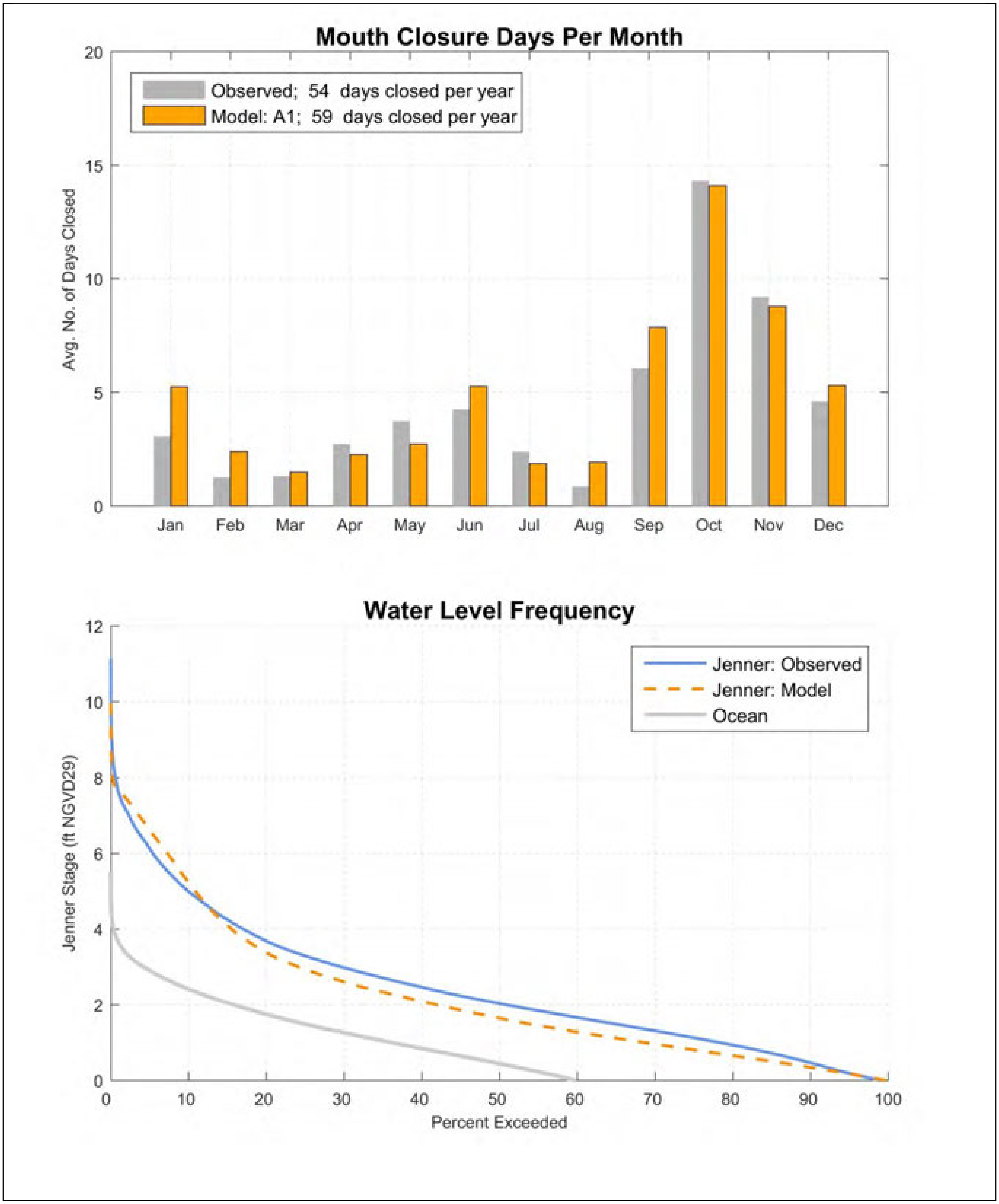
Figure 9
Summary of **(top)** monthly beach crest and **(middle)** beach width at Transect 4, measured from Water Agency surveys, compared with **(bottom)** Mouth position.



NOTE: Behrens et al. (2013) model

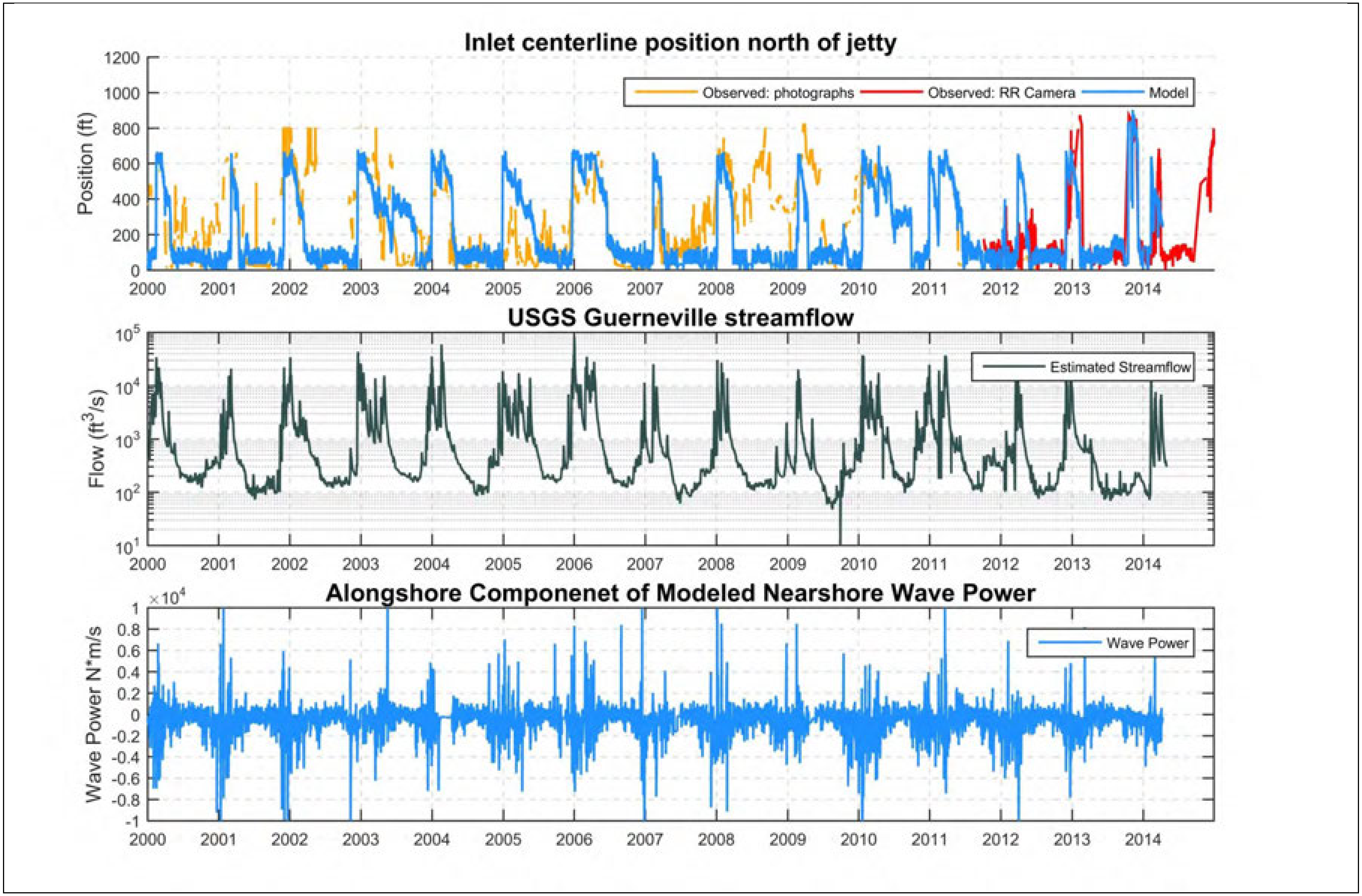
Figure 10

Test of model accuracy **(top)** and comparison of five-day closure risk before and after BO **(bottom).**



SOURCE: ESA Lagoon QCM model

Figure 11
Comparison of modeled and observed number of days closed per month **(top)** and comparison of modeled and observed Jenner stage exceedance **(bottom).**



SOURCE: ESA Lagoon QCM model

Figure 12
Comparison of modeled versus observed mouth position **(top),** compared with river flow **(middle)** and alongshore wave power vector component **(bottom).**

Attachment K. Physical Processes During the 2015 Management Period

As required by the Russian River Biological Opinion, the Sonoma County Water Agency (Water Agency) has been tasked with managing the Russian River Estuary to facilitate summer lagoon conditions to improve salmonid rearing habitat. The goal is to meet this need by creating an outlet channel while also maintaining the current level of flood protection for properties adjacent to the estuary (NMFS, 2008). The adaptive management plan, described in the main body of this report, was developed by the Water Agency with assistance from ESA PWA and the resource agency management team in 2009 and revised annually from 2010 to 2015. Because of permit constraints, the Water Agency was only able to implement the plan beginning in 2010. The revised plan was in effect for 2015, but no opportunities for management action occurred during the 2015 management period.

During the 2015 management period, May 15th to October 15th, Water Agency staff regularly monitored current and forecasted estuary water levels, inlet state, river discharge, tides, and wave conditions to anticipate changes to the inlet's state. Although a 20-day closure event started in late May (Figure 1), the mouth self-breached before an outlet channel could be created. The estuary was then tidal for several months until it closed again in early September for the first of two approximately month-long closures (Figure 2). The closure starting on September 8th self-breached on October 3rd, before water levels could reach 7 ft NGVD29. The closure starting on October 10th lasted until November 2nd, outside of the management period, and ended with artificial breaching (Figure 3). Similar to 2014, the mouth was predominantly closed for the fall season, with only several days of open-mouth conditions between closures (Figure 2).

Prior to the management period, a March 27th-31st closure ended with artificial breaching conducted north of Haystack Rock (Figure 3). After the management period, closures from November 2nd – 5th and November 13th – 23rd also ended with artificial breaching just north of the jetty (Figure 3). A closure event that began on December 2nd led to flooding in Jenner. After the mouth closed, wave overwash and river discharge rapidly increased the water levels in the lagoon. Wave overwash conditions made the beach inaccessible to construction equipment for several days starting on December 8th, thereby preventing artificial breaching. For safety reasons, power was shut off to the Visitor's Center, which also shut down the water level gage. By comparing photographs of the inundated areas with ground survey and LiDAR, ESA estimated that water levels in Jenner reached a peak of approximately 12.25 ft NGVD29 before the estuary self-breached on December 13th.

Even though no outlet channel management was implemented to inform the adaptive management process, the physical conditions and inlet response during the management period are reviewed in this attachment to contribute to site understanding and to inform future management actions.

METHODOLOGY

This review of the 2015 outlet channel management period examines water levels, ocean wave conditions, ocean water levels, riverine discharge, and beach topography, as well as inlet size and location. The sources for these parameters are listed in Table 1. These data were supplemented with personal observations and discussion with staff from the Water Agency, NMFS, CDFW, and the Bodega Marine Laboratory.

In prior years, the Point Reyes buoy provided offshore wave data. In 2015, the Point Reyes wave buoy data were not available during the management season. Data from the next closest CDIP buoy at Cape Mendocino were used instead. The Cape Mendocino buoy data were transformed to estimate nearshore wave estimates at the mouth of the Russian River. The Point Arena data are reported less frequently than the Point Reyes buoy's wave data. Neither buoy was online after mid-September.

Table 1. Data Sources

Parameter	Source
Estuary water level (h_E)	Water Agency Jenner gage
Wave height (H_s), period (T_a), and direction	CDIP Cape Mendocino buoy #094
Ocean water level (h_O)	NOAA Point Reyes #9415020
Russian River discharge (Q_f)	USGS Guerneville #11467000
Beach topography, ft NGVD	Water Agency monthly surveys
Inlet size and location	Water Agency and Bodega Marine Laboratory autonomous cameras

INLET STABILITY PARAMETER AND CLOSURE RISK PROBABILITY

In addition to considering individual parameters, researchers at the Bodega Marine Laboratory have developed a combined parameter to evaluate the stability of the inlet's state, with the aim of predicting closure risk (Behrens et al., 2013). (Note that the inlet stability parameter does not differentiate between full closure and the perched conditions with a small outlet channel. When discussing this parameter, both states are referred to as a 'closure' in that tides are prevented from propagating into the estuary.) The inlet stability parameter presented by Behrens et al. (2013) quantifies the risk of inlet closure based on a sediment balance in the inlet. It considers the daily balance between wave-driven sediment import to the inlet and sediment export driven by tidal fluctuations. The wave-driven import is assessed using nearshore wave estimates derived from a transformation matrix and offshore buoy data (ESA PWA, 2016) and the latter is estimated from tide gage data within the estuary and a stage-storage relation derived from the available bathymetry. Using daily-average values of the stability parameter within the period 1999-2008, Behrens et al. (2013) showed that high-percentile values of the parameter are closely linked to the risk of the inlet closing within five days. As the percentile of the stability parameter increases, the risk of inlet closure within five days increases exponentially, from risks of roughly five percent when the parameter is at the 50th percentile to a risk of 80 percent when it is measured at the 99th percentile.

SUMMER AND FALL CONDITIONS

Time series of estuary water levels, as well as the key forcing factors (waves, tides, and riverine discharge), are shown in Figure 1 for the entire management period. The lagoon water level time series (Figure 1a) summarizes the closure events at the beginning of the management period, as well as the subsequent tidal conditions and later closure events in fall (Figure 2). As shown in Figure 1d, flows at Guerneville dropped to 100 ft^3/s by roughly July 1st, which was more than a month later than in 2014. These higher flows contributed to the rate of water surface elevation increase during the May-June closure event. During this closure, construction equipment access could not access the beach north of the groin due to the lagoon's position and the steep drop-off on the north side of the groin (Figure 4). Therefore, no beach management was scheduled and the lagoon filled to the beach crest and self-breached.

From July to October, flows were mostly below 100 ft^3/s, and dipped below 70 ft^3/s for parts of late July, September and October. As in prior years, wave energy was minimal through the summer months.

Since waves were derived in 2015 from the Point Arena buoy instead of the Point Reyes buoy, and both of these buoys were off-line after mid-September, only a qualitative assessment of the events causing closure in 2015 was made. In prior years, closure events typically coincided with either moderately high waves ($H_s > 6$ ft) having periods greater than 10 s, or with neap oceanic tide ranges of less than approximately 5 ft. The May-June closure event happened during a neap tide cycle but during a period of relatively weak ($H_s < 5$ ft), but long period (~15 sec) waves. Moderately high waves and a neap tide cycle coincided with the closure event that began on September 8th. The persistent closure conditions from September through November are examined in more detail in Figure 5.

As in the years 2012 through 2014, all closure events occurred when the inlet was adjacent to the jetty's groin. In years prior to 2015, this positioning may have prevented perched conditions from arising by shielding this area of the beach from the wave-driven sediment deposition that caused closure, preventing the beach from accreting to a sufficient height to allow the desired outlet channel elevations from being attained. This may have been the case for the May-June and September closure events in 2015 as well.

LATE-SEASON CLOSURE EVENT

During the late-season closure that began with closure on September 8th, inflows were below 100 ft^3/s throughout most of the event, but rose slightly above 100 ft^3/s from September 15th-21st after a rainfall event and the removal of summer dams. Despite this, the lagoon stage remained lower than 7 ft NGVD for almost a month of closure. In contrast to the prolonged September 2014 closure event, no wave overwash events were apparent, and lagoon stage rose slowly throughout

26 days of closure. Like the May-June closure, construction equipment could not access the beach north of the groin during this closure (Figure 4b). The mouth self-breached near the groin on October 4th, at a stage of approximately 6.7 ft NGVD29.

To better illustrate both the lagoon stage and beach morphology during this time, Figure 5 shows a sequence of photos of the inlet before and during this closure event. As was the case for all of the management period, the inlet was located next to the groin. Figure 5a depicts the inlet when it was located next to the groin on the day of closure. Figure 5b-e shows that the beach grew only minimally during the 26-day closure event, setting up a self-breach at less than 7 ft NGVD29.

Unlike the 2012 management period, no natural outlet channels were formed near the groin in 2015. However, as with 2012 and other previous years, the lowest portion of the beach was consistently located at the groin. This persistent low portion is probably caused by wave sheltering by the groin, which may have reduced berm build-up at the inlet's location, leaving a low point in the beach berm that was the site for subsequent overtopping and self-breaching.

CLOSURE RISK PROBABILITY

The 5-day closure risk probability, a derivative of the inlet stability parameter described above, was hindcast for 2015 according to the method described in Behrens et al. (2013). This hindcast provides an indication of the utility of the stability parameter as a prediction tool for monitoring inlet conditions and planning management action. This parameter integrates wave and ocean forcing conditions, as well as estuary water levels, to provide greater predictive skill than just waves or ocean tides on their own. The stability parameter combines these factors, and the corresponding five-day closure risk time series exceeded 50 percent before most 2015 events (Figure 1e). Wave data were not available for the October closure event, so the stability parameter could not be calculated for that event. Otherwise, the predicted probability of closure exceeded 50% 2-5 days in advance of most of the other closures in 2015.

TOPOGRAPHIC CHANGE

The Water Agency has conducted monthly surveys of Goat Rock State Beach that cover a region starting from the groin and extending approximately 1,500 feet to the north. The surveys do not include bathymetry within the inlet because flow conditions in the inlet prevent safe access. Also, the survey extent can be limited by the Water Agency's compliance with its marine mammal incidental harassment authorization, which sets guidelines for the survey crew's approach to marine mammals hauled out on the beach. Water Agency survey staff collect spot elevations using RTK-GPS and then assemble these elevations into a set of contour lines at 1-ft intervals, as well as profiles along the beach berm crest, the ocean wetted edge, and the estuary water line. The survey elevations are reported in the NGVD29 vertical datum.

To characterize beach berm topographic conditions, ESA PWA assessed data from the Water Agency's 2010 (July to September), 2011 (May to October), 2012 (May to October), 2013 (May to October), 2014 (May to October), and 2015 (May to October) surveys. Profiles include two transects backed by cliff (Figure 7and Figure 8), two transects which extend into the estuary (Figure 9 and Figure 10), and two variations on a transect just north of the groin (Figure 11 and Figure 12).

This review focuses on the 2015 surveys, although the 2011 surveys are included for context in some figures. The 2015 topographic data were similar to those of 2012-2014 in that the northernmost profiles underwent little morphologic change during the management season. In 2014 the southernmost profiles underwent more morphologic change than in previous years, similar to the results from the 2010 and 2011 management seasons. This was not the case for 2015, as Figures 9 and 10 show that the beach was mostly stable throughout the management season.

At profiles 3 and 4, the beach is backed by cliff, and typically undergoes morphologic changes when the inlet migrates north during floods and returns south to the groin in spring or summer. In 2010 and 2011, migration in this area led to a sequence of erosion and accretion at these sites during the management period. The erosion seen in those years was associated with inlet migration and subsequent accretion of the beach was associated with long-period swell waves. During the 2012-2014 management seasons, the inlet remained near the groin and did not migrate north, leading to an especially stable profile at Profiles 3 and 4. In 2015, the inlet did migrate to the north during winter floods, but it returned to the groin by February, allowing the beach at the northern end to build up under energetic waves during the spring season before the management period. Thus, the beach shape at Profiles 3 and 4 were as stable as in 2012-2014, albeit for a different reason than in those years. This suggests that the northern portion of the beach will be stable under two cases, (1) if the inlet does not migrate to the north during winter, and (2) if the inlet returns to the groin before winter has ended.

Compared with 2014, Profiles 1 and 2 were much less variable, and were more similar to the conditions seen in 2012 and 2013. At Transect 2 (nearest to Haystack Rock), the beach profile was stable early in the management season, and then grew by several feet from August to October (Figure 9). This type of seasonal growth is apparent in previous years, and is expected as wave energy increases seasonally in the fall. Transect 1 experienced both erosion (July-August) and growth (August-October), as it was more strongly influenced by the inlet throughout the summer. It was lowest in August, when the inlet was fully tidal. Despite the variability shown in Figure 10, the crest was relatively stable between 11.5 and 14 ft NGVD29 throughout the management season.

Transect 0, which is located parallel to the groin, had a stable shape throughout 2015, but the western beach face shifted eastward throughout the management season (Figure 11). This may be a response to steady erosion from the inlet, which was tidal throughout the summer. The crest remained steady at 12-13 ft NGVD29. As shown in Figure 12, Transect 0 typically sees limited change during the management season and larger inter-annual variability.

Beach berm crest profiles have been collected by the Water Agency since 2013. These data make it possible to discern important changes in beach shape along the length of the berm that is north of the groin. Along-beach trends in crest elevation are generally consistent with the along-beach trend of wave energy increasing to the north and the influence of inlet migration and breaching at the south end of this section of beach.

Figure 13 shows that May through September, the change in crest elevation was minimal north of Transect 1. The beach crest was lowest south of Transect 1, where the inlet resided. As shown in Figures 7-11, most of the change to the crest resulted from seasonal beach building by waves in September and October. This may have been further encouraged by the extended closure events during this time.

BEACH WIDTH

To provide additional information about the beach morphology, ESA PWA assessed the beach width using the Water Agency survey data. Figure 14 shows the evolution of the beach width at Transect 3 during the 2012-2015 management periods. Beach width data were added for surveys that occurred outside of the management season. These provide more context for seasonal changes to beach width. In previous years during winter months, the beach was often eroded at Transect 3 to the point that the beach crest was below 12 ft NGVD, so that the width was effectively zero. In 2012 and 2013, apart from this seasonal erosion, there was no marked trend in the beach width. In 2014, the beach was wider than the previous two years, with peak width at the beginning of the management season (Figure 14). In December 2014, the inlet migrated north during winter floods for the first time since 2011. It returned to the groin by February. Although the northern transects (Transects 3 and 4) partially rebuilt due to wave action in spring, the effect of the migration appears to be a lower beach crest and smaller width at Transect 3 than in previous years. The beach width is effectively zero at 14 ft NGVD29 during the 2015 management season because the beach crest was below this elevation.

JENNER STAGE EXCEEDANCE

The Biological Opinion (NMFS, 2008) sets a target for estuary water levels "a daily minimum water surface elevation of 3.2 feet [NGVD] during 70% of the year." To facilitate this target, the Biological Opinion notes "Absent river flood flows and historic mechanical breaching practices, NMFS expects cross shore transport of sand by wave action will be sufficient to maintain the bar at this elevation."

In 2015, the daily minimum water surface elevation exceeded 3.2 ft NGVD roughly 30% of the year (Figure 15). For comparison, Figure 15 also includes hourly lagoon stage (exceeded 3.2 ft NGVD for roughly 40% of the year) and hourly Point Reyes stage (exceeded 3.2 ft NGVD for roughly 5% of the year). This amount of perched conditions results from the inlet maintaining open conditions throughout the summer of 2015. As with several of the years since 2010, lack of closure in July led to prolonged open conditions, as July and August waves were too small to cause closure. As explained in previous annual updates, if the inlet does not close in late spring, it is likely that open-inlet conditions will persist as a result of the seasonally weak waves. Since construction equipment could not access the beach during the 2015 closures, no management activities to facilitate an outlet channel could not be made and the closures ended with self-breaches.

LESSONS LEARNED AND RECOMMENDATIONS

Based on 2015 observations of the estuary, associated physical processes, and the Water Agency's planning for outlet channel management, we note the following lessons about implementing the outlet channel management plan.

CONCEPTUAL MODEL

- The beach north of the inlet remained steady between 11and 15 ft NGVD. This was lower than previous years since the inlet migrated north in early winter and later migrated south to the groin. Near the groin, the berm was lowered by inlet migration when not undergoing beach building.
- The inlet returned to the groin in late winter, much earlier than in most years. This inlet alignment is not common, but has been observed in past years (Behrens et al., 2009).
- Peak annual river discharge has remained below 43,000 ft^3/s for 9 consecutive years, a streak unmatched in the 70-year flow record. This lack of larger fluvial discharge may contribute to the predominant inlet location near the groin.
- The beach width in 2015 at Transect 3 (near Haystack Rock) was less than in 2014. This may suggest that beach width is closely tied to inlet migration – the lack of migration north of Haystack Rock for several years had previously allowed the beach to grow at this end of the littoral cell.

OUTLET CHANNEL FEASIBILITY

- Three mouth closure events occurred within the management season, a 20-day event in late May and early June, a 26-day event in September and October, and an event beginning in early October that extended past the management season. The first two events led to a self-breach. Implementing an outlet channel during these first two closures was not possible because the beach north of the groin was not accessible by construction equipment.
- As noted in previous years, once lagoon water levels reach the low point of the beach crest elevation, the lagoon self-breached. This behavior highlights the susceptibility of a sand bed outlet channel to scour, limiting conveyance capacity. The 2015 management season provided more evidence that the groin may shelter beach just north of the groin, reducing the chance of closure when the inlet is located in the groin's wave shadow. The groin's wave shadow may also limit berm growth, which then maintains a low point for self-breaching.

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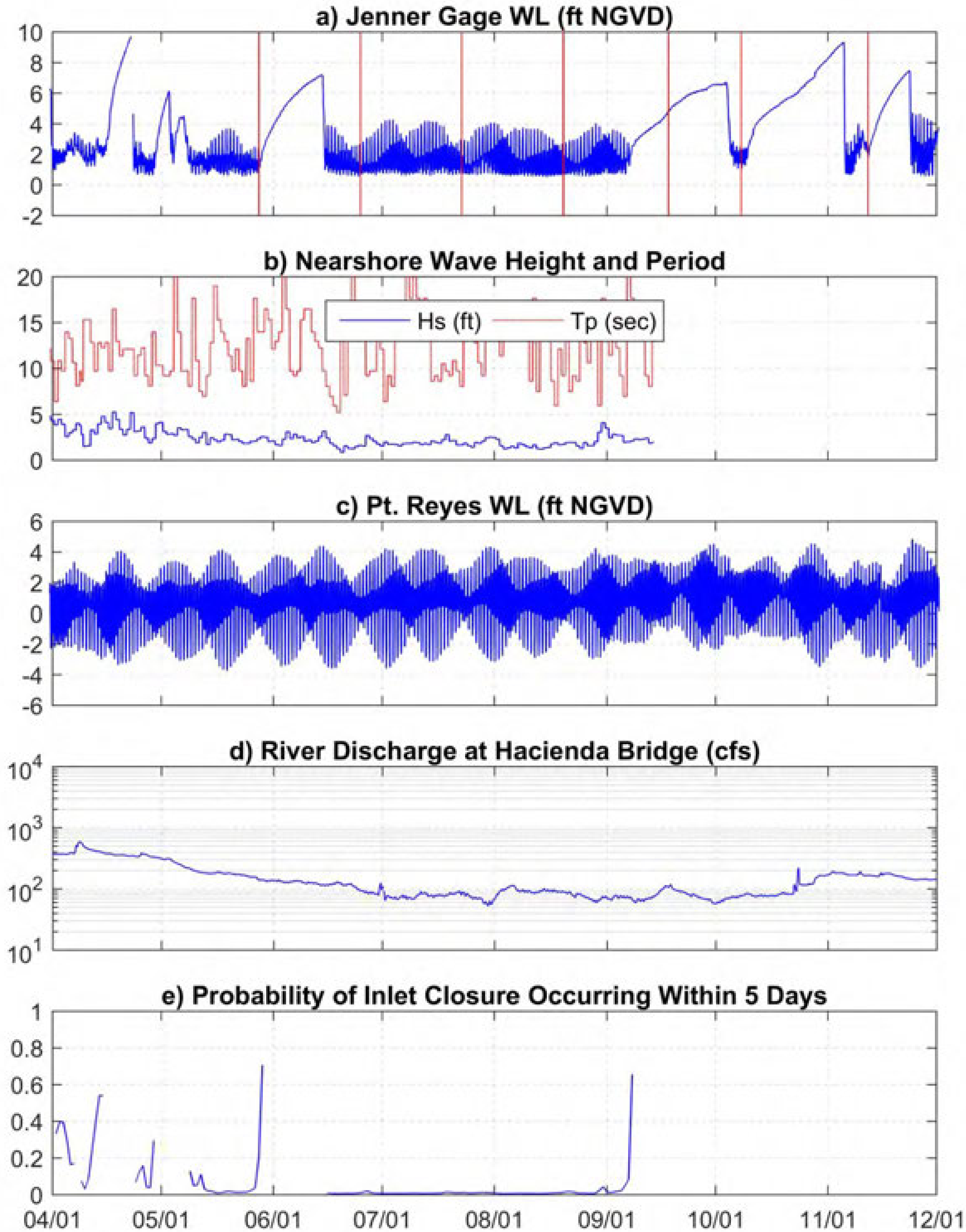
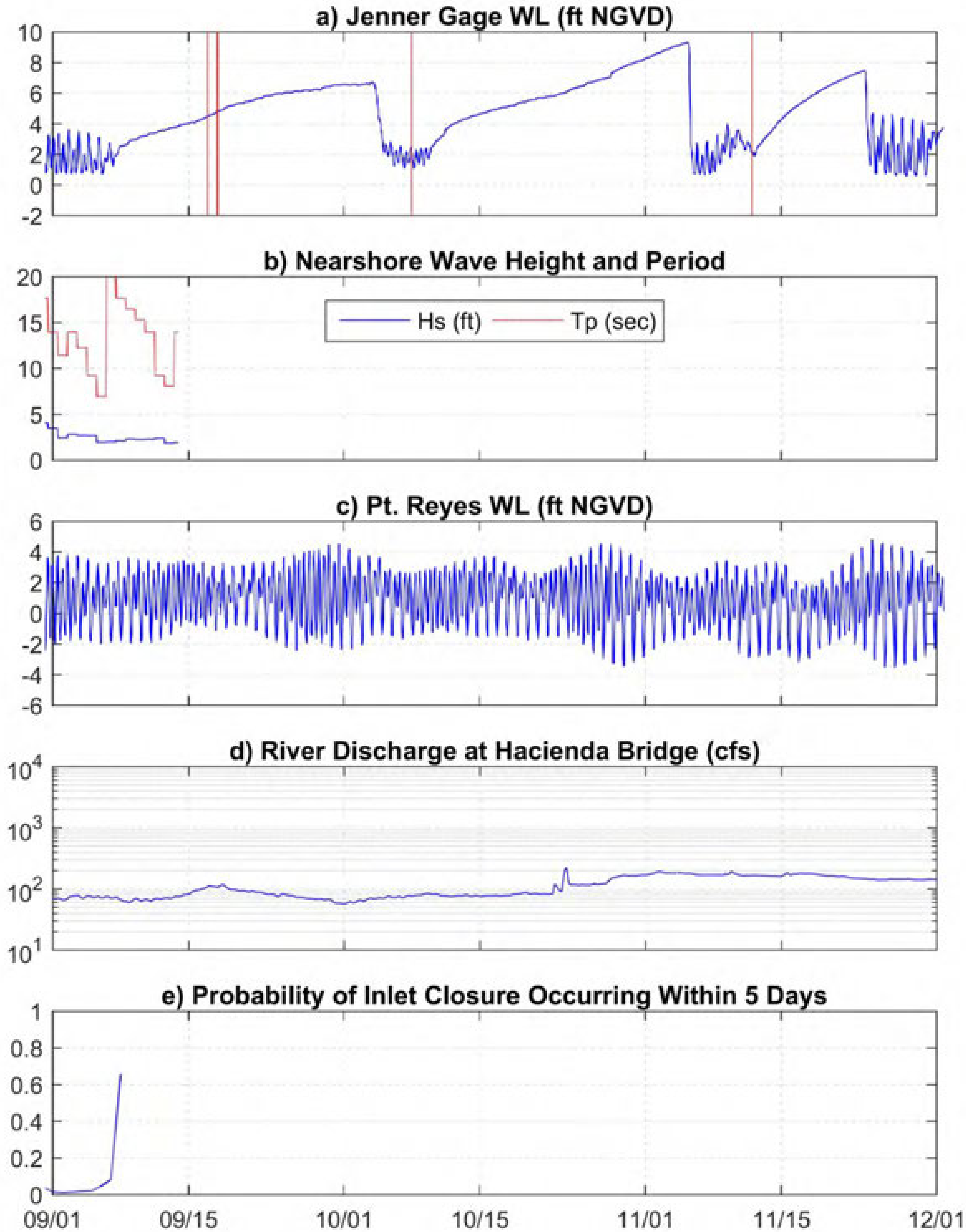


SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

Figure 1
Estuary, Ocean, and River Conditions Compared with Closure Probability: April – November 2015



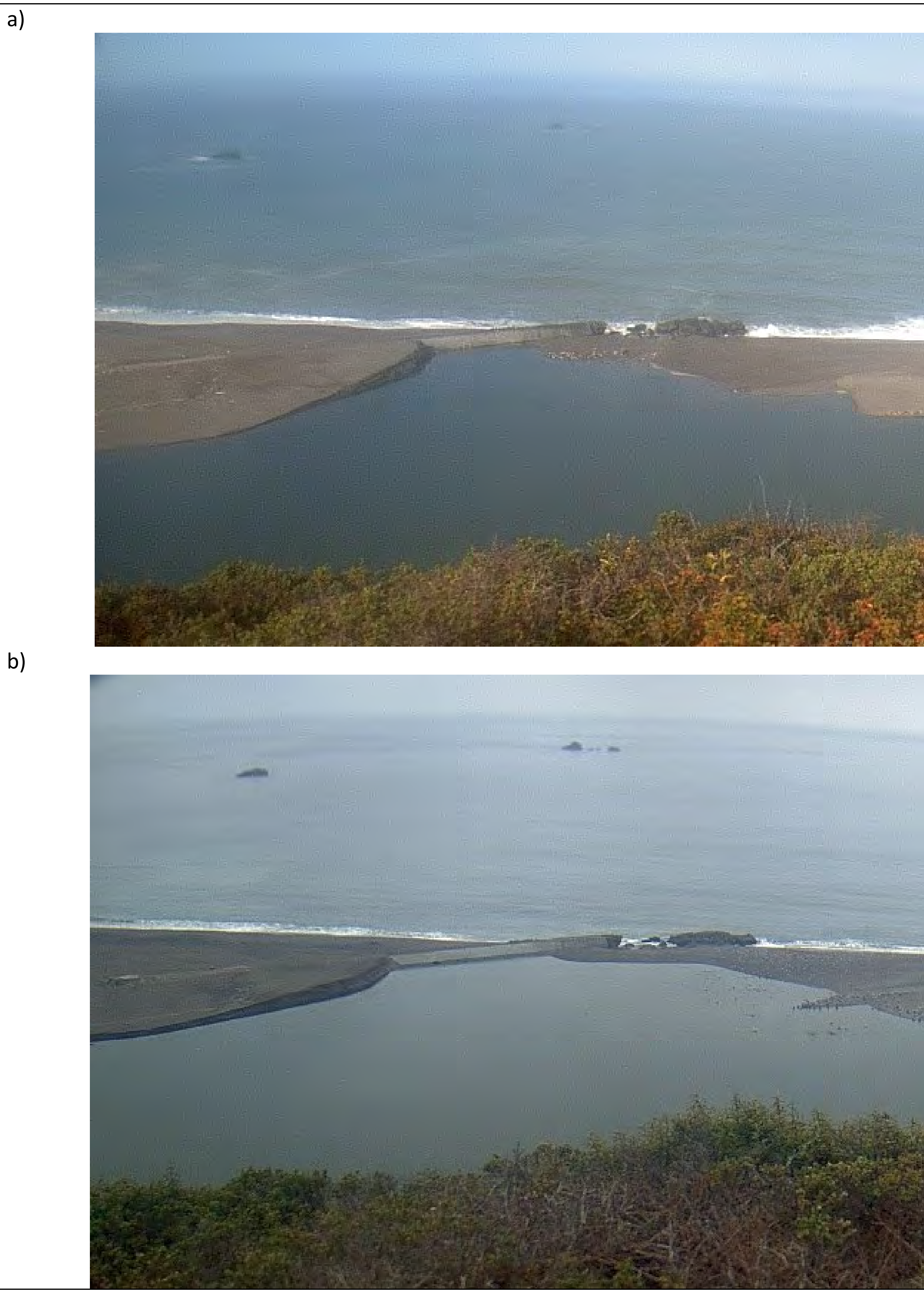
SOURCE:

a) Jenner gage water level provided by SCWA; red bar = beach survey
b) H_s = sig. wave height; Tp=peak wave period (CDIP, Pt. Reyes, #029)
c) Ocean water level provided by NOAA (Pt. Reyes #9415020)
d) River discharge provided by USGS (Guerneville #11467000)
e) Five-day closure probability provided after Behrens et al. (2013)

Figure 2
Estuary, Ocean, and River Conditions Compared with Closure Probability: September – November 2015

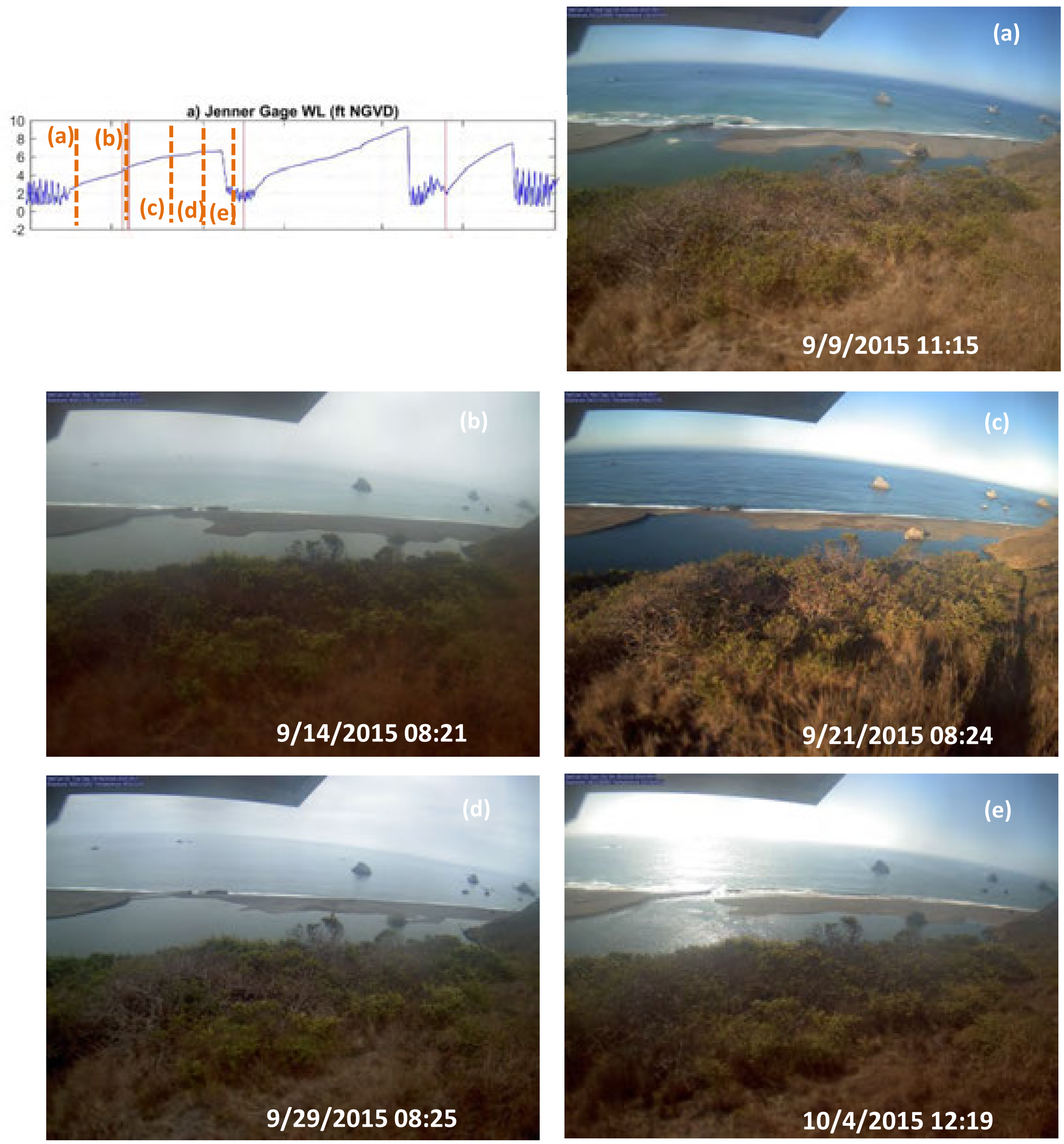
SOURCE: SCWA

Figure 3
General location of pilot channel excavations for artificial breaching



SOURCE: SCWA camera

Russian River Estuary Outlet Channel Management Plan.
DW01958.06 **Figure 4**
Blocked Beach Access During Closures
a) June 4, 2015 b) September 29, 2015



SOURCE: SCWA camera

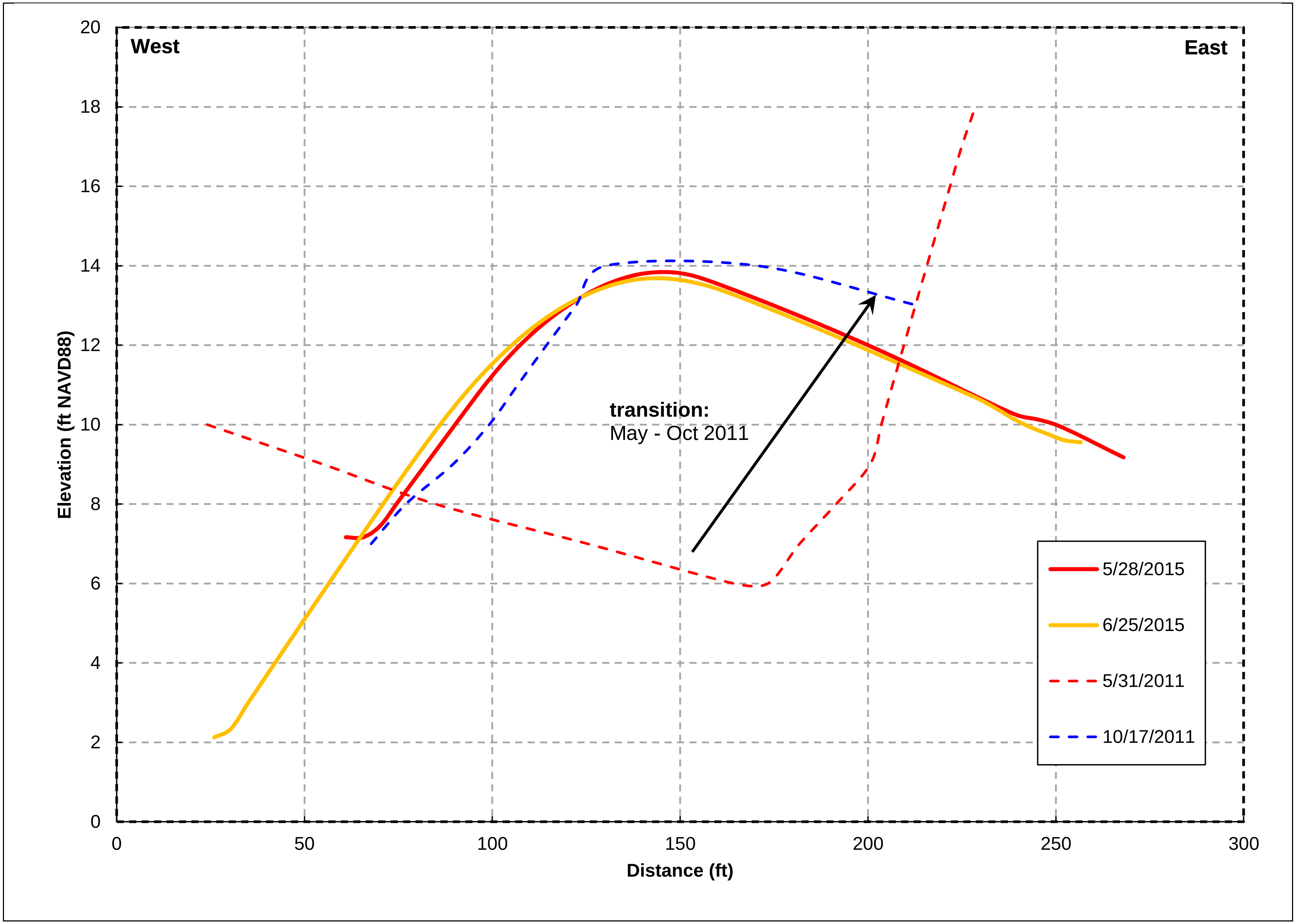
Figure 5
Russian River camera photographs showing some of the key morphologic influences during the September-October 2015 closure event.

SOURCE: image from USDA NAIP

Russian River Estuary Outlet Channel Management Plan . DW01958

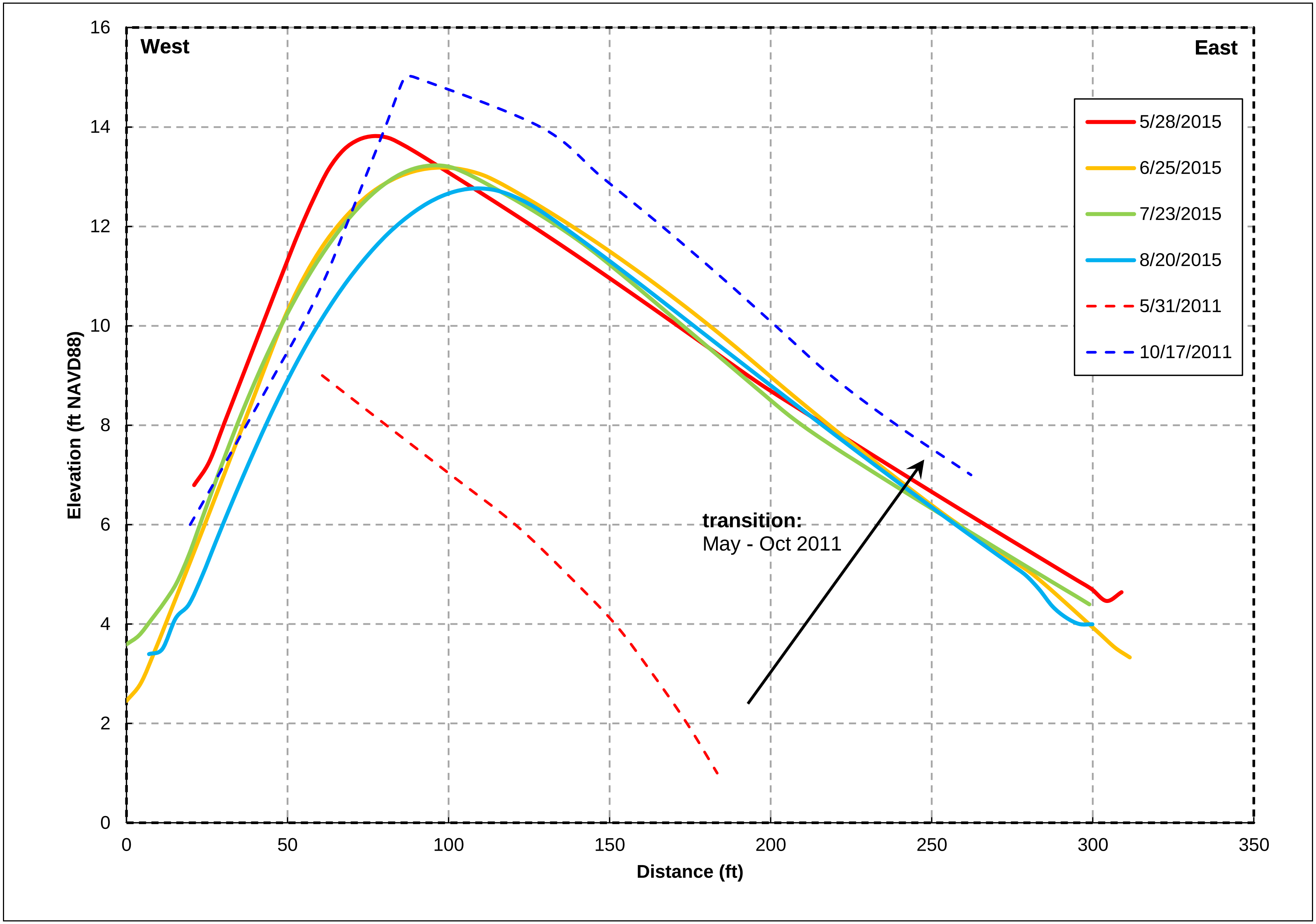
Figure 6

Beach Transect Locations



SOURCE: SCWA survey data

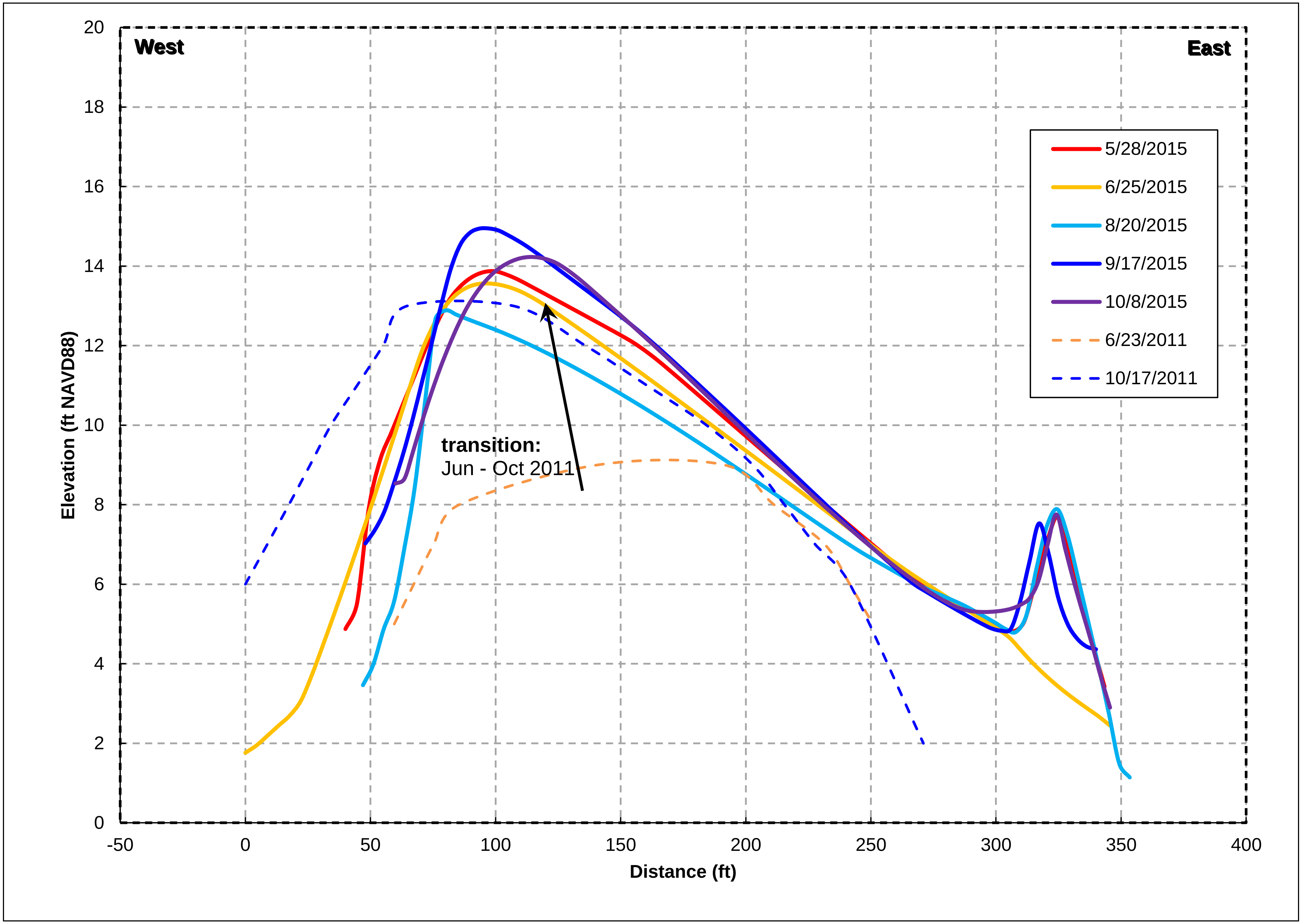
Figure 7
Beach Transect #4



SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 8
Beach Transect #3

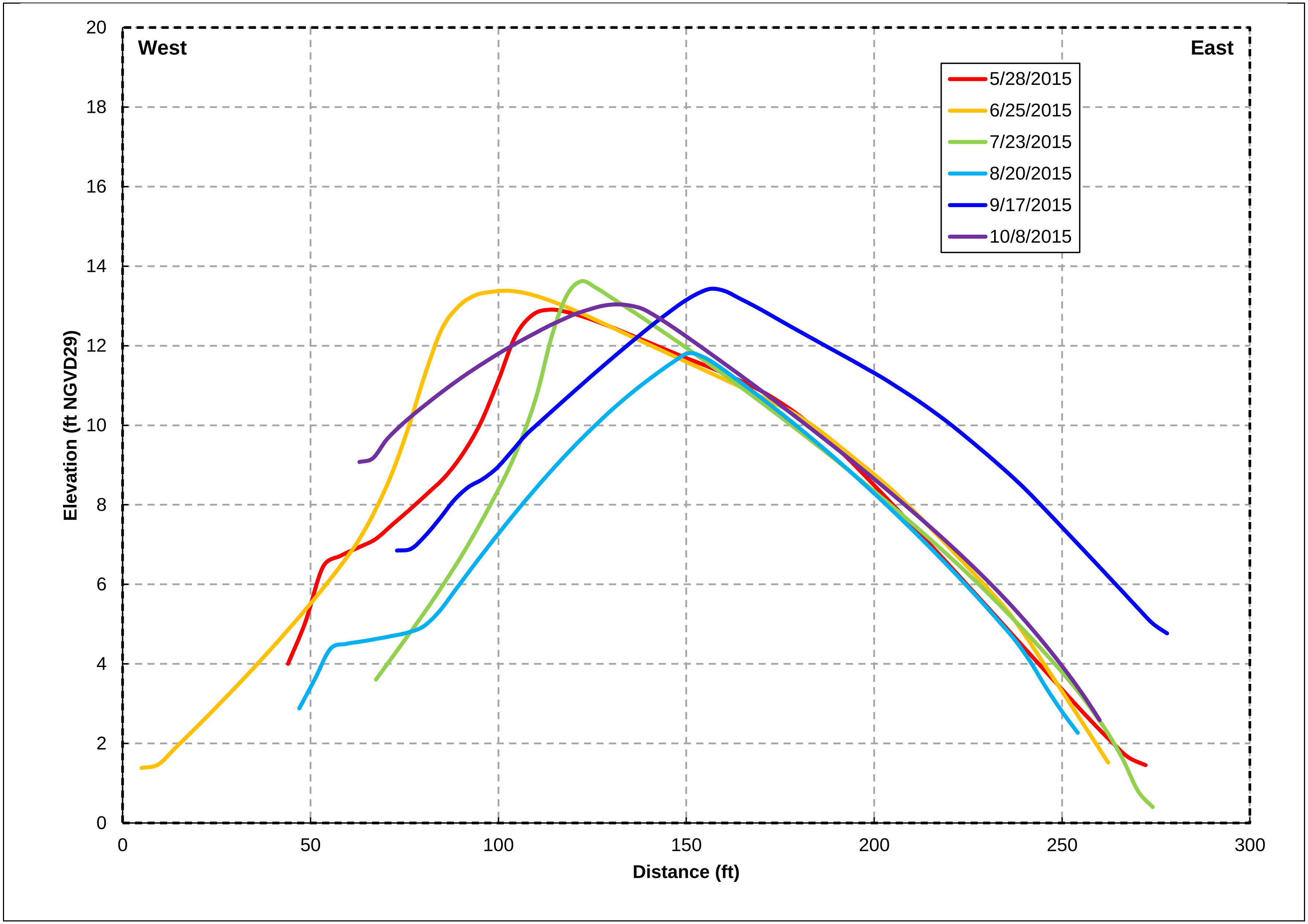


SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 9

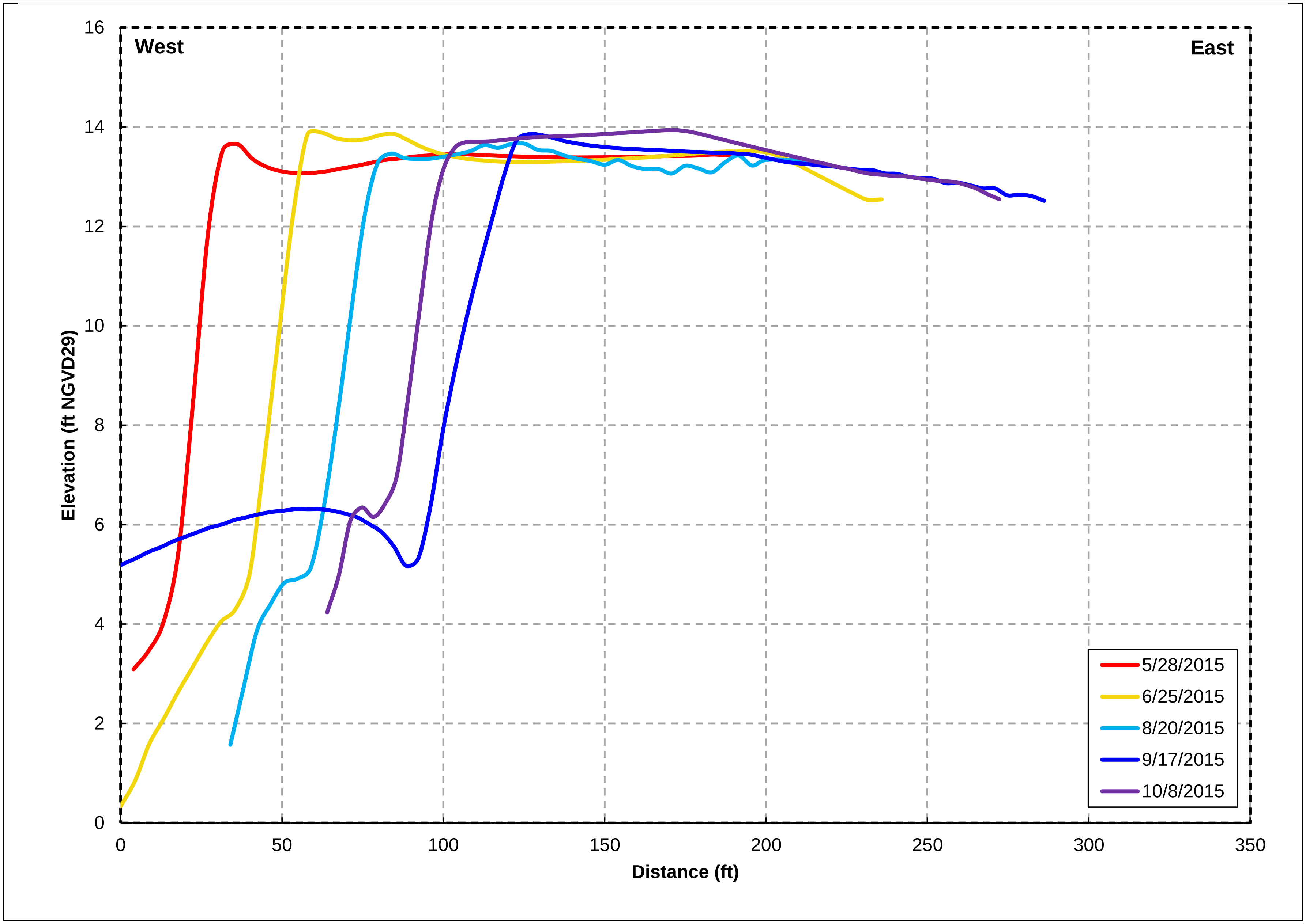
Beach Transect #2



SOURCE: SCWA survey data

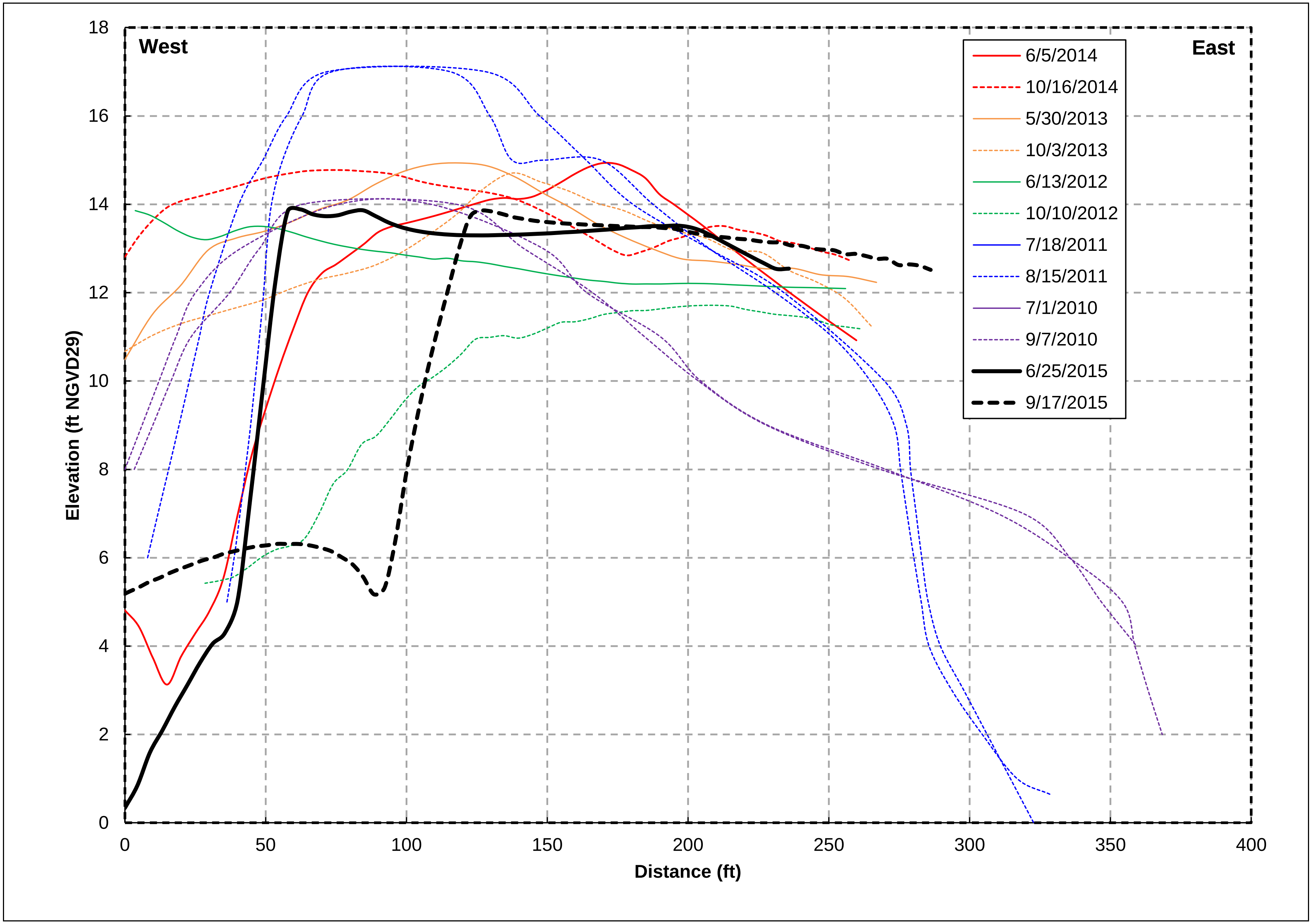
Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 10
Beach Transect #1



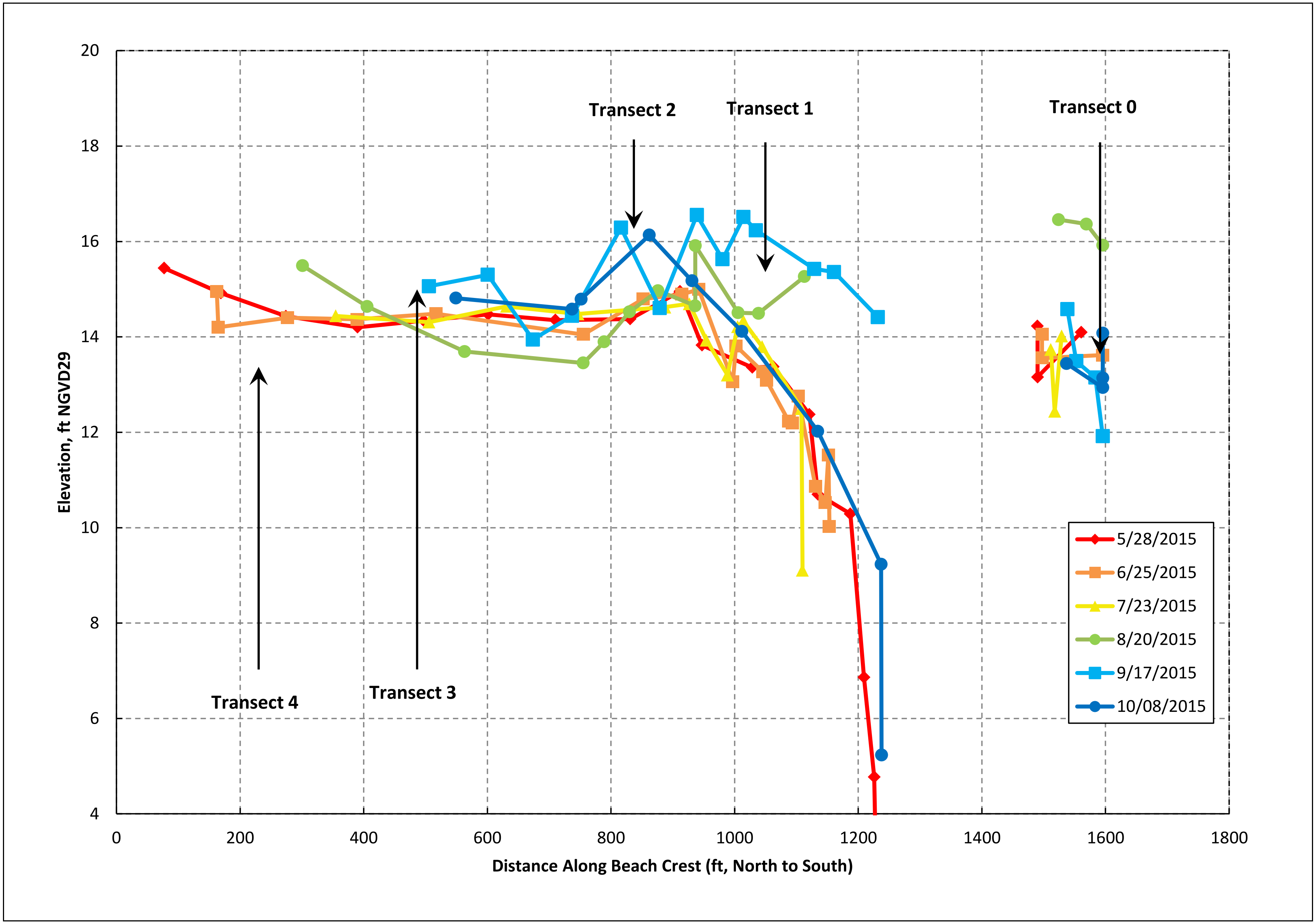
SOURCE: SCWA survey data

Figure 11
Beach Transect #0.



SOURCE: SCWA survey data

Figure 12
Beach Transect #0 from 2010-2015 management periods.

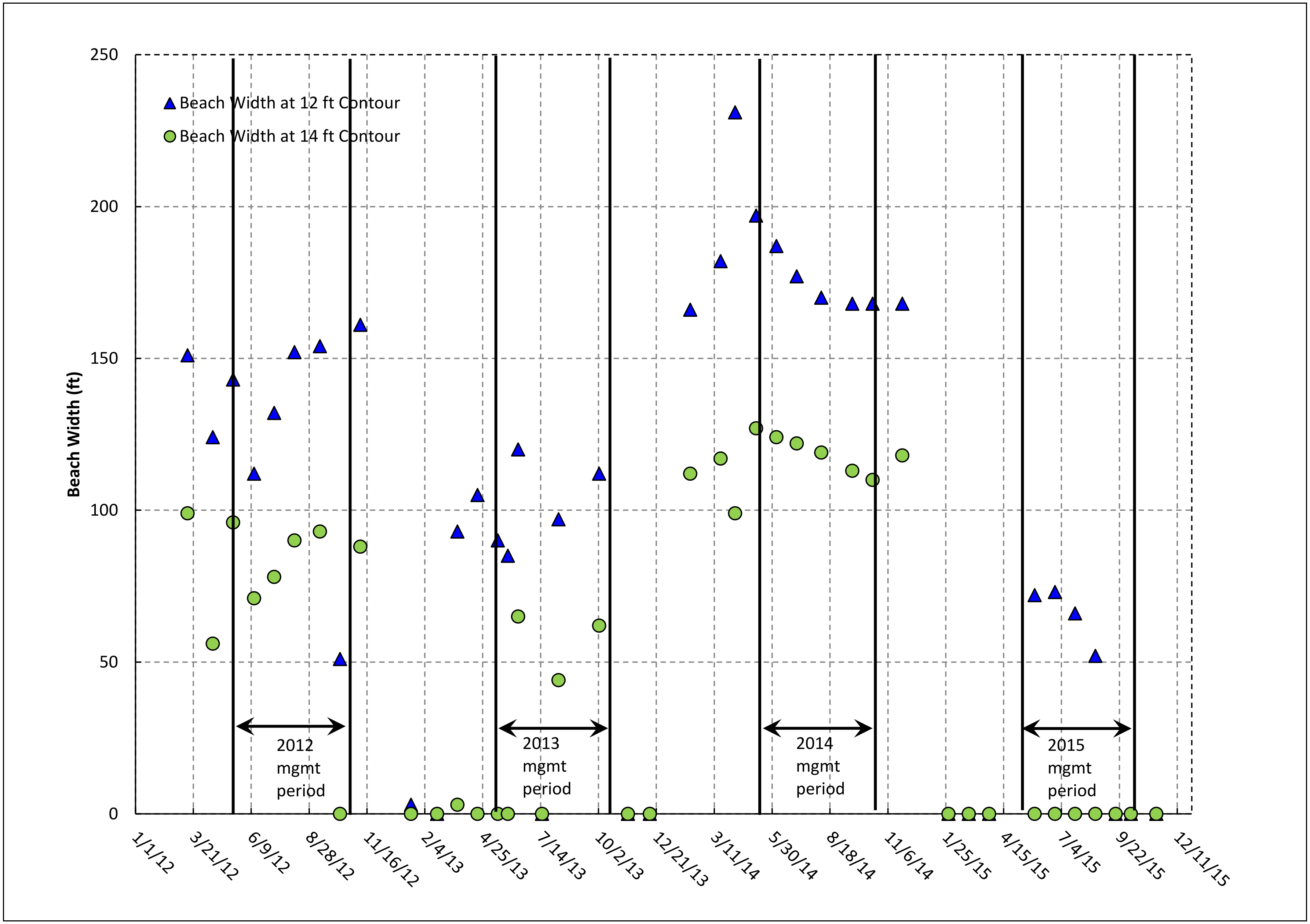


SOURCE: SCWA survey data

Russian River Estuary Outlet Channel Management Plan . DW01958

Figure 13

Beach Crest Profiles During the 2015 Management Period.

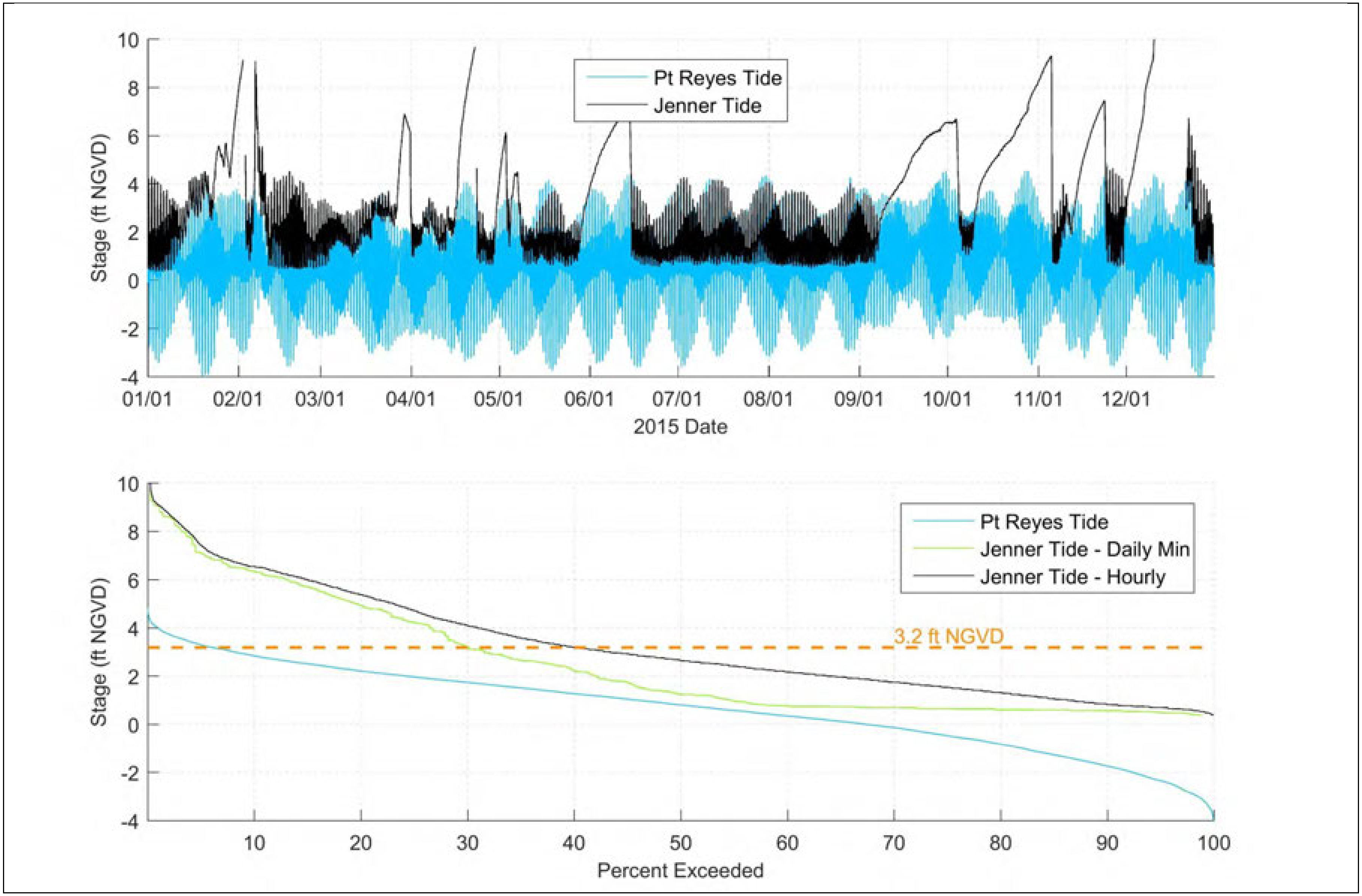


SOURCE: SCWA survey data

NOTE: width of zero indicates that the beach crest is below the elevation of 12 or 14 ft NGVD.

Figure 14

Beach Width During 2012-2015 Management Periods.



SOURCE: SCWA Jenner Gage and NOAA Pt Reyes tide data

Figure 15

Russian River Estuary stage exceedance for 2015.

Appendix 4.4

Russian River Estuary Management Project

Marine Mammal Protection Act Incidental Harassment Authorization
Report of Activities and Monitoring Results – January 1 to December 31, 2015

Prepared for
Office of Protected Resources and
Southwest Regional Administrator
National Marine Fisheries Service

Prepared by
Andrea Pecharich
Jessica Martini-Lamb
Sonoma County Water Agency

January 2016

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EXECUTIVE SUMMARY

The purpose of this report of activities and monitoring results is to comply with the requirements of the Incidental Harassment Authorization (IHA) issued pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C 1361 et seq.) to take small numbers of marine mammals, by Level B harassment, incidental to the Sonoma County Water Agency's (Water Agency) Russian River Estuary Water Level Management Activities (April 20, 2015, NMFS IHA).

The Water Agency applied in 2009 to the National Marine Fisheries Service (NMFS) Office of Protected Resources for an IHA under the Marine Mammal Protection Act (MMPA) for activities associated with water level management activities in the Russian River estuary. NMFS issued an original IHA to the Water Agency on March 30, 2010 and in each subsequent year. This report provides the results of all monitoring of baseline conditions and water level management activities for the 2015 calendar year, and additional summary information for all related activities.

The estuary may close throughout the year as a result of a barrier beach forming across the mouth of the Russian River. Closures result in the formation of a lagoon behind the barrier beach and, as water surface levels rise in the estuary, flooding may occur. The Water Agency's artificial breaching activities are conducted in accordance with the Russian River Estuary Management Plan recommended in the Heckel (1994) study. The purpose of artificially breaching the barrier beach is to alleviate potential flooding of low-lying properties along the estuary. The Water Agency and the U.S. Army Corps of Engineers (Corps) consulted with NMFS under Section 7 of the Endangered Species Act (ESA) regarding the potential effects of their operations and maintenance activities, including the Water Agency's estuary management program, on federally-listed steelhead (*Oncorhynchus mykiss*), coho salmon (*O. kisutch*), and Chinook salmon (*O. tshawytscha*). As a result of this consultation, NMFS issued the Russian River Biological Opinion (NMFS 2008) finding that artificially elevated inflows to the Russian River estuary during the low flow season (May through October) and historic artificial breaching practices have significant adverse effects on the Russian River's estuarine rearing habitat for steelhead trout. The historic method of artificial sandbar breaching, which is done in response to rising water levels behind the barrier beach, adversely affects the estuary's water quality and freshwater depths.

The Biological Opinion (NMFS 2008) concludes that the combination of high inflows and breaching practices impact rearing habitat because they interfere with natural processes that cause a freshwater lagoon to form behind the barrier beach. Fresh or brackish water lagoons at the mouths of many streams in central and southern California often provide depths and water quality that are highly favorable to the survival of rearing salmon and steelhead.

The Biological Opinion's Reasonable and Prudent Alternative (RPA) 2 (NMFS 2008) requires the Water Agency to collaborate with NMFS and to modify estuary water level management in order to reduce marine influence (high salinity and tidal inflow) and promote a higher water surface elevation in the estuary (formation of a fresh or brackish lagoon) for purposes of enhancing the quality of rearing habitat for juvenile (age-0+ and -1+) steelhead from May 15 to October 15 (the lagoon management period). A program of potential, incremental steps are prescribed to accomplish this, including adaptive management of a lagoon outlet channel on the barrier beach.

The Biological Opinion also requires the Water Agency to study the potential influences of an existing jetty at the mouth of the Russian River on water surface elevations in the estuary. In accordance with the Biological Opinion's RPA 2 the Water Agency commissioned a study plan to analyze the effects and role of the existing, remnant Goat Rock State Beach jetty on beach permeability, seasonal sand storage and transport, seasonal flood risk, and seasonal water surface elevations in the Russian River estuary (ESA PWA 2011). Implementation of this study plan began in 2014 and included the installation and maintenance of monitoring wells and geophysical surveys.

Harbor seals (*Phoca vitulina richardsi*) regularly haul out at the mouth of the Russian River (Jenner haul-out). California sea lions (*Zalophus californianus*) and northern elephant seals (*Mirounga angustirostris*) are occasionally observed at the haul-out. There are also several known resting areas in the river at logs and rock piles. The Water Agency applied for an IHA under the MMPA for activities associated with Russian River estuary management activities, which occur in the vicinity of these haul-outs, including:

- excavation and maintenance of a lagoon outlet channel that would facilitate management of a summer lagoon to improve rearing habitat for listed steelhead as required by the Russian River Biological Opinion (NMFS 2008);
- artificially breaching the barrier beach to minimize the potential for flooding of low-lying properties along the estuary;
- biological and geophysical monitoring activities associated with the management actions described above;
- construction and maintenance of monitoring wells on the barrier beach south of the jetty; and
- geophysical surveys conducted at the barrier beach.

Pinniped monitoring was performed in accordance with the requirements of the NMFS IHA issued April 20, 2015, and the Russian River Estuary Management Activities Pinniped Monitoring Plan (Sonoma County Water Agency and Stewards of the Coast and Redwoods 2011).

In an attempt to understand possible relationships between use of the Jenner haul-out and nearby coastal and river (peripheral) haul-outs, several other haul-outs on the coast and in the Russian River estuary were monitored. These haul-outs include North Jenner and Odin Cove to the north, Pocked Rock, Kabemali, and Rock Point to the south, and Penny Logs, Paddy's Rock, and Chalanchawi in the Russian River estuary.

Baseline monitoring was performed to gather additional information about the population of harbor seals utilizing the Jenner haul-out including population trends, patterns in seasonal abundance and the influence of barrier beach condition on harbor seal abundance. Pinniped monitoring was also conducted in relation to Water Agency water level management events (lagoon outlet channel implementation and artificial breaching). Each of the peripheral haul-outs was monitored concurrent with Jenner baseline monitoring and monitoring of water level management activities. Estuary management monitoring occurred during the Water Agency's monthly topographic surveys of the barrier beach, Jetty Study investigations, and biological and physical monitoring of the estuary. The purpose of estuary management monitoring is to record any pinniped disturbances during the above activities.

A barrier beach was formed eleven times during 2015, but only during four of these closure events did the Water Agency artificially breach the sand bar. The Russian River mouth was closed to the ocean for a total of 115 days (or 32%) in 2015, mostly during the fall months. Pinniped monitoring occurred no more than 3 days before, the day of, and the day after each water level management activity.

The Water Agency's biological and physical monitoring activities of the estuary are included in the NMFS IHA. The Water Agency surveys the sandbar (or barrier beach) monthly to collect a topographic map of the beach, as required by the Russian River Biological Opinion. A monitor is present during these surveys to record any disturbances of the Jenner haul-out during the survey. In 2015 the Water Agency completed the Jetty Study Plan (ESA PWA 2011) and a pinniped monitor was present to record any disturbances of the Jenner haul-out, similar to the monthly topographic surveys. Additionally, Water Agency field staff conducting biological and physical monitoring in the estuary recorded any pinnipeds they encountered hauled out and any disturbance to pinnipeds associated with their activities.

The Russian River estuary management and monitoring activities in 2015 resulted in incidental harassment (Level B harassment) of 2,383 harbor seals and 1 California sea lion, well under the total allowed by NMFS IHA. The Russian River estuary management activities in 2014, 2013, 2012, 2011 and 2010 resulted in incidental harassment (Level B harassment) of 2,121, 1,351, 208, 42 and 290 harbor seals, respectively.

INTRODUCTION

The purpose of this report of activities and monitoring results is to comply with the requirements of the Incidental Harassment Authorization (IHA) issued pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act (16 U.S.C 1361 et seq.) to take small numbers of marine mammals, by Level B harassment, incidental to the Sonoma County Water Agency's (Water Agency) Russian River estuary water level management activities (April 20, 2015, NMFS IHA).

The Water Agency applied in 2009 to the National Marine Fisheries Service (NMFS) Office of Protected Resources for an IHA under the Marine Mammal Protection Act (MMPA) for activities associated with water level management activities in the Russian River estuary. NMFS issued an original IHA to the Water Agency on March 30, 2010 and in each subsequent year. This report provides the results of all baseline monitoring, water level management activities, and activities related to the Jetty Study Plan (ESA PWA 2011) for the 2015 calendar year, and additional summary information for all related activities.

BACKGROUND

The Russian River estuary is located about 97 kilometers (km; 60 miles) northwest of San Francisco in Jenner, Sonoma County, California (Figure 1). The Russian River watershed encompasses 3,847 square kilometers (km) (1,485 square miles) in Sonoma, Mendocino, and Lake Counties. The estuary extends from the mouth of the Russian River upstream approximately 10 to 11 km (6 to 7 miles) between Austin Creek and the community of Duncans Mills (Heckel 1994).

The estuary may close throughout the year as a result of a barrier beach forming across the mouth of the Russian River. The mouth is located at Goat Rock State Beach (California Department of Parks and Recreation). Closures result in formation of a lagoon behind the barrier beach and, as water surface levels rise in the estuary, flooding may occur. Natural breaching events occur when estuary water surface levels exceed the capability of the barrier beach to impound water, causing localized erosion of the barrier beach and creation of a tidal channel that reconnects the Russian River to the Pacific Ocean.

The barrier beach has also been artificially breached for decades; first by local citizens, then the County of Sonoma Public Works Department, and, since 1995, by the Water Agency. The Water Agency's artificial breaching activities are conducted in accordance with the Russian River Estuary Management Plan recommended in the Heckel (1994) study. The purpose of artificially breaching the barrier beach is to alleviate potential flooding of low-lying properties along the estuary.

SPECIAL PROJECTS/RUSSIAN RIVER/7104-ESTUARY/EstuaryManage-PinnipedMonitoring.mxd December 9,2015

Pinniped haul-outs at the Russian River Estuary and surrounds.

Figure 1

Biological Opinion and the Estuary

The Water Agency and the U.S. Army Corps of Engineers (Corps) consulted with the NMFS under Section 7 of the Endangered Species Act (ESA) regarding the potential effects of their operations and maintenance activities, including the Water Agency's Estuary Management Program, on federally-listed steelhead (*Oncorhynchus mykiss*), coho salmon (*O. kisutch*), and Chinook salmon (*O. tshawytscha*). As a result of this consultation, NMFS issued the Russian River Biological Opinion (NMFS 2008) finding that artificially elevated inflows to the Russian River estuary during the low flow season (May through October) and historical artificial breaching practices have significant adverse effects on the Russian River's estuarine rearing habitat primarily for steelhead trout. The historical method of artificial sandbar breaching, which is done in response to rising water levels behind the barrier beach, adversely affects the Estuary's water quality and freshwater depths.

The historical artificial breaching practices create a tidal marine environment with shallow freshwater depths and high salinity. Salinity stratification contributes to low dissolved oxygen at the bottom in some areas. The Biological Opinion (NMFS 2008) concluded that the combination of high inflows and breaching practices impacted rearing habitat by interfering with natural processes that form a freshwater lagoon behind the barrier beach. Fresh or brackish water lagoons at the mouths of many streams in central and southern California often provide depths and water quality that are highly favorable to the survival of rearing salmon and steelhead.

The Biological Opinion's Reasonable and Prudent Alternative (RPA) 2 (NMFS 2008) requires the Water Agency to collaborate with NMFS to modify estuary water level management to reduce marine influence on the estuary (tidal inflow and high salinity) and to promote a higher water surface elevation in the estuary to form a fresh or brackish lagoon to enhance rearing habitat for juvenile (age-0+ and -1+) steelhead from May 15 to October 15 (the lagoon management period). The Biological Opinion outlines a program of potential, incremental steps to accomplish this, including adaptive management of a lagoon outlet channel on the barrier beach.

In accordance with the Biological Opinion's RPA 2 the Water Agency commissioned a study plan to analyze the effects and role of the existing, remnant Goat Rock State Beach jetty on beach permeability, seasonal sand storage and transport, seasonal flood risk, and seasonal water surface elevations in the Russian River Estuary (ESA PWA 2011). Implementation of this study plan began in March 2014 and included the installation and maintenance of monitoring wells and geophysical surveys.

Harbor seals (*Phoca vitulina richardsi*) regularly haul out at the mouth of the Russian River (Jenner haul-out) (Figure 1). California sea lions (*Zalophus californianus*) and northern elephant seals (*Mirounga angustirostris*) are occasionally observed at the haul-out. There are also several known resting sites in the river at logs and rock piles in the estuary (Figure 1). The Water Agency applied for an IHA under the MMPA for activities associated with Russian River estuary management activities, including:

- excavation and maintenance of a lagoon outlet channel that would facilitate management of a summer lagoon to improve rearing habitat for listed steelhead as required by the Russian River Biological Opinion (NMFS 2008);
- artificially breaching the barrier beach to minimize the potential for flooding of low-lying properties along the estuary;
- biological and geophysical monitoring activities associated with the management actions described above;

- construction and maintenance of monitoring wells on the barrier beach south of the jetty; and
- geophysical surveys conducted at the barrier beach.

The purpose of the Russian River Estuary Management Project Pinniped Monitoring Plan (Sonoma County Water Agency and Stewards of the Coast and Redwoods 2011) is to detect the response of pinnipeds to estuary management activities at the Russian River estuary. Specifically, the following questions are of interest:

1. Under what conditions do pinnipeds haul out at the Russian River estuary mouth at Jenner?

2. How do seals at the Jenner haul-out respond to activities associated with the construction and maintenance of the lagoon outlet channel and artificial breaching activities?

3. Does the number of seals at the Jenner haul-out significantly differ from historic averages with formation of a summer (May 15th to October 15th) lagoon in the Russian River estuary?

4. Are seals at the Jenner haul-out displaced to nearby river and coastal haul-outs when the mouth remains closed in the summer?

METHODS

Monitoring was performed in accordance with the requirements of NMFS IHA issued April 20, 2015, and the Russian River Estuary Management Project Pinniped Monitoring Plan (Sonoma County Water Agency and Stewards of the Coast and Redwoods 2011).

Water Agency biologists and Stewards of the Coast and Redwoods (Stewards) volunteers and staff monitored pinnipeds at Jenner and peripheral haul-outs. The Stewards and Water Agency provide annual training for all volunteers; the most recent training occurred on February 24, 2015. Water Agency biologists participating in the monitoring program also attended the training session. The training agenda covered:

- the Marine Mammal Protection Act;
- anticipated IHA monitoring requirements;
- the Russian River Estuary Management Activities Pinniped Monitoring Plan and monitoring methods therein, including completion of data sheets;
- field identification of pinnipeds of the California coast, including harbor seals, California sea lions, Steller sea lions, northern elephant seals, northern fur seals and Guadalupe fur seals;
- field identification of neonates (pups less than 1 week old);
- care and use of field equipment (e.g. cameras, spotting scopes, binoculars); and
- field visits to each haul-out monitoring location.

Twice monthly baseline monitoring of the Jenner haul-out was shared by Water Agency biologists and trained Stewards volunteers (each group monitored once a month), with Stewards volunteers monitoring the peripheral haul-outs for all baseline surveys. Monitoring of water level management activities (lagoon outlet channel and artificial breaching) at the Jenner haul-out was also shared, but Water Agency biologists monitored artificial breaching activities on the day of the event (no lagoon outlet channel activities occurred in 2015). Pre-breaching and post-breaching monitoring was shared by the organizations depending on the availability of volunteers and Water Agency staff. Water Agency biologists also monitored pinnipeds during monthly topographic surveys of the beach, Jetty Study investigations, and biological and physical monitoring of the estuary.

Baseline

Baseline monitoring was performed to gather information about the population of harbor seals utilizing the Jenner haul-out including population trends, patterns in seasonal abundance and the influence of barrier beach condition on harbor seal abundance. Baseline monitoring of the peripheral haul-outs was completed concurrently with the monitoring of the Jenner haul-out. Baseline counts were scheduled for two days out of each month with the intention of capturing a low and high tide each in the morning and afternoon. Weather conditions were recorded at the beginning of each survey. These included temperature, visibility, ocean conditions (Beaufort scale) and wind speed. Tide levels and estuary water surface elevations were correlated to each monitoring day.

Jenner Haul-out Use

Pinnipeds at the Jenner haul-out were surveyed twice monthly. Surveys began at local dawn and continued for 8 hours. All pinnipeds hauled out on the beach were counted every 30 minutes from the overlook on the bluff along Highway 1 adjacent to the haul-out using binoculars or a high-powered spotting scope. Depending on time of year and how the sandbar is formed, harbor seals may haul out in multiple groups. At each 30-minute count, the observer would indicate where groups of seals are hauled out on the sandbar (e.g. Site A, Site B mapped on datasheet) and provide a total count for each group.

Pupping Season

Adults and pups were counted separately through June, after which it became difficult to differentiate between age classes. All neonates (less than 1 week old) were also recorded and were identified using one or more of the following characteristics: less than 15 kg, thin for their body length, an umbilicus or natal pelage present, wrinkled skin, awkward or “jerky” movement. If any potentially abandoned pup was observed during monitoring, the Water Agency would contact the NMFS stranding response network (Marine Mammal Center in Sausalito, CA) immediately and report the incident to NMFS’ Southwest Regional Office and NMFS Headquarters within 48 hours. Monitors were instructed not to approach or move the pup. Monitors used the following potential indications that a pup may be abandoned: no observed contacts with adult seals, no movement of the pup, and the pup’s attempts to nurse were rebuffed.

Peripheral Haul-out Use

To understand possible relationships between use of the Jenner haul-out and nearby coastal and river (peripheral) sites, monitoring occurred at several other sites on the coast and in the Russian River estuary (Figure 1). These sites include North Jenner and Odin Cove to the north; Pocked Rock, Kabemali, and Rock Point to the south; Penny Logs, Paddy’s Rock, and Chalanchawi in the estuary. These areas are known harbor seal sites that have been monitored by Joe Mortenson for over 25 years. The peripheral sites were visited for 10 minutes four times during each baseline monitoring day. All pinnipeds hauled out during the 10 minutes were counted from the same vantage points using a high-powered spotting scope or binoculars.

Disturbance of Seals

In addition to the count data, disturbances of seals on the haul-outs were recorded. The methods for recording disturbances followed those in Mortenson (1996). Disturbances were recorded on a three-point scale that represents an increasing seal response to the disturbance (Table 1). The time, source, and duration of the disturbance, as well as an estimated distance between the source and seals, were recorded.

Table 1. Levels of pinniped response to disturbance used for Russian River Estuary Management Project pinniped monitoring. For permitting purposes a "take" or Level B harassment would include only moving or flight responses.

Level	Type of Response	Definition
1	Alert	Seal head orientation in response to disturbance. This may include turning head towards the disturbance, craning head and neck while holding the body rigid in a u-shaped position, or changing from a lying to a sitting position.
2	Moving	Movements away from the source of disturbance, ranging from short withdrawals over short distances to hurried retreats many meters in length.
3	Flight	All retreats (flushes) to the water, another group of seals, or over the beach.
SOURCE: Mortenson, J. 1996. Human interference with harbor seals at Jenner, California, 1994-1995. Prepared for Stewards of Slavianka and Sonoma Coast State Beaches, Russian River/Mendocino Park District. July 11, 1996.		

Water Level Management Activities

Pinniped haul-outs were monitored during Water Agency water level management events (lagoon outlet channel implementation and artificial breaching). Peripheral haul-outs were monitored concurrently with the Jenner haul-out during water level management activities. This provided an opportunity to investigate possible correlation between water level management activities and number of seals using these nearby haul-outs. Since the movements of individual seals are not tracked, the number of seals displaced from the Jenner haul-out to the peripheral haul-outs cannot be quantified; however, potential trends may be observed.

The monitoring methods for water level management activities followed a deliberate pattern. To begin, a one-day, pre-event survey was made within 1 to 3 days prior to all water level management events. On the day of the management event, pinniped monitoring began at least one hour prior to the crew and equipment accessing the beach work area and continued during the duration of the event until at least one hour after the crew and equipment left the beach. Monitoring continued on the day following each water level management event to document the number of seals utilizing the haul-outs. Methods followed the count and disturbance monitoring protocols described in the "Baseline" section above.

Prior to each breaching or lagoon outlet channel implementation, the Water Agency monitor participated in the onsite tailgate safety meeting to discuss the location(s) of pinnipeds at the Jenner haul-out that day and methods of avoiding and minimizing disturbances to the haul-out as outlined in NMFS IHA.

Biological and Physical Monitoring

The NMFS IHA also provides incidental take for Level B harassment of pinnipeds that may result from monitoring of biological resources and physical processes in the estuary. Water Agency field staff record the presence of pinnipeds hauled out in the estuary in the vicinity of their activities and record any resulting disturbances. The Russian River Biological Opinion also requires monthly topographic surveys of the sandbar at the mouth of the Russian River. A Water Agency biologist was present during topographic surveys to provide guidance to the survey crews on minimizing disturbance of the haul-out and to observe pinniped response to the survey work in the vicinity of the Jenner haul-out. Beginning on May 30, 2013, the methods for conducting the monthly topographic surveys of the barrier beach changed. Due to the frequent and prolonged river mouth closures there was an increased need to gather complete information about the topography and berm crest elevation of the beach to best inform water level management activities. This necessitated the survey crew to access the entire beach, including any area where seals were hauled out. Provided that no neonates or nursing pups were on the haul-out, the survey crew approached the haul-out slowly on foot and allowed for the seals to gradually vacate the beach before the survey proceeded. A pinniped monitor was present for all of these surveys and carefully documented the seals' response and total number of animals disturbed.

RESULTS

The NMFS IHA (April 20, 2015) requires the following information be provided in this report:

(a) the number of seals taken, by species and age class (if possible)
(b) behavior prior to and during water level management events
(c) start and end time of activity
(d) estimated distances between source and seals when disturbance occurs
(e) weather conditions (e.g., temperature, wind, etc.)
(f) haul-out reoccupation time of any seals based on post activity monitoring
(g) tide levels and estuary water surface elevation
(h) seal census from bi-monthly and nearby haul-out monitoring
(i) specific conclusions that may be drawn from the data in relation to the four questions of interest in SCWA's Pinniped Monitoring Plan, if possible

Estuary water surface elevations are recorded at the Jenner gauge (operated by the Water Agency), located at the State Parks visitor center in the town of Jenner. Appendix A includes the estuary water surface elevations associated with pinniped monitoring in 2015, including baseline, water level management events and estuary management investigations.

Baseline

In 2015 a total of 24 baseline surveys, 10 beach topographic surveys, 4 breaching surveys, 8 pre-breaching, 4 post-breaching and 1 jetty study survey were conducted (Appendix A). One baseline survey also functioned as a post-breaching survey and one post-breaching survey also functioned as a pre-breaching survey. In April a scheduled breaching event and a beach topographic survey were canceled due the presence of harbor seal neonates on the beach. In December a scheduled breaching event and a topographic survey were cancelled due to dangerous, high wave conditions. Two other breaching events were canceled when the barrier beach opened due to natural forces prior to the scheduled breach.

Jenner Haul-out Use

Peak seal abundance, as measured by the single greatest count of harbor seals at the Jenner haul-out, was on July 9 (548 seals). Using the average number of seals hauled out by month, seal abundance at Jenner was greatest in July (mean = 373 ± 10.3 s.e., n = 35; Unequal N HSD multiple comparisons test, $p < 0.001$) (Figure 2). Seal abundance was lowest in October (mean = 33 ± 7.6 s.e., n = 22) compared to all other months except September and November (Unequal N HSD multiple comparisons test, $p < 0.001$) (Figure 2). When compared to previous years combined, there were significantly more seals at the Jenner haul-out in June and July (Unequal N HSD multiple comparisons test, $p < 0.05$).

While it is difficult to separate the effect of river mouth condition (closed versus open) from time of year, fewer seals are present during closed conditions (mean = 49.3 ± 2.62 s.e., n =969) compared to open conditions (mean = 139.1 ± 1.60 s.e., n=2,590; ANOVA $p<0.001$). However, the overall trend was an increase in seal abundance compared to earlier years (Figure 3). The influence of mouth condition remains when the effect of season is considered (Figure 4) (Unequal N HSD multiple comparisons test, $p < 0.001$).

Pupping Season

Pups have been observed at the Jenner haul-out as early as March (SCWA 2012, 2013). In 2015 the first pups were observed on April 8, with the latest observation of pups occurring on June 11 (the last neonate was observed on April 28). Pups are counted during surveys through June, after which time it becomes difficult to distinguish pups from sub-adult seals. No distressed or abandoned pups were reported by Water Agency or Stewards monitors in 2015.

Pup production at the Jenner haul-out was 18.7% of adult seals as calculated from the peak pup count recorded on April 28 and the number of adult harbor seals present at the same time. Pup production decreased slightly since last year when 23.2% of adult seals was reported. However, the average number of pups observed (when pups were present) during April and May was up slightly for 2015: 16.4 pups compared to 13.9 pups in 2014.

Peripheral Haul-out Use

In addition to monitoring harbor seal abundance at the Jenner haul-out, eight coastal and estuary haul-outs were monitored. Similar to previous years, most of these peripheral haul-outs had very low seal abundance with three sites averaging less than one seal (North Jenner = 0.3, Penny Logs = 0.1, Paddy's Rock = 0) and three sites averaging less than 4 seals (Odin Cove = 2.8, Chalanchawi = 1.3 and Pocked Rock = 3.3), as observed during baseline surveys. The two southernmost coastal haul-outs included in our monitoring surveys, Kabemali and Rock Point, had the highest abundance of seals with a baseline average of 7.1 and 9.3 respectively. Seasonal increases in seal abundance were most apparent at Odin Cove, Kabemali, and Rock Point, where seal abundance peaked during May and June for Odin Cove and Kabemali; June, October and November for Rock Point (Table 2).

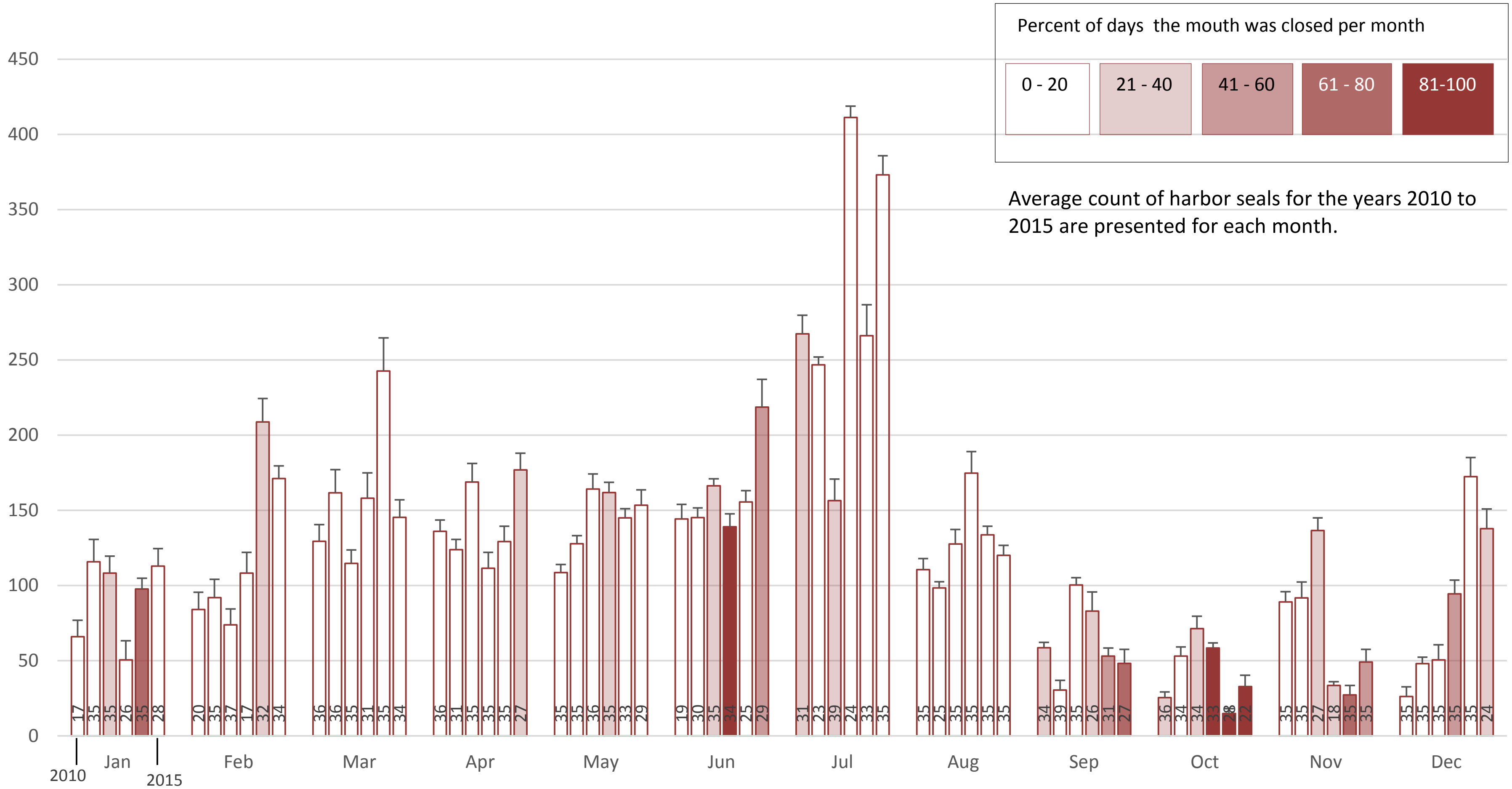

Figure 2. The average number of harbor seals hauled out at the Jenner haul-out (Russian River mouth at Goat Rock State Beach) as counted during baseline surveys for each year (January 2010 – December 2015) categorized by month. Error bars represent standard error and sample size used to calculate means are presented inside the bars.

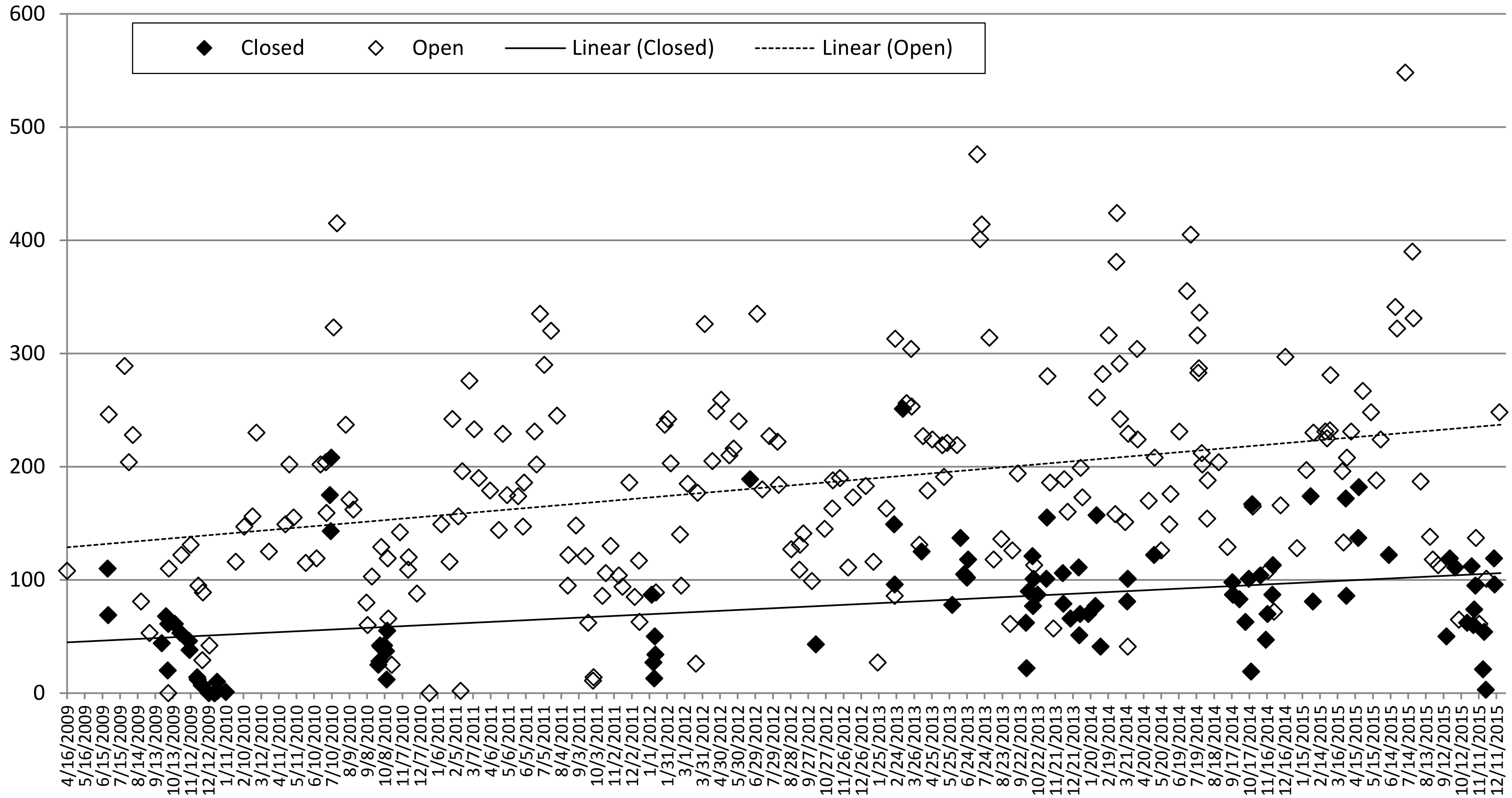

Figure 3. Maximum number of harbor seals counted during all pinniped surveys at the Jenner haul-out (Russian River mouth at Goat Rock State Beach) since 2009. Open diamonds represent counts in mouth open conditions and black filled diamonds represent counts during mouth closed.

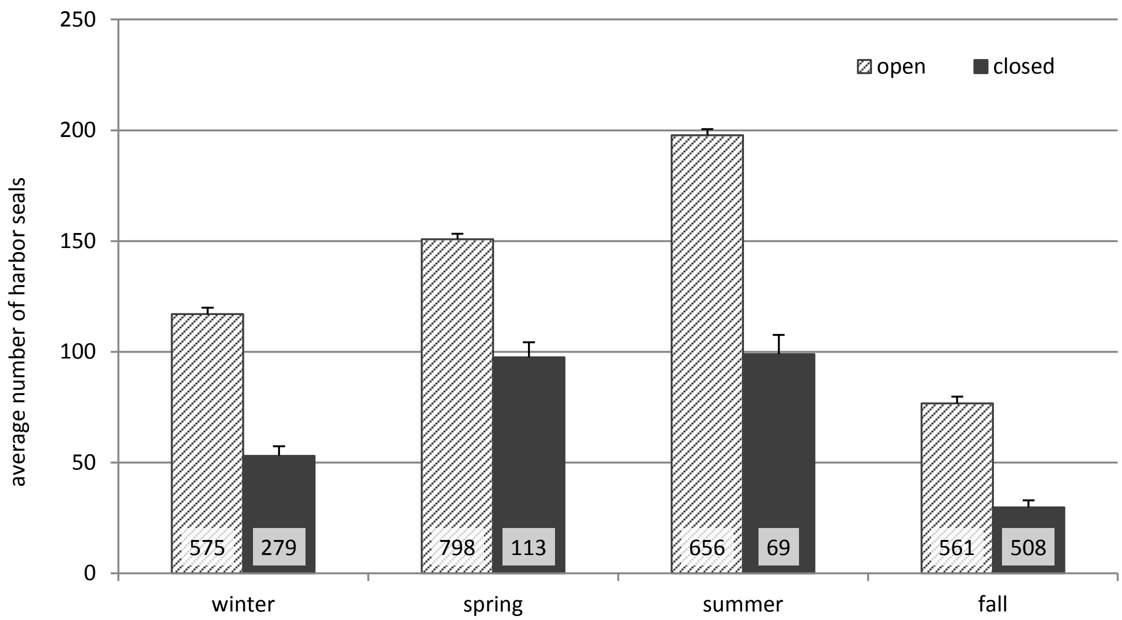

Figure 4. Average number of harbor seals at the Jenner haul-out for all surveys since 2009 for mouth open and mouth closed conditions by season. Seasons were defined as: winter = December – February; spring = March – May; summer = June – August; fall = September – November.

Table 2. The average number of harbor seals by month hauled out at peripheral sites during baseline surveys conducted in 2015. Monthly averages in bold represent seasonal peaks in seal abundance.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
North Jenner	0.5	1.7	2.5	1.1	0.8	0.9	2.5	2.8	0.3	0.0	2.3	0.8
Odin Cove	5.0	3.6	0.0	8.5	**14.3**	**12.5**	6.0	7.5	9.9	8.3	4.7	1.2
Penny Logs	0.0	0.0	0.0	0.0	0.4	2.7	0.0	0.0	0.1	0.8	0.0	0.0
Paddy's Rock	1.6	2.3	0.5	2.1	2.8	3.8	1.4	1.4	4.4	7.0	6.0	0.3
Chalanchawi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pocked Rock	0.0	0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.2	0.6	0.0	0.0
Kabemali	0.6	1.1	0.7	3.8	**6.0**	**8.3**	5.2	4.4	1.6	5.0	3.2	1.4
Rock Point	11.3	2.0	2.0	4.7	2.3	**19.3**	11.0	12.6	6.6	**15.3**	**19.7**	0.0

Disturbance of Seals

An effort was made to compare the level of disturbance between baseline surveys and surveys when Water Agency personnel are working in the vicinity of the Jenner haul-out. Disturbance sources were separated into ten categories: aircraft, bird, dog, kayak, multiple, other boat, people, unknown, vehicle, and Water Agency. Seals were considered to be disturbed if they moved on or flushed from the haul-out.

Figure 5 illustrates the proportion of surveys when harbor seals were disturbed at the Jenner haul-out, categorized by disturbance source. Harbor seals were most frequently disturbed by people on foot (59% of surveys), with a similar frequency during non-baseline surveys (62% of surveys). Water Agency personnel disturbed seals on 51% of non-baseline surveys. People in kayaks were the next most frequent source of disturbance (28% of baseline surveys) (Figure 5).

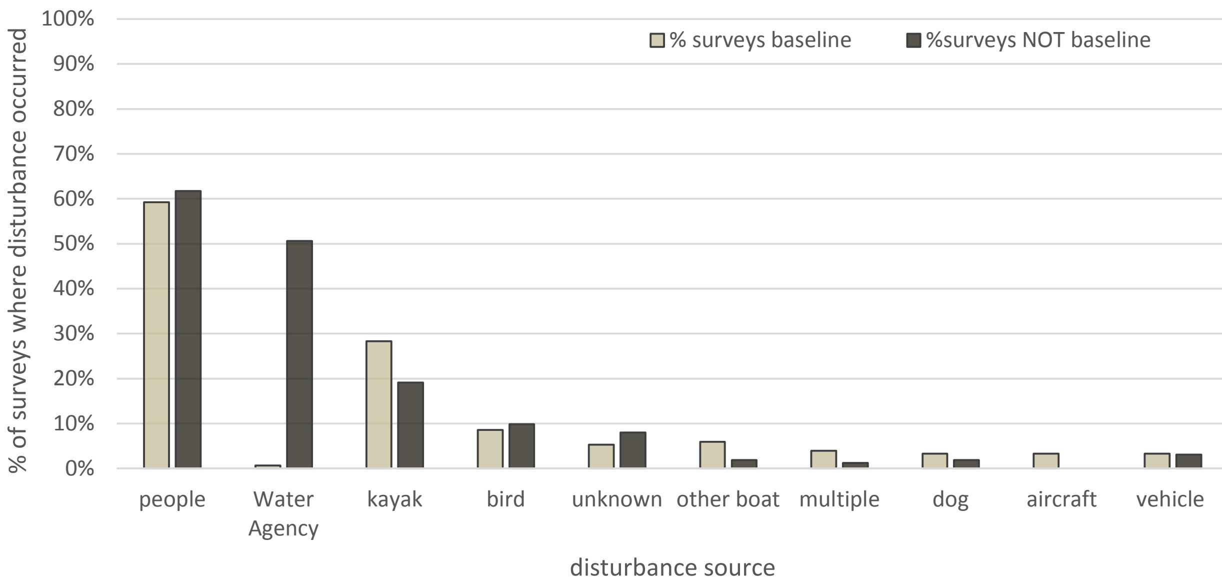

Figure 5. The proportion of baseline surveys where harbor seals were disturbed (moved or flushed) at the Jenner haul-out, described for each disturbance source. Data includes all baseline surveys since surveys began in 2009 (n=152) and all other surveys combined (i.e., breaching, pre-breaching, post-breaching, topographic surveys, jetty study, lagoon outlet implementation, pre-lagoon outlet and post-lagoon outlet) (n=162).

Displacement of Seals

In the absence of summer lagoon conditions, harbor seal abundance at all sites during the summer months was compared for mouth open and mouth closed conditions for all surveys since they began in July 2009. At the Jenner haul-out more seals were observed during mouth open conditions (Figure 6) (Unequal N HSD multiple comparisons test, $p < 0.0001$). More than ten times fewer seals were observed at all of the peripheral sites and at most of these peripheral sites mouth condition did not affect seal abundance (Figure 6). At North Jenner there were slightly more seals during closed conditions (Figure 6) (Unequal N HSD multiple comparisons test, $p < 0.05$)

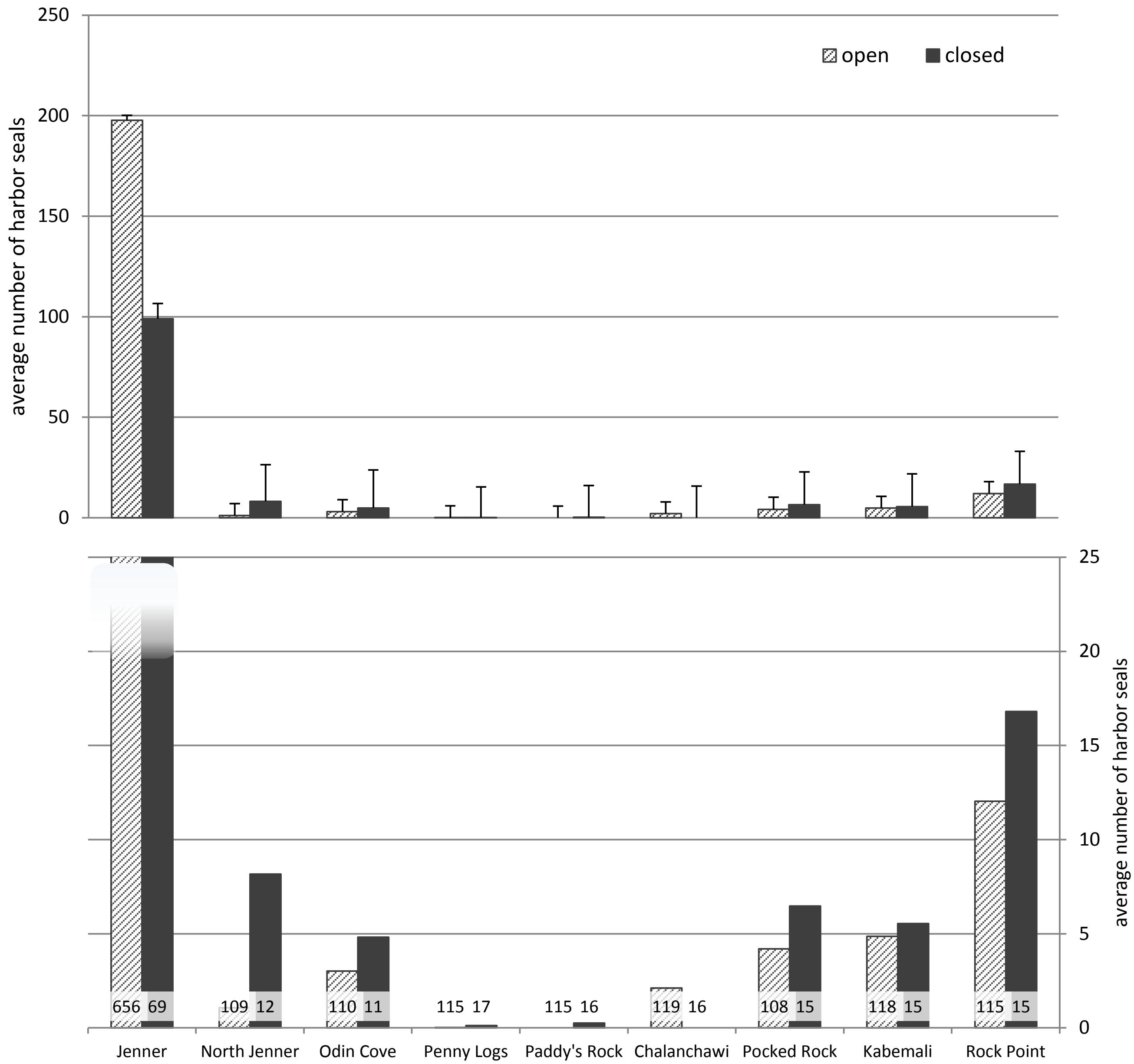

Figure 6. Average number of seals hauled out during summer months (June, July, August) by location for open and closed mouth conditions, for all surveys since they began in 2009. Error bars represent standard error of the mean and number of counts used to calculate the mean are presented inside the bars.

Water Level Management Activities

A barrier beach formed eleven times during 2015 (Table 3), and the Water Agency artificially breached the sand bar during four of these closures. The Russian River outlet was closed to the ocean for a total of 115 days (or 32%) in 2015, with 49 (or 43%) of these days occurring during the Lagoon Management Period. This is similar to the previous year where the outlet was closed for 110 days, however in 2014 only 26% of outlet closures occurred during the Lagoon Management Period.

On March 27, 2015, the river mouth closed and remained closed until it was mechanically breached by the Water Agency on March 31 at 10:39. The peak water level in the estuary was 8.8 ft NGVD as read from the Jenner gauge at 09:30 on March 31. Prior to the start of breaching activities there were 33 harbor seals hauled out on the estuary side of the barrier beach. By 11:30 there were 33 seals hauled out on the estuary side of the beach, south of the pilot channel. Water Agency staff was on the beach for less than one hour during this event.

On October 10 the river mouth closed after a period of southerly ocean swell. The mouth remained closed until November 2nd when the Water Agency excavated a pilot channel. There were 58 harbor seals hauled out in small groups on the estuary and ocean side of the beach prior to the arrival of Water Agency crews. The river level reached 8.7ft NGVD at the time of excavation at 11:10. A few seals remained hauled out north of the excavation site during the activity, and at the end of monitoring there were 3 seals on the beach at 14:56. Continued ocean swells caused the pilot channel to close again on the evening of November 2 and the mouth remained closed until November 5 when the Water Agency excavated a pilot channel in the same location as the previous activity. At this time the river level reached 9.3ft NGVD. Prior to crews entering the beach 95 harbor seals were hauled out on the ocean side of the beach. Sixteen seals remained on the beach during excavation of the pilot channel which occurred between 09:12 and 10:26. Only eight seals remained on the beach at the end of monitoring for the day at 13:20.

The river mouth closed again on November 13 and the Water Agency excavated a pilot channel on November 23, with the river level reaching a peak height of 7.5ft NGVD. On the morning of the breaching activity only a few seals (eight) were hauled out on the ocean side of the beach. Excavation activities began at 09:21 and were complete at 13:03. After activities were complete there were three harbor seals observed hauled out on the estuary side of the beach.

Harbor seal response to excavation activities was similar for all breaching events, and similar to those observed in previous years. Seals that were hauled out first alerted to the sound of the excavator being off-loaded in the Goat Rock State Beach parking lot (greater than 1,500 feet south of the haul-out). Seals then moved on the beach or flushed into the water as the Water Agency safety crew approached on foot. People on foot typically came within 200-100 feet of the haul-out before seals were disturbed. Once on the beach the noise and motion of the excavator disturbed seals at greater distances, between 800 and 200 feet. Seals remained on the beach in small numbers if the excavation activity was far enough away from their initial haul-out location. The estimated take by incidental harassment (Level B), as defined by the Marine Mammal Protection Act, of harbor seals during artificial breaching activities in 2015 was 258 harbor seals (220 flushed and 38 moved). Disturbance information for each event is provided in Table 4.

Table 3. Summary of river mouth closures in 2015 at the Russian River mouth (Goat Rock State Beach). Peak water level during the event was measured at the gauge located at the Sonoma Coast State Park Visitor's Center in Jenner, Ca.

Dates mouth closed	Peak height (ft NGVD)	Date mouth opened	Method of breach
January 29	9.2	February 3	self
February 6	9.4	February 7	self
March 27	8.8	March 31	artificial
April 16	9.7	April 23	self
April 30	6.2	May 3	self
May 28	7.2	June 14	self
September 7	6.7	October 4	self
October 10	8.7	November 2	artificial
November 2	9.3	November 5	artificial
November 13	7.5	November 23	artificial
December 1	8.4	December 8	self

In order to evaluate whether or not beach management activities cause harbor seals to leave the Jenner haul-out for near-by peripheral sites we compared average seal abundance for each peripheral site before, during and after breaching activities for 2015 (Figure 7). Very few seals were observed at the estuary haul-out sites, regardless of timing. All of the coastal haul-outs monitored exhibited an increase in seal abundance during pre-breaching surveys compared with breaching and post-breaching surveys, with the exception of Pocked Rock where post-breaching abundance was greater. However these differences did not reach significance (Unequal N HSD multiple comparisons, $p > 0.05$) (Figure 7).

Due to the small sample sizes used for comparisons of seal abundance during water level management activities for 2015 only, a similar comparison of seal abundance at the peripheral haul-outs was made for 2010-2015 observations combined. Results for the estuarine sites were similar when compared to those for 2015 observations only, with very few seals observed. The only significant differences in the number of seals observed during water level management monitoring were found at North Jenner and Rock Point. At North Jenner more seals were hauled out during pre-breaching surveys (mean = 3.5 ± 0.60 s.e., n = 72) compared to post-breaching surveys (mean = 0.2 ± 0. 65 s.e., n = 62) (Unequal N HSD multiple comparisons test, $p < 0.05$). At Rock Point more seals were observed during breaching surveys (mean = 8.6 ± 0.56 s.e., n = 82) compared to pre-breaching surveys (mean = 4.2 ± 0.62 s.e., n = 67) (Unequal N HSD multiple comparisons test, $p <0.001$).

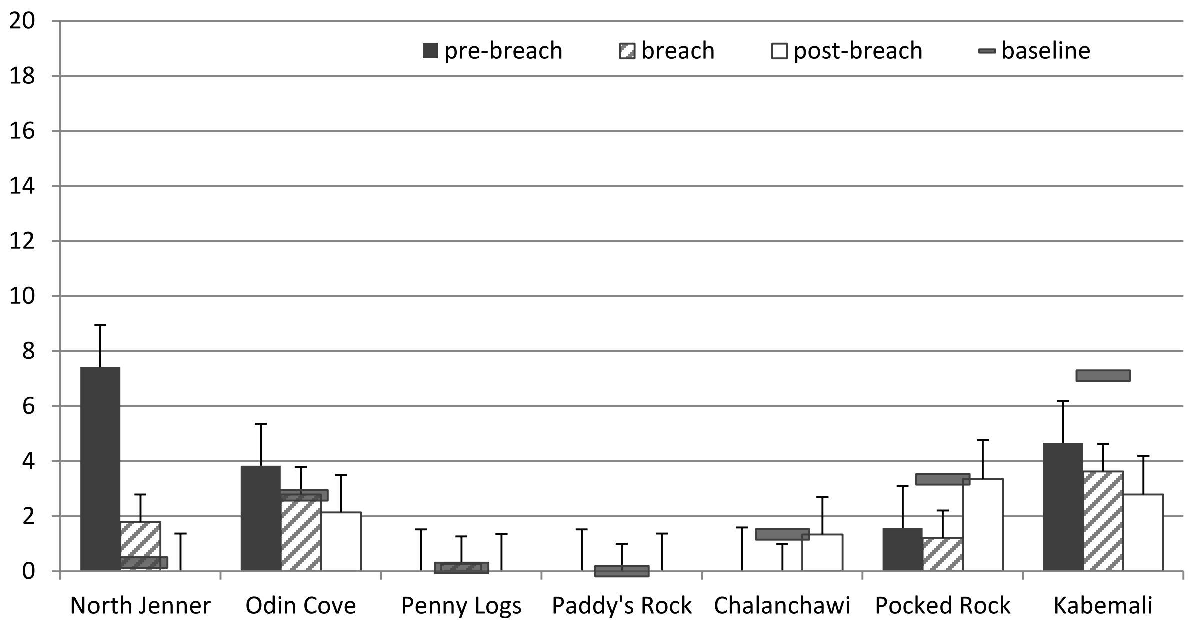

Figure 7. Average seal abundance at peripheral haul-outs as observed during pre-breaching, breaching and post-breaching surveys during 2015. Average seal abundance during 2015 baseline surveys are presented as a solid bar for each site. Error bars represent standard error.

Biological and Physical Monitoring

The NMFS IHA (2015) provides incidental take for Level B harassment of pinnipeds that may result from monitoring of biological resources and physical processes in the Russian River estuary. The number of incidental takes in 2015 was calculated based on the number of animals that responded to activities by either moving on their haul-out or flushing from their haul-out. Alerts were also recorded by monitors, but are not included in the number of incidental takes reported. Most often at haul-out sites within the estuary (excluding the Jenner haul-out on Goat Rock State Beach, Figure 1) harbor seals either had no reaction or raised their heads in alert as a boat passed. The most seals hauled out in the estuary as observed by Water Agency field staff were five at Chalanchawi. On six occasions the acoustic telemetry of steelhead in the estuary resulted in disturbance of harbor seals off their resting areas on partially submerged logs at Chalanchawi and near Duncans Mills (Table 4). No California sea lions were encountered in the estuary during monitoring of biological resources and physical processes.

The Russian River Biological Opinion requires monthly topographic surveys of the barrier beach at the mouth of the Russian River. A Water Agency biologist was present during topographic surveys to monitor the seal response to the survey crew. With the exception of the harbor seal pupping season, when survey personnel will avoid the haul-out when neonates are present, between 15% and 100% of seals were flushed from their haul-out during the monthly mapping activities (Table 4).

Table 4. Number of pinnipeds disturbed as a result of Russian River Estuary Management and Monitoring Activities for 2015, resulting in incidental take by harassment. Disturbances reported are pinnipeds moving on or flushing from their haul-out, number of disturbed seals that flushed from their haul-out is denoted by (#).

Date	Event Type	Estimated Disturbance			
		Species	Age Class	Number	Max % total seals flushed[a]
1/29/2015	topo survey	harbor seal	adult	256(226)	99%
2/2/2015	pre-breaching[b]	harbor seal	adult	38(38)	70%
		Ca. sea lion	juvenile	1(0)	
2/26/2015	topo survey	harbor seal	adult	201(180)	87%
3/26/2015	topo survey	harbor seal	adult	201(126)	47%
3/31/2015	breaching	harbor seal	adult	58(58)	100%
4/20/2015	pre-breaching[b]	harbor seal	adult	64(63)	27%
			neonate	1(1)	
5/27/2015	fisheries studies	harbor seal	adult	2(2)	100%
5/28/2015	fisheries studies	harbor seal	adult	1(1)	100%
5/28/2015	topo survey	harbor seal	adult	279(248)	58%
			pup	2(2)	
6/25/2015	fisheries studies	harbor seal	adult	2(2)	100%
6/25/2015	topo survey	harbor seal	adult	124(82)	15%
7/3/2015	fisheries studies	harbor seal	adult	1(1)	100%
7/22/2015	fisheries studies	harbor seal	adult	2(2)	100%
7/23/2015	topo survey	harbor seal	adult	642(274)	100%
7/30/2015	fisheries studies	harbor seal	adult	1(1)	100%
8/20/2015	topo survey	harbor seal	adult	74(57)	100%
9/17/2015	topo survey	harbor seal	adult	22(22)	100%
10/8/2015	topo survey	harbor seal	adult	77(59)	100%
11/2/2015	breaching	harbor seal	adult	75(57)	100%
11/5/2015	breaching	harbor seal	adult	100(80)	70%
11/12/2015	topo survey	harbor seal	adult	135(71)	100%
11/23/2015	breaching	harbor seal	adult	25(25)	100%
	2015 total	**harbor seal**	**adult**	**2,380(1,675)**	
			pup	**3(3)**	
		Ca. sea lion	**juvenile**	**1(0)**	

[a] Due to the fact that multiple disturbance episodes are represented by the total number of seals disturbed for a given day, the number reported for the percent of seals on the haul out that were flushed is the maximum value recorded for that day.

[b] Disturbance was caused by Water Agency personnel posting warning signs on beach, prior to breaching activities.

CONCLUSIONS

The water level management activities and biological and physical monitoring activities conducted by the Water Agency resulted in incidental harassment (Level B harassment) of 2,384 harbor seals and 1 juvenile California sea lion in 2015, well under the total allowed by NMFS IHA.

The purpose of the Russian River Estuary Management Project Pinniped Monitoring Plan (Sonoma County Water Agency and Stewards of the Coast and Redwoods 2011) is to detect the response of pinnipeds to estuary management activities at the Russian River estuary. Specifically, the following questions are of interest:

1. Under what conditions do pinnipeds haul out at the Russian River estuary mouth at Jenner?

2. How do seals at the Jenner haul-out respond to activities associated with the construction and maintenance of the lagoon outlet channel and artificial breaching activities?

3. Does the number of seals at the Jenner haul-out significantly differ from historic averages with formation of a summer (May 15th to October 15th) lagoon in the Russian River estuary?

4. Are seals at the Jenner haul-out displaced to nearby river and coastal haul-outs when the mouth remains closed in the summer?

Harbor seals are found at the mouth of the Russian River (Jenner haul-out) throughout the year. They are observed on the beach throughout the tidal cycle and at any time of day. Our baseline pinniped monitoring concluded that tidal state and time of day influenced harbor seal abundance at the Jenner haul-out, with seals less abundant in the early morning and at high tide (SCWA 2012). Harbor seals were most abundant on the Jenner haul-out in July during their annual molt (SCWA 2012), with these same trends being observed in subsequent years (SCWA 2013, 2014). Seasonal variation in the abundance of harbor seals at their haul-out locations is commonly observed throughout their range (Allen et al. 1989, Stewart and Yochem 1994, Gemmer 2002). The variation in their abundance can mostly be explained by changes in their biological and physiological requirements throughout the year. Peak seal abundance occurring in July during their molting season is likely a result of seals spending more time on land in order to help facilitate the molting process. This annual peak is typically followed by a decline in seal abundance which is likely a result of individual seals decreasing the amount of time on the haul-out post-molt to spend more time foraging and also coincides with the time that young seals may temporarily disperse from their natal haul-out (Stewart and Yochem, 1994, Thompson et al. 1994, Small et al. 2005).

The Jenner haul-out is a harbor seal rookery and we have attempted to standardize a measure of pup counts so that comparisons can be made across years. However, our ability to accurately measure natality (*i.e.,* proportion of births to the number of mature females) is limited by the fact that harbor seals are not sexually dimorphic so the number of adult females on the beach cannot be easily determined. Harbor seal pups are very precocial and are able to swim just after birth, so counts of pups on the beach does not accurately reflect the total number of births.

Harbor seals will use the beach when there is an open channel or when a barrier beach has formed, however, the number of seals at Jenner was influenced by river mouth condition. Daily average seal abundance was lower during closed conditions compared to open conditions. This effect is also closely related to time of year, since most closures occur during the fall and winter, when seal abundance is low. However, when seal counts were grouped by season, the influence of mouth condition was observed for winter, spring, summer and fall.

The response of harbor seals at the Jenner haul-out to water level management activities in 2015 was similar to the responses observed in previous years of monitoring (Merritt Smith Consulting 1997, 1998, 1999, 2000; Sonoma County Water Agency and Merritt Smith Consulting 2001; SCWA 2011, 2012, 2013, 2014 and 2015). Harbor seals alerted to the sound of equipment on the beach and left the haul-out as the crew and equipment approached closer on the beach. When breaching activities were conducted south of the haul-out, or when seals were hauled out on the ocean side of the beach, seals often remained on the beach during all or some of the breaching activity. This indicates that seals are less disturbed by activities when equipment and crew do not pass directly past their haul-out.

Since the beginning of the modified estuary water level management procedures as a result of the NMFS 2008 Biological Opinion a lagoon outlet channel has only been implemented once (July 2010). While the Water Agency has not had further opportunity to implement and sustain an outlet channel, observations when a barrier beach has formed during the lagoon management period provide information as to how harbor seals respond when aquatic access between the estuary and the ocean is limited. A barrier beach has formed during the lagoon management period sixteen times, the longest incidence lasting 29 days, with an average duration of fourteen days. While seal abundance was lower during closed conditions, overall there continues to be a slight increasing trend in seal abundance. These results indicate that while seal abundance may exhibit a short term decline during closed conditions it has not inhibited seals from using the Jenner haul-out during any period of the year. We conclude that the effect of barrier beach condition on seal abundance represents only a short term response, and is not an indication that seals are less likely to choose Jenner as a haul-out overall. We do not yet know how seals would respond to a maintained lagoon outlet channel.

As stated above we are unable to draw conclusions about the response of harbor seals to the implementation and maintenance of summer lagoon as outlined in the NMFS 2008 Biological Opinion. Results to date indicate that the peripheral haul-outs located in the estuary are little used by seals, and access is limited by rising water level in the estuary. At Chalanchawi seals are more likely to haul out during open conditions, as the logs that compose the site become submerged as water levels rise. Coastal sites are regularly used by harbor seals, albeit in low numbers. We did find that seals were slightly more abundant at North Jenner during mouth closed conditions, however the numbers of seals observed there remains low in either condition.

In an effort to maximize efficiency and focus monitoring efforts in order to gain new insights, the Water Agency is proposing modifications to the 2011 Pinniped Monitoring Plan. Details of the revised monitoring plan are included in the attached document (Sonoma County Water Agency and the Stewards of the Coast and Redwoods 2016) but the main goal of the revision is to focus monitoring efforts on the Jenner haul-out, where the majority of pinnipeds in the Russian River area are found, to continue to develop our understanding of the physical and biological factors that influence seal abundance and behavior. The modifications proposed include increasing the frequency of surveys at the Jenner haul-out from twice a month to four times a month and reducing the duration of each survey from eight to four hours. Visits to the peripheral haul-outs would be eliminated except in the case that a lagoon outlet channel is constructed and maintained for a prolonged period (over 21 days).

Annual reports to the NOAA Fisheries Office of Protected Resources will continue to specifically address the four questions identified in the plan (see above). The following paragraphs describe how the proposed protocol changes will affect our ability to address the questions going forward.

In regard to the first question: “Under what conditions do pinnipeds haul out at the Russian River Estuary mouth at Jenner?”, we have been able to describe some physical and temporal factors that influence seals abundance at Jenner. Proposed changes to the protocol will allow us to continue monitoring these factors and observe if there are changes over time. Furthermore, by increasing the frequency of surveys we would be able to observe the influence of physical changes that do not persist for more than 10 days, like brief periods of barrier beach closures or other environmental changes.

In regard to the second question: “How do seals at the Jenner haul-out respond to activities associated with the construction and maintenance of the lagoon outlet channel and artificial breaching activities?”, we have collected many observation that describe how seals respond directly to breaching activities, and will continue to record and report these responses under the proposed protocol. Because a lagoon outlet channel has not yet been constructed and maintained, we have been unable to describe how seals response to activities associated with the construction and maintenance of a lagoon outlet channel. Should such an opportunity arise we would be able to monitor any seal response under the proposed protocol.

In regard to the third question: “Does the number of seals at the Jenner haul-out significantly differ from historic averages with formation of a summer (May 15th to October 15th) lagoon in the Russian River estuary?”, Because a lagoon outlet channel has not yet been constructed and maintained, we have been unable to address this question. However, under the proposed changes we will continue to count seals at Jenner and would be able to compare the abundance of seals over time and with historic averages.

In regard to the fourth question: “Are seals at the Jenner haul-out displaced to nearby river and coastal haul-outs when the mouth remains closed in the summer?”, after five years of surveys we have no evidence that seals are displaced to the peripheral sites during periods of mouth closures in the summer. Because a lagoon outlet channel has not yet been constructed and maintained our only evidence comes from data collected during natural barrier beach closures during the May 15th to October 15th period. While there are small and short-term increases in seal abundance at the coastal haul-outs during and immediately after a breaching event, seal abundance at the peripheral sites remain low throughout the year regardless of river mouth condition. Peripheral sites are composed of small near shore rocks and out-crops or exposed logs in the river and are not likely to accommodate the hundreds of seals observed during the summer months at Jenner. Due to this limitation of haul-out size, only a relatively small number of seals could be displaced to any one of the peripheral sites. The most accurate way to determine if small numbers of seals have moved from Jenner to a peripheral site would be to monitor the movement of individual seals. In order to accomplish this, seals would need to be uniquely marked and re-sighted. Natural markings would be a non-invasive method to identify individual seals using photo identification techniques, but this is very labor intensive and therefore too costly for us to consider at this time. Proposed changes to the baseline monitoring would allow us to focus efforts on the Jenner haul-out where the majority of seals along the Sonoma Coast are concentrated.

In addition to maintaining our ability to address the questions outlined in the original Pinniped Monitoring Plan, the proposed changes will improve our ability to describe how seals respond to barrier beach closures and will allow us to more accurately estimate the number of harbor seal pups born at Jenner each year. Under the current protocol we have had two main challenges. First, we have few observations of the Jenner haul-out under closed mouth conditions compared to open mouth conditions. Increasing the frequency of surveys at Jenner would allow us to collect more baseline counts during closed-mouth conditions and would therefore increase the robustness of our comparisons. Second, our observations of the Jenner haul-out during pupping season does not currently provide an accurate way to estimate the total number of pups born each year. Increasing the frequency of surveys would allow us to more accurately describe the start and end of the pupping season. The proposed changes would also allow us the opportunity to count pups as newborns (within seven days of birth), leasing to better estimates of natality that could be compared to other local harbor seal rookeries.

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Appendix A. Summary of pinniped monitoring activities at the Jenner haul-out (Goat Rock State Beach, Sonoma County) conducted by the Sonoma County Water Agency and Stewards of the Coast and Redwoods from January – December 2015 for the Russian River Estuary Management Project, including summary of pinniped abundance and Estuary water level.

				HASE adult			HASE pup			HASE neonate					
date	**Activity**	**Mouth**	**Estuary water level**[a,b]	**max**	**mean**	**s.e.**	**max**	**mean**	**s.e.**	**max**	**mean**	**s.e.**	**n**	**CASL present**[c]	**NES present**
1/6/2015	Baseline	Open	1.66	128	55.8	8.40							11		
1/22/2015	Baseline	Open	3.04	197	149.8	11.34							17		
1/29/2015	Topo survey	Closed	4.83	174	116.9	17.83							9		
2/2/2015	Pre-Breach[d]	Closed	8.94	81	57.9	5.64							17	Y	
2/3/2015	Baseline	Open	2.76	230	183.0	11.16							17		
2/23/2015	Baseline	Open	1.83	231	159.2	12.63							17		
2/26/2015	Topo survey	Open	1.58	225	172.2	13.23							10		
3/3/2015	Jetty Study	Open	1.83	232	170.0	19.91							14		
3/4/2015	Baseline	Open	2.08	281	155.4	19.50							18		
3/24/2015	Baseline	Open	2.98	196	134.1	11.29							16		
3/26/2015	Topo survey	Open	2.85	133	115.0	4.66							10		
3/30/2015	Pre-Breach	Closed	--	172	138.0	8.41							15		
3/31/2015	Breach	Closed	8.80[e]	86	42.6	8.00							10		
4/1/2015	Post-Breach	Open	1.69	208	173.2	7.17							15		
4/8/2015	Baseline	Open	2.46	231	168.2	10.45	2	0.8	0.21	2	0.2	0.14	17	Y	
4/20/2015	Pre-Breach	Closed	8.27	110	88.1	4.94	8	5.5	0.50	23	15.6	1.25	15		
4/21/2015	Breach[f]/ Pre-Breach[d]	Closed	8.95	156	116.0	13.69	15	5.2	2.21	28	15.0	4.92	6		
4/28/2015	Baseline	Open	1.28	225	157.5	21.39	31	22.3	1.72	20	10.2	1.91	10		
5/12/2015	Baseline	Open	1.52	219	126.6	14.64	29	14.4	2.08	0	0.0		17		
5/21/2015	Baseline	Open	1.68	161	148.3	4.18	29	22.6	1.47	0	0.0		12		
5/28/2015	Topo survey	Open	1.64	222	142.7	12.70	2	1.5	0.22	0	0.0		13		
6/11/2015	Baseline	Closed	6.77	113	96.7	3.51	12	7.3	1.01	0	0.0		12		

Appendix A. Summary of pinniped monitoring activities at the Jenner haul-out (Goat Rock State Beach, Sonoma County) conducted by the Sonoma County Water Agency and Stewards of the Coast and Redwoods from January – December 2015 for the Russian River Estuary Management Project, including summary of pinniped abundance and Estuary water level.

				HASE adult			**HASE pup**			**HASE neonate**					
date	**Activity**	**Mouth**	**Estuary water level**	**max**	**mean**	**s.e.**	**max**	**mean**	**s.e.**	**max**	**mean**	**s.e.**	**n**	**CASL present**	**NES present**
6/22/2015	Baseline	Open	1.42	341	299.5	5.78							17		
6/25/2015	Topo survey	Open	1.32	322	265.7	19.71							11		
7/9/2015	Baseline	Open	1.69	548	414.8	17.65							18		
7/21/2015	Baseline	Open	1.59	390	328.9	11.05							17		
7/23/2015	Topo survey	Open	1.59	331	223.8	36.04							9		
8/4/2015	Baseline	Open	1.68	187	153.0	4.94							18		
8/20/2015	Topo survey	Open	1.44	138	63.0	15.79							11		
8/25/2015	Baseline	Open	1.56	118	85.2	4.29							17		
9/3/2015	Baseline	Open	1.84	113	77.0	13.12							9		
9/17/2015	Topo survey	Closed	4.63	50	13.2	5.10							11		
9/23/2015	Baseline	Closed	5.86	119	34.0	10.95							18		
10/2/2015	Baseline	Closed	6.55	111	74.8	14.49							5		
10/8/2015	Topo survey	Open	1.76	65	28.8	9.68							8		
10/22/2015	Baseline	Closed	5.82	62	20.4	6.33							17		
10/30/2015	Pre-Breach	Closed	7.90	112	65.5	6.28							17		
11/2/2015	Breach	Closed	8.68	60	22.7	6.53							15		
11/3/2015	Post-Breach/ Pre-Breach	Closed	8.92	74	52.6	3.23							17		
11/5/2015	Breach	Closed	9.31	95	37.9	10.33							13		
11/6/2015	Post-Breach/ Baseline	Open	1.36	137	83.5	11.36							18		
11/12/2015	Topo survey	Open	2.33	61	19.9	6.83							11		
11/18/2015	Baseline	Closed	5.95	21	12.8	1.72							17		
11/20/2015	Pre-Breach	Closed	6.67	54	12.9	4.68							17		

Appendix A. Summary of pinniped monitoring activities at the Jenner haul-out (Goat Rock State Beach, Sonoma County) conducted by the Sonoma County Water Agency and Stewards of the Coast and Redwoods from January – December 2015 for the Russian River Estuary Management Project, including summary of pinniped abundance and Estuary water level.

				HASE adult			**HASE pup**			**HASE neonate**					
date	**Activity**	**Mouth**	**Estuary water level**	**max**	**mean**	**s.e.**	**max**	**mean**	**s.e.**	**max**	**mean**	**s.e.**	**n**	**CASL present**	**NES present**
11/23/2015	Breach	Closed	7.46	3	1.0	0.27							11		
11/24/2015	Post-Breach	Open	2.42	101	49.1	10.43							16		
12/7/2015	Pre-Breach[d]	Closed	7.77	119	113.9	2.38							7		
12/8/2015	Baseline	Closed	8.42	96	84.7	3.11							7		
12/16/2015	Baseline	Open	--	248	159.6	15.83							17		

[a] *For breaching events Estuary water level from time of breaching*

[b] *For all other events Estuary water level is average height for the day*

[c] *Only counts for sea lions on land, does not include sea lions observed in the water*

[d] *No water level management occurred during closure, barrier beach breached naturally*

[e] *Remote link to Jenner river gauge not working, data was recorded from gauge at beginning of pinniped monitoring*

[f] *Breach canceled due to presence of neonate harbor seals on the beach*

-- missing data, Jenner river gauge offline

Appendix 4.5a

2015 Russian River Estuary Grab Sampling Data

Station Name	Date	Time	Temperature (°C)	Specific Conductance	pH	Turbidity	Dissolved Oxygen (% Sat)	Dissolved Oxygen (mg/L)
Jenner Boat Ramp	5/12/2015	9:50:00	16.71	7735	8.38	98.3	110.2	9.56
Casini Ranch	5/12/2015	10:20:00	20.11	304	8.25	5.6	104.5	9.47
Patterson Point	5/12/2015	10:40:00	19.51	303	8.18	1.3	101.9	9.34
Monte Rio	5/12/2015	11:10:00	19.49	304	8.13	1.7	104.2	9.56
Vacation Beach	5/12/2015	11:20:00	19.52	300	8.22	1.4	115.0	10.55
Jenner Boat Ramp	5/19/2015	10:30:00	17.67	8433	7.98	3.5	99.3	9.19
Casini Ranch	5/19/2015	10:50:00	20.38	300	8.27	4.7	99.6	8.98
Patterson Point	5/19/2015	11:20:00	20.04	300	8.16	1.0	100.8	9.15
Monte Rio	5/19/2015	11:40:00	20.13	299	8.20	1.4	104.5	9.47
Vacation Beach	5/19/2015	12:00:00	20.24	297	8.24	1.3	114.4	10.35
Jenner Boat Ramp	5/26/2015	11:00:00	17.08	9919	8.03	10.1	100.8	9.39
Casini Ranch	5/26/2015	11:30:00	20.60	296	8.11	2.5	97.2	8.71
Patterson Point	5/26/2015	12:00:00	20.63	298	8.00	1.6	96.7	8.68
Monte Rio	5/26/2015	12:30:00	20.75	292	8.00	1.1	101.8	9.11
Vacation Beach	5/26/2015	12:50:00	21.08	286	8.13	1.6	115.3	10.25
Jenner Boat Ramp	6/2/2015	9:50:00	17.95	3658	8.25	1.8	99.6	9.33
Casini Ranch	6/2/2015	10:10:00	21.51	295	8.07	2.7	89.6	7.91
Patterson Point	6/2/2015	10:40:00	20.32	202	8.02	1.2	90.7	8.19
Monte Rio	6/2/2015	11:00:00	20.41	289	8.06	1.3	98.4	8.86
Vacation Beach	6/2/2015	11:20:00	20.77	236	8.18	1.8	109.5	9.80
Jenner Boat Ramp	6/4/2015	10:00:00	18.12	4259	8.30	1.1	95.9	8.92
Casini Ranch	6/4/2015	10:30:00	21.16	294	8.37	1.5	97.2	8.64
Patterson Point	6/4/2015	10:50:00	21.00	288	8.22	0.9	96.7	8.61
Monte Rio	6/4/2015	11:10:00	21.30	283	8.15	1.2	105.2	9.32
Vacation Beach	6/4/2015	11:30:00	21.22	286	8.17	1.7	105.1	9.35
Jenner Boat Ramp	6/9/2015	10:40:00	20.03	3001	8.21	1.4	100.2	9.02
Casini Ranch	6/9/2015	11:10:00	22.78	294	8.29	0.6	98.3	8.47
Patterson Point	6/9/2015	11:30:00	21.57	256	8.18	0.6	99.8	8.47
Monte Rio	6/9/2015	11:50:00	23.66	288	8.08	0.9	97.1	8.22
Vacation Beach	6/9/2015	12:20:00	23.70	286	8.05	1.6	104.5	8.84
Jenner Boat Ramp	6/16/2015	9:10:00	20.18	11382	7.70	2.7	78.5	6.84
Casini Ranch	6/16/2015	9:30:00	22.30	224	7.90	0.3	86.6	7.52
Patterson Point	6/16/2015	10:00:00	22.45	289	7.90	2.1	79.5	6.86
Monte Rio	6/16/2015	10:20:00	22.40	289	7.80	1.7	82.1	7.12
Vacation Beach	6/16/2015	10:30:00	22.94	280	7.91	2.3	97.2	8.34
Jenner Boat Ramp	6/23/2015	10:30:00	17.70	20054	7.74	1.4	105.0	9.30
Casini Ranch	6/23/2015	10:50:00	22.23	282	7.94	1.1	87.7	7.63
Patterson Point	6/23/2015	11:10:00	22.69	279	7.87	1.1	90.1	7.78
Monte Rio	6/23/2015	11:30:00	23.22	278	7.85	1.3	98.8	8.43
Vacation Beach	6/23/2015	11:50:00	23.05	275	7.94	0.8	100.1	8.57
Jenner Boat Ramp	6/30/2015	9:50:00	19.23	25570	8.09	6.2	113.2	9.52
Casini Ranch	6/30/2015	10:20:00	23.58	276	8.00	2.3	88.6	7.50
Patterson Point	6/30/2015	10:50:00	23.54	273	7.84	1.3	85.3	7.24
Monte Rio	6/30/2015	11:20:00	24.50	270	7.93	1.0	105.9	8.83
Vacation Beach	6/30/2015	11:40:00	24.62	265	7.93	1.9	100.0	8.31

2015 Russian River Estuary Grab Sampling Data

Station Name	Date	Time	Temperature (°C)	Specific Conductance	pH	Turbidity	Dissolved Oxygen (% Sat)	Dissolved Oxygen (mg/L)
Jenner Boat Ramp	7/7/2015	9:20:00	19.40	33913	7.85	5.1	104.4	8.49
Casini Ranch	7/7/2015	9:50:00	23.07	262	8.53	0.2	91.8	7.86
Patterson Point	7/7/2015	10:10:00	23.70	261	8.06	3.0	89.6	7.58
Monte Rio	7/7/2015	10:30:00	23.63	255	7.95	1.2	97.6	8.27
Vacation Beach	7/7/2015	10:40:00	24.01	244	7.97	2.6	98.8	8.30
Jenner Boat Ramp	7/14/2015	10:10:00	20.00	24413	8.05	1.0	103.6	8.63
Casini Ranch	7/14/2015	10:30:00	24.03	259	7.93	0.6	97.3	8.19
Patterson Point	7/14/2015	11:00:00	23.80	254	7.69	1.7	82.4	6.96
Monte Rio	7/14/2015	11:30:00	23.63	258	7.72	1.4	100.9	8.55
Vacation Beach	7/14/2015	11:40:00	23.68	260	7.80	1.6	99.3	8.40
Jenner Boat Ramp	7/21/2015	9:30:00	20.25	26643	7.96	1.0	108.4	8.90
Casini Ranch	7/21/2015	10:10:00	24.50	271	8.21	0.0	96.5	8.03
Patterson Point	7/21/2015	10:30:00	24.81	260	7.88	1.1	84.0	6.96
Monte Rio	7/21/2015	10:50:00	24.97	258	7.78	1.7	98.3	8.13
Vacation Beach	7/21/2015	11:00:00	25.24	259	7.79	1.3	97.0	7.98
Jenner Boat Ramp	7/28/2015	9:10:00	18.90	25570	7.98	0.7	106.2	8.95
Casini Ranch	7/28/2015	9:30:00	23.35	256	8.23	0.2	95.1	8.10
Patterson Point	7/28/2015	9:50:00	24.80	254	7.96	1.4	92.2	7.78
Monte Rio	7/28/2015	10:10:00	23.66	253	7.76	2.5	93.0	7.88
Vacation Beach	7/28/2015	10:30:00	24.48	259	7.96	1.3	101.1	8.43
Jenner Boat Ramp	8/4/2015	9:40:00	19.47	28952	7.90	2.0	102.1	8.43
Casini Ranch	8/4/2015	10:00:00	22.71	254	7.94	0.4	94.8	8.17
Patterson Point	8/4/2015	10:30:00	23.45	249	7.87	2.0	86.2	7.32
Monte Rio	8/4/2015	10:50:00	23.91	246	7.83	1.0	102.2	8.62
Vacation Beach	8/4/2015	11:00:00	24.08	247	7.86	1.5	100.4	8.44
Jenner Boat Ramp	8/11/2015	9:30:00	19.84	25559	7.95	6.0	96.8	8.05
Casini Ranch	8/11/2015	10:00:00	23.06	239	7.93	4.4	92.2	7.90
Patterson Point	8/11/2015	10:30:00	23.15	165	7.83	5.0	92.1	7.88
Monte Rio	8/11/2015	10:50:00	23.45	241	7.86	6.9	106.8	9.07
Vacation Beach	8/11/2015	11:10:00	23.72	240	7.94	5.1	101.5	8.59
Jenner Boat Ramp	8/18/2015	9:20:00	18.84	25693	7.97	1.0	108.3	9.18
Casini Ranch	8/18/2015	9:50:00	22.29	260	8.00	0.2	88.9	7.73
Patterson Point	8/18/2015	10:10:00	23.22	252	7.83	1.3	89.4	7.62
Monte Rio	8/18/2015	10:30:00	23.77	253	7.85	1.0	102.1	8.62
Vacation Beach	8/18/2015	10:50:00	23.94	251	7.86	0.8	97.9	8.25
Jenner Boat Ramp	8/25/2015	9:15:00	18.20	26237	7.82	2.6	82.6	7.08
Casini Ranch	8/25/2015	9:45:00	21.31	247	8.08	0.0	94.0	8.32
Patterson Point	8/25/2015	10:05:00	22.12	245	7.89	1.1	90.8	7.91
Monte Rio	8/25/2015	10:25:00	22.04	243	7.80	0.9	96.6	8.44
Vacation Beach	8/25/2015	10:40:00	22.26	244	7.94	0.7	99.8	8.68

2015 Russian River Estuary Grab Sampling Data

Station Name	Date	Time	Temperature (°C)	Specific Conductance	pH	Turbidity	Dissolved Oxygen (% Sat)	Dissolved Oxygen (mg/L)
Jenner Boat Ramp	9/1/2015	11:00:00	19.27	31760	8.01	1.1	109.6	8.99
Casini Ranch	9/1/2015	11:30:00	23.48	226	7.93	0.2	99.5	8.45
Patterson Point	9/1/2015	12:00:00	23.47	235	7.86	3.6	94.9	8.06
Monte Rio	9/1/2015	12:20:00	23.48	245	7.74	0.6	99.7	8.47
Vacation Beach	9/1/2015	12:40:00	23.90	177	7.90	0.3	102.3	8.62
Jenner Boat Ramp	9/8/2015	10:40:00	17.38	25683	8.24	1.4	116.4	10.17
Casini Ranch	9/8/2015	11:00:00	21.54	241	8.14	0.9	105.6	9.30
Patterson Point	9/8/2015	11:30:00	21.86	244	7.97	1.8	102.4	8.97
Monte Rio	9/8/2015	11:50:00	21.77	243	7.91	1.1	103.1	9.05
Vacation Beach	9/8/2015	12:10:00	21.86	237	7.89	1.1	101.4	8.88
Jenner Boat Ramp	9/10/2015	10:40:00	17.83	16108	8.26	1.6	123.1	11.05
Casini Ranch	9/10/2015	11:00:00	21.69	240	8.12	0.5	111.4	9.77
Patterson Point	9/10/2015	11:30:00	22.05	245	8.03	0.8	108.8	9.48
Monte Rio	9/10/2015	12:00:00	21.62	196	7.77	1.0	99.7	8.78
Vacation Beach	9/10/2015	12:10:00	21.95	236	7.85	1.2	102.0	8.91
Jenner Boat Ramp	9/15/2015	10:40:00	16.60	4160	8.13	3.3	95.6	9.20
Casini Ranch	9/15/2015	11:00:00	21.24	207	7.98	0.0	100.5	8.91
Patterson Point	9/15/2015	11:30:00	20.82	243	7.78	0.1	94.6	8.47
Monte Rio	9/15/2015	11:50:00	20.24	187	7.53	0.1	86.4	7.82
Vacation Beach	9/15/2015	12:00:00	20.82	241	7.65	0.5	96.8	8.66
Jenner Boat Ramp	9/22/2015	11:10:00	19.08	6443	8.21	0.7	103.5	9.39
Casini Ranch	9/22/2015	11:40:00	21.74	224	8.02	0.5	106.9	9.40
Patterson Point	9/22/2015	12:05:00	20.99	242	7.83	1.6	99.4	8.86
Monte Rio	9/22/2015	12:30:00	21.38	244	7.77	0.3	105.2	9.30
Vacation Beach	9/22/2015	12:40:00	20.96	245	7.61	1.0	94.7	8.44
Jenner Boat Ramp	9/24/2015	8:50:00	18.03	6178	8.13	0.9	99.9	9.27
Casini Ranch	9/24/2015	9:20:00	19.96	236	8.00	2.2	100.0	9.10
Patterson Point	9/24/2015	9:50:00	20.37	244	7.85	0.7	98.1	8.85
Monte Rio	9/24/2015	10:10:00	20.29	249	7.64	1.1	91.6	8.28
Vacation Beach	9/24/2015	10:20:00	20.11	249	7.54	1.7	86.8	7.88
Jenner Boat Ramp	9/29/2015	11:00:00	18.49	5353	8.23		102.1	9.39
Casini Ranch	9/29/2015	11:20:00	20.14	511	8.09		103.2	9.34
Patterson Point	9/29/2015	11:40:00	19.76	511	7.70		92.4	8.43
Monte Rio	9/29/2015	12:00:00	20.39	516	7.89		98.2	8.84
Vacation Beach	9/29/2015	12:10:00	19.91	555	7.59		94.9	8.61
Jenner Boat Ramp	10/6/2015	9:30:00	19.39	7984	7.79		92.5	8.30
Casini Ranch	10/6/2015	10:00:00	19.40	267	7.80		88.3	8.10
Patterson Point	10/6/2015	10:20:00	20.03	257	7.74		93.1	8.45
Monte Rio	10/6/2015	10:40:00	19.55	262	7.58		89.6	8.21
Vacation Beach	10/6/2015	11:00:00	19.46	210	7.61		99.4	9.13
Jenner Boat Ramp	10/13/2015	10:20:00	17.58	19044	8.49		116.4	10.4
Casini Ranch	10/13/2015	10:40:00	20.01	247	7.94		103.2	9.38
Patterson Point	10/13/2015	11:00:00	19.30	219	7.77		93.1	8.58
Monte Rio	10/13/2015	11:20:00	19.36	246	7.75		99.0	9.11
Vacation Beach	10/13/2015	11:40:00	19.59	239	7.75		102.9	9.42

Appendix 4.5b

2015 Russian River Estuary Grab Sampling Data

Jenner Boat Ramp	Time	Temperature	pH	Dissolved Oxygen	Specific Conductance	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Orthophosphate	Dissolved Organic Carbon	Total Organic Carbon	Total Dissolved Solids	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	Total Coliforms Diluted 1:10 (Colilert)	E. coli (Colilert)	E. coli Diluted 1:10 (Colilert)	Enterococcus (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***		
MDL*						0.200	0.10	0.00010	0.030	0.030	0.10		0.020	0.020	0.0400	0.0400	4.2	0.020	0.000050	20		20		2	Flow Rate****	Estuary Status	Jenner
Date		°C		mg/L	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	MPN/100m	MPN/100m	MPN/100m	MPN/100m	MPN/100m	(cfs)		Gauge (ft)
5/12/2015	9:50:00	16.7	8.4	10.5	7735	0.32	ND	ND	0.063	ND	0.32	**0.38**	**0.065**	0.13	1.74	2.24	4200	**12**	0.0015	>2419.6	2481	**1732.9**	**1956**	**435.2**	183	Open	1.77
5/19/2015	10:30:00	17.7	8.0	9.2	8433	0.35	ND	ND	0.26	ND	0.35	**0.62**	**0.044**	0.086	1.09	1.23	7400	**2.6**	**0.0059**	>2419.6	583	12.1	31	6.3	179	Open	0.59
5/26/2015	11:00:00	17.1	8.0	9.4	9919	0.24	ND	ND	0.27	ND	0.24	**0.52**	**0.050**	0.086	1.32	1.20	6600	**2.8**	**0.0074**	>2419.6	2142	9.7	10	3.0	155	Open	0.97
6/2/2015	9:50:00	18.0	8.3	9.3	3658	0.21	ND	ND	0.28	ND	0.21	**0.49**	**0.033**	0.072	2.07	2.05	2100	1.8	**0.0027**	>2419.6	3876	24.3	50	58.3	135	Closed	4.42
6/4/2015	10:00:00	18.1	8.3	8.9	4259	ND	ND	ND	0.053	ND	ND	0.23	**0.039**	0.072	2.00	1.94	2400	1.5	**0.0023**	>2419.6	1789	**290.9**	183	**98.5**	127	Closed	5.14
6/9/2015	10:40:00	20.0	8.2	9.0	3001	0.28	ND	ND	ND	ND	0.28	0.28	**0.035**	0.052	2.09	2.24	1600	1.3	**0.011**	1299.7	1539	93.3	121	24.3	124	Closed	6.45
6/16/2015	9:10:00	20.2	7.7	6.8	11382	0.32	ND	ND	0.029	ND	0.32	**0.60**	**0.052**	0.15	1.45	1.59	7000	1.8	0.00047	>2419.6	**>24196**	2.0	10	**816.4**	117	Open	0.84
6/23/2015	10:30:00	17.7	7.7	9.3	20054	0.21	ND	ND	0.59	ND	0.21	**0.80**	**0.042**	0.11	0.931	0.950	14000	1.3	0.0014	>2419.6	3076	3.0	<10	35.5	106	Open	0.76
6/30/2015	9:50:00	19.2	8.1	9.5	25570	ND	ND	ND	0.80	ND	ND	**0.94**	**0.032**	0.056	0.849	0.852	15000	1.6	**0.0022**	>2419.6	**>24196**	45.9	122	**290.9**	105	Open	0.84
7/7/2015	9:20:00	19.4	7.9	8.5	33913	0.32	ND	ND	ND	ND	0.32	0.32	**0.036**	0.059	0.623	0.731	22000	1.8	**0.0044**	>2419.6	**>24196**	98.3	<10	31.3	72	Open	0.76
7/14/2015	10:10:00	20.0	8.1	8.6	24413	0.32	ND	ND	1.1	ND	0.32	**1.4**	**0.045**	0.023	0.748	0.807	19000	**3.5**	**0.0031**	>2419.6	**12033**	31.8	<10	**261.3**	77	Open	1.01
7/21/2015	9:30:00	20.3	8.0	8.9	26643	0.35	ND	ND	ND	ND	0.35	0.35	**0.043**	0.048	0.702	0.718	17000	1.8	**0.0024**	>2419.6	**17329**	32.7	10	33.7	86	Open	0.80
7/28/2015	9:10:00	18.9	8.0	9.0	25570	0.21	ND	ND	ND	ND	0.21	0.21	**0.033**	ND	0.785	0.742	17000	1.3	**0.0058**	>2419.6	**>24196**	**>2419.6**	20	**1046.2**	66	Open	1.18
8/4/2015	9:40:00	19.5	7.9	8.4	28952	0.24	ND	ND	ND	ND	0.24	0.24	**0.025**	0.048	0.684	0.600	18000	1.8	**0.0029**	>2419.6	**24196**	**1203.3**	109	**1299.7**	103	Open	0.67
8/11/2015	9:30:00	19.8	8.0	8.1	25559	0.28	ND	ND	1.1	ND	0.28	**1.4**	**0.027**	0.044	0.851	0.901	17000	1.9	**0.0033**	>2419.6	**12033**	85.1	62	**1413.6**	86	Open	1.18
8/18/2015	9:20:00	18.8	8.0	9.2	25693	ND	ND	ND	1.1	ND	ND	**1.2**	**0.027**	0.033	0.746	0.670	19000	1.8	**0.0021**	>2419.6	**19863**	**>2419.6**	86	**2419.6**	89	Open	0.63
8/25/2015	9:15:00	18.2	7.8	7.1	26237	0.28	ND	ND	0.92	ND	0.38	**1.3**	**0.032**	0.047	0.88	0.970	19000	1.6	**0.0039**	>2419.6	**11199**	**>2419.6**	86	**920.8**	75	Open	1.56
9/1/2015	11:00:00	19.3	8.0	9.0	31760	0.28	ND	ND	ND	ND	0.28	**1.0**	**0.038**	0.06	0.820	0.899	21000	**3.3**	**0.0024**	>2419.6	6488	**866.4**	86	**410.6**	68	Open	1.05
9/8/2015	10:40:00	17.4	8.2	10.2	25683	0.24	ND	ND	ND	ND	0.24	0.24	ND	0.020	0.833	0.851	17000	1.4	**0.0060**	>2419.6	2723	**387.3**	121	**1725.0**	62	Closed	2.61
9/10/2015	10:40:00	17.8	8.3	11.1	16108	0.28	ND	ND	ND	ND	0.28	0.28	**0.030**	0.021	1.17	2.13	13000	1.4	**0.0082**	1732.9	402	**290.9**	10	**88.6**	64	Closed	3.16
9/15/2015	10:40:00	16.6	8.1	9.2	4160	0.32	ND	ND	ND	ND	0.32	0.32	**0.037**	0.035	2.15	2.20	3000	**4.4**	**0.0049**	>2419.6	**12033**	**281.2**	20	**178.5**	90	Closed	4.09
9/22/2015	11:10:00	19.1	8.2	9.4	6443	0.21	ND	ND	0.21	ND	0.21	**0.42**	**0.027**	0.033	2.00	1.97	3400	1.2	**0.0042**	>2419.6	583	26.6	41	28.8	86	Closed	5.69
9/24/2015	8:50:00	18.0	8.1	9.3	6178	ND	ND	ND	0.22	ND	ND	**0.40**	**0.024**	ND	1.75	1.85	3500	1.4	**0.0031**	>2419.6	1597	65.7	63	**150.0**	79	Closed	5.94
9/29/2015	11:00:00	18.5	8.2	9.4	5353	0.24	ND	ND	ND	ND	0.24	0.24	**0.026**	0.060	1.75	2.13	3000	1.5	**0.0051**	648.8	285	6.3	<10	8.5	65	Closed	6.41
10/6/2015	9:30:00	19.4	7.8	8.3	7984	0.21	ND	ND	0.24	ND	0.21	**0.45**	**0.045**	0.089	1.73	1.78	4300	1.5	0.0015	>2419.6	**19863**	11.0	<10	48.5	73	Open	2.27
10/13/2015	10:20:00	17.6	8.5	10.4	19044	ND	ND	ND	ND	ND	ND	0.18	**0.026**	0.027	0.983	1.07	11000	1.4	**0.0023**	>2419.6	**>24196**	**325.5**	**256**	**>2419.6**	78	Closed	4.30

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.
** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.
*** United States Geological Survey (USGS) Continuous-Record Gaging Station
**** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Criteria based on Aggregate Ecoregion III (Values in red exceed recommended criteria)
Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L
Total Nitrogen: 0.38 mg/L
Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L
Turbidity: 2.34 FTU/NTU

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values: (Values in red exceed recommended guidance)
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
E. coli: 235 per 100 ml
Enterococcus: 61 per 100 ml

2015 Russian River Estuary Grab Sampling Data

Casini Ranch	Time	Temperature	pH	Dissolved Oxygen	Specific Conductance	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Orthophosphate	Dissolved Organic Carbon	Total Organic Carbon	Total Dissolved Solids	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	Total Coliforms Diluted 1:10 (Colilert)	E. coli (Colilert)	E. coli Diluted 1:10 (Colilert)	Enterococcus (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***		
MDL*						0.200	0.10	0.00010	0.030	0.030	0.10		0.020	0.020	0.0400	0.0400	4.2	0.020	0.000050	20		20		2	Flow Rate****	Estuary Status	Jenner
Date		°C		mg/L	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	MPN/100m	MPN/100m	MPN/100m	MPN/100m	MPN/100m	(cfs)		Gauge (ft)
5/12/2015	10:20:00	20.1	8.3	9.5	304	ND	ND	ND	0.066	ND	ND	0.24	**0.044**	0.18	1.87	2.57	180	1.6	0.0015	547.5	677	5.2	<10	2.0	183	Open	1.77
5/19/2015	10:50:00	20.4	8.3	9.0	300	0.24	ND	ND	0.21	ND	0.24	0.30	**0.035**	0.074	1.67	1.98	170	2.1	0.0013	816.4	749	22.8	10	5.2	179	Open	0.59
5/26/2015	11:30:00	20.6	8.1	8.7	296	ND	ND	ND	0.051	ND	ND	0.23	**0.036**	0.082	1.64	1.97	160	2.2	**0.0027**	686.7	932	6.3	<10	8.5	155	Open	0.97
6/2/2015	10:10:00	21.5	8.1	7.9	295	ND	ND	ND	0.14	ND	ND	0.32	**0.040**	0.099	1.67	2.18	170	2.0	**0.0028**	1299.7	1607	27.9	75	47.4	135	Closed	4.42
6/4/2015	10:30:00	21.2	8.4	8.6	294	0.21	ND	ND	0.053	ND	0.21	0.26	**0.044**	0.095	1.42	1.93	170	2.1	**0.0024**	1553.1	1720	47.1	98	35.5	127	Closed	5.14
6/9/2015	11:10:00	22.8	8.3	8.5	294	ND	ND	ND	ND	0.051	ND	0.19	**0.036**	0.091	1.57	2.04	160	1.1	0.0016	1732.9	1354	43.5	31	25.6	124	Closed	6.45
6/16/2015	9:30:00	22.3	7.9	7.5	224	0.28	ND	ND	0.053	ND	0.28	0.33	**0.047**	0.14	1.76	2.28	170	1.3	0.00082	>2419.6	2489	8.4	<10	2.0	117	Open	0.84
6/23/2015	10:50:00	22.2	7.9	7.6	282	0.21	ND	ND	0.040	ND	0.21	0.25	**0.042**	0.10	1.78	2.30	160	0.85	**0.0021**	2419.6	2014	6.3	10	7.3	106	Open	0.76
6/30/2015	10:20:00	23.6	8.0	7.5	276	0.28	ND	ND	0.044	ND	0.28	0.32	**0.038**	0.085	1.72	2.20	160	1.4	0.0012	>2419.6	7270	15.8	31	7.4	105	Open	0.84
7/7/2015	9:50:00	23.1	8.5	7.9	262	ND	ND	ND	ND	ND	ND	0.18	**0.040**	0.093	1.77	2.28	150	0.66	0.0014	>2419.6	**11199**	7.4	10	2.0	72	Open	0.76
7/14/2015	10:30:00	24.0	7.9	8.2	259	ND	ND	ND	ND	ND	ND	0.18	**0.035**	ND	1.50	2.00	140	0.65	0.0013	2419.6	1860	8.4	<10	16.0	77	Open	1.01
7/21/2015	10:10:00	24.8	8.2	8.0	271	0.28	ND	ND	ND	ND	0.28	0.28	**0.046**	0.10	1.48	2.06	140	0.66	0.0012	2419.6	1421	4.1	20	3.1	86	Open	0.80
7/28/2015	9:30:00	23.4	8.2	8.1	256	ND	ND	ND	0.049	ND	ND	0.19	**0.038**	0.070	1.53	2.07	120	1.0	0.0009	1119.9	960	5.1	20	9.6	66	Open	1.18
8/4/2015	10:00:00	22.7	7.7	8.2	254	0.24	ND	ND	ND	ND	0.24	0.24	**0.029**	0.083	1.58	2.06	140	1.0	0.0014	770.1	809	4.1	10	1.0	103	Open	0.67
8/11/2015	10:00:00	23.1	7.9	7.9	239	ND	ND	ND	ND	ND	ND	0.18	**0.028**	0.052	1.59	2.08	92	0.75	0.00064	1299.7	1100	6.2	<10	4.1	86	Open	1.18
8/18/2015	9:50:00	22.3	8.0	7.7	260	0.21	ND	ND	0.076	ND	0.21	0.29	**0.031**	0.049	1.62	2.06	140	1.4	0.00074	1119.9	767	5.2	<10	2.0	89	Open	0.63
8/25/2015	9:45:00	21.3	8.1	8.3	247	0.21	ND	ND	ND	ND	0.21	0.25	**0.036**	0.051	1.58	2.33	140	0.67	0.00094	816.4	851	14.6	10	3.1	75	Open	1.56
9/1/2015	11:30:00	23.5	7.9	8.5	226	ND	ND	ND	ND	ND	ND	0.21	**0.027**	0.078	1.67	2.27	140	0.78	0.0012	816.4	689	8.6	<10	2.0	68	Open	1.05
9/8/2015	11:00:00	21.5	8.1	9.3	241	ND	ND	ND	ND	ND	ND	0.18	ND	0.043	1.65	2.23	79	0.98	0.00096	920.8	884	7.4	10	41.0	62	Closed	2.61
9/10/2015	11:00:00	21.7	8.1	9.8	240	0.21	ND	ND	ND	ND	0.21	0.21	0.021	0.049	1.69	1.68	130	0.92	0.0011	980.4	620	13.4	20	3.1	64	Closed	3.16
9/15/2015	11:00:00	21.2	8.0	8.9	207	ND	ND	ND	ND	ND	ND	0.18	**0.028**	0.047	2.11	2.30	150	1.0	**0.0019**	1413.6	1664	38.4	75	60.2	90	Closed	4.09
9/22/2015	11:40:00	21.7	8.0	9.4	229	ND	ND	ND	ND	ND	ND	0.18	0.021	0.049	1.51	2.07	140	1.0	**0.0019**	1413.6	1354	42.2	63	45.0	86	Closed	5.69
9/24/2015	9:20:00	20.0	8.0	9.1	263	ND	ND	ND	ND	ND	ND	0.14	**0.024**	0.046	1.74	2.02	140	1.1	0.0015	1986.3	1956	60.2	63	**79.4**	79	Closed	5.94
9/29/2015	11:20:00	20.1	8.1	9.3	511	ND	ND	ND	ND	ND	ND	0.18	ND	0.048	1.86	2.23	140	1.2	**0.0021**	1119.9	1314	42.0	75	**82.0**	65	Closed	6.41
10/6/2015	10:00:00	19.4	7.8	8.1	267	ND	ND	ND	0.041	ND	ND	0.15	**0.032**	0.070	1.84	2.13	150	0.84	0.0013	547.5	512	14.5	20	6.3	73	Open	2.27
10/13/2015	10:40:00	20.0	7.9	9.4	247	ND	ND	ND	ND	ND	ND	ND	**0.031**	0.090	1.73	1.99	140	1.5	0.00071	1986.3	2143	28.1	74	58.1	78	Closed	4.30

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.
** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.
*** United States Geological Survey (USGS) Continuous-Record Gaging Station
**** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Criteria based on Aggregate Ecoregion III (Values in red exceed recommended criteria)
Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L
Total Nitrogen: 0.38 mg/L
Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L
Turbidity: 2.34 FTU/NTU

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values: (Values in red exceed recommended guidance)
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
E. coli: 235 per 100 ml
Enterococcus: 61 per 100 ml

2015 Russian River Estuary Grab Sampling Data

Patterson Point	Time	Temperature	pH	Dissolved Oxygen	Specific Conductance	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Orthophosphate	Dissolved Organic Carbon	Total Organic Carbon	Total Dissolved Solids	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	Total Coliforms Diluted 1:10 (Colilert)	E. coli (Colilert)	E. coli Diluted 1:10 (Colilert)	Enterococcus (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***		
MDL*						0.200	0.10	0.00010	0.030	0.030	0.10		0.020	0.020	0.0400	0.0400	4.2	0.020	0.000050	20		20		2	Flow Rate****	Estuary Status	Jenner
Date		°C		mg/L	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	MPN/100m	MPN/100m	MPN/100m	MPN/100m	MPN/100m	(cfs)		Gauge (ft)
5/12/2015	10:40:00	19.5	8.2	9.3	303	0.28	ND	ND	0.075	ND	0.28	0.36	**0.040**	0.085	1.82	2.50	170	2.3	0.0011	770.1	521	4.1	10	3.1	183	Open	1.77
5/19/2015	11:20:00	20.0	8.2	9.2	300	0.21	ND	ND	0.054	ND	0.21	0.26	**0.031**	0.066	1.71	1.82	170	0.82	0.00083	547.5	512	14.8	20	6.3	179	Open	0.59
5/26/2015	12:00:00	20.6	8.0	8.7	298	0.21	ND	ND	0.051	ND	0.21	0.26	**0.034**	0.078	1.67	2.04	160	1.5	**0.0019**	770.1	1050	14.6	10	7.3	155	Open	0.97
6/2/2015	10:40:00	20.3	8.0	8.2	202	ND	ND	ND	ND	ND	ND	0.18	**0.035**	0.084	1.68	2.13	170	1.5	0.0016	1046.2	906	26.2	10	32.7	135	Closed	4.42
6/4/2015	10:50:00	21.0	8.2	8.6	288	ND	ND	ND	0.051	ND	ND	0.23	**0.043**	0.11	1.63	2.19	170	1.6	0.0010	1299.7	1674	32.7	10	49.6	127	Closed	5.14
6/9/2015	11:30:00	23.6	8.2	8.5	256	0.21	ND	ND	0.14	0.048	0.21	**0.40**	**0.036**	0.091	1.60	2.08	160	1.3	0.00082	1732.9	2481	36.9	41	22.8	124	Closed	6.45
6/16/2015	10:00:00	22.5	7.9	6.9	289	0.24	ND	ND	0.058	ND	0.24	0.30	**0.064**	0.15	1.78	2.49	160	1.2	0.00082	>2419.6	4352	20.1	30	20.0	117	Open	0.84
6/23/2015	11:10:00	22.7	7.9	7.8	279	0.35	ND	ND	ND	ND	0.35	0.35	**0.038**	0.099	1.75	2.25	160	1.6	**0.0021**	2419.6	1722	5.2	<10	18.7	106	Open	0.76
6/30/2015	10:50:00	23.5	7.8	7.2	273	ND	ND	ND	0.045	ND	ND	0.22	**0.041**	0.081	1.66	2.20	160	1.2	**0.0018**	1553.1	2603	39.9	20	16.9	105	Open	0.84
7/7/2015	10:10:00	23.7	8.1	7.6	261	0.24	ND	ND	ND	ND	0.24	0.24	**0.045**	0.085	1.73	2.31	160	1.2	**0.0022**	>2419.6	2909	12.2	41	14.1	72	Open	0.76
7/14/2015	11:00:00	23.8	7.7	7.0	254	0.21	ND	ND	0.049	ND	0.21	0.26	**0.039**	0.031	1.39	1.92	150	**3.6**	0.0014	1986.3	1904	37.3	31	42.5	77	Open	1.01
7/21/2015	10:30:00	24.8	7.9	7.0	260	0.28	ND	ND	ND	ND	0.28	0.28	**0.041**	0.092	1.40	1.94	140	1.6	0.00094	1986.3	2143	6.3	10	4.1	86	Open	0.80
7/28/2015	9:50:00	24.1	7.8	7.8	254	0.21	ND	ND	ND	ND	0.21	0.21	**0.036**	0.053	1.49	1.91	140	1.8	0.0016	1046.2	1872	52.0	52	6.3	66	Open	1.18
8/4/2015	10:30:00	23.5	7.9	7.3	249	ND	ND	ND	ND	ND	ND	0.18	**0.031**	0.088	1.42	1.99	150	**2.9**	0.00091	1553.1	2187	5.2	10	12.8	103	Open	0.67
8/11/2015	10:30:00	23.2	7.8	7.9	165	ND	ND	ND	ND	ND	ND	0.14	**0.023**	0.048	1.52	1.98	130	0.88	0.0013	1553.1	2143	6.3	<10	3.1	86	Open	1.18
8/18/2015	10:10:00	23.2	7.8	7.6	252	ND	ND	ND	0.071	ND	ND	0.25	**0.030**	0.057	1.55	1.98	140	1.5	0.00050	1553.1	2046	4.1	10	7.4	89	Open	0.63
8/25/2015	10:05:00	22.1	7.9	7.9	245	0.24	ND	ND	ND	ND	0.24	0.24	**0.029**	0.047	1.51	2.01	150	1.3	0.00094	920.8	1145	17.5	<10	19.9	75	Open	1.56
9/1/2015	12:00:00	23.5	7.9	8.1	235	ND	ND	ND	ND	ND	ND	0.070	**0.025**	0.060	1.56	2.14	150	1.5	0.0011	472.1	1081	8.6	20	----	68	Open	1.05
9/8/2015	11:30:00	21.9	8.0	9.0	244	0.21	ND	ND	ND	ND	0.21	0.21	ND	0.039	1.62	2.13	120	1.4	0.00068	770.1	749	5.2	31	10.0	62	Closed	2.61
9/10/2015	11:30:00	22.1	8.0	9.5	245	ND	ND	ND	ND	ND	ND	0.18	**0.029**	0.037	1.54	2.12	130	1.2	0.0016	866.4	1198	9.0	<10	8.4	64	Closed	3.16
9/15/2015	11:30:00	20.8	7.8	8.5	243	ND	ND	ND	ND	ND	ND	0.14	**0.028**	0.055	1.74	2.29	150	1.3	**0.0019**	2419.6	2046	69.1	74	26.5	90	Closed	4.09
9/22/2015	12:05:00	21.0	7.8	8.9	242	ND	ND	ND	ND	ND	ND	0.18	**0.023**	0.06	1.74	2.00	140	1.2	0.0013	1299.7	1333	96.0	98	**95.9**	86	Closed	5.69
9/24/2015	9:50:00	20.4	7.9	8.9	244	0.21	ND	ND	ND	ND	0.21	0.21	**0.022**	0.037	1.53	2.07	150	0.58	0.00093	1553.1	1860	63.7	85	**93.3**	79	Closed	5.94
9/29/2015	11:40:00	19.8	7.7	8.4	511	ND	ND	ND	ND	ND	ND	0.14	**0.022**	0.048	1.49	2.03	140	0.99	0.0015	613.1	1236	42.0	20	**62.0**	65	Closed	6.41
10/6/2015	10:20:00	20.0	7.7	8.5	257	ND	ND	ND	0.046	ND	ND	0.15	**0.036**	0.082	1.46	2.00	150	1.0	0.00087	816.4	813	14.5	20	27.5	73	Open	2.27
10/13/2015	11:00:00	19.3	7.8	8.6	219	ND	ND	ND	ND	ND	ND	0.10	**0.036**	0.082	1.38	2.01	130	1.4	0.0011	1203.3	1291	68.3	**331**	59.4	78	Closed	4.30

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.
** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.
*** United States Geological Survey (USGS) Continuous-Record Gaging Station
**** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Criteria based on Aggregate Ecoregion III (Values in red exceed recommended criteria)
Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L
Total Nitrogen: 0.38 mg/L
Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L
Turbidity: 2.34 FTU/NTU

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values: (Values in red exceed recommended guidance)
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
E. coli: 235 per 100 ml
Enterococcus: 61 per 100 ml

2015 Russian River Estuary Grab Sampling Data

Monte Rio	Time	Temperature	pH	Dissolved Oxygen	Specific Conductance	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Orthophosphate	Dissolved Organic Carbon	Total Organic Carbon	Total Dissolved Solids	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	Total Coliforms Diluted 1:10 (Colilert)	E. coli (Colilert)	E. coli Diluted 1:10 (Colilert)	Enterococcus (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***		
MDL*						0.200	0.10	0.00010	0.030	0.030	0.10		0.020	0.020	0.0400	0.0400	4.2	0.020	0.000050	20		20		2	Flow Rate****	Estuary Status	Jenner Gauge (ft)
Date		°C		mg/L	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	MPN/100m	MPN/100m	MPN/100m	MPN/100m	MPN/100m	(cfs)		
5/12/2015	11:10:00	19.5	8.1	9.6	304	0.21	ND	ND	0.071	ND	0.21	0.28	**0.040**	0.089	1.82	2.35	170	1.8	0.0014	727	880	8.5	20	5.2	183	Open	1.77
5/19/2015	11:40:00	20.1	8.2	9.5	299	ND	ND	ND	0.053	ND	ND	0.23	**0.028**	0.062	1.59	1.93	180	1.0	0.0012	920.8	697	14.6	<10	1.0	179	Open	0.59
5/26/2015	12:30:00	20.8	8.0	9.1	292	0.24	ND	ND	0.051	ND	0.24	0.30	**0.035**	0.086	1.64	2.00	160	1.2	**0.0019**	686.7	1145	13.4	10	3.0	155	Open	0.97
6/2/2015	11:00:00	20.4	8.1	8.9	289	0.24	ND	ND	ND	ND	0.24	0.24	**0.035**	0.080	1.60	2.07	180	1.6	0.0010	866.4	1274	22.8	10	6.3	135	Closed	4.42
6/4/2015	11:10:00	21.3	8.2	9.3	283	ND	ND	ND	0.050	ND	ND	0.19	**0.041**	0.080	1.62	2.18	170	1.9	0.00028	913.9	2181	67.6	110	45.7	127	Closed	5.14
6/9/2015	11:50:00	23.7	8.1	8.2	288	ND	ND	ND	0.14	0.048	ND	0.36	**0.038**	0.091	1.55	2.08	160	0.77	0.0011	>2419.6	2613	76.7	121	48.7	124	Closed	6.45
6/16/2015	10:20:00	22.4	7.8	7.1	289	0.32	ND	ND	0.054	ND	0.32	0.37	**0.050**	0.150	1.73	2.41	180	1.5	0.00070	>2419.6	5172	43.5	20	37.3	117	Open	0.84
6/23/2015	11:30:00	23.2	7.9	8.4	278	0.28	ND	ND	0.040	ND	0.28	0.32	**0.036**	0.110	1.75	2.28	160	2.2	**0.0023**	1732.9	3448	31.3	20	13.1	106	Open	0.76
6/30/2015	11:20:00	24.5	7.9	8.8	270	ND	ND	ND	0.043	ND	ND	0.22	**0.032**	0.064	1.68	2.20	160	1.2	0.0012	1046.2	1607	20.1	10	4.1	105	Open	0.84
7/7/2015	10:30:00	23.6	8.0	8.3	255	0.21	ND	ND	ND	ND	0.21	0.21	**0.038**	0.080	1.87	2.32	150	1.3	**0.0025**	1553.1	2909	18.1	98	17.4	72	Open	0.76
7/14/2015	11:30:00	23.6	7.7	8.6	258	0.28	ND	ND	ND	ND	0.28	0.28	**0.034**	ND	1.41	1.91	140	2.2	0.0015	1732.9	2909	13.1	<10	36.8	77	Open	1.01
7/21/2015	10:50:00	25.0	7.8	8.1	258	0.21	ND	ND	ND	ND	0.21	0.21	**0.040**	0.064	1.42	1.89	130	1.3	**0.0019**	1413.6	2187	6.3	41	3.0	86	Open	0.80
7/28/2015	10:10:00	23.7	7.8	7.9	253	0.24	ND	ND	ND	ND	0.24	0.24	**0.032**	0.048	1.44	1.89	140	2.2	0.0014	1553.1	1597	12.0	20	22.8	66	Open	1.18
8/4/2015	10:50:00	23.9	7.8	8.6	246	ND	ND	ND	ND	ND	ND	0.18	**0.030**	0.083	1.49	2.01	150	1.9	0.0011	1986.3	1670	9.8	10	20.6	103	Open	0.67
8/11/2015	10:50:00	23.5	7.9	9.1	241	ND	ND	ND	ND	ND	ND	0.18	**0.026**	0.036	1.54	2.00	120	0.88	0.0010	1299.7	1223	2.1	<10	6.2	86	Open	1.18
8/18/2015	10:30:00	23.8	7.9	8.6	253	ND	ND	ND	0.072	ND	ND	0.25	**0.028**	0.049	1.58	1.97	150	1.6	0.00074	1986.3	1421	14.6	20	5.2	89	Open	0.63
8/25/2015	10:25:00	22.0	7.8	8.4	243	ND	ND	ND	ND	ND	ND	0.17	**0.024**	0.047	1.49	1.97	140	1.1	**0.0020**	1119.9	1119	5.2	<10	5.2	75	Open	1.56
9/1/2015	12:20:00	23.5	7.7	8.5	245	ND	ND	ND	ND	ND	ND	0.18	**0.022**	0.048	1.54	2.13	130	0.70	0.0011	980.4	882	3.1	<10	2.0	68	Open	1.05
9/8/2015	11:50:00	21.8	7.8	9.1	243	0.21	ND	ND	ND	ND	0.21	0.21	ND	0.031	1.59	2.18	120	1.7	0.0014	920.8	959	7.3	20	41.0	62	Closed	2.61
9/10/2015	12:00:00	21.6	7.8	8.8	196	ND	ND	ND	ND	ND	ND	0.18	**0.025**	0.045	1.53	1.93	150	0.77	0.0011	727.0	1198	7.5	<10	3.0	64	Closed	3.16
9/15/2015	11:50:00	20.2	7.5	7.8	187	ND	ND	ND	ND	ND	ND	0.18	**0.022**	0.043	1.64	2.26	140	1.4	0.0014	1046.2	1450	6.2	<10	7.4	90	Closed	4.09
9/22/2015	12:30:00	21.4	7.8	9.3	244	ND	ND	ND	ND	ND	ND	0.18	ND	0.049	1.84	2.02	140	0.79	0.00080	1986.3	1374	58.3	62	**98.7**	86	Closed	5.69
9/24/2015	10:10:00	20.3	7.6	8.3	249	ND	ND	ND	ND	ND	ND	0.14	0.020	0.037	1.46	1.99	140	0.73	0.00053	1986.3	1515	70.6	63	**93.3**	79	Closed	5.94
9/29/2015	12:00:00	20.4	7.9	8.8	516	ND	ND	ND	ND	ND	ND	0.10	0.020	0.040	1.43	1.99	140	1.3	0.0011	2419.6	1439	**307.6**	110	**98.8**	65	Closed	6.41
10/1/2015	12:40:00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	913.9	1932	97.7	41	**80.5**	59	Closed	6.53
10/6/2015	10:40:00	19.6	7.6	8.2	262	ND	ND	ND	0.050	ND	ND	0.12	**0.037**	0.089	1.45	1.98	140	1.2	0.00087	1203.3	1376	15.8	<10	27.5	73	Open	2.27
10/13/2015	11:20:00	19.4	7.8	9.1	246	ND	ND	ND	ND	ND	ND	0.14	**0.042**	0.090	1.40	1.94	130	1.9	0.0014	980.4	624	12.1	<10	11.0	78	Closed	4.30

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.
** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.
*** United States Geological Survey (USGS) Continuous-Record Gaging Station
**** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Criteria based on Aggregate Ecoregion III (Values in red exceed recommended criteria)
Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L
Total Nitrogen: 0.38 mg/L
Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L
Turbidity: 2.34 FTU/NTU

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values: (Values in red exceed recommended guidance)
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
E. coli: 235 per 100 ml
Enterococcus: 61 per 100 ml

2015 Russian River Estuary Grab Sampling Data

Vacation Beach	Time	Temperature	pH	Dissolved Oxygen	Specific Conductance	Total Organic Nitrogen	Ammonia as N	Ammonia as N Unionized	Nitrate as N	Nitrite as N	Total Kjeldahl Nitrogen	Total Nitrogen**	Phosphorus, Total	Total Orthophosphate	Dissolved Organic Carbon	Total Organic Carbon	Total Dissolved Solids	Turbidity	Chlorophyll-a	Total Coliforms (Colilert)	Total Coliforms Diluted 1:10 (Colilert)	E. coli (Colilert)	E. coli Diluted 1:10 (Colilert)	Enterococcus (Enterolert)	USGS 11467000 RR near Guerneville (Hacienda)***		
MDL*						0.200	0.10	0.00010	0.030	0.030	0.10		0.020	0.020	0.0400	0.0400	4.2	0.020	0.000050	20		20		2	Flow Rate****	Estuary Status	Jenner
Date		°C		mg/L	µs/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	MPN/100m	MPN/100m	MPN/100m	MPN/100m	MPN/100m	(cfs)		Gauge (ft)
5/12/2015	11:20:00	19.5	8.2	10.6	300	0.21	ND	ND	0.076	ND	0.21	0.29	**0.033**	0.062	1.84	2.23	220	1.8	0.0015	722	789	12.1	10	<1.0	183	Open	1.77
5/19/2015	12:00:00	20.2	8.2	10.4	297	ND	ND	ND	0.053	ND	ND	0.23	**0.028**	0.062	1.65	1.91	170	0.96	**0.0018**	727.0	697	7.5	10	13.0	179	Open	0.59
5/26/2015	12:50:00	21.1	8.1	10.3	286	0.21	ND	ND	0.052	ND	0.21	0.26	**0.032**	0.078	1.65	2.01	160	1.0	0.0017	613.1	1019	10.9	10	8.6	155	Open	0.97
6/2/2015	11:20:00	20.8	8.2	9.8	236	0.24	ND	ND	ND	ND	0.24	0.24	**0.029**	0.080	1.63	2.10	170	1.3	0.0010	920.8	1314	21.8	10	16.1	135	Closed	4.42
6/4/2015	11:30:00	21.2	8.2	9.4	286	0.24	ND	ND	0.051	ND	0.24	0.30	**0.036**	0.084	1.61	2.18	170	2.0	0.0013	866.4	1935	27.2	10	21.3	127	Closed	5.14
6/9/2015	12:20:00	23.7	8.1	8.8	286	ND	ND	ND	0.14	0.047	ND	0.36	**0.036**	0.087	1.53	2.07	160	1.2	0.00082	1208.3	1565	10.9	10	30.8	124	Closed	6.45
6/16/2015	10:30:00	22.9	8.9	8.3	280	0.42	ND	ND	0.052	ND	0.42	**0.47**	**0.041**	0.11	1.81	2.43	170	1.8	0.0015	2419.6	5475	45.0	41	**73.3**	117	Open	0.84
6/23/2015	11:50:00	23.1	7.9	8.6	275	0.21	ND	ND	0.040	ND	0.21	0.25	**0.034**	0.075	1.80	2.28	160	1.7	**0.0031**	>2419.6	**19863**	41.4	<10	54.6	106	Open	0.76
6/30/2015	11:40:00	24.6	7.9	8.3	265	ND	ND	ND	0.043	ND	ND	0.22	**0.032**	0.064	1.70	2.18	160	1.2	**0.0019**	>2419.6	**11199**	21.8	41	22.6	105	Open	0.84
7/7/2015	10:40:00	24.0	8.0	8.3	244	0.21	ND	ND	ND	ND	0.21	0.21	**0.042**	0.050	1.86	2.43	140	1.7	**0.0034**	>2419.6	5475	14.6	30	52.1	72	Open	0.76
7/14/2015	11:40:00	23.7	7.8	8.4	260	0.24	ND	ND	ND	ND	0.24	0.24	**0.037**	ND	1.45	1.91	160	1.9	**0.0024**	2419.6	2481	24.6	10	14.6	77	Open	1.01
7/21/2015	11:00:00	25.2	7.8	8.0	259	ND	ND	ND	ND	ND	ND	0.14	**0.037**	0.060	1.47	1.88	140	1.3	**0.0028**	>2419.6	3448	63.7	98	47.1	86	Open	0.80
7/28/2015	10:30:00	24.5	8.0	8.4	259	0.24	ND	ND	0.049	ND	0.24	0.29	**0.029**	0.040	1.49	1.88	140	1.7	0.0016	>2419.6	2481	17.3	20	**204.6**	66	Open	1.18
8/4/2015	11:00:00	24.1	7.9	8.4	247	0.21	ND	ND	ND	ND	0.21	0.21	**0.023**	0.053	1.58	2.01	140	1.7	0.0016	>2419.6	4106	9.6	10	38.9	103	Open	0.67
8/11/2015	11:10:00	23.7	7.9	8.6	240	0.28	ND	ND	ND	ND	0.28	0.28	0.020	0.024	1.59	2.06	120	1.1	0.0010	2419.6	1860	2.0	<10	16.0	86	Open	1.18
8/18/2015	10:50:00	23.9	7.9	7.9	251	ND	ND	ND	0.074	ND	ND	0.25	**0.026**	0.033	1.60	2.02	130	1.0	**0.0020**	1732.9	2755	23.1	<10	45	89	Open	0.63
8/25/2015	10:40:00	22.3	7.9	8.7	244	0.21	ND	ND	ND	ND	0.21	0.25	**0.023**	0.039	1.55	2.11	140	1.1	**0.0023**	1413.6	1624	8.3	<10	9.5	75	Open	1.56
9/1/2015	12:40:00	23.9	7.9	8.6	177	0.21	ND	ND	ND	ND	0.21	0.21	ND	0.040	1.61	2.16	140	1.0	**0.0020**	1986.3	1872	4.1	10	6.3	68	Open	1.05
9/8/2015	12:10:00	21.9	7.9	8.9	237	0.28	ND	ND	ND	ND	0.28	0.28	ND	0.031	1.60	2.23	110	1.1	0.0015	1986.3	1723	1.0	10	**63.0**	62	Closed	2.61
9/10/2015	12:10:00	22.0	7.9	8.9	236	ND	ND	ND	ND	ND	ND	ND	0.021	0.029	1.54	1.77	140	1.1	**0.0019**	1732.9	2755	10.9	10	8.6	64	Closed	3.16
9/15/2015	12:00:00	20.8	7.7	8.7	241	ND	ND	ND	ND	ND	ND	0.18	**0.024**	0.027	1.67	2.25	150	0.99	0.0015	2419.6	1785	48.7	41	20.1	90	Closed	4.09
9/22/2015	12:40:00	21.0	7.6	8.4	245	ND	ND	ND	ND	ND	ND	0.18	**0.024**	0.049	1.47	2.03	140	**2.4**	0.00080	1203.3	1081	30.5	52	16.0	86	Closed	5.69
9/24/2015	10:20:00	20.1	7.5	7.9	249	ND	ND	ND	ND	ND	ND	0.14	**0.028**	0.050	1.35	1.82	140	1.4	0.00080	960.6	1187	51.2	73	**76.7**	79	Closed	5.94
9/29/2015	12:10:00	19.9	7.6	8.6	555	ND	ND	ND	ND	ND	ND	0.10	**0.024**	0.052	1.42	2.04	150	2.3	0.0016	1299.7	1670	114.5	146	**228.2**	65	Closed	6.41
10/1/2015	10:50:00	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	>2419.6	**>24196**	**>2419.6**	**7270**	**>2419.6**	59	Closed	6.53
10/6/2015	11:00:00	19.5	7.6	9.1	210	ND	ND	ND	0.041	ND	ND	0.15	0.021	0.031	1.43	2.07	140	**2.4**	0.0016	980.4	1198	44.1	108	42.2	73	Open	2.27
10/13/2015	11:40:00	19.6	7.8	9.4	239	ND	ND	ND	ND	ND	ND	0.10	**0.023**	0.035	1.29	1.84	140	1.7	0.0013	980.4	1211	45.9	109	**85.5**	78	Closed	4.30

* Method Detection Limit - limits can vary for individual samples depending on matrix interference and dilution factors, all results are preliminary and subject to final revision.
** Total nitrogen is calculated through the summation of the different components of total nitrogen: organic and ammoniacal nitrogen (together referred to as Total Kjeldahl Nitrogen or TKN) and nitrate/nitrite nitrogen.
*** United States Geological Survey (USGS) Continuous-Record Gaging Station
**** Flow rates are preliminary and subject to final revision by USGS.

Recommended EPA Criteria based on Aggregate Ecoregion III (Values in red exceed recommended criteria)
Total Phosporus: 0.02188 mg/L (21.88 ug/L) ≈ 0.022 mg/L
Total Nitrogen: 0.38 mg/L
Chlorophyll *a* : 0.00178 mg/L (1.78 ug/L) ≈ 0.0018 mg/L
Turbidity: 2.34 FTU/NTU

CDPH Draft Guidance for Fresh Water Beaches - Single Sample Values: (Values in red exceed recommended guidance)
Beach posting is recommended when indicator organisms exceed any of the following levels:
Total coliforms: 10,000 per 100 ml
E. coli: 235 per 100 ml
Enterococcus: 61 per 100 ml