CHAPTER 3.0

Project Background and Environmental Setting

3.1 Introduction

The following section discusses existing conditions and establishes the environmental baseline for several key issue areas. The California Environmental Quality Act (CEQA) requires that an Environmental Impact Report (EIR) describe the physical environmental conditions in the vicinity of the project, or the environmental setting, which constitutes the baseline conditions by which the Lead Agency determines impact significance (CEQA Guidelines Section 15125). CEQA usually defines baseline as the conditions at the time of publication of the Notice of Preparation (NOP). However, because artificial breaching is a historical practice, and because the physical conditions within the Russian River Estuary (Estuary) are highly variable on a daily, monthly, and annual basis, this chapter provides an overview of Estuary management and the factors that influence its implementation each year. As part of its current Estuary management, the Sonoma County Water Agency (Water Agency) monitors water surface elevations, water quality parameters, and biological resource conditions, and has developed bathymetry mapping within the Estuary Study Area. This information provided below summarizes the best available information regarding the "existing conditions" in the Estuary Study Area. **Chapter 4.0** analyzes how implementation of the Estuary Management Project may change or alter these existing conditions both within the Estuary Study Area, and for certain impacts, within the maximum backwater area. As noted in **Chapter 2.0, Project Description**, the maximum backwater area is defined as extending upstream within the Russian River channel to approximately Vacation Beach. The following discussion is organized as follows to provide an overview of existing conditions within the Estuary:

1. *Estuary Management*. Provides discussion and data regarding the frequency and timing of natural and artificial breaching events since 1996. Discusses relationship of observed and expected Russian River inflow to the Estuary, formation of barrier beach conditions, and subsequent closure events

2. *Estuary Management and Minimum Instream Flows*. Provides a discussion of the relationship between Estuary Management and Decision 1610 (D1610) flows and proposed D1610 changes (Fish Habitat Flows and Water Rights Project).

3. *Estuary Water Surface Elevations*. Provides discussion of water surface elevations (WSEs) experienced in the Estuary during closure events, their frequency of occurrence, and their duration. Maps water surface elevations experienced in the Estuary during closure events.

4. *Estuary Monitoring Programs*. Provides an overview of biological processes, water quality and physical processes monitoring, including pinniped monitoring, implemented by the Water Agency.

5. *Estuary Conditions and National Marine Fisheries Service (NMFS) Russian River Biological Opinion (*Russian River Biological Opinion*).* Provides a summary of conditions in the Estuary as identified in the Russian River Biological Opinion.

6. *2009 Extended Closure Data Report.* Provides an overview of data gathered for salinity, temperature and dissolved oxygen during an extended closure period of 29 days occurring September 7 through October 5, 2009. Because of the high resolution of the data collected, this information provides insight into Estuary processes under closed lagoon conditions. However, it should be noted that the data presented in this EIR is from a single extended closure, and cannot be interpreted as being representative of all closure conditions, which will vary substantially depending upon hydrologic year type, the seasonal timing of the closure, and closure duration.

3.2 Estuary Management

The Water Agency currently manages Estuary water levels with the primary objective of minimizing flooding of low-lying properties when barrier beach formation occurs. Specifically, when conditions allow (i.e., during safe wave and river flow conditions), the Water Agency mechanically breaches the barrier beach following a natural closure when the water surface level in the Estuary is between 4.5 and 7.0 feet and to avoid Estuary water levels greater than 9 feet, as determined by the gage at the Jenner Visitor's Center, in accordance with the *Russian River Estuary Study 1992–1993* (Heckel, 1994). [1] Water surface elevations above 9 feet could result in flood damage to low-lying structures.

The Estuary may close at any time of the year, although the closures occur most often between spring and late fall. This is a period of generally lower instream flows and increased creation of barrier beach conditions due to wave activity. Following formation of the barrier beach and Estuary closure, natural breaching of the barrier beach occurs when Estuary water levels exceed the capability of the barrier beach to impound this water, causing localized erosion of the barrier beach and creation of a tidal channel that reconnects the Russian River to the Pacific Ocean. This condition depends on the elevation of the barrier beach, and can vary throughout the year. However, under existing conditions and management practices, the barrier beach is more often artificially breached by the Water Agency. In some cases, private citizens take it upon themselves to breach the barrier beach. As a result of the current management regime, the barrier beach is typically closed for no more than five to fourteen days at a time (Entrix, 2004).

The number of breaching events varies from year to year, depending on the amount of inflow to the Estuary, and beach and ocean conditions that determine the frequency of closure of the Russian River barrier beach (SCWA, 2006). The number of events between 1996 and 2009 are

[1] The Water Agency maintains a recording, water level gage upstream of the Estuary mouth, at the Jenner visitor's center. The gage records water surface elevations in 0.5-hour increments. Water levels for 2000-2009 are provided in the *Russian River Estuary Sandbar Breaching 2009 Monitoring Report*, SCWA, 2010.

shown in **Table 2-1** and **Figure 2-4a and b**, **Chapter 2.0, Project Description**. The maximum number of artificial breach events during the lagoon management period was eight, which occurred in 1997 and 2008.

Review of flow data for the 119 closure events occurring between 1996 and 2009 indicated a median flow at the USGS Guerneville Gage at the time of these closure events of 250 cubic feet per second (cfs), with a minimum flow of 71 cfs and a maximum flow of 1,120 cfs. Therefore, closure events due to barrier beach formation have occurred over a wide range of flow conditions. During the lagoon management period, the outlet channel would be expected to perform over the range of flow conditions that could be experienced between May to October.

River flows typically decline rapidly over the five month lagoon management period. Flows in May averaged 767 cfs for the years 1939 to 2009, and averaged 178 cfs in September for the same time period. Because of this decline in river flow during the lagoon management period, the primary factors in barrier beach formation are wave activity and tidal exchange, with river outflow being a secondary factor. Average monthly wave energy changes with the seasons; wave energy is greatest in winter, reduces over spring, and is minimal from July to September. However, late spring storms, early fall storms and Southern Hemisphere storms can occasionally produce waves exceeding 10 feet in the vicinity of the river mouth during the lagoon management period. Swell waves with periods longer than 10 seconds from either the northwest or south are often the cause of closure during the management period. Large wave events are particularly likely to cause closure when they coincide with the reduced tidal exchange that occurs approximately every two weeks during neap tides.

3.3 Estuary Management Plan and Minimum Instream Flows

The Water Agency releases water from Coyote Valley Dam and Warm Springs Dam to meet minimum instream flow requirements and for water supply purposes in accordance with the requirements of Decision 1610 (D1610), adopted on April 17, 1986 by the State Water Resources Control Board (SWRCB). D1610 specifies minimum instream flow requirements for the Russian River and Dry Creek. These minimum flow requirements vary based on hydrologic conditions, which are also defined by D1610. From Dry Creek to the Pacific Ocean, the required minimum flows in the Russian River are 125 cfs during *Normal* conditions, 85 cfs during *Dry* conditions and 35 cfs during *Critical* conditions.

The Russian River Biological Opinion (NMFS, 2008) concluded that the summer minimum instream flows in the upper Russian River and Dry Creek required by D1610 are too high for optimal juvenile salmonid habitat. The Russian River Biological Opinion also concluded that the historical practice of breaching the barrier beach that builds up and frequently closes the mouth of the Russian River during the late spring, summer, and fall may also adversely affect the listed species. Consequently, the Russian River Biological Opinion concludes that reducing D1610 minimum instream flow requirements will enable alternative flow management scenarios that will increase available rearing habitat in Dry Creek and the upper Russian River, and provide a lower, closer-to-natural inflow to the Estuary between late spring and early fall, thereby enhancing the potential for maintaining a seasonal freshwater lagoon that would likely support increased production of juvenile steelhead and salmon (NMFS, 2008).[2]

The Russian River Biological Opinion acknowledges that implementing permanent changes to the minimum instream flow requirements for the Russian River and Dry Creek will take several years, including the time needed for review under CEQA and compliance with state and federal regulations. Consequently, the Russian River Biological Opinion mandates that the Water Agency file annual petitions with the SWRCB for temporary changes to the D1610 minimum instream flow requirements on the mainstem Russian River, starting in 2010 and for each year thereafter, until the SWRCB has issued an order on the Water Agency's petition for permanent changes to the D1610 minimum in-stream flow requirements. The Water Agency submitted a Petition for Temporary Urgency Change on April 4, 2010, and the SWRCB approved the Temporary Urgency Change on May 24, 2010 for the season between May 1 and October 15, 2010.

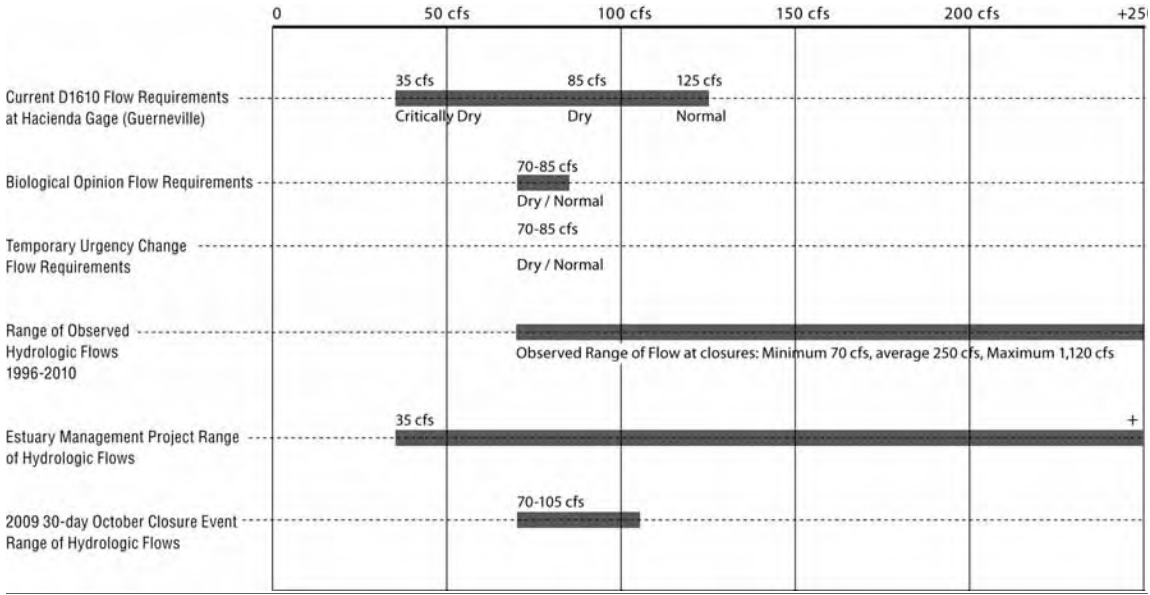
The changes to D1610 minimum instream flow requirements would benefit juvenile steelhead rearing habitat in the upper mainstem Russian River and in the Estuary. The Russian River Biological Opinion requires the Water Agency to request that the minimum instream flow requirements for the mainstem Russian River be temporarily changed each year to the following values:

1. 70 cfs at the U.S. Geological Survey (USGS) Guerneville gage located at Hacienda Bridge, between May 1 and October 15, with the understanding that, because of the need for an operational buffer above this minimum requirement, the Water Agency will typically maintain approximately 85 cfs at this gage; and

2. 125 cfs at the USGS gage located at Healdsburg between May 1 and October 15.

Figure 3-1 summarizes lower Russian River flow requirements from Dry Creek to the Pacific Ocean that would influence flows into the Estuary during the lagoon management period. **Figure 3-1** includes existing D1610 flow requirements, the proposed minimum instream flow changes identified in the Russian River Biological Opinion, the flows identified in the 2010 Petition for Temporary Urgency Change, and the anticipated range of flows that would be expected to occur during the lagoon management period, based upon observed conditions. As previously noted, closure events due to barrier beach formation have occurred over a wide range of flow conditions. During the lagoon management period, the outlet channel would be expected to perform over a range of flow conditions that could be experienced from May to October. As such, the Estuary Management Project is not reliant upon temporary or permanent changes to D1610 for its implementation. Rather, the Estuary Management Project has been developed to adaptively manage the Estuary under any likely range of flow conditions following barrier beach formation under varying hydrologic year types and conditions.

[2] National Marine Fisheries Service. Russian River Biological Opinion, Page 243, September 2008.



Russian River Estuary Management Plan Project ▪ 207734

SOURCE: ESA, 2010

Figure 3-1
Comparison of Lower Russian River Flow Requirements and Anticipated Hydrologic Flow Range for Estuary Management Project

3.4 Estuary Water Surface Elevations

The Water Agency currently manages Estuary water levels with the primary objective of minimizing flooding to surrounding properties. Under the Estuary Management Project, the Water Agency will implement adaptive management of the Estuary with the primary objectives of enhancing rearing habitat for juvenile salmonids, particularly steelhead, and managing Estuary water levels to minimize flood hazard. The following discussion of water surface elevations that have occurred within the Estuary following barrier beach formation, and subsequent artificial breaching by the Water Agency is provided for the years 1996 through 2010. The Water Agency water surface elevation dataset represents the best available information relative to water surface elevations, and their duration, that have been experienced in the Estuary, presented in **Figure 3-4A** through **3-4E** (EDS, 2009). This information represents the existing conditions baseline with respect to water surface elevations in the Estuary.

Natural breaching of the barrier beach occurs when Estuary water levels exceed the capability of the barrier beach to impound this water, causing localized erosion of the barrier beach and creation of a tidal channel that reconnects the Russian River to the Pacific Ocean. This overtopping condition depends on the elevation of the barrier beach, and can vary throughout the year. Artificial breaching has occurred every year from 1996 to 2009, except 2006, when only natural breaching events occurred. The number of artificial breaching events in any given month varied from year to year, but the majority of the artificial breaching events occurred from April through June and September through November. Of the years when the Water Agency completed artificial breaches, the lowest number of artificial breaching events was one event in 2004 and the highest number was 15 attempted breaches (with 13 successful breaches) in 2009 (**Table 2-1** and **Figure 2-4 of Chapter 2.0**, **Project Description**). It is not possible to ascertain how many artificial breaching events would be required each year, but there have been an average of six artificial breaching events annually over the last 14 years.

The Water Agency records information pertaining to Estuary closure events, including the date on which the barrier beach was breached (either natural, citizen [if known], or artificial) and the Estuary water surface elevation at the time of breaching. **Figure 3-2** depicts the recorded water surface elevations upon breaching between June 1996 and December 2010. The lowest recorded water surface elevation upon breaching was 4.3 feet (September 8, 1996); the highest water surface elevation was 11.1 feet during a natural breach event on November 13, 2001. As evidenced in **Figure 3-2**, the average (7 feet) and maximum (9 feet) water surface elevations targeted by the Estuary Management Project are within the existing range of water surface elevations associated with the current closure and breaching processes within the Estuary.

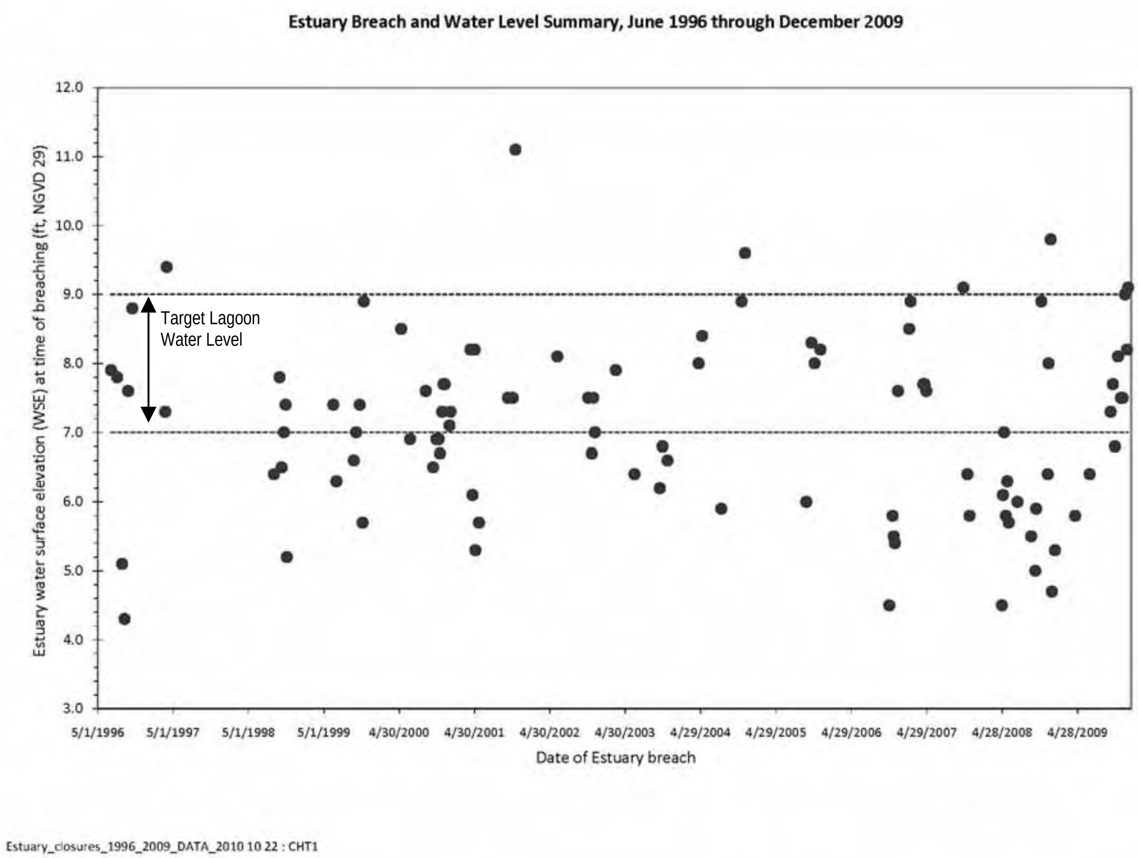


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Figure 3-2
Water Surface Elevations at All Breaching Events (Water Agency, Citizen and Natural) 1996-2009

Using this same information, **Figure 3-3** shows the frequency with which given Estuary water surface elevations were exceeded at the time of breaching. For example, of the 101 breaching events for which a water surface elevation was subsequently recorded, over half of the events (i.e., 52 percent) had water surface elevations that exceeded 7 feet and were sometimes as high as 8 to 9 feet. The average Estuary water surface elevation at the time of breaching was 7.1 feet. During closure events, water surface elevations of 7 feet affect the shoreline frontage of approximately 46 parcels within the Estuary, primarily through inundation of the shoreline and beach areas; however no structures are directly affected.

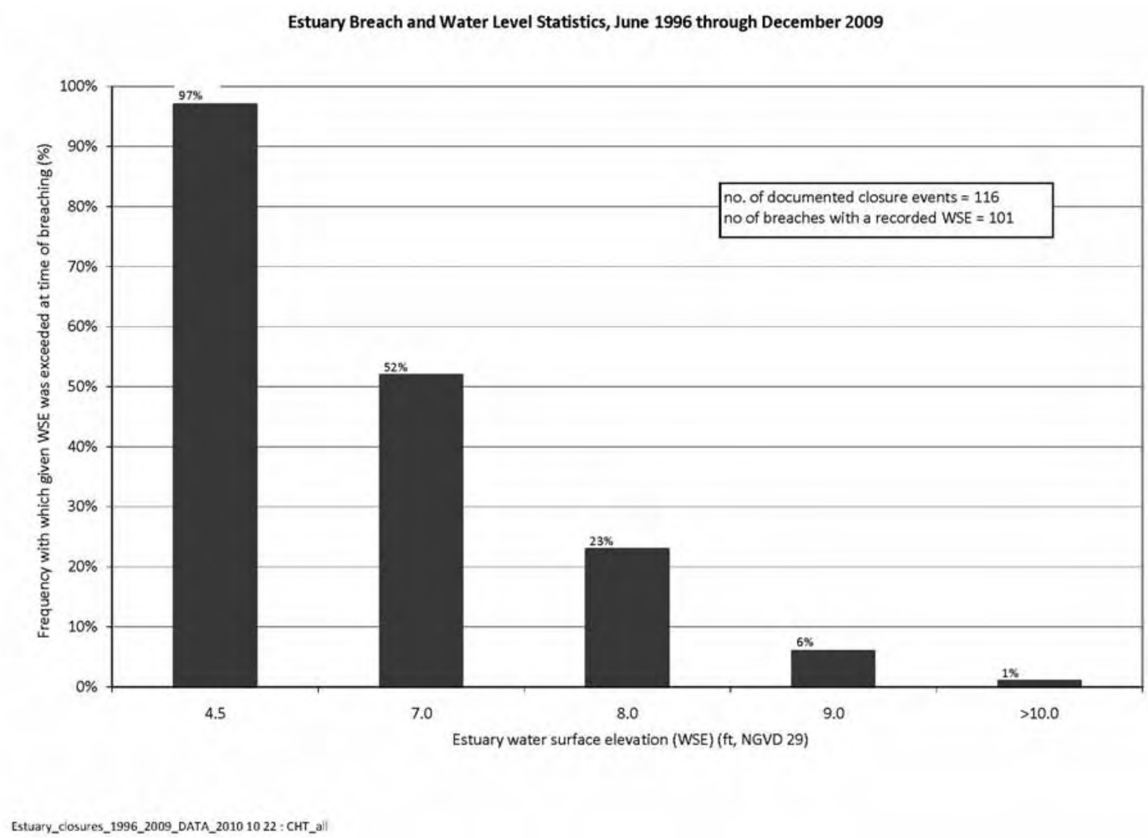

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Figure 3-3
Frequency of Water Surface Elevations at
All Breaching Events (Water Agency, Citizen and Natural) 1996-2009

Water surface elevations of 7 to 9 feet inundate the shoreline frontage of approximately 78 parcels, including 9 structures (boat docks). The approximate area of inundation between the 4.5 to 7-foot contours and the 7 and 9-foot contours in **Figures 3-4A through 3-4E**.

The water surface elevation of the Estuary is generally well below the elevations typically associated with breaching events and potential flooding for most of the year. For example, based upon data from the Water Agency's Jenner gage, the average water surface elevation in the Estuary from May 2000 through December 2009 was approximately 2.2 feet. Over this same period of time, within the lagoon management period (May 15 – October 15), the average water surface elevation in the Estuary was approximately 1.9 feet. Over 99 percent of the time, the Estuary water surface elevation, as recorded at the Jenner gage, was below 7.7 feet. A typical example of the range and seasonal distribution of Estuary water levels is shown in **Figure 3-5** for the year 2003, which had close to an average number of breaching events. Russian River flow data from the Guerneville gage for 2003 also exhibited a typical range of variability, (i.e., no extreme peaks, and base flow was not unusually high or low).

3.5 Estuary Monitoring Programs

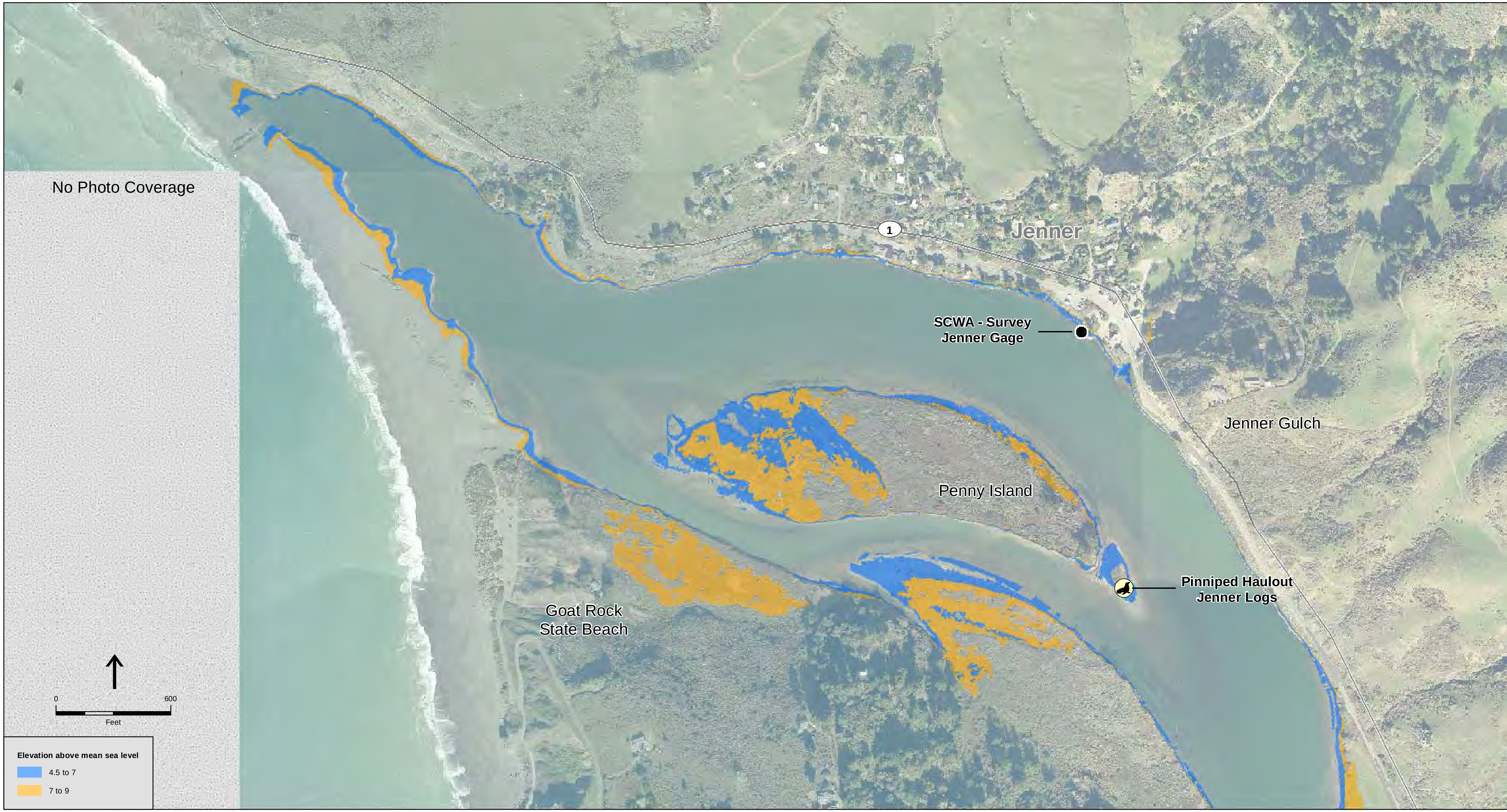
3.5.1 Monitoring Programs

The Water Agency monitors biological resources, water quality, and physical processes in the Estuary. From 1996 to 2000, the Water Agency monitored the effects of artificially breaching the Estuary. The responses of fish, macroinvertebrates, and pinnipeds, as well as changes in water quality, in the Estuary to formation of the barrier beach and subsequent artificial breaching were the primary focus of monitoring during these years. Fisheries, macroinvertebrates, and pinnipeds were monitored before, during, and after artificial breaching events. Water quality vertical profiles (temperature, salinity, conductivity, and dissolved oxygen) were taken at stations in the middle and lower reaches of the Estuary during each biological sampling event. In addition, water quality monitoring stations were established in and near Willow Creek from confluence with the Russian River (SCWA and Merritt Smith Consulting, 2001).

In 2003, the Water Agency began monitoring biological resources and water quality in the Estuary not only to understand how artificial breaching affects resources, but also to better understand Estuary ecology during the spring, summer, and fall months when the Water Agency was most often managing water surface elevations. By this time, coho salmon, Chinook salmon, and steelhead were listed under the federal Endangered Species Act (ESA) and additional information regarding how these species, and more common species, utilized the Estuary was needed. Fisheries, macroinvertebrate, and water quality monitoring changed from breaching-related monitoring to monitoring at regular intervals. Monitoring stations were also expanded from the lower and middle Estuary to include the upper Estuary.

The Russian River Biological Opinion mandates the Water Agency to continue fisheries and water quality monitoring in the Estuary, as well as requires invertebrate sampling to better understand juvenile steelhead prey resources in the Estuary and how these resources may be affected by summer lagoon management.

In 2009, the Water Agency, in collaboration with Stewards of the Coast and Redwoods (Stewards), began a new pinniped monitoring program to collect additional baseline information on the harbor seal haulout at the mouth of the river, as well as to monitor pinniped response to summer lagoon management as part of the Water Agency’s application for incidental harassment authorization (IHA) under the Marine Mammal Protection Act (SCWA and Stewards, 2009). The purpose of the monitoring is to detect the response of pinnipeds to Estuary management activities.



SOURCE: EDS, 2009; SCWA, 2010; (aerial photo, 2008)

Note: Elevations shown for display purposes only;
areas between elevations are shaded to depict
incremental inundation areas relative to 7 and 9 foot elevations.

Russian River Estuary Management Project. 207734.01

Figure 3-4a

Estuary Study Area: Elevation Contours

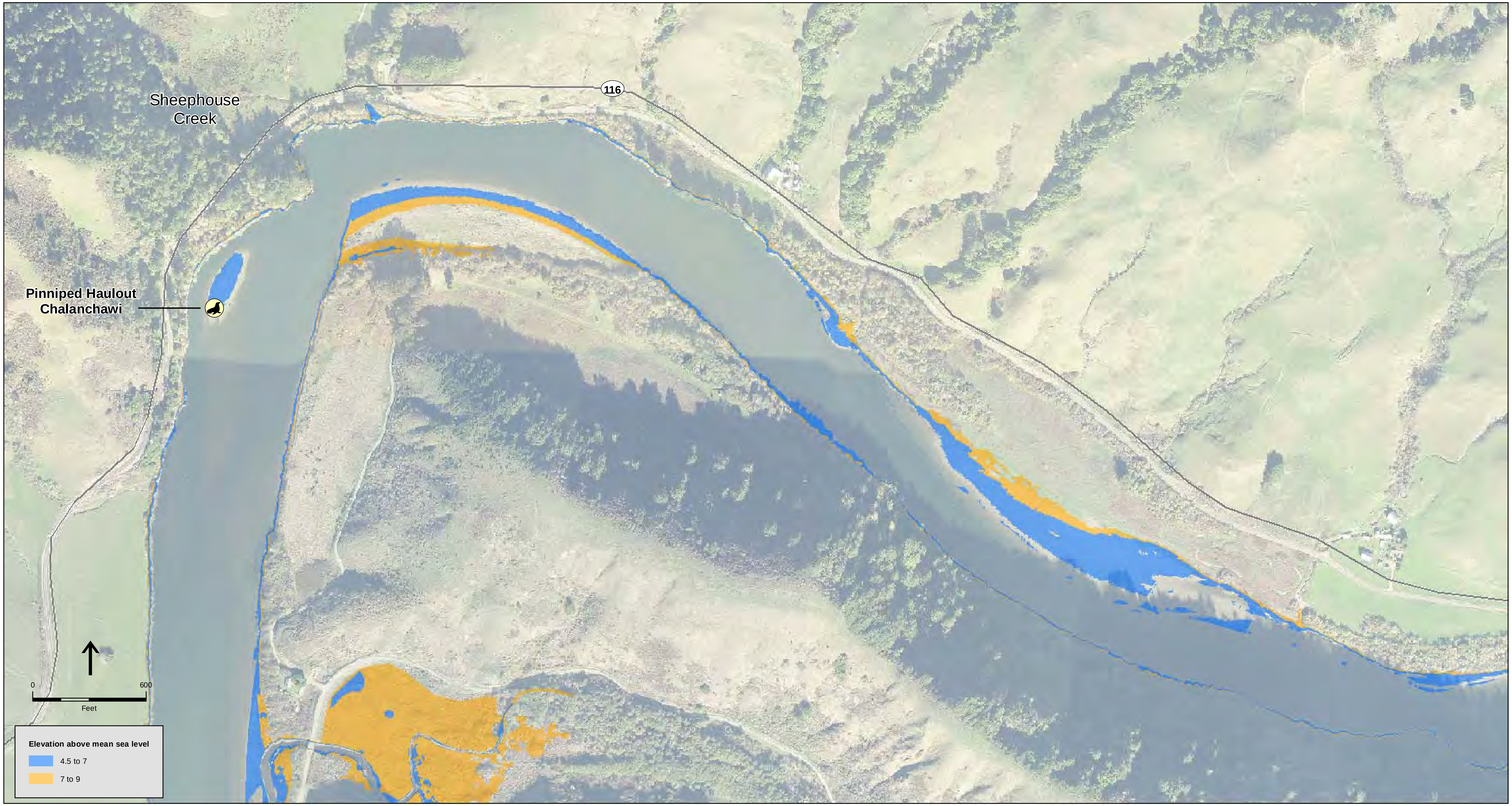
SOURCE: EDS, 2009; SCWA, 2010; (aerial photo, 2008)

Note: Elevations shown for display purposes only;
areas between elevations are shaded to depict
incremental inundation areas relative to 7 and 9 foot elevations.

Russian River Estuary Management Project. 207734.01

Figure 3-4b

Estuary Study Area: Elevation Contours



SOURCE: EDS, 2009; SCWA, 2010; (aerial photo, 2008)

Note: Elevations shown for display purposes only;
areas between elevations are shaded to depict
incremental inundation areas relative to 7 and 9 foot elevations.

Russian River Estuary Management Project. 207734.01

Figure 3-4c

Estuary Study Area: Elevation Contours

SOURCE: EDS, 2009; SCWA, 2010; (aerial photo, 2008)

Note: Elevations shown for display purposes only;
areas between elevations are shaded to depict
incremental inundation areas relative to 7 and 9 foot elevations.

Russian River Estuary Management Project. 207734.01

Figure 3-4d

Estuary Study Area: Elevation Contours

SOURCE: EDS, 2009; SCWA, 2010; (aerial photo, 2008)

Note: Elevations shown for display purposes only;
areas between elevations are shaded to depict
incremental inundation areas relative to 7 and 9 foot elevations.

Russian River Estuary Management Project. 207734.01

Figure 3-4e

Estuary Study Area: Elevation Contours

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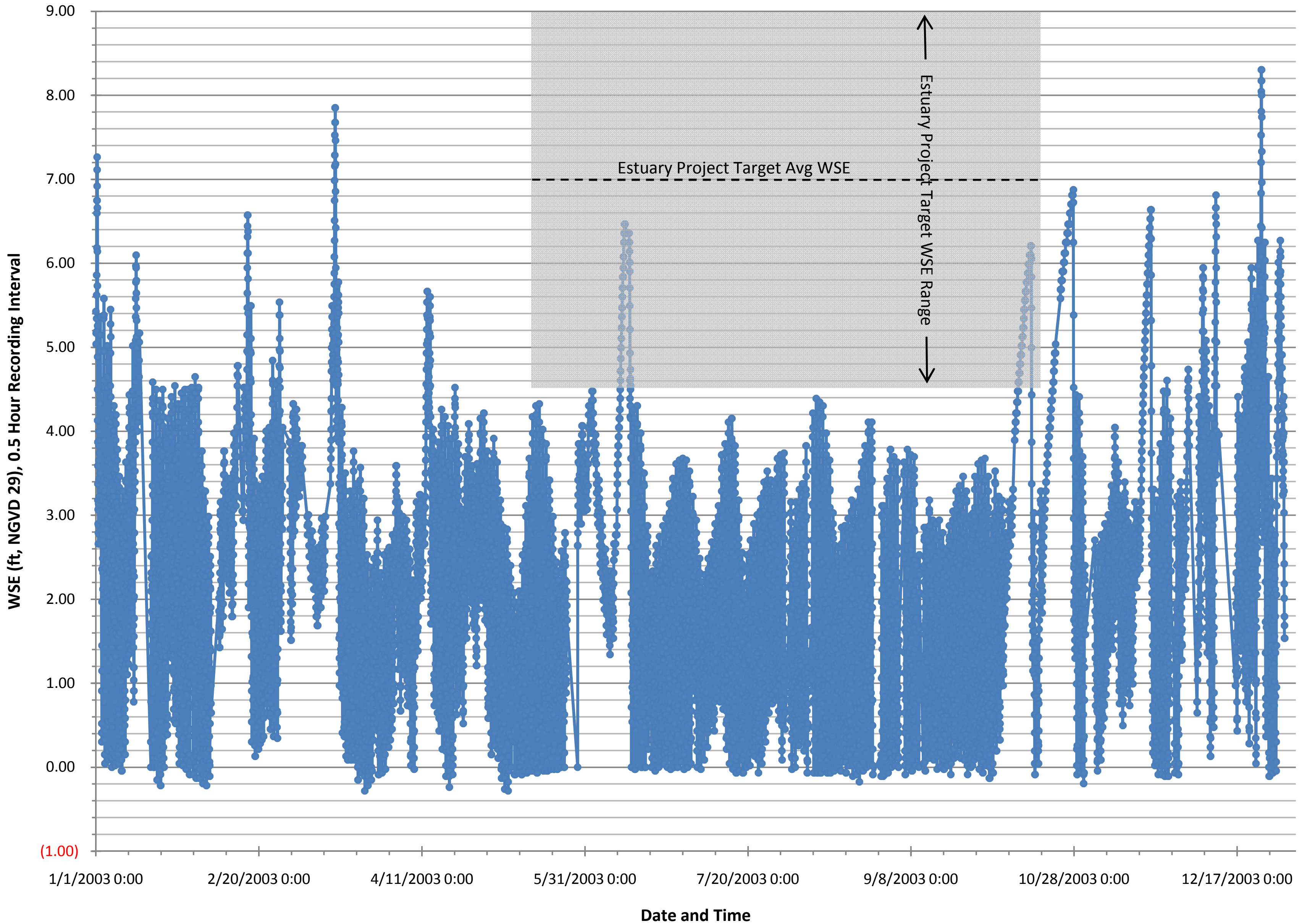

SOURCE: Delaney (2010); ESA

Russian River Estuary Management Project . 207734.01

Figure 3-5
Estuary Water Level at Jenner Gage

Monitoring results would inform the Water Agency about the conditions under which pinnipeds haulout; how the seals respond to creation and maintenance of the lagoon outlet channel and artificial breaching activities; whether the number of seals at the Jenner haulout differ significantly from historic averages after formation of a freshwater lagoon during the lagoon management period; and whether seals displace to nearby haulouts when the river mouth remains closed during the summer. Pinniped monitoring and Russian River haulouts are discussed in detail in **Section 4.4, Biological Resources**.

Also in 2009, the Water Agency began working with University of California, Davis', Bodega Marine Laboratory on a study of physical processes related to circulation, stratification, and mixing in the Estuary. Results of monitoring conducted by Bodega Marine Laboratory during an extended closure event in 2009 are further discussed in **Section 3.7**, below.

In addition to the above sampling programs, the U.S. Geological Survey (USGS) prepared a report in cooperation with the Water Agency to establish baseline water quality data during summer flows in the Russian River. Monitoring sites in the Estuary (Jenner and Willow Creek Marsh) were sampled in summer 2004 for inorganic and organic constituents, nutrients, trace elements, organic carbon, and mercury (Anders et al., 2006). The most recent monitoring in the Estuary conducted by the Water Agency in June through October, 2010, included testing for nutrients such as total organic nitrogen, ammonia, total kjeldahl nitrogen (TKN), nitrates, nitrites, total phosphorus and indicator bacteria. This most recent sampling program is further discussed in **Section 4.3, Water Quality**.

3.6 Estuary Conditions and NMFS' Russian River Biological Opinion

3.6.1 Historic Estuary Conditions and Salmonid Habitat

The Russian River Biological Opinion (2008) evaluated historic estuarine habitat conditions by combining information on current conditions and limited historic information about river flow and bar closures in the Russian River and other California estuaries. Unless otherwise noted the following discussion is summarized from the Russian River Biological Opinion.

Natural California coastal estuaries are typically open to full tidal mixing in the winter and early spring. In late spring, summer, and fall, many of these estuaries are typically converted to freshwater or brackish lagoons. Lagoon formation is a factor of annual precipitation patterns in California, which result in sharp declines in streamflows in coastal rivers during summer months. Declining streamflows and summer beach development[3] typically result in the development of barrier beaches which dam the mouths of many estuaries to produce a lagoon (Smith, 1990).

Freshwater from upstream continues to flow into the newly-formed lagoon and builds up on top of the salt water layer, gradually forcing the salt water layer to seep back into the ocean through

3 Beach development refers to the sand and gravel build up on the beach cause by changes in ocean swell size and direction.

the barrier beach (NMFS, 2008; Smith, 1990). After barrier beach formation, a variety of other factors, including hydrogeology and the volume of saltwater impounded in the lagoon at the time of closure, freshwater inflow rates, wind action, and wave overwash, dictate the amount of time required for a full conversion of the lagoon habitat from saltwater to freshwater (Swanson, 2001). If inflow is insufficient to displace saltwater impounded at the time of closure there is a higher likelihood that stratification will occur, resulting in an anoxic layer in the lower water column (Smith, 1990; Swanson, 2001). In addition, the conversion time required to convert many lagoons to freshwater can affect the primary and secondary producers in the food chain that require relatively stable hydrologic conditions (Swanson, 2001).

Prior to dams and diversions in the Russian River watershed, the Estuary was likely open to ocean tides for several months between late fall and early spring in nearly all years, and then closed to ocean tides sometime during the late spring through the early fall of most years (NMFS, 2008). This historic pattern of open estuarine conditions followed by Estuary closure to ocean tides through the late spring to early fall period is consistent with other coastal lagoons. This seasonal pattern remains evident today and continues to occur even with summer inflows to the Estuary augmented by releases from upstream dams (NMFS, 2008). In some instances, similar to other coastal lagoons, closure may not have occurred until late summer due to the absence of barrier beach building wave events in the spring (NMFS, 2008; Smith, 1990).

Historically, flows during summer months were low and were unlikely to have breached the barrier beach once formed. In some wetter years, a perched lagoon may have formed, with freshwater outflow over the Estuary's bar (NMFS, 2008). The duration of the perched lagoon through the summer as river flows receded is unknown. It is likely that, historically, the Estuary either converted to freshwater after bar closure, or stratified, with denser salt water remaining at depth (NMFS, 2008; Smith, 1990). The Estuary's condition after bar closure was likely variable across water year types.[4]

Information does not exist on water quality conditions relating to habitat in the Estuary prior to increased summer flows in the Russian River from dam releases. As shown by Smith (1990), natural estuarine systems tend to provide highly productive aquatic habitat during open and fully estuarine conditions as well as during closed and fully converted freshwater conditions. The transition period between those two states, however, tends to be a time of low productivity and result in the loss of some species (e.g., marine species intolerant of freshwater conditions). In the estuary/lagoon systems Smith (1990) studied, it generally took thirty days or more for a freshwater lagoon to form following formation of a barrier beach. Natural estuaries were also observed to remain stratified in some years throughout the summer and fall, with denser salt water on the bottom (Smith, 1990) forming high temperature, low dissolved oxygen salt water lenses. As such, it is important to recognize that even though stratified lagoons are widely understood to present adverse habitat conditions for a variety of species, stratified conditions do at times occur in natural lagoons, and represent one possible physical state among a wide variety of conditions that may be present in highly dynamic ecosystems such as lagoons.

[4] A water year type characterizes the hydrological conditions over the period of one year. There are five common types, normal, very wet, wet, dry, and critically dry, based on relative amounts of surface water inflows.

Whether the Estuary converted to freshwater conditions or remained stratified in some years historically, habitat was likely beneficial for salmonids rearing during the summer months (NMFS, 2008; Smith, 1990; Bond et al., 2008). Smith (1990) and Bond et al. (2008) evaluated closed freshwater lagoons in California and found beneficial salmonid rearing habitat in those lagoons, including abundant food supplies and increased salmonid growth rates over stream-raised fish. The Navarro River Estuary, which is more similar in size and configuration to the Russian River Estuary than the smaller estuary/lagoons studied by Smith (1990), did not convert to freshwater after it closed and became a lagoon in September of 1996 and 1997 (NMFS, 2008). Nevertheless, steelhead productivity remained higher than productivity in other open, salt water tidally-influenced estuaries in California (NMFS, 2008). Steelhead productivity in the Navarro was high due to abundant food and a stable surface freshwater layer (NMFS, 2008).

3.6.2 Current Estuary Management and Fish Habitat

Current Estuary Management

Current Estuary management, including frequency of artificial breaching events, is described in **Sections 3.2** and **3.4** above. During the lagoon management period, the Estuary generally functions as a tidally influenced estuary that experiences periodic transitions between marine and freshwater habitat between May and October of most years when a barrier beach forms. Under the current Estuary management, the barrier beach is generally closed no more than five to 14 days, although it is occasionally closed for longer periods (Entrix, 2004). A prolonged river mouth closure lasting 29 days occurred recently from September 7 through October 5, 2009 (Behrens and Largier, 2010). Based on past breaching records, under current practices, the Estuary has not remained closed for a period longer than 30 days. Conversely, Smith (1990) observed that natural coastal lagoons in California typically take thirty days or more to fully transition from a marine or brackish water habitat to a freshwater habitat. Smith (1990) found that salmonid survival and growth is poor in California coastal lagoons if they undergo long stratified transition periods between barrier beach closure and conversion of the lagoons to freshwater. Artificial summer breaching programs abruptly terminate the transition between marine and freshwater conditions and typically do not allow for a full conversion to productive freshwater habitat. In the case of the current Estuary breaching program, full conversion in the Russian River Estuary is not expected due to hydrogeology (Behrens and Largier, 2010).

Estuary Fish Habitat

Species distribution and abundance within the Estuary is dependent, in part, on water quality conditions, which in turn are dependent on a wide variety of physical conditions such as open or closed river mouth (presence of a barrier beach), freshwater inflow rates, ambient air temperature, wind action, and tidal circulation. These water quality characteristics create a range of habitat conditions that favor different species of fish. Water quality characteristics critical to fish habitat within the Estuary include temperature, dissolved oxygen (DO), and salinity. Depending on the status of the barrier beach (Estuary open to tidal influence or closed), these water quality characteristics can vary across a wide range. Certain fish species share similar habitat requirements and tend to associate together in assemblages (SCWA, 2008). Additionally, based on current breaching practices between May and October, these water quality characteristics can change rapidly within the project area. The following section summarizes the current trends for critical habitat water quality characteristics in the project area under the current artificial breaching regime based on monitoring data collected by the Water Agency (SCWA 2006, 2010).

Water quality is generally of higher habitat value (lower temperatures and higher DO) in the near-bottom saline layers when the Estuary is open to tidal mixing than when the Estuary has been closed for a short time. When the barrier beach forms, saltwater is trapped in the lagoon. Because saltwater is denser than fresh water, it forms a layer under the freshwater river inflows (stratification), forming a saltwater lens that traps heat (Smith, 1990; Entrix, 2004). Through natural processes, dissolved oxygen (DO) becomes depleted in the bottom saline layer and anoxic conditions can develop. Currently, the Estuary is known to stratify after formation of the barrier beach. When the barrier beach closes, salinity stratification leads to reductions in DO and increases in temperature from solar heating in the lower water column. In the deepest areas cold anoxic saltwater occurs. When the barrier beach is breached, tidal mixing contributes to a renewal of DO and a reduction in temperatures within the Estuary, and especially within the stratified lower water column. This process occurs most rapidly near the mouth of the river following breaching, but can take up to several days at upstream sites. The rate of change of salinity, DO, and temperature within the Estuary is also influenced by the volume of river freshwater inflow to the Estuary, spring and neap tides, and the length of time the barrier beach remains open. This cycle was documented in the Estuary during ongoing monitoring studies conducted by the Water Agency (SCWA, 2006; SCWA, 2010).

Open Estuary Conditions

Salinity

The Estuary exhibits conditions typical of estuarine environments with varying salinity levels. Salinity steadily increases from low levels (0-5 parts per thousand [ppt]) at the freshwater/Estuary interface in the upper reach, to moderate levels in the middle reach (approximately 15 ppt), to the highly saline tidal zone near the ocean (30-35 ppt).

Saline water is denser than freshwater and a salinity “wedge” forms as freshwater outflow passes over the denser tidal inflow. The lower and middle reaches of the Estuary up to Sheephouse Creek are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater. The upper reach of the Estuary transitions to a predominantly freshwater environment, which is periodically underlain by a denser, saltwater layer that migrates upstream as far as the Moscow Road Bridge in Duncans Mills during summer low flow conditions. River flows, tides, and wind action affect the amount of mixing at various longitudinal and vertical positions within the Estuary. However, in most estuaries, including the Russian River Estuary, water stratification is common in deeper sections of the Estuary or when vertical mixing is limited (SCWA, 2006).

Salinities in much of the Estuary are beyond the tolerable range for smaller age classes of non-smolting juvenile steelhead when the Estuary is open during the late spring, summer, and fall (NMFS, 2008). Water quality data indicates that when the Estuary is open to tidal mixing, the most upstream portion of the Estuary from Freezeout Creek to Austin Creek (upper one mile of the

Estuary) is the only portion where predominantly freshwater habitat is maintained throughout the summer. The lower and middle Estuary are predominantly saline environments with a thin freshwater layer that flows over the denser saltwater. Temporary decreases in salinity concentrations have been observed during Estuary closure and following breaching events. The middle Estuary (one to five miles from the mouth) is most subject to fluctuation in salinities throughout the water column due to ocean tides (SCWA, 2006). In the middle Estuary, salinities can range as high as 30 ppt in the saltwater layer, with brackish conditions prevailing at the upper end of the salt wedge, to less than 1 ppt in the freshwater layer on the surface. Salinities near the mouth are similar to ocean salinities (SCWA, 2006; SCWA, 2009).

Dissolved Oxygen

The DO levels in the Estuary fluctuate significantly during the monitoring season, and fluctuations are not necessarily associated with tidal cycles or a diurnal cycle (SCWA, 2006). DO levels in the Estuary also depend upon factors such as the extent of diffusion from surrounding air and water movement including freshwater inflow. DO levels are also a function of nutrients, which can accumulate in standing water during an extended period of time and promote excessive plant and algal growth that utilize the DO. This can reduce DO levels leading to eutrophication and affecting overall ecological health of the Estuary. Estuaries tend to be naturally eutrophic because land-derived nutrients are concentrated where runoff enters the marine environment in a confined channel. [5] A discussion of nutrient levels within the Estuary is presented at the end of this section.

DO concentrations also affect habitat quality and use, physiological stress, and mortality of fish and other aquatic organisms. In general, DO concentrations less than 5 to 6 milligrams per liter (mg/l) are considered to be unsuitable for most fish species, including steelhead (Bell, 1973; Barnhardt, 1986). Salmonids generally require a DO level of at least 8 mg/l for optimal growth and survival, and depending on temperature, the lower lethal limit for salmonids is a DO level of around 3 mg/l. When the Estuary is open, DO typically ranges from approximately 7 to10 mg/l in the surface layers, and varies, on average, from 4 to 9 mg/l in bottom areas of Estuary pools (NMFS, 2008).

Temperature

Water temperature has direct and indirect effects on aquatic ecology. For example, oxygen is more soluble in cold water than hot water (i.e., solubility is a function of water temperature); therefore DO levels may be higher in waters at lower temperatures. Temperature also influences the rate of photosynthesis by algae and aquatic plants. Water bodies such as the Russian River Estuary have naturally fluctuating temperatures due to the dynamic conditions associated with a coastal climate, localized weather patterns, and tidal mixing.

Temperatures recorded during open Estuary conditions typically range from 10° C to 18° C at mid and bottom depths in saline and brackish water. Temperatures are generally warmer in the freshwater layer, which can reach as high as 25° C for short periods, especially in the upper reach of the Estuary, furthest from the natural cooling effects of a marine environment. Temperatures less

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5 *National Estuarine Eutrophication Assessment* by NOAA National Centers for Coastal Ocean Science (NCCOS) and the Integration and Application Network (IAN), 1999.

than 17° C are typically preferred by juvenile steelhead (Sullivan et al., 2000). In general, salmonids in warmer waters require more food and oxygen because their metabolism increases with temperature (Moyle, 2002). The high productivity associated with healthy estuaries provides an abundant food source for many fish species and can allow temperature-sensitive fish, such as juvenile salmonids, to withstand greater water temperatures than the typical optimal range, and can actually result in greater growth rates (Bond et al., 2008).

Closed Estuary Conditions

Salinity

Typically salinity steadily increases from the freshwater/estuary interface in the upper reach with low salinity (0-5 ppt), to a predominantly saline environment with a thin freshwater layer that flows over the denser saltwater in the lower and middle reaches of the Estuary. When the barrier beach is formed at the mouth of the Estuary, water quality conditions can undergo abrupt alteration. Salinity, DO and temperature changes can begin within 24 hours (SCWA 2006, 2010). The freshwater layer begins to thicken at the surface, starting at the mouth and extending upstream. Highly saline conditions are present in the mid and bottom depths of the lower and middle reaches of the Estuary within a few days of barrier beach closure. While surface water becomes fresh, some deeper saline water at the bottom may persist in the lower Estuary, and some may migrate upstream to the middle Estuary due to reduced velocities of river inflows and redistribution of the saltwater wedge.

Furthermore, brackish water has been observed to extend into the lower half of the water column in the upper Estuary during sandbar closure, as far upstream as Freezeout Creek. These increases in salinity concentrations suggest that the salt layer is stratifying and flattening out as the hydraulic forces of freshwater inflow, that serve to counteract tidal inundation, retreat upstream as the Estuary continues to backwater.

Dissolved Oxygen

The DO levels in the Estuary fluctuate significantly during the management period, and fluctuations are not necessarily associated with tidal cycles or a diurnal cycle (SCWA, 2006). DO is affected by salinity and temperature stratification, tidal and wind mixing, abundance of aquatic plants, and presence of decomposing organic matter. DO affects fish growth rates, embryonic development, metabolic activity, and under severe conditions, stress and mortality. Cold water has a higher saturation point than warmer water; therefore cold water is capable of carrying higher levels of oxygen.

When the mouth closes, salinity stratification results in pronounced DO stratification in the closed lagoon. DO fluctuations increase in the mid and upper depths and the bottom depths experience sharp drops in DO concentrations. Data from 1996 to 2000 monitoring indicates stratification, with hypoxic to anoxic conditions in the near-bottom layers of the Estuary within a few days of closure. Supersaturation, hypoxic, and anoxic events were observed, with prolonged hypoxic and anoxic events occurring at the bottom through the duration of Estuary closure. Decreasing DO concentrations were also observed in the middle layers of the water column during barrier beach closures. In deeper pools, DO typically drops to less than 5 mg/l (SCWA 2006; NMFS, 2008).

However, DO levels at the surface in the Estuary did not appear to be negatively impacted by Estuary closure and remained similar to pre-closure conditions, or increased in some instances (SCWA, 2006). DO concentrations near the surface remain similar to those found when the Estuary is open (7 to 10 mg/l). Similar stratified conditions were also observed when the barrier beach was open during neap tides or low river flows, indicating that the deeper portions of the Estuary may not be subject to mixing even during open tidal conditions.

Temperature

Because saltwater trapped in the lagoon is denser than freshwater it forms a layer under the fresh water from river inflows, which creates a saltwater lens that traps heat resulting in increased temperature in the saline and brackish layers below the freshwater layer of the Estuary during barrier beach closure. A three layer system forms with a cooler saline to brackish bottom layer that is below the effects of solar heating, a hot mid-depth layer of saline to brackish water subject to the effects of solar heating, and a relatively warm freshwater layer on the surface. Deeper pools are often stagnant saltwater that are cold and anoxic. Surface waters range between 18-21° C, but can reach temperatures of 25° C for periods. Typically, the mid-depth water column within the saline stratified zone will have higher temperatures than surface waters, with temperatures ranging between 21-24° C (SCWA, 2006, 2010; Behrens and Largier, 2010). This warmer, more saline mid-water column layer is generally consistent with other natural coastal lagoons in California that undergo transition to a freshwater lagoon or remain stratified over the summer months (Smith, 1990). When the barrier beach is breached, tidal mixing contributes to reduced temperatures. This process occurs most quickly near the mouth of the river and lower Estuary, and can take up to several days in the upper Estuary. These higher temperatures can be tolerated by steelhead if food supplies are abundant and the highest temperatures are not constant (NMFS, 2008).

Because the barrier beach is breached soon after closure under current practices, the duration of low DO and high temperature conditions within the lower water column are generally limited to approximately two weeks or less. Data from the monitoring surveys conducted by the Water Agency (2006) show that water quality in near-bottom layers and in deep pools is typically better when the barrier beach is open than when it has been closed for a short period of time (two weeks; Entrix, 2004). Under current practices, summer breaching of the barrier beach draws freshwater through the Estuary and accelerates mixing of stratified layers, which increases DO at depth. However, flows caused by breaching may not be sufficient to mix saline waters located at the bottom of the deepest pools. The deepest pools often remained stratified until an influx of tidal flows or higher winter flows flush the pools or cause mixing of the stratified layers. When the barrier beach re-forms, salinity stratification again leads to a deterioration of water quality in the project area during the one week period monitored following closure (SCWA, 2006; Behrens and Largier, 2010; Entrix, 2004). As described in **Section 4.3, Water Quality**, hypoxia and anoxia can also develop under tidal conditions in deep portions of the Estuary during neap tides and/or low river flows.

The water quality monitoring studies described here have, to date, only monitored water quality during short periods of barrier beach closure (typically two weeks). The Estuary has not been closed for longer time periods after mouth closure and creation of a freshwater lagoon has not been observed. Additionally, the monitoring conducted by the Water Agency (SCWA, 2005, 2006 and 2010) provides a general assessment of water quality changes in the Estuary, but does not assess the extent of microhabitat within the Estuary that may provide refugia for salmonids and other aquatic species (Entrix, 2004).

Effects to Sensitive Species Habitat

The distribution of fish in the Estuary is, in part, based on a species preference for or tolerance to salinity (SCWA, 2006). The distribution of species in the project area is largely influenced by the salinity gradient in the Estuary that is typically seawater near the mouth of the Russian River and freshwater at the upstream end. The fishery habitat zones relevant to the project area are generally characterized as marine/tidally influenced in the lower Estuary, estuarine/brackish in the middle Estuary, and freshwater in the upper Estuary (**Figure 2-2, Chapter 2.0, Project Description**). The borders between these habitat zones and the fish communities utilizing them are not distinct, and occurrences of overlap are typical. These zones form a gradually shifting continuum in response to changes in water quality characteristics related to instream flows, tidal cycles, barrier beach formation and are influenced by current breaching practices.

Fish monitoring surveys completed in the Estuary (SCWA, 2006; SCWA, 2010) demonstrate a shift in fish species composition during Estuary closures. During open-mouth conditions marine and estuarine fish species are typically found throughout the lower and middle Estuary with freshwater species generally inhabiting the upper Estuary. However, when the mouth closes, marine fish presence shifts towards the lower portion and concentrates around the river mouth where the highest salinities occur. Estuarine fish species, such as starry flounder and bay pipefish, expand their distribution into the upper Estuary. This upward movement of estuarine fish is a function of the upstream migration of the saline wedge resulting from Estuary closure. After the Estuary is re-opened, fewer marine species are typically detected in the Estuary and estuarine species are typically redistributed into the lower and middle Estuary.

In summary, the current practice of artificial breaching when the barrier beach closes the Estuary during the period from late spring to early fall has created a dynamic environment that ranges from near freshwater to marine conditions in the Estuary in the summer. Each time the barrier beach is mechanically breached, much of the freshwater lens in the Estuary that forms following closure of the barrier beach is discharged to the ocean. Near the mouth of the Estuary aquatic conditions (*e.g.*, salinity and temperature) are typical of marine habitat. Under current practices, suitable stable freshwater aquatic habitat (rearing habitat for salmonids) is currently only maintained in the upper reach of the Estuary and possibly near tributary mouths, where freshwater inflow maintains low salinity conditions regardless of tidal action. However, the upper Estuary contains freshwater that is warmer than optimal for rearing salmonids for much of the summer.

3.7 Extended Closure Data Report - 2009

3.7.1 Sampling Program Summary

In 2009, the Water Agency contracted with Bodega Marine Laboratory (University of California, Davis) to provide a view of circulation, stratification, residence and salinity in the Estuary Study Area from July through October 2009. An extended closure period lasting 29 days from September 7 through October 5, 2009, allowed for a study of prolonged closure conditions in the Estuary at high spatial and time resolution, along with two subsequent shorter closures (October 14-17 and October 22-27). This information is reported in *Hydrography of the Russian River Estuary Summer-Fall 2009* (Behrens and Largier, 2010).

Observed closure conditions in 2009 included formation of stratified conditions within the Estuary, as freshwater flows over the top of denser saline water at rates of approximately 70 to 95 cfs. Halocline conditions became established and persisted for the duration of the 29 day closure. Additionally, water balance analysis of the Estuary indicated that depending upon the elevation of the perched lagoon conditions, losses of between 30 and 78 cfs, with an average of 63 cfs, occur through the barrier beach (Largier and Behrens, 2010).

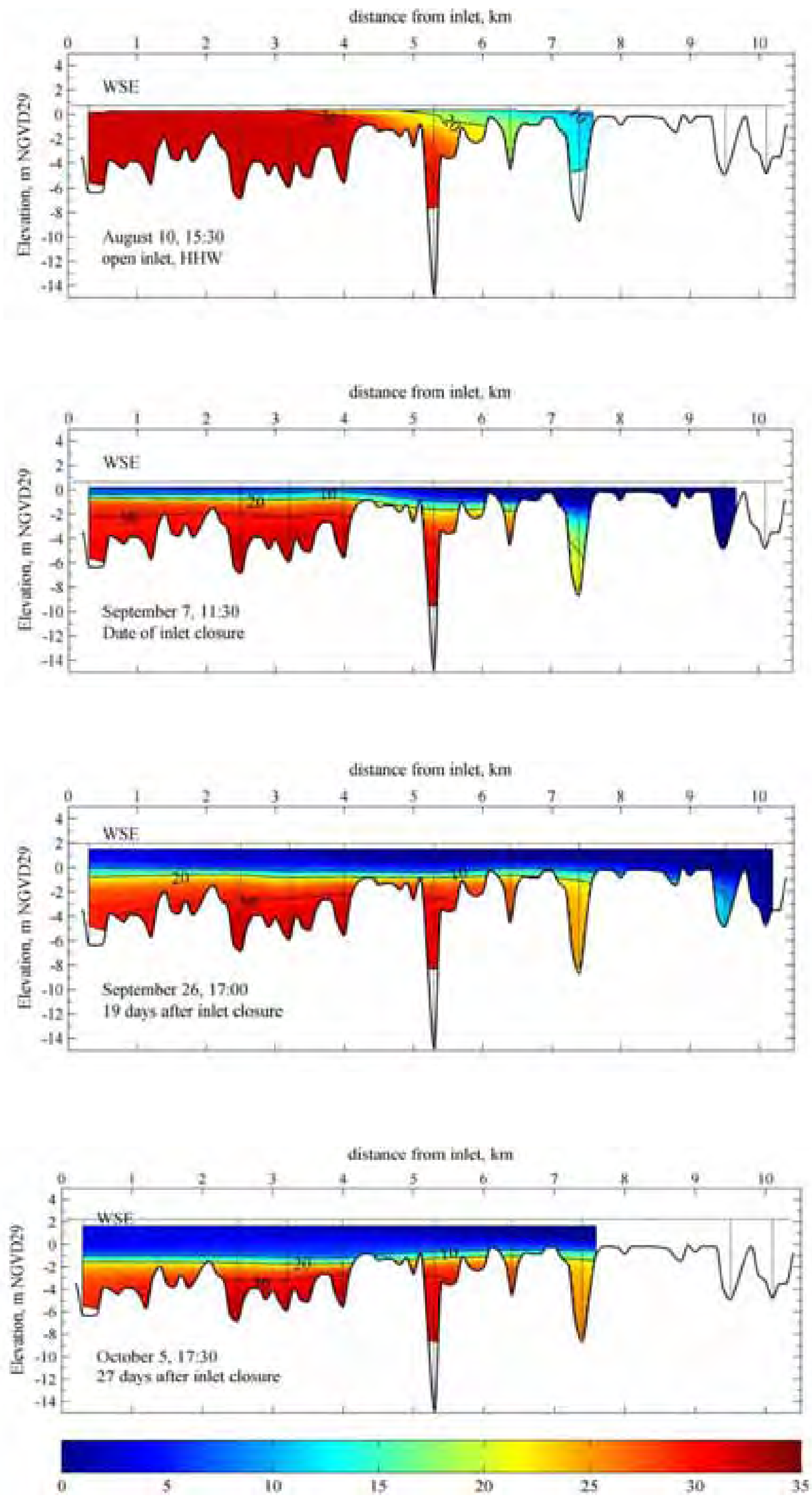
3.7.2 Salinity

Monitoring in 2009 showed a strong longitudinal gradient during open inlet conditions (August 10) prior to the Estuary closure on September 7, with relatively high saline water (>30 practical salinity units [psu])[6] dominating the water column at the mouth and extending approximately 5 kilometers (3.1 miles) up the Estuary (see **Figure 3-6**). Following the closure of the barrier beach on September 7, sharp vertical stratification was already present, with lowest salinity levels (less than 10 psu) at the top and highest (over 30 psu) toward the bottom (see Figure 3-6). For the first several weeks of the closure period, the halocline[7] was approximately three feet higher in the lower three-mile reach of the Estuary than at Sheephouse Creek. By the end of the closure period, the maximum salinity at the mouth was up to 35 psu toward the bottom layers and between 5 and 20 psu in the upper layers. By September 26, the halocline was nearly horizontal within the lower 6 miles, with over six feet of freshwater dominating the top layer of the water column in the lower and middle Estuary (Behrens and Largier, 2010).

When the barrier beach was naturally breached on October 5, the relatively fresh water near the surface was the first to exit the Estuary and the halocline dropped in all the monitoring locations. After one tidal cycle, a longitudinal salinity gradient was formed again, and salinity in the upper water layer extended incrementally farther upstream each day after the closure into the middle

6 Practical Salinity Unit. Used to describe the concentration of dissolved salts in water, the UNESCO Practical Salinity Scale of 1978 (PSS78) defines salinity in terms of a conductivity ratio, so it is dimensionless. Salinity elsewhere in the document is expressed in terms of parts per thousand (ppt), the amount of salt per 1,000 pounds of water. That is, a salinity of 35 ppt meant 35 pounds of salt per 1,000 pounds of water. Open ocean salinity is generally in the range from 32 to 37 ppt. Nonetheless, values of salinity in psu and ppt are nearly equivalent. Behrens and Largier use psu in their report, so the unit is included in this discussion.

7 Vertical salinity gradient in water column.



Russian River Estuary Management Plan Project ▪ 207734

SOURCE: Behrens and Largier, 2010

Figure 3-6
Salinity Profiles (in psu) in Russian River Estuary, 2009 Closure Event

reach of the Estuary. Conversely, salt water was observed to migrate into the upper reach of the Estuary along the bottom of the streambed during barrier beach closure, and then retreat following a breach, with the timing dependent in part on freshwater inflow rates, water surface elevations, and tidal cycles. The salinity patterns during the shorter closures (October 14-17 and October 22-27) were similar to that of the prolonged closure from September 7 to October 5 (Behrens and Largier, 2010).

3.7.3 Dissolved Oxygen

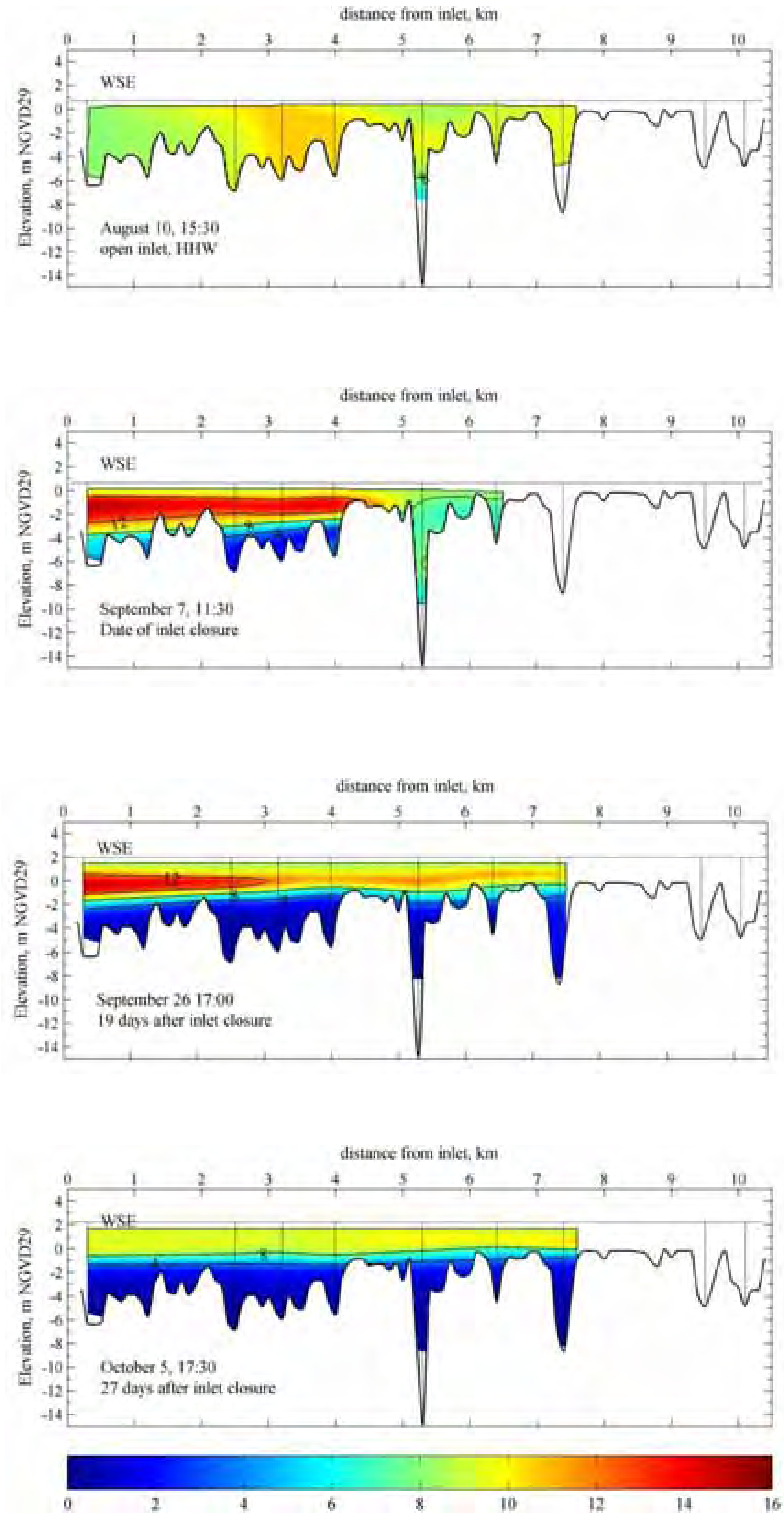
During 2009, DO levels in the Estuary during open and closed river mouth conditions were monitored by Bodega Marine Lab. In mid-August and during an open Estuary condition, DO levels throughout the Estuary were above 8 mg/L, with the exception of low DO levels near the bottom of a deep pool near Sheephouse Creek (**see Figure 3-7, August 10 Panel**). During the period of September 1 through September 7 when the barrier beach was nearly an overflow channel prior to the Estuary closure, DO levels decreased in the deeper parts of the Estuary between 1.2 and 3 miles (1.9 to 5 km) upstream of the barrier beach (**see Figure 3-7, September 7 Panel**). Following closure on September 7, low DO conditions were observed at the mouth, and by September 26, most of the Estuary from the mouth to four miles (6.5 km) upstream (approximately to Heron Rookery) was hypoxic to anoxic below a depth of 9 feet (**see Figure 3.7, September 26 Panel**). However, those conditions also maintained a nearly horizontal, uniform, 9-foot thick layer of high DO water at the surface varying from 8 mg/L near the mouth to above 10 mg/L upstream (**Figure 3.7, September 26 and October 5 panels).** Supersaturation conditions also occurred in the lower three kilometers of the Estuary in the top two meters of water, with DO levels over 14 mg/L.

Following the natural breach event on October 5, there was an incremental restoration of the DO in the Estuary, beginning at the mouth and extending upstream. Within approximately five days, the DO in the Estuary nearly resembled the conditions when the barrier beach had first begun to close on September 1 (Behrens and Largier, 2010).

3.7.4 Temperature

Temperature monitoring in the Estuary during 2009 showed temperature stratification coinciding with the location of the salt wedge. Since the saltwater was significantly colder than the freshwater(Behrens and Largier, 2010). Mean and maximum water temperatures in the Estuary were typically lower at the bottom and mid-depths, which were located primarily in saltwater. Surface temperatures had the greatest degree of fluctuation due to their location at the saltwater-freshwater interface. However, temperatures were also observed to exhibit daily fluctuations (13.5ºC and 15.1ºC [Anders et. al., 2006]) based on the heating and cooling effects of night and day, as well as longer-term seasonal heating and cooling events (SCWA, 2006).

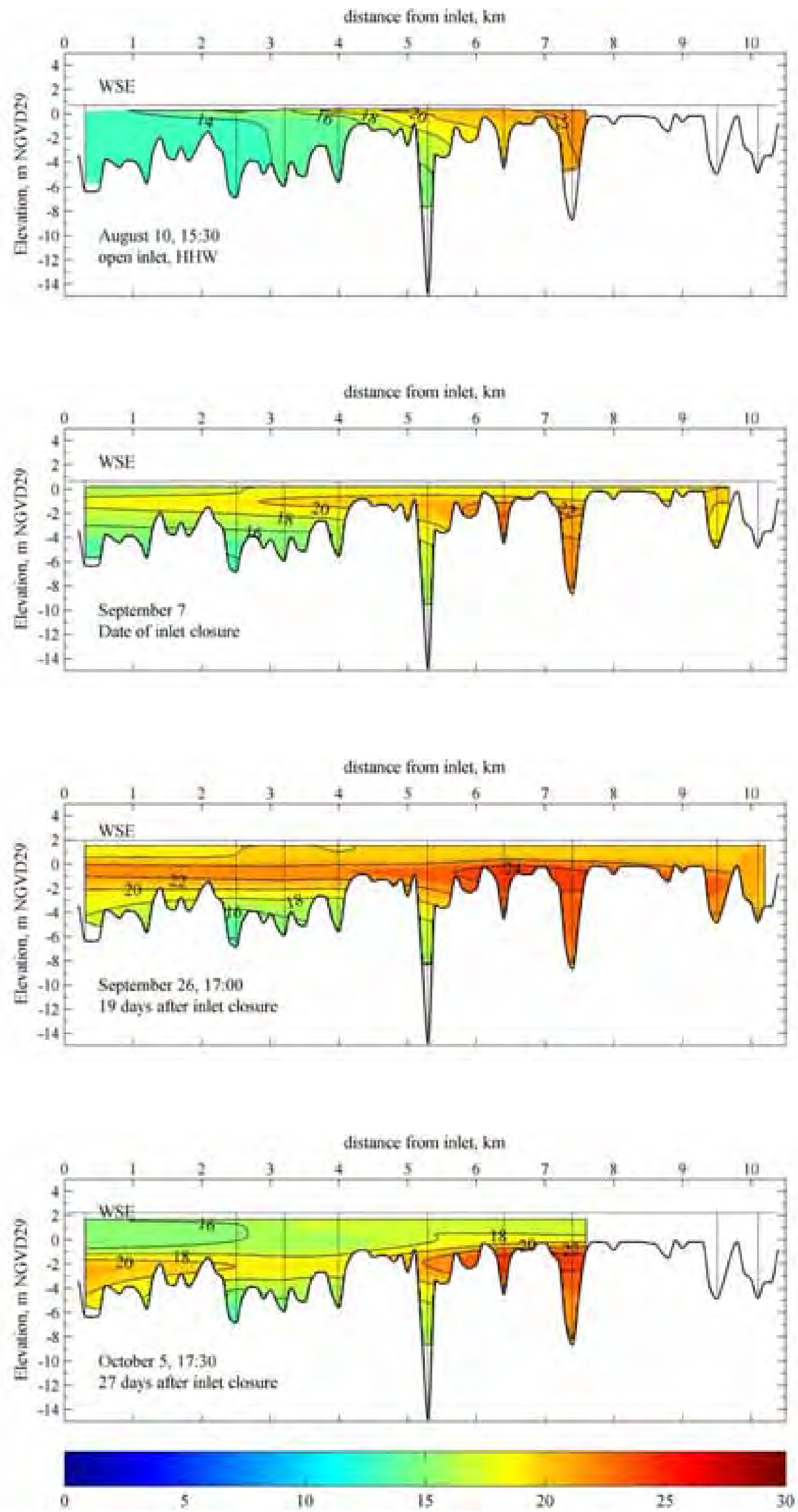
The Estuary showed a strong longitudinal temperature gradient prior to the closure on September 7 **(Figure 3-8, August 10 Panel**). At the onset of the closure on September 7, the Estuary already showed temperature stratification due to the perched conditions of the Estuary mouth (**Figure 3-8, September 7 Panel**). The mean temperature in the Estuary rose considerably with maximum temperature of 22 to 24ºC; however there were low (cooler) temperatures in deep holes that deviate



Russian River Estuary Management Plan Project ▪ 207734

SOURCE: Behrens and Largier, 2010

Figure 3-7
Dissolved Oxygen Profiles (in mg/L) in Russian River Estuary, 2009 Closure Event



Russian River Estuary Management Plan Project ▪ 207734

SOURCE: Behrens and Largier, 2010

Figure 3-8
Temperature Profiles (in ºC) in Russian River Estuary
2009 Closure Event

from the mean. The amount of warm water (16ºC) at the mouth increased sharply primarily in the mid layer of the water column. A vertical gradient was again formed (stratification), which continued through the closure period, and development of a three layer system was observed, with a cooler saline to brackish bottom layer that is below the effects of solar heating, a warmer mid-depth layer of saline to brackish water subject to the effects of solar heating, and a relatively warm freshwater layer on the surface. The peak temperature (>22ºC) was consistently located at the in the middle and upper Estuary in surface waters. Although the peak temperature was lower in other reaches, the same structure formed, with the maximum temperature present near the surface. As shown in Figure 3.8 (October 5 panel), a longitudinal slope in the boundary between high and low temperature water formed with temperature cooler at the river mouth (up to 20ºC) than that near Sheephouse Creek (over 25ºC). Similar to the salinity profile, the warm (and more saline) layer was found to underlie the relatively cooler freshwater layer.

When the river mouth was breached on October 5, the first water to exit the Estuary was the relatively warm (20 to 22 ºC) water in the upper 9 to 12 feet of the water column. In subsequent tidal cycles, the Estuary incrementally became colder, with a strong longitudinal temperature gradient re-forming between the Estuary mouth and Sheephouse Creek. The Estuary closures on October 14 and October 22 did not generate similar temperature structures to that of the prolonged Estuary closure period from September 7 to October 5. The shorter closures resulted in temperature gradients with lower temperatures (12 to 18ºC) than during the extended closures (over 20ºC). However, in both cases, a vertical temperature gradient was formed, with the temperatures of 16-18ºC at the surface.

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