EXHIBIT ESR--21

Testimony of Dr. Charles H. Hanson
El Sur Ranch Water Right Permit Application
Before the State Water Resources Control Board
Application No. 30166, Big Sur River, Monterey County

1. My name is Charles H. Hanson. I am a principal in the firm of Hanson Environmental, Inc., located at 132 Cottage Lane, Walnut Creek, California. My academic training includes Bachelor of Science and Master of Science degrees in fisheries from the University of Washington, College of Fisheries, graduate studies in environmental engineering at the Johns Hopkins University and a Ph.D. in fisheries and ecology from the University of California, Davis. A statement of my qualifications is presented in Appendix A to this testimony.

2. I have been involved in issues related to the status of fish species in the Sacramento-San Joaquin Delta since 1976. These issues have included state and federal Endangered Species Act studies regarding fisheries populations, including the biological monitoring of listed fish species, preparation of biological assessments, preparation of habitat conservation plans and service as a member of the United States Fish and Wildlife Service's (USFWS) Sacramento-San Joaquin Delta Native Fisheries Recovery Planning Team and the National Marine Fisheries Service's (NMFS) Central Valley Salmonid Technical Recovery Team. I served as a member of the National Scientific Peer Review Panel for Stanislaus River Water Temperature Criteria for Salmonid Restoration. I serve on a number of technical advisory committees that address fishery issues including the Mokelumne River Technical Advisory Committee and provide recommendations to the Restoration Administrator on San Joaquin River fishery habitat restoration as part of the restoration Technical Advisory Committee.

3. I also served as an expert witness on fishery issues on the American River in the case of Environmental Defense Fund v. East Bay Municipal Utility District, Alameda County Superior Court No. 425955 and in numerous water right hearings before the State Water Resources Control Board (SWRCB). I served as an expert witness on fishery issues in the delta smelt federal court proceeding (*NRDC et al. v. Kempthorne*) regarding the SWP and CVP OCAP biological opinion and interim remedies. I currently serve on the consultant team assisting in developing conservation strategies for water project operations and fishery habitat protection and enhancement within the Sacramento-San Joaquin Delta as part of the Bay Delta Conservation Plan (BDCP). I also served on the independent scientific peer review panel for the USBR 2008 OCAP biological assessment.

4. I have conducted fishery studies and analyses on a number of river systems with the primary focus being on Chinook salmon and/or steelhead. These river systems include the Trinity, Klamath, Santa Ynez, Feather, American, Sacramento, and San Joaquin rivers as well as Salmon and Arroyo Grande creeks. In particular, I have been actively involved in working on Southern and Central California Coast steelhead issues through my participation in the fishery management program and Adaptive Management Committee for the Santa Ynez River in Santa Barbara County as well as serving as the lead scientist in preparing a Habitat Conservation Plan (HCP) for steelhead inhabiting Arroyo Grande Creek in San Luis Obispo County.

5. For the past seven years, I have been the Principal Investigator for the fisheries habitat investigations of the Big Sur River and the potential impact of El Sur Ranch's irrigation well operations. These investigations involved extensive field studies and subsequent data analysis in which I participated and directed the work of other personnel of Hanson Environmental, Inc. The work was coordinated with that of The Source Group Inc. (SGI), which was investigating the hydrologic and hydrogeologic systems of the Big Sur River.

Summary Of Findings

6. El Sur Ranch operates two irrigation wells located adjacent to the Big Sur River. The Big Sur River provides a migratory corridor, spawning and egg incubation, and juvenile rearing habitat supporting a population of steelhead (*Oncorhynchus mykiss*). Fisheries investigations were designed and implemented to provide site-specific field information on instream habitat conditions within the lower portions of Big Sur River and the lagoon throughout the summer and early fall of 2004, 2006, and 2007. Based upon results of these investigations, we have concluded that the lower Big Sur River and lagoon provide suitable habitat for juvenile steelhead/rainbow trout rearing over the late spring, summer, and early fall period. Additional findings and conclusions of the investigations include:

- Summer baseflows observed during the 2004, 2006 and 2007 investigation were sufficient to provide physical habitat within the lower river and lagoon to support juvenile steelhead/rainbow trout rearing.
- Taking into account the natural variation in flows within the river, the effect of well operations on river flows could not be detected statistically during the critically low flows in 2007. Based on the small change in water surface elevation estimated by SGI (2008) it was concluded that a change of this magnitude would not result in a detectable adverse impact on the quality or availability of habitat for juvenile steelhead within the lower river and lagoon.
- Potential instream flows sufficient for adult steelhead passage during the December to April time period at Passage Transect 11 were estimated at 28 cfs from measurements made at higher flows on September 1, 2010.
- The lower river and lagoon showed evidence of groundwater accretions (upwelling) that contributed to increased summer flows within the lower reaches of the system when compared to upstream reference sites.
- Water quality conditions, including water temperatures, electrical conductivity, and dissolved oxygen concentrations, were within the range considered to be suitable for juvenile steelhead/rainbow trout rearing with the exception of the Creamery Meadow

reach under extremely low flow conditions where the available data indicate that localized groundwater upwelling affected water quality within the river, typically along one bank.

- No significant differences in water quality were detected that were correlated or attributed directly to irrigation well operations. Results of statistical analysis of water temperature data collected in 2007 under critically dry hydrologic conditions detected a small (0.3 C) change in water temperatures at two locations when the wells were on when compared to conditions when the wells were off. However, the incremental effects of this de minimis increase is well within the natural daily variation in water temperatures and would not adversely affect natural seasonal patterns or environmental cues within the river.

- Streamflows were sufficient to maintain connectivity among habitat units throughout the study period except when a sand bar deposit along the beach blocked the lagoon outfall and temporarily precluded access to the ocean. Formation of sand bars is a typical coastal process and did not appear to be the result of irrigation well operations. The sand bar did not close during our study periods in 2006. Water quality and habitat conditions within the lagoon remained good throughout all three years of investigation. There was no indication of prolonged vertical stratification in water quality that would adversely affect habitat suitability for juvenile steelhead rearing. Localized and temporary salinity stratification was observed when waves overtopped the sandbar that would mix and dissipate in a matter of days.

- Juvenile steelhead/rainbow trout were observed rearing within the lower river and lagoon during surveys conducted in July and October 2004 and during October 2007. The juvenile steelhead/rainbow trout were characterized as being in good health and condition, showed good summer survival, good summer growth rates, and evidence of the physiological transformation (smolting) during the fall that is typical of juvenile steelhead preparing to emigrate from the river into coastal waters

- Results of the streamflow, connectivity, habitat conditions, water quality measurements, and observations of juvenile steelhead/rainbow trout inhabiting the lower river and lagoon during the 2004, 2006, and 2007 study periods provided no evidence of adverse effects on habitat quality or availably as a result of El Sur Ranch irrigation well operations.

Scope and Objectives

7. The lower Big Sur River (Figure 1) and adjacent habitats support a variety of fish and wildlife species. The Big Sur River provides a migratory corridor, as well as habitat for spawning, egg incubation, and juvenile rearing supporting a population of Central California Coast steelhead (*Oncorhynchus mykiss*). Steelhead inhabiting the Big Sur River have been listed as a threatened species under the federal Endangered Species Act (ESA). El Sur Ranch has continuously operated irrigation wells located adjacent to the Big Sur River since approximately 1950 (Figure 2). The “Old Well” was placed in operation in about 1950 and the “New Well” was placed in operation in 1984. Questions have been raised regarding the potential for El Sur Ranch irrigation well operations to adversely affect instream flows and passage conditions for adult and juvenile steelhead as well as habitat quality and availability for juvenile steelhead rearing and other species inhabiting the lower river and lagoon during the summer and early fall.

8. As part of developing the technical foundation for the fishery and habitat investigations conducted on the Big Sur River by Hanson Environmental, Inc., a literature review and compilation of information relevant to assessing steelhead habitat on the Big Sur River and the effects of the El Sur Ranch irrigation wells was conducted. Such studies and reports are listed in the references to this testimony and the Hanson Environmental, Inc. fisheries investigations (Exhibits ESR—22, ESR—23, ESR—24 and ESR—25). A number of these studies have shown that the Big Sur River habitat is in good condition (Titus et al. 2003(Exhibit ESR—33)) and supports good growth and abundance of juvenile steelhead (Collin 1998 (Exhibit ESR—32), Titus et al. 2003). Titus et al. (2003) characterized the Big Sur River as mostly pristine.

9. The series of fishery habitat investigations conducted by Hanson Environmental, Inc. have been designed and implemented to provide site-specific field information on instream habitat conditions within the lower reaches of the Big Sur River and the lagoon

throughout the summer and early fall. These investigations began in 2004 and were continued in 2006 and 2007 to represent a range of hydrologic conditions within the Big Sur River watershed from wet (2006) to dry (2004) to critically dry (2007). Although the investigations have primarily focused on aquatic habitat within the Big Sur River, with a specific focus on habitat conditions for steelhead, botanical surveys have also been conducted as part of these investigations along both the river corridor as well as the El Sur Ranch coastal pastures, including Swiss Canyon (MGA 2007). Additional observations have been made to characterize changes in aquatic habitat primarily supporting populations of amphibians, including red-legged frogs (*Rana auropa draytonni*) within Swiss Canyon that could be affected by El Sur Ranch irrigation well operations. The field survey data collection activities have been conducted during the summer and early fall months of 2004, 2006, and 2007 were part of a multidisciplinary investigation integrating surveys of potential changes in aquatic habitat conditions with changes in surface water hydrology and hydrogeology in the basin (SGI 2005 (Exhibit ESR—4), 2007 (Exhibit ESR—5), 2008(Exhibit ESR—6) to provide information on the potential effects of El Sur Ranch irrigation well operations on surface waters supporting habitat for fish and wildlife.

10. It has been hypothesized that the potential effects of El Sur Ranch irrigation well operations on hydrogeology and surface hydrology affecting habitat quality and availability for juvenile steelhead and other species would vary in response to both the rate of well diversions by El Sur Ranch (e.g., no well operations, Old Well or New Well operating independently, or both Old and New wells operating simultaneously) and Big Sur River flow rates during the summer and early fall months. If El Sur Ranch irrigation well operations were adversely affecting habitat quality and availability for juvenile steelhead or other fishery resources within the Big Sur River, the potential effect would be expected to be greatest during those periods when well operations were highest (both Old and New wells were operating simultaneously) and summer and early fall flow rates within the Big Sur River were at their lowest levels.

11. Habitat quality and availability within the lower river and lagoon for juvenile steelhead are influenced by a variety of environmental factors. These factors could include, but are

not limited to, seasonal patterns in stream flows, seasonal water temperatures, dissolved oxygen concentrations, electrical conductivity, surface water connectivity among habitat units, habitat diversity, instream cover (large debris and undercut banks), riparian vegetation, substrate, availability of macroinvertebrates as prey, and a variety of other factors. Many of the factors affecting habitat quality and availability for juvenile steelhead rearing are independent of operations of the El Sur Ranch irrigation wells, such as availability of instream cover, riparian vegetation, and substrate. As a general proposition, other environmental parameters, such as water temperature, dissolved oxygen concentrations, electrical conductivity, and habitat connectivity may potentially be affected by irrigation well operations. To evaluate potential adverse effects to instream habitat, the fishery investigations were designed to meet the following primary objectives:

- Determine whether or not seasonal changes occur in the lower Big Sur River and lagoon that would adversely affect habitat quality and availability for juvenile steelhead/rainbow trout (steelhead are characterized by a life history of *O. mykiss* that migrates to the ocean for a part of their life cycle but return to freshwater to spawn; rainbow trout are characterized by a life history of *O. mykiss* that remains within freshwater throughout their life span; for purposes of simplicity the term steelhead is used in this testimony to represent *O. mykiss* inhabiting the Big Sur River) rearing throughout the summer and fall months;
- Determine the geographic distribution of, relative abundance of, and habitat use within the lower Big Sur River and lagoon by steelhead with respect to instream habitat parameters; and
- If changes in habitat quality or availability are detected within the lower river and/or lagoon, assess the potential effects of El Sur Ranch irrigation well operations on habitat conditions for steelhead and/or other sensitive wildlife. Habitat quality and availability for steelhead within the lower Big Sur River was used as an indicator of changes in overall quality of habitat conditions within the lower river and the potential effects of habitat changes on sensitive or protected species.

12. In addition, periodic surveys and routine monitoring were conducted to characterize changes in aquatic habitat conditions occurring within Swiss Canyon that would potentially be related to El Sur Ranch irrigation well operations.

13. Specific questions and evaluation criteria used to assess habitat conditions as part of these investigations included:

- Was there a significant reduction in stream flows along the longitudinal gradient from upstream areas outside of the potential influence of the El Sur Ranch irrigation wells and the lower river adjacent Creamery Meadow lying within the zone of potential influence of the irrigation wells and the lagoon (as described by SGI 2008)?
- Was surface water connectivity disrupted at any location between the lagoon and the parking area for the Andrew Molera State Park? Loss of surface water connectivity among habitat units would adversely affect steelhead habitat and limit the ability of juvenile fish to move and forage among various habitat units and, potentially, could result in stranding of juvenile fish within dewatered reaches of the river. Evaluation criteria for steelhead passage used in the field investigations included the identification of any location along the lower river or lagoon where water depths were reduced to less than 0.6 feet over 25% of the channel cross section and 10% of the contiguous channel section for adult steelhead passage and 0.3 feet over 25% of the channel cross section and 10% of the contiguous wetted channel cross section for juvenile steelhead. In 2010, after the completion of the field studies and related reports, the SWRCB adopted a policy for instream flows on north coast rivers that included a passage depth criterion for adult steelhead upstream migration of 0.7 feet (SWRCB 2010). For purposes of developing a recommended winter bypass flow objective for the lower Big Sur River, I applied the 0.7 foot adult passage depth criterion to the critical passage riffle (Riffle 11) as part of these investigations.
- Were dissolved oxygen concentrations within the lower river or lagoon decreased to a level that would be stressful or unsuitable for juvenile steelhead rearing? For

purposes of this evaluation, dissolved oxygen concentrations less than 6 mg/l were identified as stressful and/or unsuitable conditions for juvenile steelhead rearing;

- Were water temperatures within the lower river or lagoon seasonally elevated to a level that would result in stressful or unsuitable habitat conditions for juvenile steelhead rearing? For purposes of this investigation, stressful or unsuitable habitat conditions for juvenile steelhead rearing were identified by average daily temperatures greater than 20°C (68°F) or maximum daily (hourly) temperature greater than 24°C (75°F). The assessment of habitat conditions based on water temperature considered both water temperature conditions along the longitudinal gradient of the lower river and lagoon, and the identification of potential cold-water microhabitat pool refugia habitat that may provide suitable areas for juvenile steelhead to over-summer within the lower river and lagoon;
- Was electrical conductivity (salinity) elevated within the lower river or lagoon to a level that would be considered unsuitable or stressful for juvenile steelhead rearing? Juvenile steelhead are known to successfully rear within brackish water areas in lagoons and estuaries and are tolerant of low levels of salinity during their juvenile rearing period prior to undergoing the physiological smolting transition when they are adapted to higher salinities in preparation for migration into coastal marine waters. For purposes of this habitat assessment, electrical conductivities within the lower river or lagoon in excess of 1,500 uS/cm were identified as potentially stressful or unsuitable juvenile steelhead rearing habitat;
- Was there water quality stratification within the lagoon that would adversely affect habitat conditions for juvenile steelhead?
- Were juvenile steelhead present and rearing within the lower river including the lagoon? What was their abundance, their size distribution, and their geographic distribution within the lower river and lagoon relative to other habitat conditions and the location of the El Sur Ranch irrigation wells?

14. The results of these studies have been documented in the following detailed reports and are incorporated as part of this testimony.

- *Assessment of Habitat Quality & Availability within the Lower Big Sur River: April – October 2004.* March 11, 2005 ("2004 Study"). Exhibit ESR—22
- *Evaluation of the Potential Relationship between El Sur Ranch Well Operations & Aquatic Habitat Associated with the Big Sur River During Late Summer and Early Fall 2006.* March 2007("2006 Study"). Exhibit ESR—23
- *Assessment of the Potential Effects of El Sur Ranch Well Operations on Aquatic Habitat within the Big Sur River and Swiss Canyon During Late Summer and Early Fall* – 2007. April 2008 ("2007 Study"). Exhibit ESR—24
- *Juvenile Steelhead Habitat Suitability and Rearing Conditions Within the Big Sur River Lagoon.* May 2011. Exhibit ESR – 25.

Study Area

15. The reach of the Big Sur River selected for habitat and water quality monitoring during the 2004 investigations (Hanson Environmental 2005) extended over a distance of approximately 1 mile from the Andrew Molera State Park downstream to the confluence between the Big Sur River and Pacific Ocean (Figure 2). The study reach encompassed the area adjacent to Creamery Meadow and both the El Sur Ranch Old and New wells. The reach was selected to include reference areas located both upstream and downstream of the Creamery Meadow area that could be used to account for changes in river conditions resulting from natural inter-annual and intra-annual variation in stream flow rates within the Big Sur River. Additional sampling sites were located throughout the river reach to include areas that may potentially be affected by El Sur Ranch irrigation well operations. Although the same reach of the river surveyed in 2004 was included in the 2006 investigations (Hanson Environmental 2007), the majority of data collection activities during the 2006 study focused on a 2000-foot reach of the lower Big Sur River located in the immediate vicinity of the El Sur Ranch irrigation wells and Creamery Meadow (Figure 3). Field data collection activities during 2007 (Hanson Environmental 2008) replicated the 2006 station deployment. Field measurement instruments and

monitoring equipment were typically deployed in the low-flow summer period in August within the study reach and maintained through mid-October.

Steelhead Life Cycle

16. The Big Sur River is designated by the National Marine Fisheries Service (NMFS) as critical habitat for the federally threatened, and State species of special concern, steelhead – South Central California Coast Distinct Population Segment (DPS) (*Oncorhynchus mykiss irideus*). The abundance of adult steelhead that return to the Big Sur River to spawn has been estimated to be within the general range from approximately 100 to 1000 adults based on various surveys (Duffy 2003, Exhibit ESR—30). There does not appear to be a pattern in steelhead abundance that would suggest that the population abundance has declined substantially which is consistent with observations that the river habitat is in good conditions. Steelhead are an anadromous form of rainbow trout, meaning they spawn in freshwater streams and spend the majority of their adult lives in the ocean. Steelhead exhibit a variety of life history patterns, but generally adhere to the following sequence (Figure 4). Adults migrate from the ocean to natal freshwater streams to spawn where the gravel substrate and fast-flowing oxygen-rich waters provide for proper egg development. After the eggs hatch, they develop as alevins within the gravel interstices until they emerge as fry. Fry develop into juveniles while feeding and seeking cover in rearing areas, and after one or two years of freshwater rearing eventually begin their emigration to the ocean. On the Big Sur River our investigations and those of Titus et al. (2003) and Collin (1998) show that growth rates of juvenile steelhead rearing in the lower river are high with juveniles reaching smolt stage at age 1. Before completing their emigration, juveniles may reside in a lagoon/estuarine environment as they smolt, a process whereby physiological changes occur allowing steelhead to tolerate increases in salinity before venturing out into the ocean.

17. Juvenile steelhead rear in their native streams for a period of one to two years before migrating downstream into coastal marine waters. Depending on habitat conditions such as seasonal water temperatures and food availability the juvenile steelhead that experience rapid growth may undergo the smolt transition and migrate at age 1.

Observations of the length frequency and smolting condition of juvenile steelhead inhabiting the lower Big Sur River and lagoon in 2004 and 2007 show that the juvenile fish are in good health and condition, were of sufficient size to emigrate at age 1, and showed physical characteristics (silver scales without parr marks) of smolting in October.

18. On the Big Sur River and other California coastal streams and rivers, adult steelhead migratory behavior is cued by natural changes in flow regime from the upper watershed. High flows during the winter rainy season provide attraction flows and sufficient water depths within the stream channel to allow adult steelhead to reach spawning locations higher up in the watershed. Greater instream flows in turn provide greater coverage of the gravel substrate, thereby increasing the area of potential spawning habitat. Juvenile emigration requires stream flows during the late winter and early spring of an adequate volume to provide surface water connectivity of a sufficient water depth to allow the juvenile steelhead to migrate downstream to the ocean.

19. In most coastal river systems sand bars form and close that isolate the river from coastal waters. However, in the Big Sur River the sand bar does not close in every year, thereby maintaining connectivity between the river and lagoon and adjacent coastal waters. Juvenile steelhead will remain in the lagoon during the summer and fall while acclimating to changes in salinity and feeding on estuarine fauna. After the sandbar is breached by natural high flows during the winter rainy season, steelhead are free to again migrate between riverine and ocean environments.

20. Additionally, there must be adequate instream flow for steelhead to persist in the stream and lagoon until flows increase again the following winter. Decreases in flow may reduce rearing habitat quantity and quality. Under a worst case, depleted instream flow may cause juveniles to perish in small, isolated, oxygen-depleted pools. However, there are no reports of fish kills associated with such a worst case scenario on the Big Sur River. Our studies, even under a critically dry water year (2007), provide no evidence that El Sur Ranch irrigation well operations result in channel dewatering or fish stranding within the lower river or lagoon.

21. Steelhead are a cold water fish that have evolved and adapted to seasonal variation in thermal tolerance of various lifestages. US EPA (2003) has offered general guidance for establishing water temperatures for the various lifestages of steelhead in EPA Region 10 (Washington, Oregon, and Idaho). However, studies demonstrate that steelhead survival occurs in central and southern California streams and rivers at substantially higher temperatures than those experienced in the Pacific Northwest. Although the US EPA Region 10 guidance for steelhead spawning and egg incubation, smolting, and oversummering rearing are not directly applicable to the Big Sur River the guidance acknowledges the importance of maintaining natural seasonal patterns in water temperatures to provide environmental cues for spawning and migration. As a result of the location of the El Sur Ranch wells and their operations in the lowest reach of the river, its pumping is not expected to adversely affect the natural seasonal pattern of water temperatures in the Big Sur River. The EPA guidance also recognizes that activities that have only a very small potential effect on local water temperatures (e.g., less than 0.25 C) are de minimis in their impacts to salmonid habitat.

22. The National Marine Fisheries Service (NMFS 2009), the federal agency with responsibility for protecting steelhead under the ESA, has developed water temperature guidelines and objectives that have been applied in California. These objectives reflect the seasonal timing of various life history stages of steelhead. Although the biological response of steelhead to seasonal water temperature varies in response to factors such as food supply and habitat conditions, general indicators of habitat conditions include 13.3 C (56 F) or less during steelhead egg incubation, 14 C (57 F) or less during late winter and early spring smolting and juvenile migration, and average daily temperatures of 18 C (64 F) or less during the late spring, summer, and fall juvenile rearing period. In a number of California rivers an average daily water temperature of 20 C (68 F) or less has been used to characterize suitable juvenile steelhead oversummer rearing habitat. Results of a laboratory study conducted using juvenile steelhead from the American River (Nimbus strain) by Cech and Myrick (1999) showed behavioral preference for water temperatures within the range from 17 to 20 C, independently of ration level, which is consistent with the general guidance provided by NMFS for juvenile rearing habitat.

23. Instream flows for adult steelhead passage and to support juvenile rearing habitat are also important aspects of habitat conditions in the lower Big Sur River. In the past, general guidelines for adult steelhead upstream passage have been based on recommendations originally developed for steelhead in Oregon streams and rivers by Thompson (1972). The guidance recommended a minimum instream flow during the seasonal period when adult steelhead are migrating upstream (winter and early spring) sufficient to provide a depth of 0.6 feet of water over 25% of the channel cross-section and 10% of the contiguous cross-section. These criteria were intended to provide a sufficient water depth to allow adult steelhead the ability to migrate upstream to spawning sites during the winter and early spring months. As part of the original instream flow and fish passage analyses presented in our technical reports, a water depth criterion of 0.6 feet for adult steelhead passage was used based on the Thompson Method. More recently, after the fisheries investigations were completed, the State Water Resources Control Board (2010) adopted a policy for maintaining instream flows in northern California coastal streams that identified a general minimum upstream passage depth criterion of 0.7 feet for adult steelhead. However, this threshold is not absolute and other passage criteria may be applied on a site specific basis. Within the lower reaches of the Big Sur River we identified Passage Transect 11 as the critical riffle for passage purposes within the entire study area. PT 11 is located at the edge of the theoretical zone of influence of the well operations based on changes in groundwater elevations , but at this location changes in surface water depth could not be detected (SGI 2008). Analysis of winter bypass flows for adult steelhead upstream migration and passage were therefore based on assessing the instream flow, measured at the USGS gage, that met the 0.7 foot criterion at Passage Transect 11. Since adult steelhead passage occurs during the winter and early spring months when no passage measurements were made as part of these studies, data from the late summer passage measurement, in 2006 (the highest flows during our study) were used, in part, as a basis to estimate passage flows for adults using a regression to extrapolate data from the summer studies to winter passage.

24. Instream flows to maintain juvenile steelhead summer rearing habitat in the lower reaches of the Big Sur River have been based on instream flows that provide at least 0.3 feet of

water depth over 25% of the channel cross section or 10% of the contiguous channel cross section.

Approach and Methods

25. Aquatic habitat and terrestrial vegetation surveys were conducted during the summer and early fall of 2004 which was characterized by moderately low flows within the Big Sur River. During the 2004 investigations water quality measurements used to characterize fishery habitat conditions were made periodically using grab sample techniques, however no effort was made to coordinate the timing of field surveys with scheduling specific El Sur Ranch irrigation well operations. Although results of the 2004 investigation (Exhibit ESR – 22) did not detect a relationship between El Sur Ranch irrigation well operations and aquatic habitat conditions within the Big Sur River, the surveys did identify a localized area (typically along the right bank) in the vicinity of Creamery Meadow that was characterized by reduced water temperatures and reduced dissolved oxygen concentrations thought to be the result of groundwater upwelling into the river channel. There was no indication that El Sur Ranch irrigation well operation resulted in decreased dissolved oxygen concentrations that adversely impacted juvenile steelhead rearing habitat in the lower river or lagoon.

26. The experimental design for the study was refined during the summer and early fall of 2006 to include the addition of continuously recording dissolved oxygen meters as well as coordinated operations between El Sur Ranch irrigation well diversions (scheduled well operations including no wells, one well, and two wells operating simultaneously) and field data collection measurements. Flows within the Big Sur River during 2006 were moderately high and it was hypothesized that the lack of a detectable relationship between El Sur Ranch irrigation well operations and habitat conditions within the Big Sur River may have been obscured by high flows occurring within the river. (Exhibit ESR—23)

27. Precipitation on the Big Sur coast was abnormally low during the winter and spring of 2007 resulting in dry hydrologic conditions and substantially reduced flows (critically dry) within the Big Sur River during the summer and early fall 2007. These unusually

low flow conditions in 2007 offered an opportunity to conduct additional field measurements and investigations to further evaluate the potential effects of El Sur Ranch irrigation well operations on habitat conditions within the river under critically dry hydrologic conditions. In response to the low flow conditions within the river during the late-summer 2007, additional field surveys were designed and implemented, using continuously recording water temperature and dissolved oxygen monitoring equipment, in addition to routine visual observations, grab sample water quality monitoring, and measurements of river flow and water depth potentially affecting fish passage and habitat connectivity. These field measurements were scheduled to coordinate with specific El Sur Ranch irrigation well operations (e.g., no wells in service, one well operating, both wells operating simultaneously). The 2007 surveys provided the best opportunity to test the potential effects of El Sur Ranch well operations on aquatic habitat conditions within the lower river, including simultaneous operation of both irrigation wells for a maximum diversion rate, in combination with critically low flows within the Big Sur River. (Exhibit ESR – 24).

Habitat Characteristics

28. Habitat characteristics of the study area are shown in Figures 5 through 17. These photographs show the river conditions within the lagoon and upstream into the lower river. Habitat conditions include a series of pools and riffles within the river channel as well as riparian vegetation along the channel banks. The habitat in the lower reaches of the Big Sur River and lagoon are characterized by good riparian vegetation along the channel margins, sand substrate in the lagoon with bedrock outcroppings near the mouth of the lagoon, and a series of pool and riffle habitats within the lower river. The dominant substrate in the lower river is sand and small gravel, although pockets of gravel that would provide suitable spawning conditions for steelhead were present. There is very little submerged or emergent aquatic vegetation along the lower river or lagoon. Water depths and velocities vary throughout the reach from pools with depths greater than 3 feet to shallow riffle areas with depths less than 1 foot. There is evidence of human disturbance at several locations along the channel where trails provide access to the river by both day use and campers accessing the river, lagoon, and beach through the

State Park. In general, the lower river and lagoon are characterized as providing high quality habitat for steelhead migration and juvenile rearing. Natural barriers located upstream of the lower river and lagoon preclude access by adult steelhead to suitable habitat for spawning and rearing. As such, access to the river for steelhead spawning and rearing is limited to approximately the lower 7 miles of the river and lagoon.

Big Sur River Flow

29. Flow within the Big Sur River measured at the USGS gauging station between September 1, 2004, and October 31, 2007 is shown in Figure 18. The average monthly flow at the USGS gauging station during the September and October, 2007 study period ranged from 7.5 (September) to 9.8 cfs (October). Table 1 presents a comparative summary of the average monthly flows measured at the USGS gauging station during April-October in 2004, 2006, and 2007 (the three study years). Results of flow measurements (Figure 18) show that the highest river flows occurred during the 2006 study period (wet year). The lowest Big Sur River flows occurred during the 2007 study period (critically dry year). Based on a probability of exceedance analysis using the USGS flow, September 2007 had a flow exceedance of greater than 80% reflecting the extremely dry hydrologic conditions occurring within the river during the 2007 study period (this means that average monthly September flow exceeded 8.0 cfs in 80% of the Septembers since 1950).

30. Results of the 2007 river flow monitoring showed a pattern of declining flows in the reach extending from the USGS gauging station to a location just upstream of the Andrew Molera campground and downstream of the parking lot (Figure 2; referred to as VT-1 which was used as the upstream reference location). The VT-1 monitoring location was determined to be located outside of the potential zone of influence of El Sur Ranch well operations (SGI 2008). SGI (2008) discuss results of instream flow monitoring conducted as part of these studies that were used in the analysis of the potential effects of El Sur Ranch well operations on river flows and fishery habitat. Results of these studies show a general pattern of declining river flows in the upper reaches of the river extending downstream to monitoring site VT-3 located approximately mid-distance downstream of the parking area and upstream of the lagoon (Figure 2). The

reach of the river extending from VT-3 downstream towards the lagoon showed evidence of increased flows (accretions) associated with groundwater upwelling that was observed in the general vicinity of Creamery Meadow (VT-2). The minimum flow in the river observed during 2007 occurred during and just following the Labor Day weekend (*see* SGI 2008 for daily flow measurements during 2007; Testimony of Paul D. Horton, P.G., C.H.G, Exhibit ESR—2, p. 5-3 and Figure 5-3).

31. Given the extremely low flows within the river during the summer and early fall of 2007 it was expected that the potential effects of El Sur Ranch irrigation well operations on aquatic habitat within the river would be most detectable, particularly under conditions of maximum diversion rates (both Old and New wells operating simultaneously) during these critically dry hydrologic conditions. There was a small effect of well operations on river flows (maximum theoretical change in stage under critically dry conditions was estimated at 0.03-0.04 feet at the downstream edge of the zone of influence (SGI Surface Drawdown Memo, Exhibit ESR—8)), however, given the variation in river flows and ambient conditions, differences between flows when the wells were on and off were not determined to be statistically significant. There was no statistically significant difference ($P>0.05$) between flows upstream, at control station VT-1, compared with flows downstream at VT-3 and VT-2, with the pumps off versus the pumps on (normalized for variation in river flow) demonstrating that no detectable difference in flow downstream was attributable to well operations (Figure 2). A ratio of flow at VT-1, and VT-2 and VT-3 was used, in order to normalize data for seasonal differences in flow amongst weeks measured during the study period, and a chi-square test was performed on the flow ratios comparing days when both pumps were on (e.g., October 3) to all days when both pumps were off. P values resulting from these tests ranged from 0.23-0.092, and thus, did not show that the effects of pumping operations were significant on downstream river flows. Taking into account the natural variation in flows within the river, the effect of well operations on river flows could not be detected statistically. Based on the small change in water surface elevation estimated by SGI (2008) it was concluded that a change of this magnitude would not result in a detectable adverse impact on the quality or availability of habitat for juvenile steelhead within the lower river and lagoon.

32. During the September 1 through October 11, 2007 study period, field surveys and data collection activities were also scheduled to coincide with specific operations of the El Sur Ranch irrigation wells. A schedule was established as part of the basic experimental design for the 2007 investigations which included approximately weekly periods when (1) no wells were in operation, (2) either the New Well or the Old Well was in operation, or (3) both the New and Old wells were in operation simultaneously. During those periods when neither the Old Well nor New Well was in operation no water was diverted for El Sur Ranch irrigation. During those periods when the New Well was in operation the diversion rate was estimated to average 2.37 cfs (SGI 2008). During those periods when the Old Well was in operation the diversion rate was estimated to average 2.26 cfs (SGI 2008). During those periods when both the Old and New wells were operating simultaneously the diversion rate was estimated to average 5.02 cfs (SGI 2008). The schedule of actual El Sur Ranch irrigation well operations during 2007 study period is summarized in Table 2.

33. The well operations schedule established for use during the 2007 investigations was designed to allow comparisons of habitat conditions and water quality parameters, under low river flow conditions during 2007, in response to specific irrigation well operations. During each of the weekly field surveys, data collection was scheduled to occur during the end of a given well operational period to help assure that the hydrodynamics between groundwater and surface water had reached equilibrium. It was anticipated that if El Sur Ranch irrigation well operations were having a significant effect on aquatic habitat conditions within the Big Sur River, the best method for detecting the effect of well operations would be a comparison between periods when no wells were diverting and when both wells were operating simultaneously for a maximum diversion rate. For those parameters such as hourly water temperature a sufficient number of observations were recorded during the 2007 study to be able to statistically test for differences between those periods when no irrigation wells were operating, when one well was operating, and when both wells were operating together.

Water Temperature

34. Results of average daily and maximum daily water temperature monitoring within the Big Sur River during the 2004, 2006, and 2007 studies showed that late summer and early fall water temperatures were well within the range considered to be suitable for juvenile steelhead rearing habitat. Figures 19 and 20 show an example of the hourly and average daily water temperatures measured under critically dry hydrologic conditions that occurred in 2007. For reference, a horizontal line has been included on the temperature graph showing the average daily temperature criterion of not to exceed 20°C (68°C) and the hourly criterion of not to exceed 24°C (75°C) selected for use in this study to assess the suitability of water temperatures for juvenile steelhead rearing. Also shown are the periods when El Sur Ranch irrigation wells were both off, one well was operating, or both wells were operating.

35. Results of the 2007 water temperature monitoring showed a typical pattern of daily variation in temperatures which were typically within the range of 5-7°C (9-13°F) (daily minimum to daily maximum) or less. The results also show a general pattern of seasonally declining water temperatures between early September and early October reflecting seasonal cooling in atmospheric temperatures (particularly cooling at night during the fall) with a corresponding trend of reduced river temperatures. The exception to this general pattern was observed at two locations (Passage Transect 7 right bank and piezometer location 3 right bank; Figure 2) where water temperatures were typically cooler than at other locations and daily variation in temperatures was reduced, both of which are thought to reflect the influence of groundwater upwelling in this area along the right bank of the river.

36. Results of our studies showed evidence of a localized area in the vicinity of Creamery Meadow (primarily along the right bank of the river) upstream of the lagoon where water temperatures were observed to be cooler than those observed either upstream or downstream. The cooler temperatures were attributed to localized groundwater upwelling into the river. It was hypothesized that this localized area of cooler water temperatures might provide a thermal refuge for juvenile steelhead, if needed, in response

to elevated water temperatures in the lower river. During our studies, which included a period under critically low flow conditions, water temperatures were suitable for juvenile steelhead rearing throughout the lower river and lagoon and, hence, there was no biological benefit to steelhead to preferentially inhabit the localized area where coldwater upwelling was detected.

37. Furthermore, results of the earlier studies showed no evidence of a cause-effect relationship between El Sur Ranch irrigation well operations and locally elevated water temperatures within the lower river. To further investigate the potential relationship between El Sur Ranch irrigation well operations and water temperatures within the lower Big Sur River during the 2007 study, hourly temperatures measured at each location were analyzed using the General Linear Model Procedure (GLM) within the Statistical Analysis System (SAS) to determine if water temperatures exhibited statistically significant differences ($P<0.05$) based on variation in irrigation well operations. In addition to well operations the statistical analysis also included consideration of air temperature, river flow, and whether or not the lagoon mouth was open. For purposes of this statistical analysis hourly water temperatures measured at VT-1 located upstream of the Andrew Molera campground (Figure 2) were shown to be independent of well operations and served as a reference location to establish naturally occurring variation in river flow and ambient water temperatures. The CONTRAST procedure within SAS was used to test the hypothesis that there were no statistically significant differences in water temperatures between the upstream reference location (upstream of the campground at VT-1) and other locations and that the differences in temperatures that did occur were independent of irrigation well operations. The analysis also accounted for data from recorders located on the right or left bank of the river and hour of the day. It was expected that if irrigation well operations were affecting water temperatures within the river the effect would be greatest when both wells were operating simultaneously. More than 23,000 observations were included in the statistical analysis of 2007 monitoring results.

38. No significant differences in water temperature in response to well operations were detected in 2004 or 2006, when river flows were greater than those in 2007. Results of

the statistical analysis under the critically dry 2007 conditions detected statistically significant differences ($P<0.05$) at some locations in water temperatures between periods when there were no irrigation wells in operation, one well was operating, and two wells were operating, with temperatures both increasing and decreasing in a pattern inconsistent with well operations. In fact, in a number of comparisons, the temperatures measured when one well was operating were greater than when either no wells were in service or when both wells were operating. Moreover, the absolute differences in temperature were small (all differences were less than 1°C [2°F]) between no, one, and two well operations) and were well within the range of natural daily variation. Since the increased temperatures when one well was operating (less than 1 C increase when compared to either no wells or two wells in operation) occurred at a number of locations along the river, including stations located upstream and out of the area of potential well influence, no physical cause-effect relationship between the observed results and El Sur irrigation well operations was identified. We hypothesized that the statistically significant difference in water temperature (when temperatures were higher under the one well operating condition when compared to either no wells or the two well operating condition) detected at several stations were the result of some covarying environmental factor other than irrigation well operation. The inclusion of the lagoon mouth being open or closed did not significantly affect results of the statistical analysis. Results of the statistical analysis by location and irrigation well operations showed that at only two of the locations (PT-5, PT-6; Figure 3) were temperatures significantly ($P<0.05$) higher, although within the range of suitable temperatures, when both wells were operating compared to periods when no wells were in operation. At both locations PT-5 and PT-6 the statistical difference between no well operations and two well operations was less than 0.3°C (0.5°F). The fact that we were able to detect a statistically significant difference in water temperatures and well operations at PT-5 and PT-6 is, in large part, attributable to the extreme power of these analyses.

39. As part of the evaluation and interpretation of results of the 2007 study we considered whether differences in environmental parameters such as water temperatures were statistically different as well as whether observed or statistically significant differences

were biologically meaningful to the suitability and availability of juvenile rearing habitat within the river (a difference in a parameter such as water temperature may be statistically significant when comparing conditions when no wells are in operation and when two wells are in operations but may not be biologically meaningful to the observed habitat conditions in the river; e.g., the observed variation is within the range of natural diel variation, or water temperatures are within the suitable range independently of a small difference related to one or more factors such as well operations). The small statistical increase in water temperatures detected at locations PT 5 and PT 6 with both wells in operation (<0.3°C [0.5°F]) would not result in adverse effects on habitat quality or availability for juvenile steelhead rearing. The incremental effects of this de minimis increase in water temperatures is well within the natural variation in water temperatures and would not adversely affect natural seasonal patterns or environmental cues within the river. This conclusion is consistent and supported by the observation that neither the maximum hourly water temperature nor the average daily water temperatures at any of the monitoring locations within the lower river exceeded the selected criteria for steelhead habitat suitability.

40. Water temperatures even under critically low flows in September were consistently within a range considered to be suitable for juvenile steelhead rearing independently of whether no wells, one well, or both irrigation wells were in operation. Results of water temperature monitoring in 2007 are consistent with results in 2004 and 2006 in showing that habitat within the lower river is suitable for juvenile steelhead rearing over a range of hydrologic conditions and El Sur Ranch irrigation well operations.

41. Observations made during the dry year 2004 snorkel surveys showed that the juvenile steelhead inhabiting the lower reaches of the river, appeared to be growing at a rate comparable or greater than that reported for many other California rivers (Figure 21; Table 3), showed evidence of smolting characteristics, and appeared active and in good condition (Hanson Environmental 2005). Observations of juvenile steelhead rearing in the lower river and lagoon in 2007 also showed that the fish were healthy and in good condition, actively foraging, and showed signs in the fall of smolting at age 1. These conditions are consistent with a finding that the lower river and lagoon provide good

habitat conditions, even under the critically dry conditions in late summer and early fall of 2007, for juvenile rearing, growth, smolting, and emigration at age 1. The observations of the 2004 and 2007 snorkel surveys are consistent and support the general finding that water temperatures were suitable for juvenile steelhead rearing.

Dissolved Oxygen Concentrations

42. Dissolved oxygen measurements were made during periodic water quality surveys (grab samples) during 2004, 2006, and 2007 in the lower river and lagoon. Results of monitoring during the 2004 surveys showed evidence of localized reductions in dissolved oxygen concentrations in the vicinity of Creamery Meadow that were thought to be the result of localized groundwater upwelling along the right bank of the river. Evidence of localized groundwater upwelling was consistent with observations of reduced water temperatures in the same areas as reduced dissolved oxygen concentrations. Within the rest of the study area in 2004 dissolved oxygen concentrations were within the suitable range for juvenile steelhead rearing. With the higher river flows in 2006 dissolved oxygen concentrations were suitable throughout the study.

43. Results of the 2007 habitat and water quality monitoring are consistent with findings of the 2004 and 2006 studies in showing that dissolved oxygen concentrations were above 6 mg/L consistently in the lagoon and lower riverine reaches as well as the reaches upstream of Creamery Meadow and would not adversely affect habitat quality and availability for steelhead rearing within the lower river or lagoon. In the vicinity of Creamery Meadow, dissolved oxygen levels in 2007 were observed to be less than 6 mg/L during early September in the localized area where groundwater upwelling has been detected (piezometer locations 2, 3, ands 4, and at passage transect locations PT 4 through PT 8; see e.g., Figure 22). Although localized reductions in dissolved oxygen had previously been observed along the right bank of the river, the reduced dissolved oxygen observed in early September 2007 was detected across the river channel before mixing with surface water within the river channel had completely occurred. The low dissolved oxygen concentrations coincided with the period of lowest flows in the river. On September 5, 2007, for example, the flow at VT-1 was 1.62 cfs, the flow at VT-2 was

1.34 cfs, and the flow at VT-3 was 0.35 cfs (Hanson Environmental 2008). Under these extremely low-flow conditions the effects of groundwater upwelling were most pronounced. As flows increased following the Labor Day weekend, dissolved oxygen concentrations increased. By the next survey (September 12, 2007) when flow at VT-1 was 5.03 cfs dissolved oxygen concentrations increased to above 6 mg/L and remained above 6 mg/L over the remainder of the 2007 study period (Hanson Environmental 2008). Results of these studies are consistent with the hypothesis that localized groundwater upwelling results in locally reduced dissolved concentrations in the vicinity of Creamery Meadow upstream of the upper lagoon and that these effects are greater when river flows are low. Under the critically low flow conditions in early September 2007, irrigation well operations appeared to have a de minimis influence on localized dissolved oxygen concentrations near Creamery Meadow at piezometer locations 2 and 3 (Figure 2) that were not found to be statistically significant, i.e., were not found to be attributable to well operations. Dissolved oxygen concentrations remained within a range considered to be stressful or unsuitable for juvenile steelhead both when irrigation wells were in operation and when they were not. Dissolved oxygen concentrations appeared to be independent of irrigation well operations at other locations within the lower river.

Electrical Conductivity

44. Results of habitat surveys and snorkel surveys conducted within the lower river during 2004 and 2006 showed that juvenile steelhead inhabited a range of salinities ranging from freshwater in the upper reaches of the river to brackish water habitat within the lagoon, but that salinity levels were consistently within the range suitable for juvenile steelhead rearing. Salinities were typically lower in the river during 2006 when flows were higher with the brackish waters of the lagoon extending further upstream when river flows are low (e.g., 2004 and 2007). The distribution of salinity within the lower river and lagoon is also affected by opening and closing of the lagoon connection to the ocean by formation of the sand bar and by wave overtopping of the sandbar. Juvenile steelhead have a relatively high tolerance to salinity and have been reported to rear in estuaries and lagoons prior to emigrating to the ocean. The lower river and lagoon provided a gradient of salinities ranging from freshwater in the riverine reaches to brackish water in the lower

lagoon near the sand bar that offer a variety of suitable microhabitats for juvenile steelhead rearing.

45. During the 2007 study period, electrical conductivity (a measure of salinity) in the lagoon increased briefly in late-September but appeared to be related to wave overtopping of the sand bar and was independent of irrigation well operations (Figures 23 to 27). Electrical conductivity at locations upstream of the lagoon remained constant throughout the study period and were independent of El Sur Ranch irrigation well operations (no statistically significant differences in electrical conductivity were detected in relationship to El Sur Ranch irrigation well operations; P>0.05). Based on results of the 2007 studies and similar results from the 2004 and 2006 studies, there was no evidence that irrigation well operations affected habitat quality or availability for steelhead rearing as a result of changes in electrical conductivity.

Steelhead Passage and Habitat Connectivity

46. Results of observations within the lower river and lagoon during the 2004 and 2006 habitat surveys showed that connectivity was maintained among all habitat units within the lower river to allow juvenile steelhead the opportunity to move among habitat units, other than during those periods when the sand bar closed and precluded access to the ocean. These results of fisheries habitat monitoring, as well as hydraulic analyses presented by the SGI work (SGI 2007) show that El Sur Ranch operations do not impact habitat connectivity under the 2004 and 2006 flow conditions.

47. Since river depth and habitat connectivity within the lower river vary in response to changes in river flow, it was hypothesized that passage among habitats and river connectivity would be most critical during years when river flows are lowest. The critically dry hydrologic conditions that occurred within the river in 2007 offered an opportunity to test whether habitat connectivity varies based on irrigation well operations under these extreme low flows. The studies focused on instream flows that would provide suitable water depths for movement of juvenile steelhead among habitat units during the late summer and fall (August – October period of our studies). Although adult

steelhead migrate upstream during the winter months, adult passage was evaluated using summer and fall flows in order to estimate potential instream flows that would meet a greater water depth (0.7 feet) for adult passage during the winter months.

48. Periodic measurements were made throughout the 2007 study period at 11 transects (Figure 3) to assess changes in wetted channel width and cross-sectional depths during periods when no irrigation wells were in operation, one well was operating, and both wells were operating (Table 2). During the habitat surveys visual observations were also made of habitat connectivity. Results of the visual observations showed that surface water connectivity was maintained within the lower river and lagoon throughout the 2007 study period.

49. Average water depths within the lagoon were typically greater than 2 feet during all 2007 passage surveys. The largest variation in water depth observed during the 2007 study occurred at passage transects PT 2 and PT 3 located immediately upstream of the lagoon (Figure 3) where changes in the sand bar at the mouth of the lagoon, tidal effects within the lagoon, and associated backwater effects at the head of the lagoon affected water depths during the surveys. Average water depths typically ranged from approximately 0.5 to 1.25 foot at PT 2 and from 0.25 to 1 foot at PT 3. The sandbar at the lagoon mouth was identified as a temporary factor affecting passage opportunities between the river and lagoon and coastal marine waters for steelhead. Once the sandbar was breached opportunities for steelhead passage were re-established.

50. Water depths in the riverine reach immediately upstream of the lagoon (PT 4 and PT 5) did not show the effects of tides and lagoon dynamics on water depths and remained relatively constant during the low-flow September and October 2007 conditions. Average water depths at PT 4 were consistently less than 0.3 feet, however 10.8 to 28.6% of the channel cross-section was 0.3 feet or greater (Hanson Environmental 2008) and would have provided opportunities for juvenile steelhead to pass among habitat units. Moreover, the water depths at PT 4 were greater than 0.3 feet over 15% of the contiguous channel cross section in all but one of the surveys in 2007 (September 5, 2007 on which flow at VT3 was 0.35 cfs) (Hanson Environmental 2008). The major factor contributing

to the shallow water depths at PT 4 were the naturally low river flows and the configuration and elevation of the riffle. The effects of El Sur Ranch well operations on river stage at PT 4 was difficult to detect but were estimated to be in the range of 0.03-0.04 (SGI Surface Drawdown Memo, Exhibit ESR—8)). However, the differences in water depths at PT 4 were not statistically significant between surveys conducted when no wells were operating and when one or both wells were in service. Water depths further upstream at PT 5 through PT 10 met juvenile passage criteria, except for PT 10 on one survey date following the Labor Day weekend (September 5, 2007) under conditions of extreme low flow noted above. Shallow water depths were also observed in 2007 at PT 11 located at the theoretical edge of the zone of influence of irrigation well operations (SGI 2008) that did not meet juvenile passage criteria for multiple survey dates in late August to mid-September 2007.

51. However, shallow water depths occurring at passage transects upstream of the lagoon, in particular PT 4 and PT 10, as well as PT 11, located at the theoretical edge of the zone of influence of irrigation well operations (SGI 2008), were not significantly related to well operations. The differences in water depths at these locations appear to be a response to channel gradient, width, and low river flows that occurred during the 2007 study. Given the pattern of results in instream flows and hydrologic conditions observed at the various locations within the river, in combination with detailed monitoring by SGI (2008) as part of the 2007 studies, there was no evidence that well operations were a statistically significant factor affecting passage conditions in the river.

52. Adult steelhead migrate upstream into the Big Sur River during the winter and early spring months (e.g., December-April) to spawn. After spawning, adult steelhead have the potential to migrate back downstream (referred to as kelts) and return to coastal marine waters. The fishery surveys performed as part of this investigation focused on the juvenile rearing period in late summer and early fall and therefore did not directly address adult steelhead passage. Data collected during the 2006 studies under higher flow conditions were used as a proxy to assess potential instream flows for adult passage during the December-April period. Results of field observations during 2006 demonstrated that a flow of 23 cfs at the USGS gage did not provide a water depth of 0.7

feet over 25% of the channel cross-sectional area at the critical riffle (Passage Transect 11) located at the theoretical upstream edge of the El Sur Ranch irrigation well zone of influence. Extrapolating from the 2006 data, it was estimated that a flow of 30 cfs at the USGS gage would meet the adult steelhead passage criterion. Additional field measurements were made at Passage Transect 11 on September 1, 2010 when flow at the USGS gage was 28 cfs that met the depth criterion over 26% of the channel cross-section, which was consistent with the results extrapolated from the 2006 field measurements.

Distribution and Relative Abundance (Density) of Steelhead and Other Aquatic Species

53. During 2004 and 2007 divers were used to conduct snorkel studies designed to characterize the abundance, size, characteristics, and distribution of juvenile steelhead within the lower river and lagoon. The methods used in conducting the surveys are described in Hanson Environmental (2005).

54. In 2004 and 2007 the reach of the lower river surveyed (Figure 28) by divers (Figure 29) extended approximately one mile from the lagoon mouth upstream to the State Park parking area. Four species of fish were observed during snorkel surveys in October 2007. In order of abundance, steelhead (*O. mykiss*), threespine stickleback (*Gasterosteus aculeatus*), riffle sculpin (*Cottus gulosus*), and starry flounder (*Platichthys stellatus*) were observed. Threespine stickleback was the most abundant species with 715 individuals observed. Additionally, signal crayfish (*Pacifasticus leniusculus*) were observed. Thus, the classical coastal stream fish assemblage was observed during these surveys.

55. Snorkel surveys were conducted on the lower Big Sur River during July and October of 2004 to determine the distribution, abundance and length frequency of steelhead/rainbow trout within the reach extending from the lagoon upstream to the state park parking area (Hanson Environmental 2005). Comparative fishery surveys during the summer and early fall provided the opportunity to assess changes in oversummering abundance (survival) and size distribution (growth) and the basis to evaluate changes in the fishery population over the summer irrigation season. Results of the fishery surveys provide

corroboration of habitat quality conditions derived from measurements of physical habitat conditions (stream flows) and water quality conditions.

56. No obvious limiting factors to juvenile steelhead/rainbow trout survival were observed during the surveys. Spawning habitat was marginal throughout the surveyed reaches due to substrate size and abundant fines. Habitat conditions remained relatively constant between the July and October surveys. The formation of a sand bar across the river mouth prohibited adult and juvenile steelhead migration into and out of the river until the bar was breached. Formation of a bar completely blocking the lagoon is a rare occurrence according to a park ranger and usually breaches during the first large rain event.

57. A total of 358 juvenile steelhead/rainbow trout were observed during the October 2004 survey compared to 417 observed during the July survey. Juvenile steelhead/rainbow trout were observed inhabiting all eight reaches surveyed during both the July and October surveys. The highest densities of juvenile steelhead/rainbow trout were observed consistently within the lagoon and within a pool with overhead cover located in approximately the middle of the survey reach (0.47 miles upstream from the lagoon mouth) where habitat cover, provided by larger woody debris and instream cover was high. Steelhead/rainbow trout densities were lower within other reaches of the river surveyed during both the July and October surveys. Sixty-five percent of the total number of juvenile steelhead/rainbow trout observed were found in the lagoon during the July survey and 84 % during the October survey.

58. The highest densities of juvenile steelhead/rainbow trout were observed in 2004 in habitat units characterized by extensive instream cover combined with deep water where large schools of steelhead/rainbow trout were observed. Peak densities (0.49 and 0.39 juvenile steelhead/rainbow trout per linear foot in July and 0.54 and 0.12 trout/ft in October) occurred within the lagoon and in the vicinity of Creamery Meadow, which reflected the preferred rearing habitat conditions for juvenile fish. Localized densities within reaches were often greater as young steelhead tended to congregate in tight schools in specific areas of sampling units. Unlike the July surveys, juvenile steelhead showing

characteristics of smolting were observed in the lagoon reach in October. Approximately 80% of juvenile steelhead/rainbow trout larger than 100 mm observed during the October survey were either silvery parr or smolt stages.

59. The juvenile steelhead/rainbow trout observed rearing in the lower river and lagoon were young-of-the-year and yearling age classes ranging in length from approximately 70 mm to 250 mm. Comparison of the length frequency distributions for juvenile steelhead/rainbow trout observed in July and in October (Figure 30) showed a pattern of increased size and growth over the summer months. It was hypothesized that if El Sur Ranch irrigation diversions were adversely affecting habitat conditions within the lower river and lagoon then growth rates of juvenile steelhead/rainbow trout in the Big Sur River would be lower than observed in other river systems. Results of the comparison, however, showed that juvenile growth rates in the Big Sur River are among the highest when compared to results from other river systems (Figure 21; Table 3). Results of the comparison of juvenile steelhead/rainbow trout growth rates indicate that habitat conditions within the Big Sur Rive and lagoon were suitable for juvenile rearing over the summer and early fall period when deliveries were being made from the El Sur Ranch irrigation wells.

60. Results of the juvenile steelhead/rainbow trout growth rate comparison are also consistent with information from the snorkel surveys regarding changes in abundance over the summer. During the July 2004 survey, 417 juvenile steelhead/rainbow trout were observed in the river reaches surveyed. During the October 2004 survey, 358 juvenile steelhead/rainbow trout were observed. The change in observed juvenile steelhead/rainbow trout abundance between July and October (a reduction of 59 fish) reflects an oversummering survival rate of 86% (a 14% reduction in abundance). The estimated survival rate from these surveys assumes that there was no immigration or emigration of juvenile steelhead/rainbow trout from the surveyed reaches over the summer months. Results of these analyses suggest that oversummering survival in the Big Sur River is extremely high for juvenile steelhead/rainbow trout which is consistent with observations of habitat quality and availability over the summer months: consistently suitable water quality conditions, the absence of predatory fish within the

lower river and lagoon, minimal evidence of mammalian or avian predation, a catch-and-release policy for angling within the lower river and lagoon, and good summer baseflows that provided physical habitat and surface water connectivity among habitats throughout the lower river and lagoon during the period of this investigation. Steelhead/rainbow trout observed in the Big Sur River and lagoon during the July and October surveys were characterized as healthy and in good conditions, showed evidence of good growth over the summer, appeared to have high summer survival, and showed characteristics during the October survey of the physiological transitions (smolting) in preparation for emigration downstream to the ocean. Results of these observations of oversummering abundance and survival within the Big Sur River showed that habitat conditions and juvenile steelhead/rainbow trout survival rates were good over the summer and early fall period when the El Sur Ranch irrigation wells were in service.

61. Additional snorkel surveys were conducted in the lower river and lagoon in October 2007 to assess conditions of the juvenile steelhead population rearing in the river under critically dry hydrologic conditions. A total of 380 steelhead were observed during the October 2007 snorkel survey. The steelhead observed rearing in the river were almost exclusively juveniles including young-of-year (YOY) and yearlings. Observed densities were highest from the lagoon through mile 0.24 upstream from the lagoon above which densities sharply declined in sub-reach C. Sub-reaches A, B, D and F possessed both the highest numbers and highest relative densities of steelhead (0.03 - 0.49 individuals per linear foot (No/ft)). Reaches C, E, G, and H had relatively low densities of steelhead (0.0-0.007/ft). As in 2004, the lagoon reach had the highest density of juvenile steelhead. The number of steelhead observed in the lagoon reach was 2.5 times greater than all other reaches combined.

62. In general, the highest observed steelhead densities in 2007 were in habitat units with extensive cover combined with deep water where large schools were observed (primarily in sub-reach A). Peak densities (0.05-0.49 individuals per linear ft) occurred in sub-reaches A through F (Figure 28) where most of the preferred rearing habitat occurred (the availability of deeper pools and instream cover was greater in the lower reaches of the river when compared to stream habitat conditions located further upstream). Localized

densities within sub-reaches were often 10 times greater than the overall average as young steelhead tended to congregate in tight schools in specific areas of habitat units (e.g., non-random habitat use). The primary habitat utilized by juvenile steelhead included cover in the form of large woody debris (LWD) or instream brush located adjacent to deep pools (>3 feet of water). We hypothesize that the distribution of juvenile steelhead within and between sub-reaches was primarily a reflection of available habitat. Preferred habitat appeared to be deep water pools combined with a cover component. Available cover appeared to be limiting in several of the sub-reaches surveyed (e.g., sub-reaches C, G, and H where densities were equal to or less than 0.01 fish/foot) and observed steelhead densities were correspondingly low. No obvious limiting factors to juvenile steelhead survival were observed during the surveys. Spawning habitat was marginal throughout the sample reach due to substrate size and abundant fines. The production of juvenile steelhead within the lower Big Sur River, and therefore juvenile abundance in the lower river and lagoon, may be limited by barriers to upstream migration that prohibit access to suitable upstream spawning and juvenile rearing habitat, for example above the gorge in Pfeiffer Big Sur State Park.

63. Classical smolting characteristics (e.g., silvery scales with minimal parr marks) were observed in all steelhead within the lagoon (sub-reach A) in 2007. Approximately 70% were fully smolted and the remaining were silvery parr. All steelhead observed upstream of the lagoon reach were parr.

64. YOY and yearling steelhead were observed during the surveys. Estimated lengths ranged from 60-300/mm with the majority of juvenile steelhead ranging in length between 100 mm and 200 mm in 2007. Length frequency distributions varied significantly between reaches, with the majority of the steelhead (100-300 mm) inhabiting sub-reaches A and G.

65. One wild adult steelhead approximately 650 mm in length was observed during the survey. The adult steelhead was observed in sub-reach F (Figure 28) holding in a lateral scour depression. The adult steelhead appeared emaciated but did not look as though it had spawned as there were no abrasions on the caudal fin. The adult may have been

attracted into the river by increased flow caused by early October rains in the area as there was evidence of recent increased flows on the stream banks.

66. Juvenile steelhead were observed inhabiting the lower river in 2007 with the greatest densities in the lower portion of the river and lagoon where habitat conditions (pool depth, cover, etc.) appeared to be most suitable. A total of 380 steelhead, including young-of-the-year and yearlings (demonstrating successful spawning and egg incubation in the river) and one adult were observed in the study reach. The juvenile steelhead all appeared to be healthy and in good condition with those fish inhabiting the lagoon area showing evidence of smolting in preparation for migration to the ocean. These observations are significant in showing that despite the critically low flows that occurred in the river in 2007, localized areas of depressed dissolved oxygen, effects of upstream diversions and water use, and operation of the El Sur Ranch irrigation wells, steelhead and other fish species typical of a coastal tributary fish assemblage were able to experience successful rearing within the lower river. As a result of the critical hydrologic conditions that were observed in September 2007, naturally occurring habitat conditions for juvenile steelhead rearing were at or near worst possible conditions. There was no evidence from the 2004, 2006, or 2007 studies that indicated that El Sur Ranch irrigation well operations were a limiting factor affecting the ability of juvenile steelhead to successfully rear within the lower reaches of the Big Sur River. Other investigators (Duffy 2003; Titus et al 2003, NMFS 2008, TNC 2008) have examined factors that potentially limit steelhead production and abundance on the Big Sur River. For example, the effects of summer dams, wading, trails, and other aspects related to local recreational use of the areas surrounding the river have been identified as factors affecting habitat conditions for steelhead. In addition, natural barriers to steelhead migration into upstream habitat (e.g., boulder accumulation in the gorge; waterfalls and other passage barriers) have been identified that prevent steelhead from accessing suitable spawning and juvenile rearing habitat further upstream.

Juvenile Steelhead Habitat Suitability And Rearing Conditions Within The Big Sur River Lagoon

67. Lagoon habitats associated with coastal streams and rivers along the central California coast have been found to be important for juvenile rearing prior to migration into coastal marine waters. (*See* Atkins 2010; Bond 2006). Studies of the habitat conditions and rearing by juvenile steelhead within the Carmel River lagoon showed that water quality conditions, including seasonal stratification, directly affect habitat quality and the abundance of juvenile rearing steelhead within the lagoon (Daniels et al. 2010).

68. The fisheries investigations conducted in 2004, 2006, and 2007 (Hanson Environmental 2005, 2007 and 2008) included observations and data collection concerning water quality conditions (temperature, dissolved oxygen and electrical conductivity) and steelhead abundance (in 2004 and 2007) within the Big Sur River lagoon. Precipitation on the Big Sur coast was abnormally low during the winter and spring of 2007 resulting in dry hydrologic conditions and substantially reduced flows (critically dry) within the Big Sur River during the summer and early fall of 2007. These unusually low flow conditions offered an opportunity to conduct field measurements and investigations to evaluate habitat conditions within the lagoon under critically dry hydrologic conditions. Results of the investigations regarding the lagoon are summarized and discussed in the report titled Juvenile Steelhead Habitat Suitability and Rearing Conditions within the Big Sur Lagoon dated May 2011 (Exhibit ESR—25). The purpose of this report was to characterize primary water quality conditions and habitat conditions that would affect the suitability of habitat within the lagoon for juvenile steelhead rearing.

69. For purposes of this characterization, the Big Sur River lagoon has been defined as that aquatic habitat located downstream of PT5 with PT4 and PT5 conservatively representing the upper end of a transition point to riverine habitat. Habitats downstream of PT5 experience greater tidal effects on changes in water depth and water surface elevation as well as increased electrical conductivity (a measure of salinity) at locations closer to the ocean.

70. Results of water temperature monitoring within the Big Sur River during the 2004 and 2006 studies showed that late summer and early fall water temperatures within the lagoon were within the range considered to be suitable for juvenile rearing habitat. Observations made during the dry year 2004 snorkel surveys showed that the juvenile steelhead inhabiting the lower reaches of the river and lagoon appeared to be growing at a rate comparable or greater than that reported for many other California rivers, showed evidence of smolting characteristics, and appeared active and in good condition (Hanson Environmental 2005). The growth rates observations of the 2004 snorkel surveys are consistent with and support the general finding that water temperatures were suitable for juvenile rearing. Results of the 2007 water temperature monitoring showed a typical pattern of daily variation in temperatures which were within the range of 5-7°C (9-13°F) (daily minimum to daily maximum) or less. The results also show a general pattern of seasonally declining water temperatures between early September and early October reflecting seasonal cooling in atmospheric temperatures (particularly cooling at night during the fall) with a corresponding trend of reduced river temperatures. Both average daily and maximum hourly water temperatures at all locations monitored within the lagoon during the 2007 study were within the range suitable for juvenile steelhead rearing.

71. In the main lagoon sites (PT1, PT2 and PT3) results of the 2007 habitat and water quality monitoring are consistent with the findings of the 2004 and 2006 studies in showing that dissolved oxygen concentrations were above 6 mg/L consistently and would not adversely affect habitat quality and availability for steelhead rearing within the lagoon.

72. The distribution of salinity within the lower river is affected by opening and closing of the lagoon connection to the ocean by formation of the sand bar. Juvenile steelhead have a relatively high tolerance to salinity and have been reported to rear in estuaries and lagoons prior to emigrating to the ocean. During the 2007 study electrical conductivity in the lagoon increased in late-September but appeared to be related to waves overtopping the sand bar and was independent of irrigation well operations. Electrical conductivity at locations upstream of the lagoon remained constant throughout the study period. Based on results of the 2007 studies and similar results from the 2004 and 2006 studies, there

was no evidence that salinities in the lagoon or lower river exceeded the suitable range for juvenile steelhead rearing.

73. Results of the field surveys showed no evidence of persistent vertical stratification in water quality within the Big Sur River lagoon. Localized and temporary salinity stratification was observed when waves overtopped the sandbar that would mix and dissipate in a matter of days. Freshwater entering the lagoon from the river was sufficient to maintain good vertical mixing within the lagoon water column, avoid stratification of water quality, maintain a low salinity freshwater and brackish (e.g., typically less than 2 ppt salinity), and maintain a breach of the sand bar that provided access between the lagoon and coastal water throughout the summer and fall months (the lagoon sand bar blocked access only during one period while these studies were underway and resulted in a temporary increase in water depth and a reduction in salinity within the lagoon until the sand bar naturally breached).

74. In 2007, a total of 380 steelhead, including young-of-the-year and yearlings (demonstrating successful spawning and egg incubation in the river) and one adult were observed in the study reach. As in 2004, juvenile steelhead were observed inhabiting the lower river in 2007 with the greatest densities in the lower portion of the river and lagoon where habitat conditions (pool depth, cover, etc.) appeared to be most suitable. The number of steelhead observed in the lagoon reach was 2.5 times greater than all other reaches combined. The juvenile steelhead all appeared to be healthy and in good condition with those fish inhabiting the lagoon area showing evidence of smolting in preparation for migration to the ocean.

75. As a result of the critical hydrologic conditions that were observed in September 2007, naturally occurring habitat conditions for juvenile steelhead rearing were at or near worst possible conditions. There was no evidence from the 2004, 2006, or 2007 studies that indicated that habitat conditions within the lagoon were a limiting factor affecting the ability of juvenile steelhead to successfully rear within the lower reaches of the Big Sur River. Other factors such as lack of access to suitable spawning habitat as a result of both impassable barriers to migration located approximately 7 miles upstream from the lagoon

as well as limited amounts of suitable gravel for spawning in the lower reaches of the river may be reducing juvenile rearing densities within the lagoon to levels that appear to be less than carrying capacity.

Limiting Factors

76. A number of studies have shown that the Big Sur River habitat is in good condition (Titus et al 2003) and supports good growth and abundance of juvenile steelhead (Collin 1998, Titus et al. 2003). Titus et al. (2003) characterized the Big Sur River as pristine with functional habitat supporting a healthy steelhead population. A report prepared for the National Marine Fisheries Service (NMFS 2008, (Exhibit ESR—34)) characterized the Big Sur River as one of the best preserved and least altered watersheds for South-Central Coast Steelhead. The Nature Conservancy (TNC 2008, Exhibit ESR—35) has also identified habitat conditions within the Big Sur River as being good or very good based on a number of metrics and criteria. Collin (1998) conducted a study of the age and growth of steelhead adults and smolts inhabiting the Big Sur River. Results of this study found that steelhead smolts are significantly larger in the Big Sur River when compared to other northern river including the populations from Waddell Creek (Santa Cruz), Garcia River (Mendocino County), Gualala River (Mendocino County), Jacoby Creek (Humboldt County), the Mad River (Humboldt County), and the Alsea River (Lincoln County, Oregon). Collin (1998) also reported that there is a higher proportion of one year old smolts in the Big Sur River when compared to other northern rivers. These findings are consistent with the observation that the lower river and lagoon supports juvenile steelhead rearing, good juvenile growth rates and health, and that water quality conditions are suitable to support juvenile steelhead rearing within the lower river and lagoon (Hanson Environmental 2005, 2007, and 2008). The high juvenile growth rates and percentage of juvenile steelhead in the Big Sur River that smolt at age 1 are also consistent with the findings that seasonal water temperatures are suitable and that food supplies are sufficient to support high rates of juvenile growth and physiological development.

77. Moreover, results of surveys in 2004 and 2007 showed that approximately 350 to 400 juvenile steelhead reared in the lower reaches of the river. This density of juvenile steelhead is substantially lower than juvenile densities reported for Scott Creek (Bond 2006; Hayes et al. 2008; Bond et al. 2008) and in San Gregorio lagoon (Atkinson 2010) where estimated juvenile density ranged from approximately 550 to 2,500 fish. Based on the otherwise good habitat conditions and low density of rearing steelhead it appears that the lower Big Sur River is not at carrying capacity for juvenile steelhead rearing under current conditions. It appears that the limiting factors identified below may be holding down the population.

78. Previous investigations and reports have identified potential limiting factors to steelhead habitat quality and production on the Big Sur River (Titus et al. 2003, Duffy 2003, NMFS 2008, TNC 2008). Natural barriers to steelhead migration into upstream habitat (e.g., boulder accumulation in the gorge; waterfalls and other passage barriers) have been identified that prohibit steelhead access to upstream suitable spawning and juvenile rearing habitat (Titus et al. 2003, Duffy 2003, NMFS 2008). Limitations on access to upstream spawning and juvenile rearing habitat by natural barriers reduce the potential production of juvenile steelhead within the lower Big Sur River. In addition, the availability of suitable spawning habitat (e.g., gravel deposits) has been identified as a limiting factor due to substrate size and abundant fines. Other threats to steelhead identified for the Big Sur River include wildfires, other passage barriers and roads (NMFS 2008). Finally, the effects of summer dams, wading, trails, and other aspects related to local recreational use of the areas surrounding the river have been identified as potential factors affecting habitat conditions for steelhead (Duffy 2003, NMFS 2008).

79. As part of the 2004, 2006, and 2007 fishery studies, consideration has been given to identifying potential limiting factors that impact steelhead production, abundance, habitat quality and availability for steelhead migration, spawning, and juvenile rearing on the Big Sur River. Based on results of these investigations I have concluded that:

- There was no evidence from the 2004, 2006, or 2007 studies that indicated that habitat conditions within the lagoon were a limiting factor affecting the ability of juvenile steelhead to successfully rear within the lower reaches of the Big Sur River.

- On some occasions, flow can be a limiting factor to steelhead during the summer-fall low flow period under critically dry hydrologic conditions (e.g., 2007) particularly when there is increased human activity, typically associated with upstream uses at Pfeiffer Big Sur State Park, resorts and summer residences.
- Formation of a sandbar completely blocking the Big Sur River lagoon is a rare occurrence and usually breaches during the first large rain event, but when closed could serve as a limiting factor affecting connectivity for steelhead migration between the river and ocean.
- Available cover appeared to be limiting in several of the reaches of the lower river.
- The availability of suitable spawning habitat (e.g., gravel deposits) has been identified as a likely limiting factor due to substrate size and abundant fines.
- There was no evidence from the 2004, 2006, or 2007 studies that indicated that El Sur Ranch irrigation well operations were a limiting factor affecting the ability of juvenile steelhead to successfully rear within the lower reaches of the Big Sur River. The main threats to steelhead in the Big Sur River identified by NMFS (2008) were natural barriers and recreational facilities.

Swiss Canyon

80. The irrigated pasture land of the El Sur Ranch water right is bisected by Swiss Canyon, a perennial incised drainage channel that discharges into the ocean. Swiss Canyon has a small creek that conveys water from the area upstream of the Highway 1 culvert to the ocean. Swiss Canyon does not provide habitat for fish such as steelhead. Swiss Canyon supports a variety of species including native grasses, shrubs and other riparian plants, birds and other wildlife, and aquatic species including a population of red-legged frogs (MGA 2007). The canyon is accessible to cattle grazing.

81. As part of the 2004, 2006, and 2007 studies, observations and periodic measurements were made within Swiss Canyon to assess the potential effects of irrigation well operations on surface water within the canyon. It was hypothesized that runoff from the pastures was passing into Swiss Canyon, causing erosion across the ocean beach from the ephemeral stream during and after irrigation events. To test this hypothesis in 2007, a series of three transects were established within Swiss Canyon and measurements were made of cross-sectional water depths periodically during the study to coincide with periods when the irrigation wells were not in service, one well was operating, and both wells were operating. It was expected that if irrigation was a major source of water within Swiss Canyon it would be apparent under the dry 2007 conditions and that surface water flows would be observed throughout the canyon which is immediately adjacent to the pastures on both sides and that channel depth in the creek would increase in response to irrigation of the pastures and decrease when no irrigation was occurring.

82. No surface water was apparent in Swiss Canyon at either the upstream (near the Highway 1 culvert) or mid-point monitoring locations during any of the 2007 surveys. Surface water was always present at the downstream monitoring location during the 2007 survey. Results of water depth measurements at the lower transect location ranged from 0.56 to 0.64 feet. Although the water depth measured on October 3 (0.56 ft) with both wells operating was the lowest observed, there was no statistically significant difference ($P>0.05$) in water depths between periods when irrigation wells were in operation (average 0.62 ft) and when the wells were off (average 0.62 feet). Results of these surveys indicate that Swiss Canyon has a limited water supply source during critically dry years in the lower reaches (e.g., groundwater, spring, etc.) with surface water entering the canyon from the upstream drainage area during periods of precipitation and runoff. These observations also show that under the critically dry conditions that occurred in 2007, aquatic habitat units remained in the lower reaches of Swiss Canyon and continued to support amphibians and other species

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FIGURES

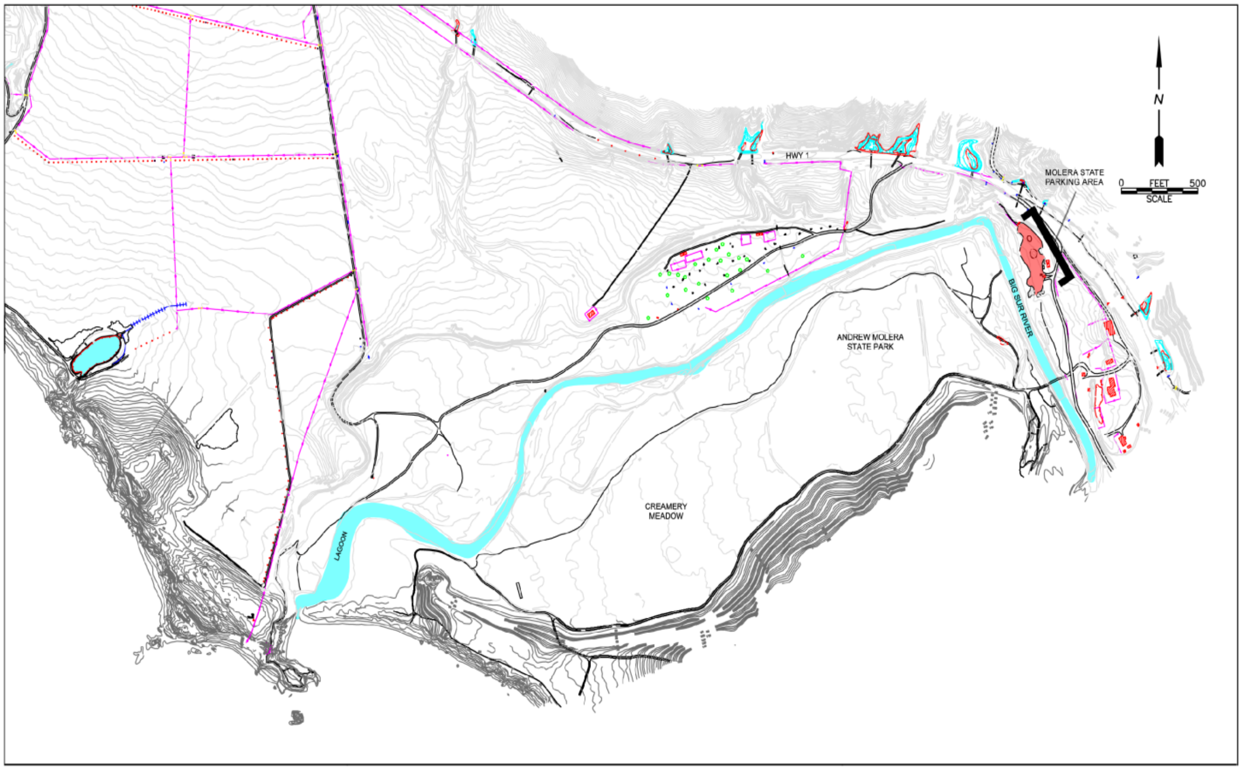


Figure 1. The lower Big Sur River and surrounding area.

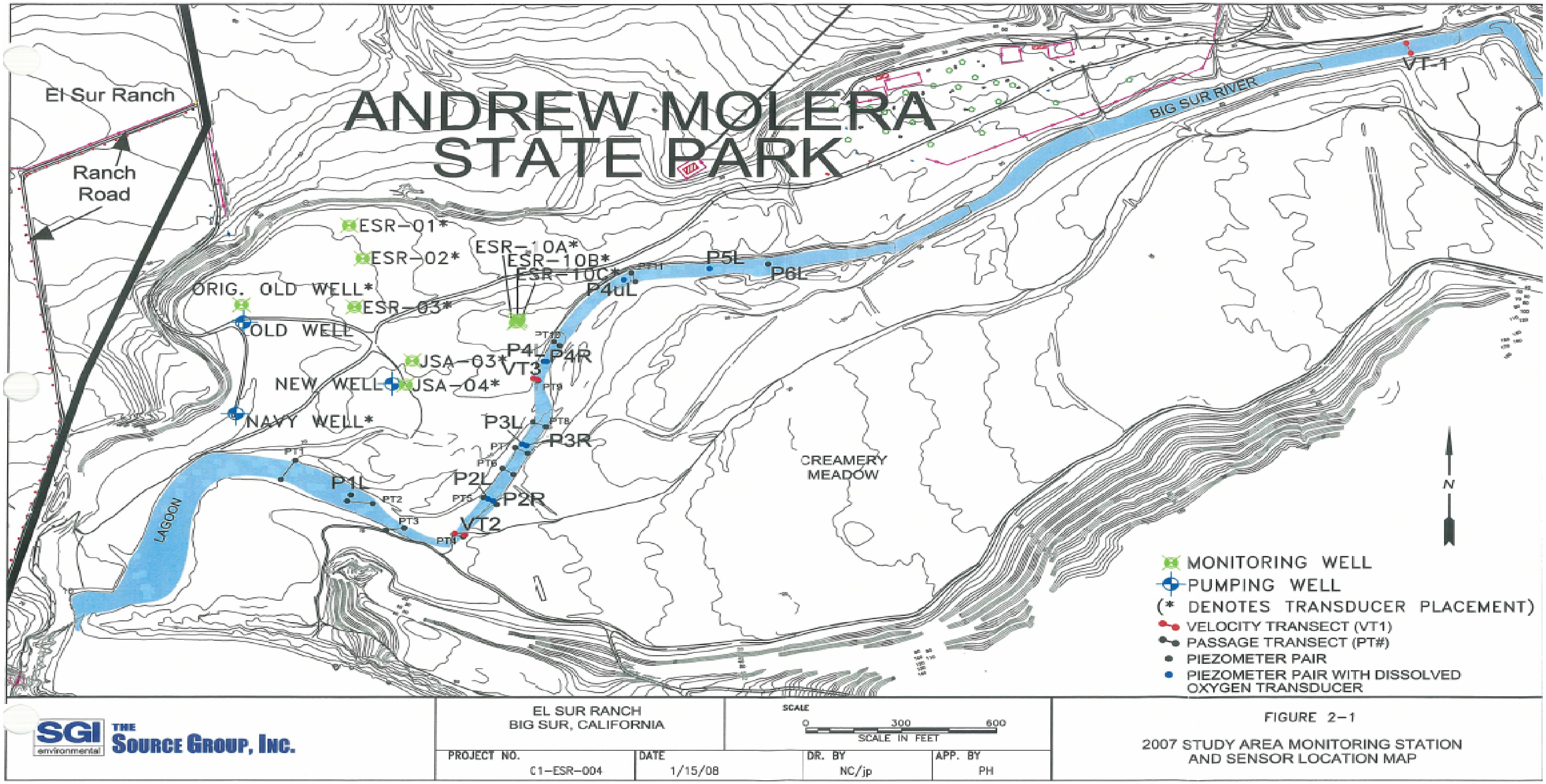


Figure 2. Map of the lower Big Sur River survey locations (Source: SGI 2008)

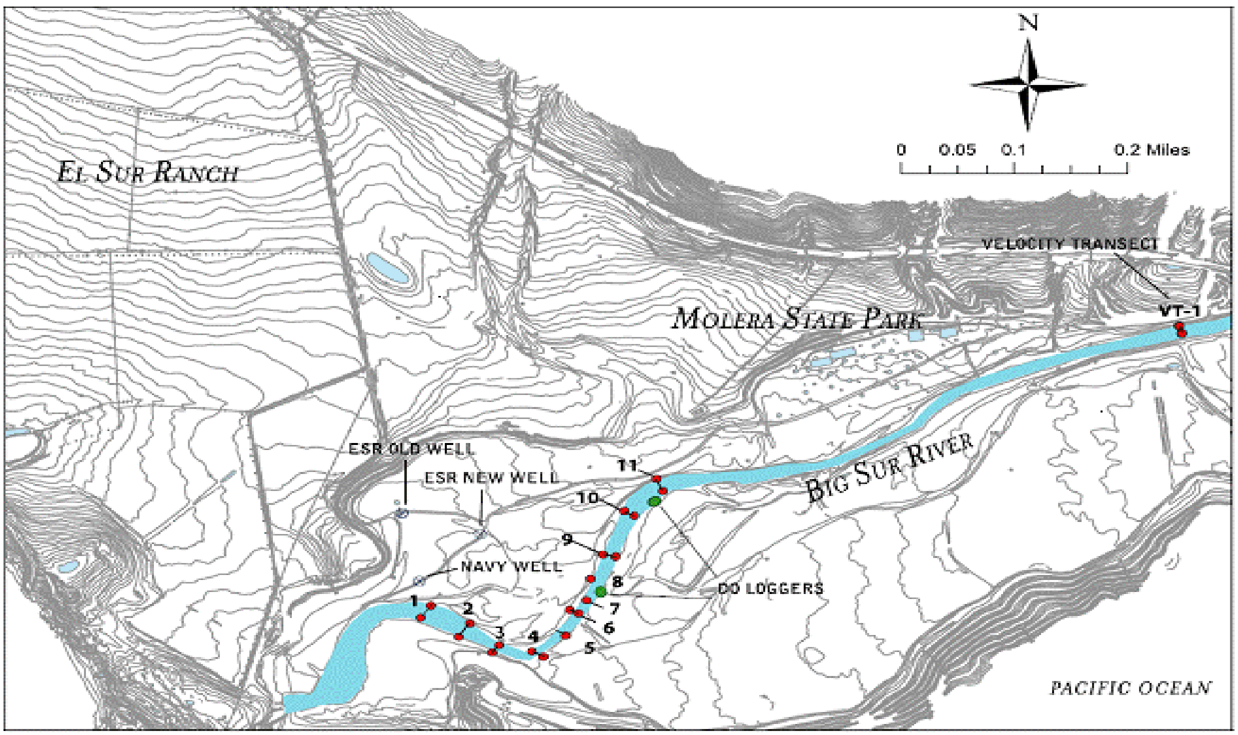


Figure 3. Passage transects monitored during the 2007 study period.

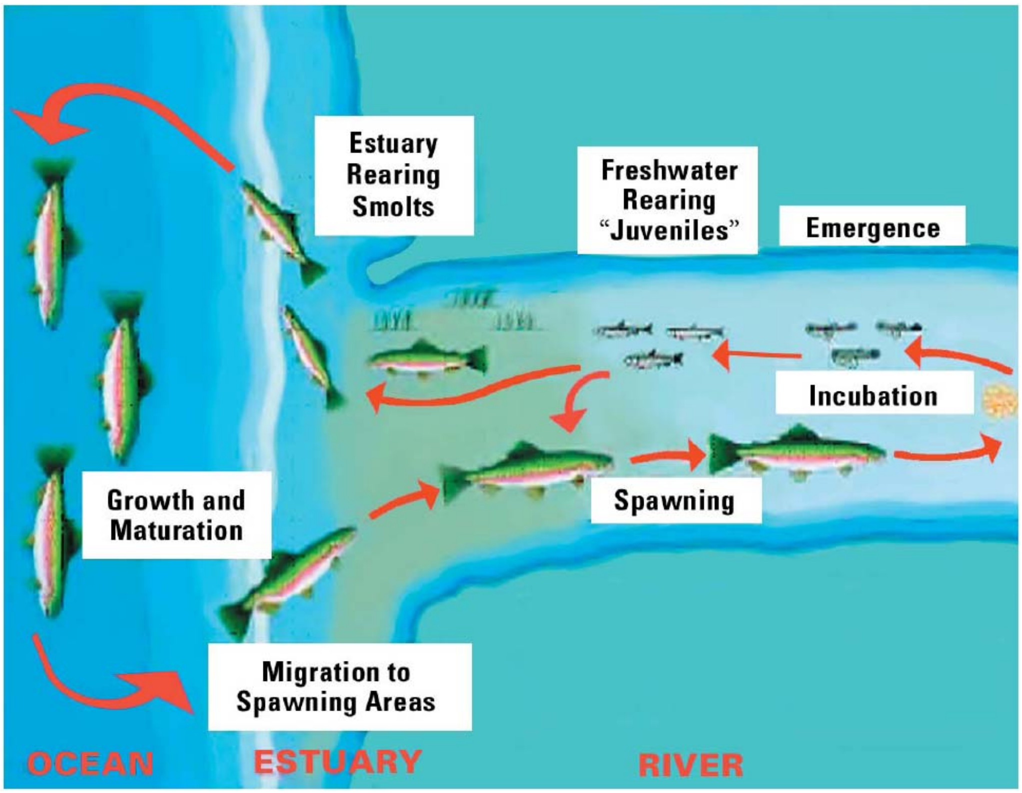


Figure 4. **Lifecycle of steelhead (*source: Sonoma County Water Agency*).**

Figure 5. Big Sur River sand bar at the mouth of the lagoon looking downstream.

Figure 6. Big Sur River lagoon looking upstream.

Figure 7. Big Sur River lagoon looking downstream.

Figure 8. Big Sur River sand bar looking downstream.

Figure 9. Opening in the Big Sur River sand bar looking upstream

Figure 10. Habitat 200 ft. upstream of lagoon pool. Water depth approximately six feet.

Figure 11. Big Sur River looking upstream from the lagoon into the riverine reach.

Figure 12. Lagoon pool habitat.

Figure 13. Near the mouth of the Lagoon in 2004 before lagoon pool blocked.

Figure 14. **Upstream from Creamery Meadow showing the deeper water/pool located downstream from a riffle.**

Figure 15. Upstream of the Andrew Molera State Park Campground showing shallow water and heavy bank riparian vegetation.

Figure 16. Water Quality transect #8 (2004). Cold water upwelling.

Figure 17. Habitat downstream of water quality transect #8 (2004). Water depth approximately 2.5 feet.

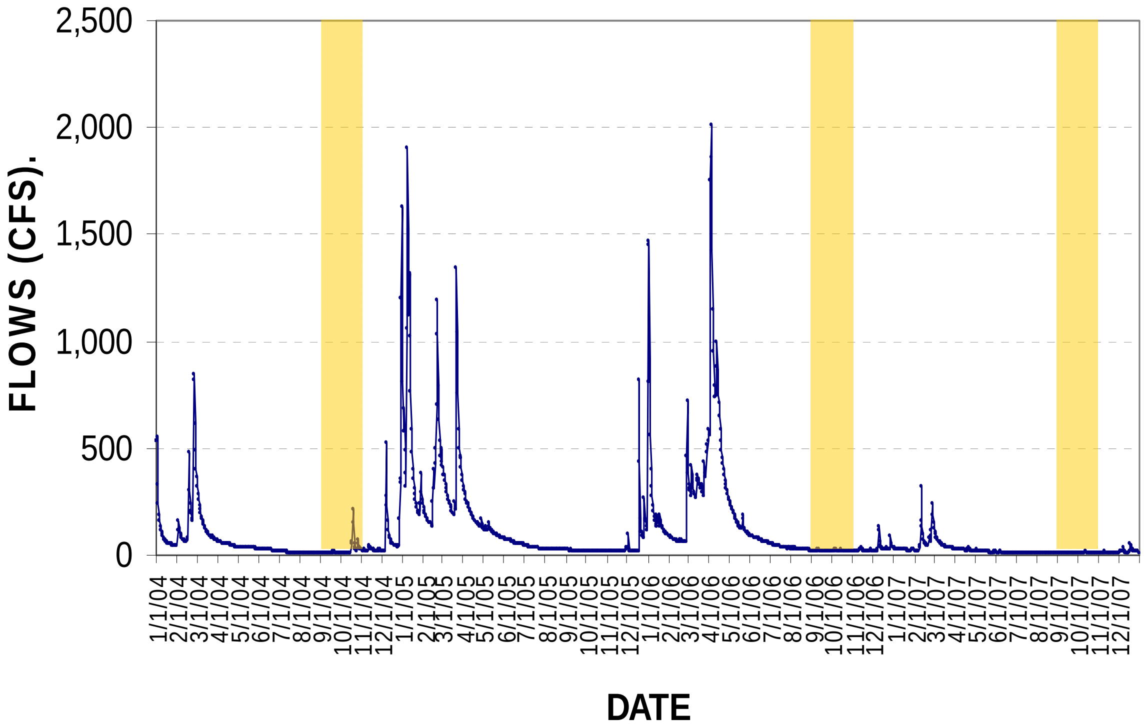


Figure 18. **USGS Big Sur River gauging of daily flows on the Big Sur River (yellow bars indicate the 2004, 2006, and 2007 study periods). (Source: USGS 2008).**

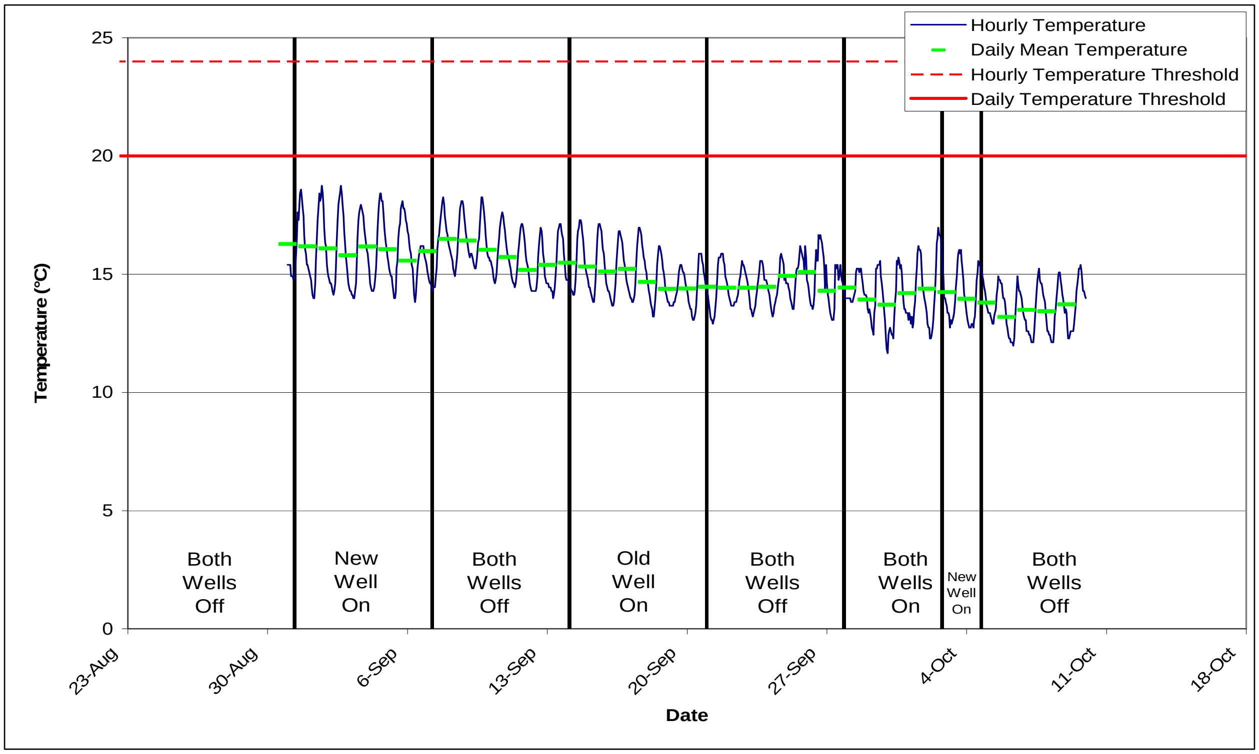


Figure 19. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 1, right bank

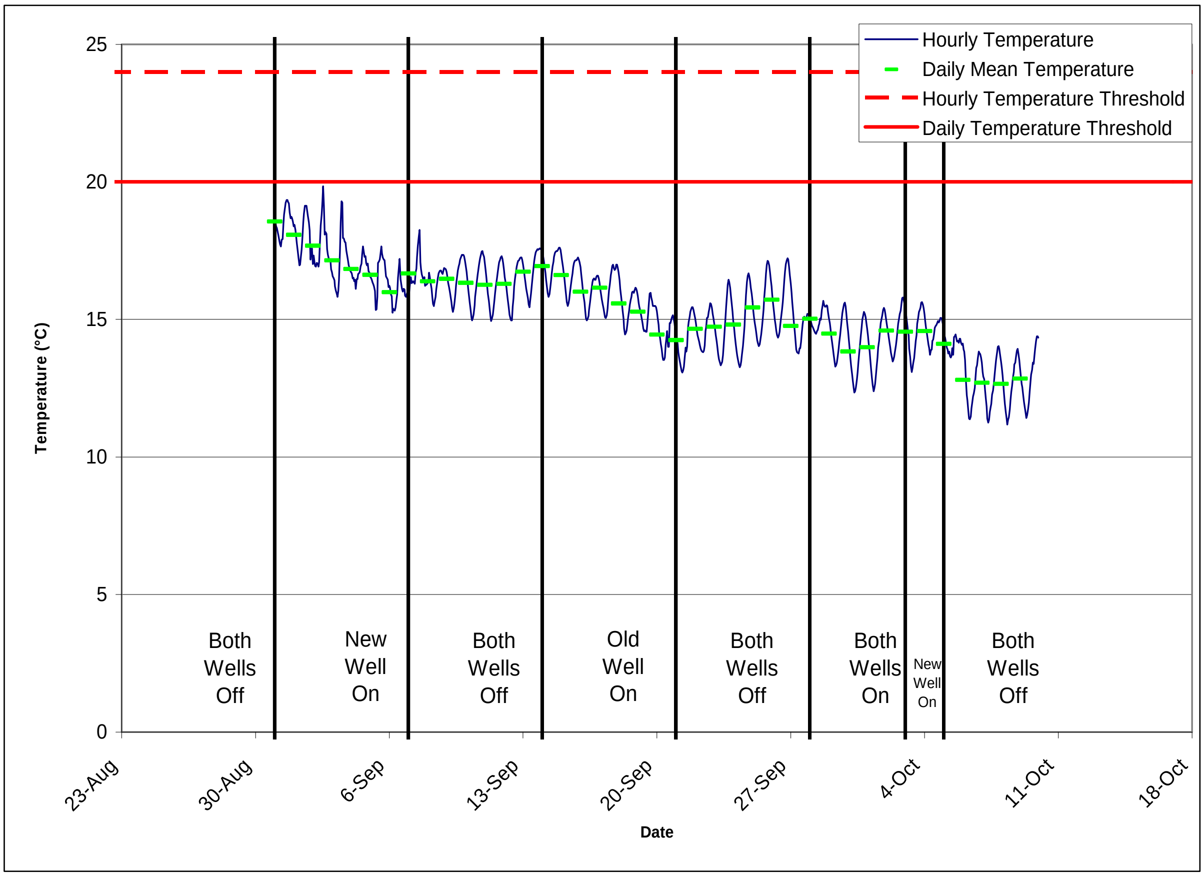


Figure 20. Hourly and average daily water temperatures recorded during 2007 in the lower Big Sur River at PT 11, left bank.

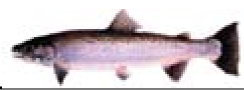
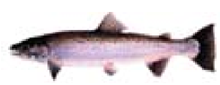
River System	Period	F 	Growth Rate (mm/day)
Lower Big Sur	*July-October*		0.48
Navarro	*September-October*		0.61
Navarro estuary	*July-September*		0.53
Mattole	*September-October*		0.40
Artificial channel	*July-September*		0.34
Navarro	*June-November*		0.33
Mattole	*July-October*		0.24
Eel experiment	*June-August*		0.23
Navarro	*July-August*		0.13
Navarro tributaries	*July-September*		0.09
Mattole	*August-September*		-0.02

Figure 21. Side-by-side comparison of juvenile steelhead growth rates in coastal streams. (See Table 3 for details).

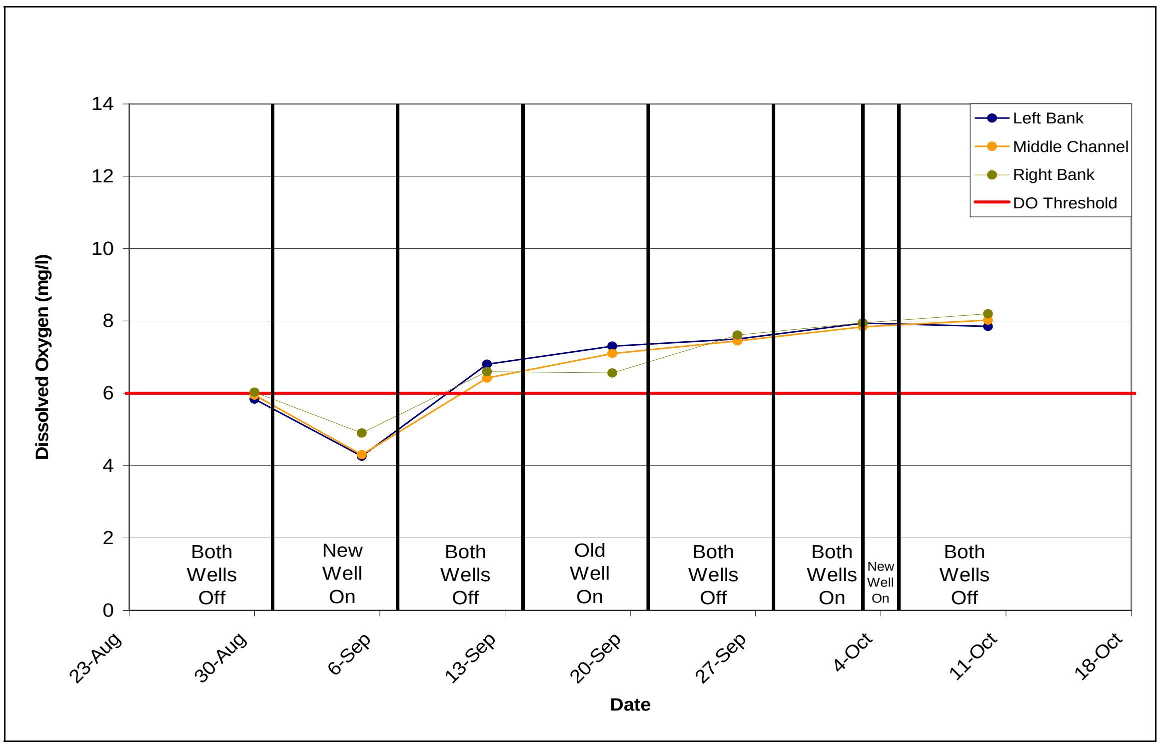


Figure 22. Dissolved oxygen concentrations measured during periodic water quality surveys in the Big Sur River during 2007 at Passage Transect 5.

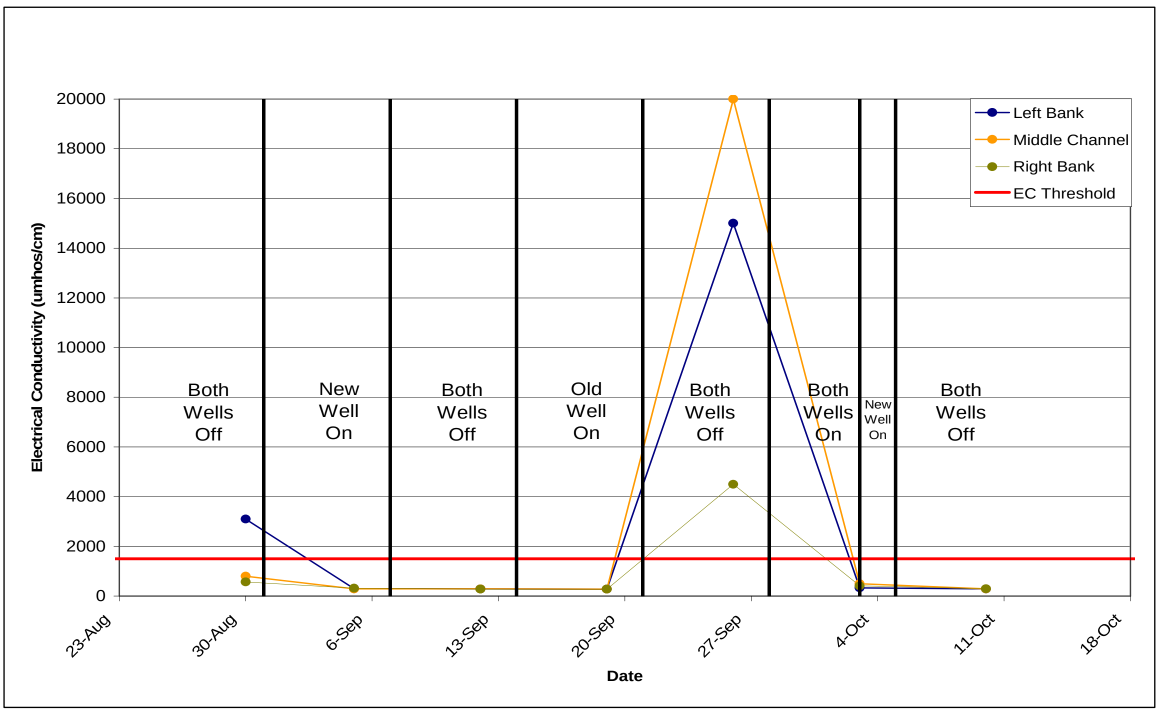


Figure 23. Electrical conductivity measured in the Big Sur River during 2007 at Passage Transect 1.

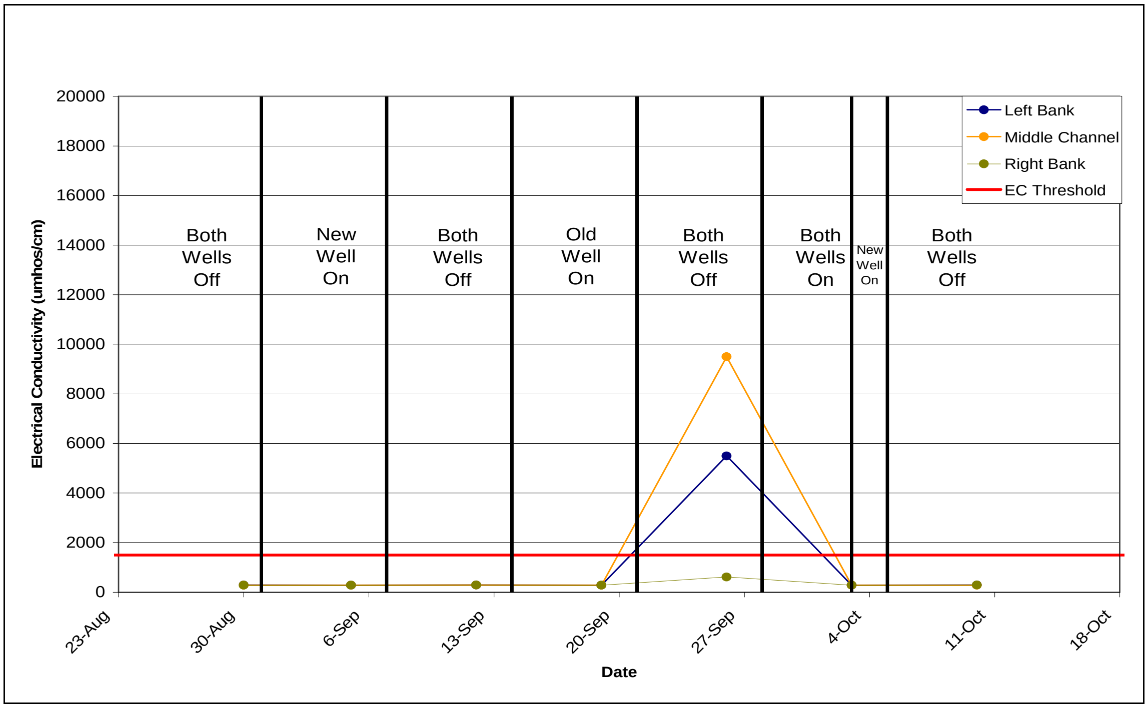


Figure 24. Electrical conductivity measured in the Big Sur River during 2007 at Passage Transect 2.

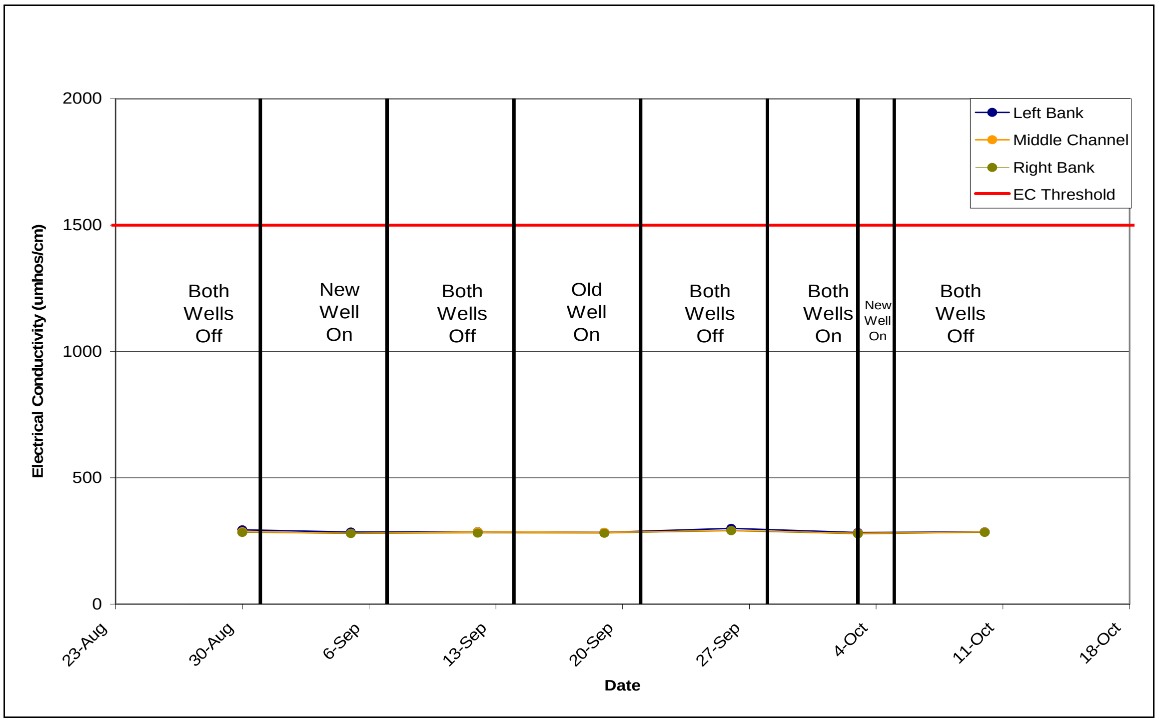


Figure 25. Electrical conductivity measured in the Big Sur River during 2007 at Passage Transect 3.

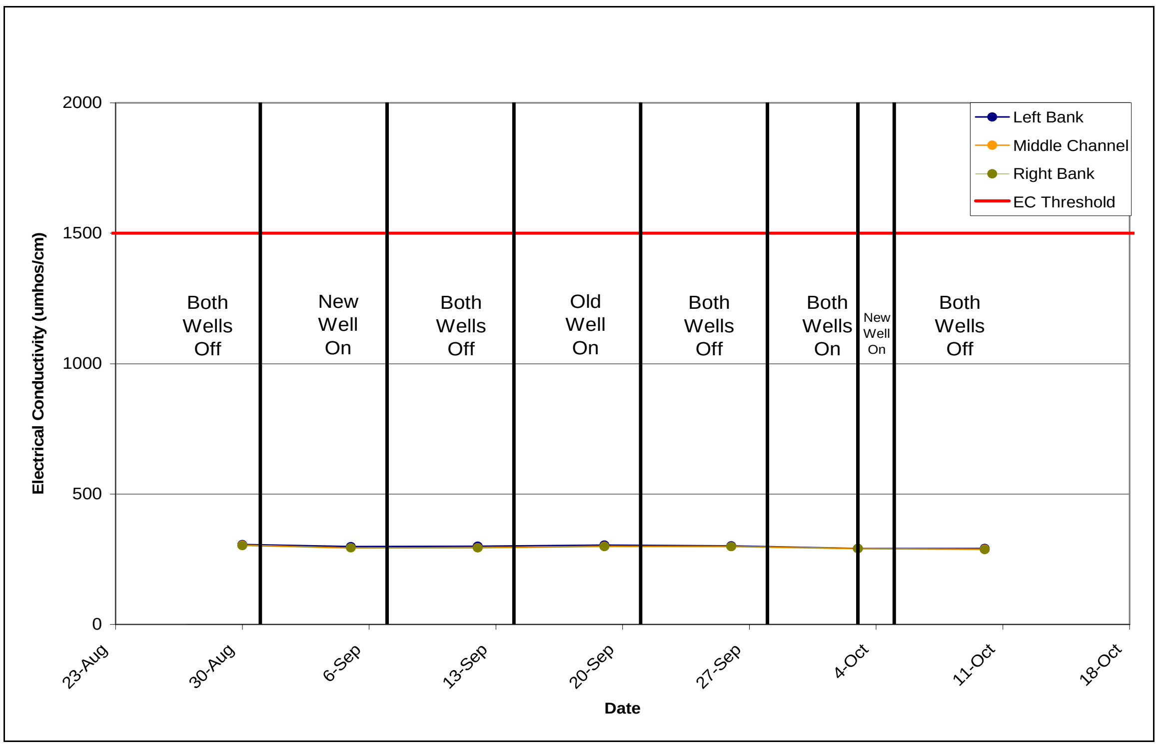


Figure 26. Electrical conductivity measured in the Big Sur River during 2007 at Passage Transect 4.

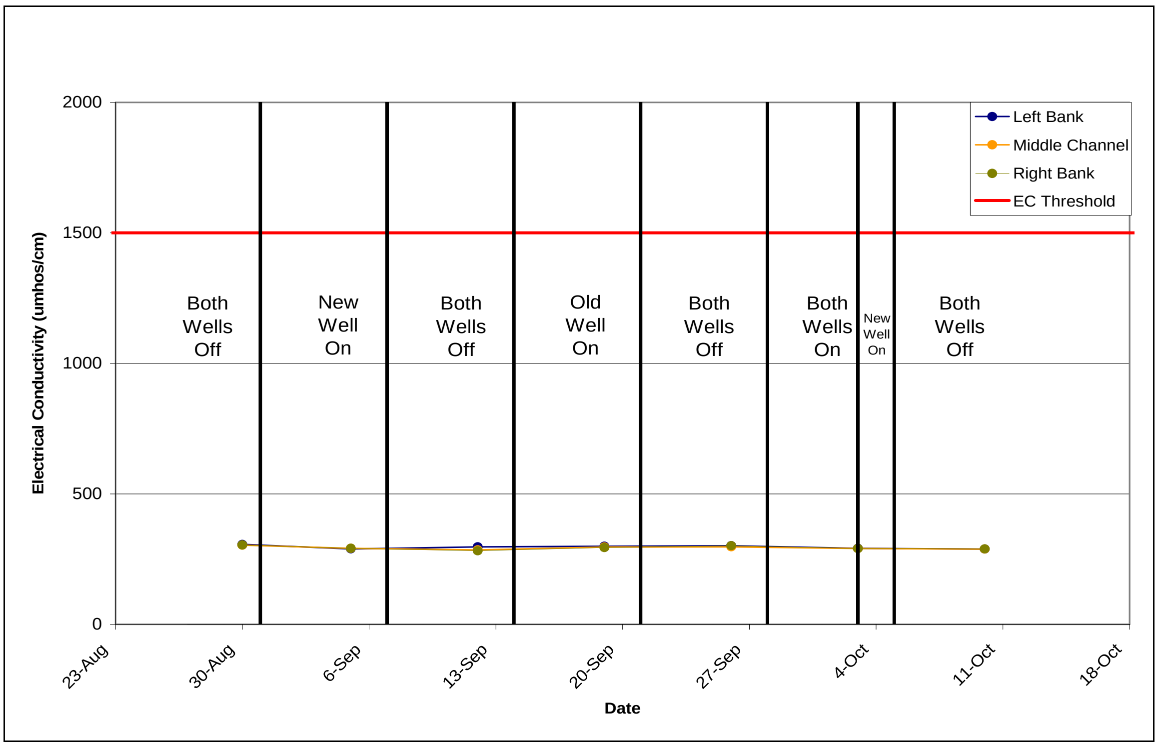


Figure 27. Electrical conductivity measured in the Big Sur River during 2007 at Passage Transect 5.

Figure 28. Sub-reach locations for snorkel surveys conducted on the Big Sur River, CA. Upper sub-reach boundaries are shown with the sub-reach letter.

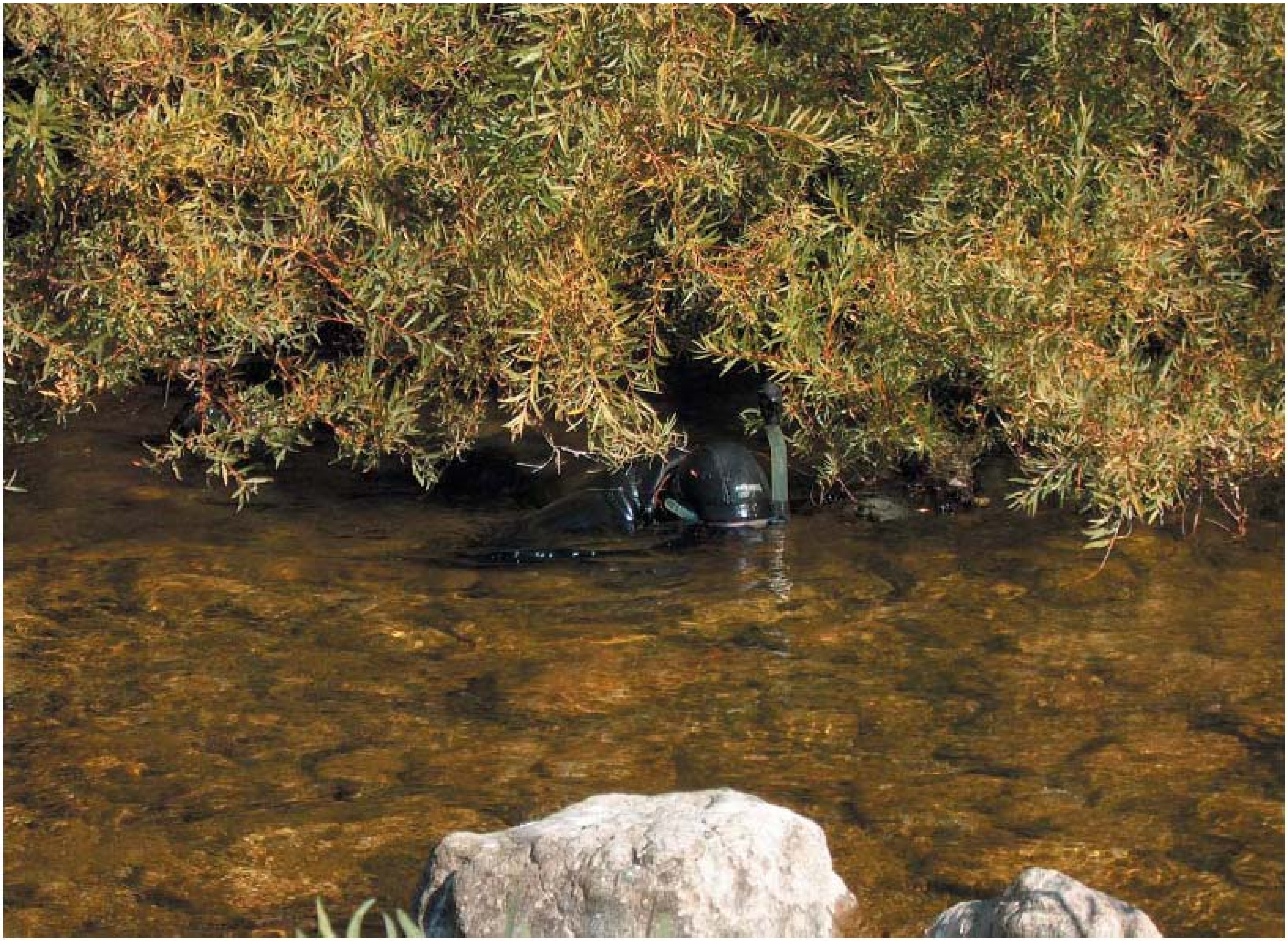


Figure 29. Photograph of divers performing steelhead snorkel surveys within the lower Big Sur River and lagoon.

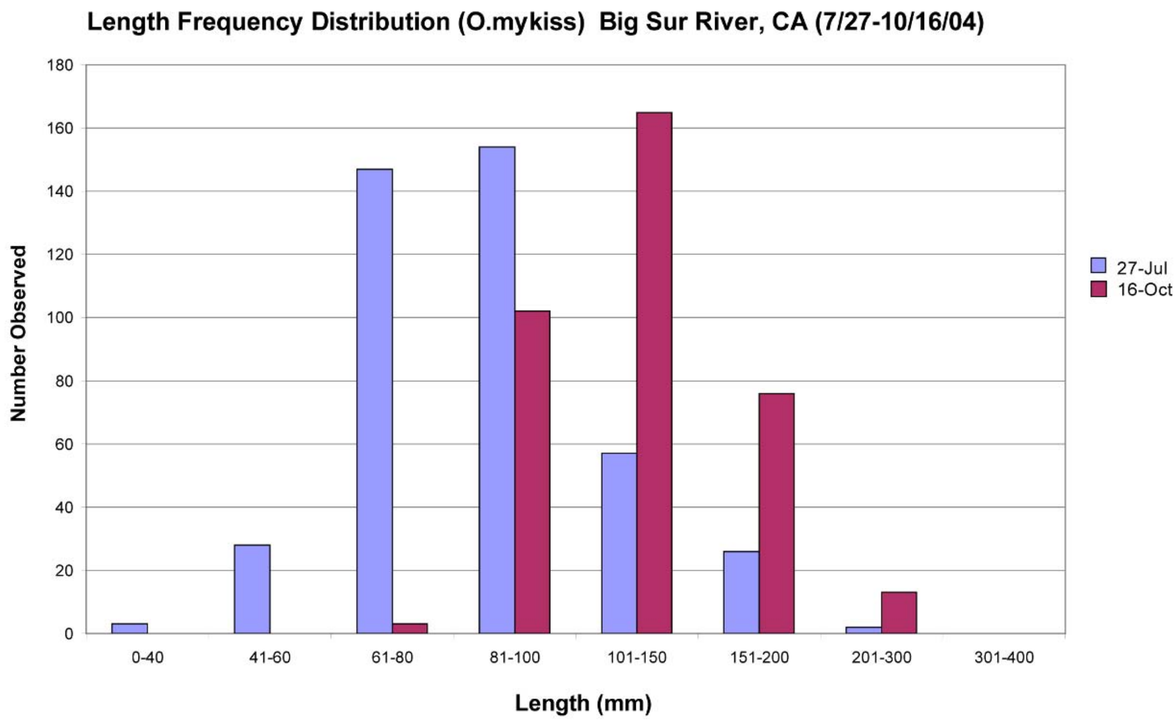


Figure 30. **Length frequency distribution of juvenile steelhead/rainbow trout observed in the lower river and lagoon during the July and October snorkel surveys.**

TABLES

Average Monthly Flow (CFS)			
Month	**2004**	**2006**	**2007**
	Year Type		
	Dry	**Wet**	**Critically Dry**
April	**50.4**	**751.2**	**24.4**
May	**33.7**	**158.2**	**15.8**
June	**23.4**	**72.6**	**11.7**
July	**14.6**	**40.5**	**8.6**
August	**12.3**	**26.9**	**7.6**
September	**12.2**	**21.0**	**7.5**
October	**34.6**	**20.9**	**9.2**

Table 1. Summary of USGS Big Sur River gauging records of average monthly flows during April-October, 2004, 2006, and 2007. (Source: USGS 2008).

Start Date	End Date	Well Operation	Water Quality Surveys*	Habitat and Passage Surveys
--	8/31/07	Both wells off	X	X
8/31/07	9/07/07	New well on	X	X
9/07/07	9/14/07	Both wells off	X	X
9/14/07	9/21/07	Old well on	X	X
9/21/07	9/28/07	Both wells off	X	X
9/28/07	10/03/07	Both wells on	X	X
10/03/07	10/05/07	New well on	X	X
10/05/07	--	Both wells off	X	X

Table 2. Summary of El Sur Ranch irrigation well operations during the 2007 study period.

***Temperature, electrical conductivity, and dissolved oxygen.**

River System	Period	Growth Rate (mm/day)	Reference
Lower Big Sur	July-October	0.48	This study
Navarro estuary	July-September	0.53	Bush undated
Navarro	July-September	0.09	Bush undated
Eel experiment	June- August	0.23[(1)]	Suttle *et al.* 2004
Artificial channel	July-September	0.34	Keeley 2001
Navarro	June-November	0.33	Cannata 1998
Navarro	September-October	0.61[(2)]	Cannata 1998
Navarro	July-August	0.13[(3)]	Cannata 1998
Mattole	July-October	0.24	Zedonis 1992
Mattole	September-October	0.40[(2)]	Zedonis 1992
Mattole	August-September	-0.02[(3)]	Zedonis 1992

Table 3. Summary of juvenile steelhead growth rates in coastal streams.

(1) Growth with no embedded substrate. As substrate embeddedness increased to 100% growth rates decreased to approximately 0.07 mm/day

(2) Peak observed growth rates

(3) Minimum observed seasonal growth rates – coincided with closure of the sand bar and blockage of flow through the estuary

Appendix A.
Qualifications of Dr. Charles H. Hanson

Charles H. Hanson
Senior Fishery Biologist

Education

Ph.D. Ecology and Fisheries Biology, University of California, Davis, 1980
M.S. Fisheries Biology, University of Washington, 1973
B.S. Fisheries Biology, University of Washington, 1972

Certification

Certified Fisheries Biologist
American Fisheries Society

Experience

Dr. Hanson has more than 31 years of experience in freshwater, estuarine, and marine biological studies. Dr. Hanson has contributed to the study design, analysis, and interpretation of fisheries, stream habitat, and stream flow (hydraulic) data used to develop habitat restoration strategies, Habitat Conservation Plans, Endangered Species Act consultations, and environmental analyses. Dr. Hanson has conducted evaluations of the effectiveness of various water diversion fish screening systems, assisted in fish screen design and permitting, and developed operational modifications to reduce organism losses while maintaining operational reliability of the water projects and hydroelectric systems. He has directed numerous investigations and environmental impact analyses for projects sited in freshwater, estuarine, and marine environments of the San Francisco Bay/Delta, the central and northern California Coast, Puget Sound, Hudson River, and Chesapeake Bay. Dr. Hanson has participated as an expert witness on fisheries and water quality issues in numerous public hearings and superior court litigation. Dr. Hanson has been extensively involved in incidental take monitoring and investigations of endangered species, development of recovery plans, consultations, listing decisions and identification of critical habitat, and preparation of aquatic Habitat Conservation Plans. Dr. Hanson served as a member of the USFWS Native Delta Fish Recovery Team, Central Valley Technical Recovery Team, 2007 USFWS Delta Smelt Recovery Team, numerous technical advisory committees, and as science advisor to settlement negotiations. Dr. Hanson has directed studies on the effects of selenium on waterbird reproduction and designed compensation wetland habitat. Dr. Hanson has also participated in the development of adaptive management programs including real-time monitoring, management of power plant cooling water and other diversion operations, and the San Joaquin River Vernalis Adaptive Management Plan (VAMP). Dr. Hanson has authored more than 75 technical and scientific reports.

1991-Present ***Senior Biologist/Principal*****, Hanson Environmental, Inc.**

Provides services in the design, execution, and interpretation of biological monitoring, fishery sampling, and regulatory compliance programs. Prepares technical compliance reports and exhibits for submittal to regulatory agencies, public hearings, and litigation. Presents findings to the public and press and presents expert witness testimony in litigation and regulatory hearings. Develops the design, implementation, and performance monitoring of habitat enhancement and mitigation projects to benefit fish and wildlife.

1982-1991 ***Senior Biologist, Vice President*****, TENERA, L.P**

Provided services related to the collection, analysis, and interpretation of biological and engineering data, preparation of documents submitted to regulatory agencies, presentation of findings to the public and press, and presentation of expert testimony in regulatory hearings.

1978-1982 ***Senior Scientist*****, Ecological Analysts, Inc.**

Responsible for the collection, analysis, and interpretation of data on the abundance, distribution, and dynamics of various fisheries and invertebrate populations for use in evaluating the impact of power plant operations on aquatic populations for more than ten coastal and estuarine power plant sites in California. Prepared various regulatory environmental exhibits, technical reports, and generic and site-specific analyses of biological and engineering information for the applicability of alternative cooling water intake technologies.

1975-1978 ***Research Assistant*****, University of California, Davis**

Conducted extensive investigations into behaviorally selected and energetically optimal swimming speeds of juvenile fish in relationship to selected microhabitats to help in establishing a data base and methodology for determining instream flow criteria. Conducted laboratory studies on the swimming performance and behavioral responses of fish to hydraulic gradients to develop biological design criteria for water intake systems.

1973-1975 ***Research Scientist,*** **The Johns Hopkins University**

Conducted fishery and zooplankton surveys in freshwater and marine environments along the Atlantic coast. Evaluated the acute and chronic effects of exposure to elevated water temperatures on freshwater and marine fish and invertebrates. Developed onsite and mobile bioassay laboratory facilities.

1969-1973 *Research Assistant*, **University of Washington**

Conducted bioassays to determine the synergism between elevated water temperature and duration of exposure on the toxicity of chlorine to two species of salmon. Determined the effectiveness of various techniques, including use of chlorine and thermal shock treatment in minimizing colonization by marine fouling organisms. Evaluated the acute and chronic effects of exposure to elevated water temperature on freshwater and marine fish and invertebrates. Participated in the evaluation of the behavioral attraction and avoidance of response of juvenile fish to thermal and chemical gradients.

Professional Associations

American Fisheries Society (Life Member)
American Institute of Fisheries Research Biologists (past Program Committee Chairman)
Pacific Fisheries Biologists (past Program Chairman)
Who's Who in the West
San Francisco Bay and Estuarine Society (past President)

Technical Advisory Committees

State Water Resources Control Board Striped Bass Workshop
American River Technical Advisory Committee
Mokelumne River Technical Advisory Committee
Santa Ynez River Technical Advisory Committee
Bay-Delta Oversight Committee (BDOC) Aquatic Resources
USFWS Delta Native Fish Recovery Team
CVPIA Striped Bass Technical Team

Publications

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Dr. Hanson has authored more than 100 technical and scientific reports.