Big Sur River Steelhead Habitat Assessment

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INTRODUCTION

The Big Sur River is one of the largest river systems in Monterey County that still has a viable steelhead (*Oncorhynchus mykiss*) population. In the past it has been the focus of several steelhead studies including downstream migrant trapping, creel surveys, juvenile steelhead habitat use and juvenile abundance estimate surveys. The biological surveys were concentrated in the lower 8.3 miles of the watershed where anadromous *O. mykiss* reside.

Qualitative habitat surveys were done during August 1978 in the headwaters of the Big Sur River to determine the impact of the Marble Cone Fire (1977) on stream habitat. In 1981, the headwaters were again qualitatively assessed to estimate the approximate amount of spawning and rearing habitat available for steelhead in order to determine the value of modifying the boulder falls in the gorge starting at river mile (r.m.) 8.3. To date, the spawning and rearing habitat below the falls had not been quantitatively assessed. However, after the Basin-Complex fire (2008) burned a significant portion of the Big Sur watershed, the short and long term effect to spawning and rearing habitat could be substantial. In order to document post-fire and post storm habitat conditions, detailed habitat mapping surveys were conducted from the lagoon to the falls in the gorge during June, September and October 2010. This report describes the habitat conditions in the lower 8.3 miles of Big Sur River after the Basin Complex Fire and two moderate winters.

STUDY AREA

For south central coastal California, the Big Sur River is a relatively large watershed (47 square miles) that is located in Monterey County approximately 30 miles south of town of Carmel. It originates in the Santa Lucia Mountain Range at elevations ranging between 800 and 1,200 feet and flows in a north-westerly direction for approximately 25 miles before discharging into the ocean at Andrew Molera State Park beach (36° 16' 51.4" 121° 51' 35.6"). A boulder falls located in the gorge section at river mile (r.m.) 8.3 may prohibit adult steelhead from accessing the headwaters during most, if not all years. Big Sur River is a third order stream with numerous fish bearing and non-fish bearing tributaries throughout the watershed. The named tributaries within the study area include Pheneger Creek (r.m. 4.1), Juan Higuera Creek (r.m.4.9), Pfeiffer-Redwood Creek (r.m.6.6), and Post Creek (r.m.7.8). Of these only the lower 1,000 feet of Juan Higuera Creek and the lower 400 feet of Post Creek could potentially support steelhead spawning and rearing.

HABITAT ASSESSMENT METHODS

In order to assess habitat conditions in the Big Sur River several parameters were evaluated including channel form, habitat types, and stream temperatures. Daily stream flow data was obtained from the U.S.G.S. gage located in Pfeiffer Big Sur State Park.

A. Channel Typing

Channel typing was conducted according to the classification system developed and revised by David Rosgen (1994) and is described in the California Salmonid Stream Habitat Restoration Manual (Flosi et al, 1998). Channel typing was conducted concurrently with habitat typing and followed a standard form to record measurements on: 1) water slope gradient, 2) sinuosity, 3) entrenchment, 4) width/depth ratio, and 5) substrate composition.

B. Habitat Features

To evaluate instream habitat features several parameters were noted including habitat type; average length, width, and depth of the unit; maximum depth; abundance and type of instream shelter; substrate composition; embeddedness of the substrate at the pool tail crest; canopy; stream bank substrate composition; stream bank vegetation coverage; and comments on landmarks or issues that may be impacting instream habitat.

Every habitat unit was classified according to habitat type and measured for average length. In all pool units, maximum depth, depth at the pool tail crest (measured in the thalweg), dominant substrate at the pool tail crest, and embeddedness of that substrate were also measured. However, only 10% of the habitat units are measured for all the parameters including those habitat types encountered for the first time and one randomly selected unit on each page. A detailed description of the habitat typing method can be found in the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al, 1998).

1) Habitat Typing

To describe stream habitat, 24 mesohabitat types as defined by McCain et.al. (1990) were used to categorize the units. Habitat units were numbered sequentially starting at 0001 and assigned a type identification number selected from the list of 24 habitat types (Appendix A). For a particular habitat unit to be classified as a discreet unit the minimum length of the unit must have been equal to or greater than the stream's mean wetted width.

2) Measuring dimensions

Once a unit was identified as a particular habitat type, the average length was measured. For those units that were measured for average width and depth, the number of measurements made to obtain an average depended upon the uniformity of the channel with more measurements being taken if the channel was irregular. All measurements were in feet to the nearest half foot and the dimensions were measured using a laser range finder and stadia rod.

3. Shelter Rating

Instream shelter components included wood (e.g. logs, root mass, tree's, terrestrial vegetation), boulders, undercut banks, and other elements within the stream channel that could provide juvenile and adult salmonids protection from predation, reduce water velocities so fish could rest and conserve energy, and allow for the separation of territorial units to reduce density related competition. At each fully measured unit, the type of shelter present and the percentage of that type relative to other shelter components were recorded. In addition, percent cover was derived by estimating how much of the volume of a particular unit contained cover components.

4. Substrate Composition

Substrate composition ranged from silt/clay sized particles to boulders and bedrock. Because of the recent fire in the Big Sur basin and the subsequent high flow events, the two most prevalent substrate types were noted for each habitat unit. The dominant and sub-dominant substrate elements were estimated using a list of seven size classes and recorded as a one and two, respectively.

5. Substrate Composition and Embeddedness at Pool Tail Crests

The dominant or primary substrate composing the pool tail crest was recorded at each pool (except step-pools). In addition, the depth of fine sediment surrounding or burying the cobbles at the crest was estimated. This embeddedness figure is expressed as a value and the following criteria were used: 0 - 25% buried (value 1), 26 - 50% (value 2), 51 - 75% (value 3), and 76 - 100% (value 4). A value of 5 was assigned to tail-outs deemed unsuitable for spawning because of an inappropriate substrate such as bedrock, log sills, or boulders.

6. Canopy

Canopy was considered anything hanging or situated over the creek (e.g. vegetation, bridges) that would provide shade on the water. It was measured by standing in the center

of the unit and visually estimating how much of the unit is covered. Canopy does not take into account topographic shade or other upslope features which may be shading a stream. Estimates of canopy were made at every third unit in addition to every fully-described unit, giving an approximate 30% sub-sample.

7. Bank Composition and Vegetation

For every fully described unit, the dominant bank composition type (e.g. bedrock, cobble, soil) and vegetation type (e.g. grass, brush, and trees) were recorded for both the right and left banks. Additionally, the percent of each bank covered by vegetation (including downed trees, logs, and root wads) was estimated and recorded.

8. Comments and Landmarks

In addition to collecting data on the specific habitat units, comments on adjacent land use, water quality, bank erosion, sediment sources, non-native vegetation, impediments, and other issues which may be impacting stream habitat were noted. Landmarks such as tributaries, road or bridge crossings, buildings, or other structures which are not likely to move were noted to facilitate locating certain areas of the stream for future sampling.

Habitat Typing Data Analysis

Data from the habitat inventory was entered into Stream Habitat 2.0.16, a Visual Basic data entry program developed by Karen Wilson, Pacific States Marine Fisheries Commission in conjunction with the California Department of Fish and Wildlife.

C. Temperatures

Water and air temperatures were measured and recorded during the habitat typing survey at the start of a new page or every tenth habitat unit. Water temperatures were taken within one foot of the surface of the water and air temperatures were taken in the shade.
In addition to collecting temperature data during the habitat typing in 2010, eleven Hobo® temperature data loggers were deployed throughout the river on June 2, 2011 and began taking measurements every half hour starting at midnight on June 3, 2011 until

they were retrieved on November 2, 2011. The results of the data collected from the temperature data loggers will be described in a supplemental report.

CHANNEL TYPING RESULTS

Channel and habitat typing began at the upper end of lagoon, 1,225 feet upstream from the confluence with the ocean. To simplify the classification of reaches, the most prevalent channel type was used to designate reaches. For example, if there was a short reach of a "C" channel type in an otherwise "F" dominated channel, the "C" channel was not called out separately. Using this criterion, reach 1 was a C3/C4 channel type that extended from the upper end of the lagoon upstream 42,400 feet. There were a few short sections (<1000 feet in length) of "F" channel type within reach 1 primarily between the upper end of Andrew Molera State Park and the Highway 1 bridge crossing. The "C" channel type is a low gradient, meandering, alluvial channel with point-bars, riffle/pool sequences and broad, well defined floodplains. While all substrate types could be found within reach 1 to one extent or another the small cobble (3) and gravel (4) were the most prevalent. The "F" type channels are entrenched, low gradient, meandering, with riffle/pool sequences and high width/depth ratios. Like with the C channel, gravel and small cobble dominated the substrate size class.

Reach 2 began at 42,105 feet and extended upstream to the end of the survey at the boulder falls within the gorge at 43,925 feet. This reach had some attributes of both A and B channel types. The A channel type characteristics in this reach included step pool dominated, cascading, and high energy/debris transport capabilities. The B channel type characteristics included stable banks, entrenched channel and a gradient that ranged from 3% to 8%. While boulders were the most prominent substrate feature, gravel was the dominant substrate within the pools, at the pool tail crest and among the interstitial spaces around the boulders.

HABITAT TYPING RESULTS

The Big Sur River was surveyed on June 9, September 20, 21, 29, 30 and October 5, 6, 2010 at stream flows ranging between 23 and 26 cubic feet per second (cfs). A total of 405 main channel habitat units were identified in the approximate 43,925 of feet surveyed. An additional 29 perennial habitat units were identified in side channels.

Based on total stream length, 32% (14,124) of the main channel was pool habitat, 40% (17,642 feet) was flatwater, 27.5% (12,096 feet) was riffle habitat, 0.09% (38 feet) was a cascade, 0.06% (25 feet) was a concrete ford (Table 1 and Figure 1). Based on frequency of occurrence, approximately 27.2% of the units were pools, 3.3% were flatwater units, 35.1% were riffles, 0.2% was cascade, and 0.2% was a culvert/concrete ford (Figure 2).

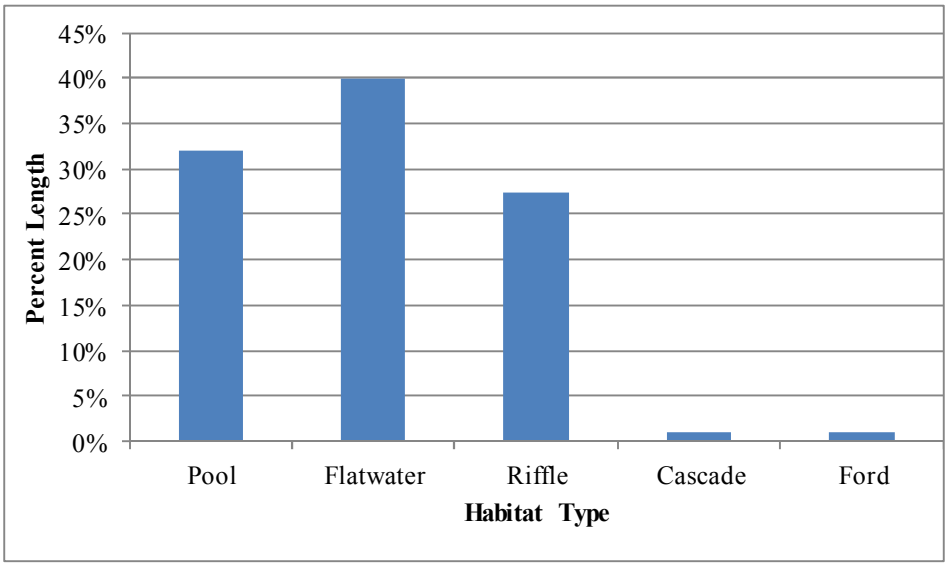

Figure 1. Percent length of each habitat type, Big Sur River, 2010.

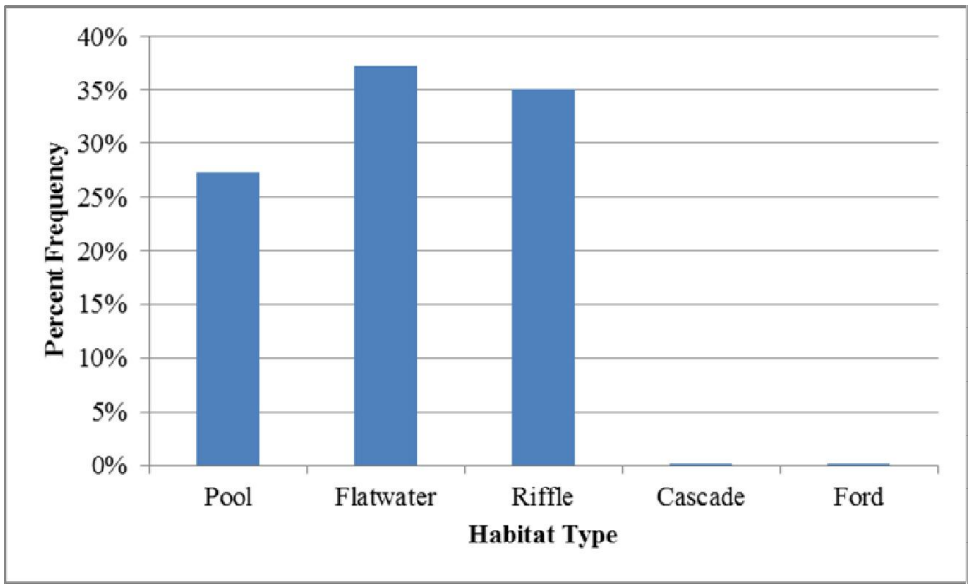

Figure 2. Percent frequency of habitat types, Big Sur River, 2010.

Pool Results

Of the 405 units identified, 110 of these units were pools. Pool types in the Big Sur River included mid-channel pools (32 pools), lateral scour log pools (21 pools), lateral scour root pools (24 pools), lateral scour bedrock pools (12 pools), lateral scour boulder pools (17 pools), plunge pools (1), corner pool (1), channel confluence pool (1), and one step pool (Table 2).

Average length, width, and depth of each of these pools types can be found in Table 2. Maximum depth of all pool types ranged from between two and three feet (25 pools) to over six feet (10 pools). An additional 40 pools ranged between 3 and 4 feet maximum depth; 20 pools ranged between 4 and 5 feet; and 15 pools ranged between 5 and 6 feet deep (Table 3 and Figure 3).

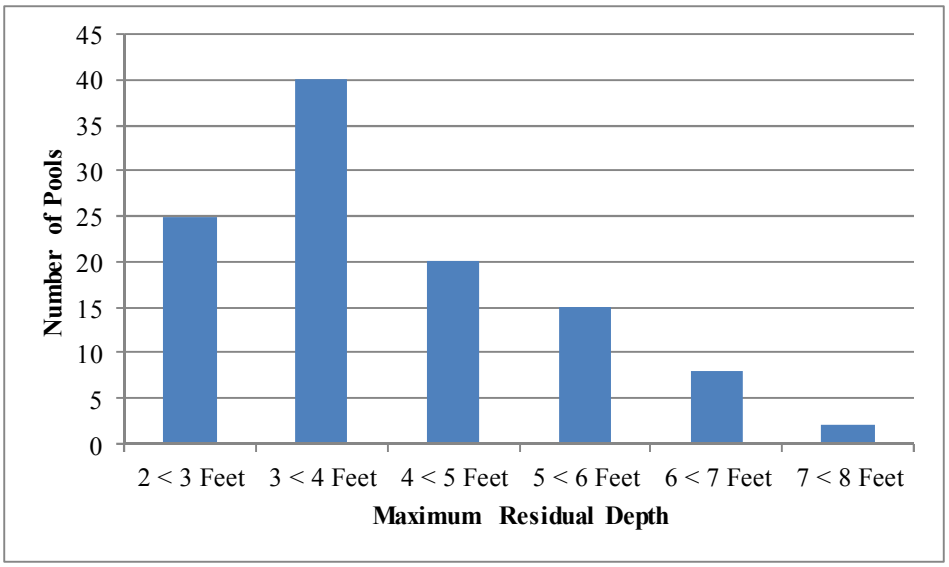

Figure 3. Distribution of maximum residual pool depths in Big Sur River, 2010.

Instream cover or shelter in all pool types combined included root mass (24.5%), terrestrial vegetation (18.2%), boulders (15%), large woody debris (12%), bedrock ledges (8.5%), small woody debris (8.5%), white water (8%), undercut banks (5%), and aquatic vegetation (0.3%)(Figure 4). Dominant shelter components per pool type are described in Table 4.

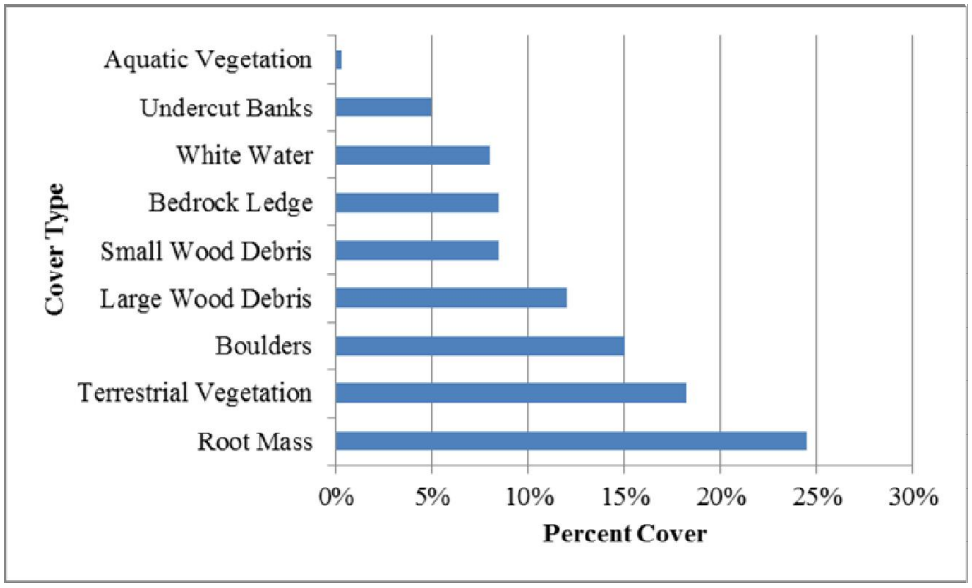

Figure 4. Instream cover types found in all pools, Big Sur River, 2010.

The percentage of pool volume with instream shelter ranged from 5% to 50% in the 32 pools that were fully measured (Table 5).

Percentage of Pool Volume with Cover	Percentage of Pools
0% – 10%	16 %
11% - 20%	50 %
21% - 30%	25 %
31% - 40%	6 %
41% - 50%	3 %

Table 5. Percentage of pool volume with cover components, Big Sur River, 2010.

Primary substrate within pools consisted of sand (38% of the pools), small cobble (26%), gravel (13%), large cobble (8%), and boulders (15%)(Table 6).

Substrate Composition and Embeddedness at Pool Tail Crests

Of the 109 pool tail crests which were measured, 2 consisted of sand and 37 crests consisted of boulders and could not be used for spawning, consequently they had a rating of 5. The remaining 70 pool tail crests consisted of gravel (20 pools), small cobble (24 pools), and large cobble (26 pools). The pool tail crest in the step pool was not measured.

The pool tail crests that consisted of gravel, small cobble and large cobble were also measured for embeddedness. It was found that 12 of the pools tail crests were less than 25% embedded or surrounded by fines (Value 1), 42 were between 26% – 50% embedded (Value 2), and 16 were embedded between 51% – 75% [Value 3(Table7)]. Many, if not most, of the pool tail crests consisting of boulders did have gravel accumulated directly upstream of the crests and these areas could be used for spawning.

Substrate at Pool Tail Crest	Less than <25% embedded (Value 1)	Between 26% and 50% embedded (Value 2)	Between 51% and 75% embedded (Value 3)	Between 76% and 100% embedded (Value 4)	Substrate cannot be used for spawning (Value 5)
Silt/clay					
Sand					2
Gravel	10	10			
Small Cobble	1	17	6		
Large Cobble	1	15	10		
Boulders					37
Bedrock					

Table 7. Substrate composition and embeddedness at pool tail crests in the Big Sur River, 2010.

Other potential spawning areas not located at pool tail crests are identified in the Comments and Landmarks section of this report.

Riffle Results

In the Big Sur River, 141 low gradient riffles, one high gradient riffle, and one boulder cascade were identified. Detailed information on the average length, width, and depth of these units can be found in Tables 1 and 2. The average maximum depth in the low gradient riffles was 1.5 feet and the maximum depths in the high gradient riffle and cascade were 1.6 feet and 3.1 feet, respectively.

Instream shelter in the riffles and cascade consisted primarily of white water (54%) and boulders (30%); however minor quantities of submerged terrestrial vegetation (7.1%), small woody debris (4%), root mass (3.3%), large woody debris (1.3%) and aquatic

vegetation (0.3%) were also present (Table 4). Instream cover was the most diverse in the low gradient riffles while in the high gradient riffle and cascade the only cover was provided by boulders and while water. The volume of riffle habitat with instream shelter ranged from 0% to 60% (Table 8). The boulder cascade had shelter in 90% of the volume.

Percentage of Riffle Volume with Instream Shelter	Percentage of Riffles
0% – 10% of the volume	26%
11% – 20% of the volume	20%
21% - 30% of the volume	7%
31% - 40% of the volume	30%
41% - 50% of the volume	10%
51% - 60% of the volume	7%

Table 8. Percentage of riffle volume with instream cover, Big Sur River, 2010.

Primary substrate within low gradient riffles included small cobble (37%), large cobble (37%), boulders (16%), gravel (9%), and sand (1%). The primary substrate within the high gradient riffle and cascade was boulders (Table 6).

Flatwater Results

Flatwater habitat in the Big Sur River included runs (99 units), glides (48 units), step runs (2 units), pocket water (1 unit), and edge water (1 unit). Average length, width and depth of these units can be found in Table 2. Maximum depth averaged 2.1 feet in runs, 1.7 feet in glides, 1.5 feet in step runs, and 1.3 feet and 3.5 feet in the pocket water and edgewater units, respectively.

Instream shelter in all flatwater units combined included boulders (30%), root mass (25.3%), submerged terrestrial vegetation (15%), undercut banks (12%), small woody material (9%), large woody material (3.7%), aquatic vegetation and white water (2% each) and bedrock ledge (1%). Primary cover composition per flatwater type is described in Table 4.

In all flatwater units combined instream shelter was present in 0% to 45% of the volume with 60% of the flatwater units having shelter in 0% to 10% of the volume; 17% of the units had shelter in 11% to 20%; 3% of the units had shelter in 21% to 30%; and 20% of the units had shelter between 41% to 50% of the volume (Table 9). Generally, the runs and step-runs had the greatest percentage of cover and the cover was distributed throughout the entire unit. The edgewater and pocket water units had minimal cover and it was confined to either the margins of the stream or behind a few mid-channel boulders. Cover in the glides was also confined to margins of the stream.

Habitat Type	Percentage of units with 0% – 10% cover	Percentage of units with 11% – 20% cover	Percentage of units with 21% – 30% cover	Percentage of units with 31% – 40% cover	Percentage of units with 41% – 50% cover
Pocket Water	100%				
Glide	64%	36%			
Run	35%	48%	17%		
Step-run					100%
Edgewater	100%				

Table 9. Percentage of units with cover by flatwater habitat type, 2010.

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cobble (10.5%), and sand (6.5%). Primary substrate within runs consisted of small and large cobble (46% each), boulders (6%), sand and gravel (1% each). The step-runs

consisted entirely of boulders while the edgewater and pocket water consisted entirely of sand and large cobble, respectively (Table 6).

Side Channel Habitat Results

Side channel habitat included those units that were situated parallel to one or more main channel units, but at low flow are separated from the main channel by a cobble bar. Side channels are connected to the main channel at the upstream and/or downstream end. Within the Big Sur River, 29 perennial side channels units were identified and in all comprised 2,752 feet. Twenty-two of the side channel units were within the lower 1.5 miles and included seven riffles (457 feet), three glides (329 feet), four runs (702 feet), four mid-channel pools (320 feet), two log scour pools (92 feet), and one unit that could not be surveyed because it was underneath a log jam (47 feet). Four additional side channel units were located at approximately river mile (r.m.) 3 and included one riffle (66 feet) and three mid-channel pools (413 feet). The three remaining side channel units were located between r.m.7.3 and 7.8 and included a run (138 feet), riffle (137 feet), and a boulder scour pool (51 feet).

Canopy and the Riparian Condition Results

Canopy density was measured in approximately one-third of all the habitat units. In addition, general native riparian vegetation communities and non-native species locations were noted. In the surveyed reach of the Big Sur River, canopy density averaged 54% (range: 0% - 95%)(Table 10). Approximately 1.5% of the units did not have canopy and for the most part these units were either clustered in the vicinity of the lagoon or at the upstream end of the surveyed area where the channel was wide and the bedrock walls of the canyon precluded vegetation growth. Canopy was provided primarily by willow (in the lower 2.5 miles of river), alder, sycamore, oak, and cottonwood trees. Beginning at approximately r.m. 1.5 and extending to r.m. 8.1 redwood trees also provided canopy, but for the most part alder was the dominant species at the river's edge. Within the gorge itself, the banks were bedrock walls and had some ferns, yucca's and other clinging plant species, but growth was not extensive.

Non-native plant species located in the riparian zone included cape ivy, English ivy, nasturtiums and grass (lawns). While English ivy, nasturtiums and grass were in small isolated patches, cape ivy was extensive in distribution. Locations of non-native species can be found in the Comments and Landmarks section.

Stream Bank Composition Results

Stream banks throughout the river were composed of sand/silt/clay (25.5% of the units), cobble/gravel (55%), boulder (14%), and bedrock (5.5%)(Table 10). In the 10% of the units fully measured the stream bank area with vegetation was high with 97% of the right bank and 96% of the left bank having some type of vegetative cover. Vegetation types consisted of hardwood trees (86.6%), redwood trees (8%), and brush (2%). An additional 3.4% of the stream banks had no vegetation and included those banks with trails and beach areas located in the campgrounds; the gorge; bridge abutments; bank erosion sites; and those banks that had some type of revetment. In several locations along the river, the riparian width was one or two trees wide with little to no understory. In other areas extensive bank revetment covered the banks precluding vegetation growth (Figures 5 - 11).

Figure 5. Bank revetment consisting of metal screens with concrete blocks behind and at the base of the screens, Big Sur River, 2010.

Figure 6. Rock rip-rap revetment along a bare bank in Big Sur River, 2010.

Figure 7. Concrete block revetment, Big Sur River, 2010.

Figure 8. Metal structure used for bank revetment, Big Sur River, 2010.

Figure 9. Wood revetment at the base of Highway 1, Big Sur River, 2010.

Figure 10. River cobble bank revetment, Big Sur River 2010.

Figure 11. Boulder riprap at the edge of Highway 1, Big Sur River, 2010.

Streambed Modification

Within some sections of the Big Sur River stream bed modification was extensive, persistent and detrimental to juvenile steelhead and Pacific lamprey. All modifications involved moving wood, bed material, or taking cobble from adjacent cobble bars to create chutes, side channel pools, and dams. Modifications began in early spring and increased over the summer months until the first rains in the fall. Chutes consisted of stacked cobbles that span most of the channel, but leave an opening to force the flow

down the deepest part of the channel where cobble walls were built parallel to the flow and spaced several feet apart. Dams, on the other hand, spanned the channel and ranged in height from one foot in the low gradient reaches of the river to five feet in the gorge and were physical barriers to all fish movement. Side channel pools were created by placing large cobble and boulders in a large semi-circle along the margins of the stream (Figures 12 – 14).

Figure 12. Example of streambed modification where cobbles are stacked to create a dam, chute and a pool. Three of these structures were with 200 feet of each other, Big Sur River, 2010.

Figure 13. A cobble dam constructed to increase the depth of the pool upstream. This prevented juvenile movement upstream and de-watered the left side of the channel, Big Sur River, 2010.

Figure 14. An example of the most extensive modification whereby cobbles were arranged to create a chute and pools, Big Sur River, 2010.

Impediments and Barriers

In addition to the aforementioned seasonal barriers, one permanent anthropogenic impediment/barrier was located at r.m. 4.5. The structure is a concrete ford that spans the channel width and is approximately 11 feet long (from downstream to upstream edges) and 3.5 to 4 feet high. Five culverts of various dimensions conveyed water through the ford at lower flows. On the downstream side of the ford a concrete apron extends approximately 9 feet downstream (Figures 15 and 16). On the upstream side of the ford an extensive gravel/cobble bar extended upstream 130 feet along the left bank.

Figure 15. The downstream view of the concrete ford and apron located at river mile 4.5, Big Sur River, 2010.

Figure 16. Looking downstream to the concrete ford at river mile 4.5, Big Sur River, 2010.

In addition to the concrete ford crossing on the Big Sur River the only other anthropogenic passage issue was on Juan Higuera Creek where a four foot diameter

culvert under a private drive impeded adult passage and prevented juvenile passage. The culvert is located approximately 15 feet upstream of the confluence with the Big Sur River and is perched on a ten foot high boulder falls (Figure 17). Further details on this barrier will be in the Juan Higuera Creek Habitat Report.

Figure 17. The culvert on Juan Higuera Creek, 2010.

No other anthropogenic barriers were observed at the time of the survey; however several natural boulder cascades were surveyed starting at r.m. 8.2 and extending up to the boulder falls in the gorge. The cascades spanned the channel in various configurations and ranged in height from 3 to 7 feet. At low flows all were considered to be impediments to juvenile and adult upstream movement, but not downstream movement (Figure 18). The falls located at r.m. 8.32 is a series or stack of large boulders may be the end of anadromy during some years, but if flows remain high enough to allow passage without becoming a velocity barrier then passage upstream may be feasible (Figure 19). Upstream from the boulder falls the channel becomes low gradient and no other impediments have been observed until upstream of Barlow Flats campground.

Figure 18. One of several cascades located downstream of the boulder falls in the gorge, Big Sur River, 2010.

Figure 19. The downstream end of the boulder falls in the gorge, Big Sur River, 2010.

Water Diversions

While conducting habitat mapping several instream diversions and water well pump houses were noted starting at the upstream of Andrew Molera State Park to just downstream of Highway 1. Instream diversions were screened and placed in either natural pools or built-up pools along the margin of the river.

Temperature

Air and water temperatures were taken at every tenth unit or at the start of a new page while habitat mapping. Throughout the entire survey water temperatures were well within range for juvenile steelhead rearing; however the survey was not conducted at a time of year when temperatures might be an issue.

Date	Location (Feet)	Time	Water Temperature (C)	Air Temperature (C)
June 9	0	0900	15	17
June 9	1,407	1100	15	18
June 9	1,651	1300	17	18
June 9	4,163	1425	17	19
June 9	5,598	1600	17	20
Sept 20	6,853	1040	15	19
Sept 20	7,481	1055	16	19
Sept 20	7,481*	1330	16	19
Sept 20	8,788	1500	16.5	21
Sept 20	9,626	1630	16.5	20.5
Sept 21	10,835	0930	15	19
Sept 21	11,936	1045	15.5	18
Sept 21	12,715	1200	15.5	19
Sept 21	13,626	1430	16	17
Sept 21	15,173	1540	16	19
Sept 29	16,200	0945	16.5	18

Sept 29	17,175	1100	17	20
Sept 29	17,991	1220	17.5	21.5
Sept 29	19,189	1400	18	21.5
Sept 29	20,273	1545	18	21
Sept 30	21,915	0820	16	15
Sept 30	22,871	0950	16	16
Sept 30	23,797	1040	16	19
Sept 30	24,711	1140	16.5	21
Sept 30	25,870	1310	17	20
Sept 30	26,724	1400	17.5	18.5
Sept 30	27,667	1510	17	19
Oct 5	29,599	0945	13.5	15
Oct 5	30,749	1115	14	16
Oct 5	32,519	1300	14.5	17
Oct 5	33,295	1430	14.5	15
Oct 5	34,466	1550	14.5	15
Oct 5	35,266	1640	14	15
Oct 6	36,625	0830	13.5	11
Oct 6	37,716	0945	13	13
Oct 6	39,257	1115	13	15
Oct 6	39,984	1200	13.5	16
Oct 6	40,243	1330	14	15
Oct 6	41,214	1410	13.5	14.5
Oct 6	42,496	1500	13.5	14.5
Oct 6	43,206	1545	13.5	14.5

Table 11. Air and water temperatures taken during habitat mapping, Big Sur River, 2010.

*Temperatures taken while mapping side channel habitat.

Discussion

The purpose of habitat mapping the Big Sur River was to determine the quantity and quality of rearing and spawning habitat available for steelhead and to identify habitat deficiencies or limiting factors that may be adversely affecting the population. The habitat mapping effort on Big Sur River was completed two years after the Basin Complex Fire and after two winters of moderate rainfall. In evaluating the habitat, features that could have been attributed to the fire (e.g. excessive sand deposition, log jams, riparian damage, significant channel changes, etc…) were taken into account. The most obvious signs of the fire on the mainstem included burned trees and riparian damage, charred logs, diminished pool depth, and glides of sand that covered other types of habitat. In terms of steelhead habitat, excessive sand deposition in pools and other types of habitat effectively reduced the carrying capacity of the river and was the most pronounced negative consequence of the fire. Fortunately, this effect is relatively short lived as the sand works its way through the system and slopes revegetate.

Taking into account the effects of the fire, steelhead spawning and rearing habitat, migration corridors for adults and juveniles and issues that may be impacting any of these activities were still able to be evaluated.

Although juvenile steelhead utilize a variety of habitat types for rearing depending on their life stage, it is usually the habitat for larger juveniles or pre-smolts that is limiting. Deeper, larger pools with abundant instream cover and fast water at the head of the pool to deliver drifting invertebrates is considered ideal for this life stage. In Big Sur River, 32% of the length of the main channel consisted of pools although the highest density of pools was in river miles 1, 2, 3, and 5 with 13 to 15 pools per mile. With the exception of 23 pools throughout the river, all pools had either riffles or runs (e.g. fast water) directly upstream that could provide insect drift to the pools. In the remaining 23 pools, 3 had glides at the head of the pool while 20 had another pool upstream.

Most pools (77%) were relatively deep (> 3 feet), but will be deeper when sediment that was deposited as a result of the Basin Complex fire works its way through the system. Shallower and deeper pools were dispersed throughout the river, although the deepest

pools tended to be associated with either boulders or bedrock. The exception to this was in the lower river where large woody debris or channel confinement was the scouring element.

Instream cover was diverse, but not abundant in most pools. Wood material of some sort (e.g. root mass, terrestrial vegetation, small, and large woody debris) comprised 63% of all cover and this was especially true for the lower section of the river. Generally speaking boulders and to a lesser degree bedrock ledges became a more prevalent cover element beginning at river mile 3.8.

Though woody material was a prominent cover element throughout the river, the majority of large and small wood the river moves was either held up in a four log jams or deposited on the flood plain. There may also be wood management in certain sections of the river because of liability or personal property concerns.

The diversity of cover types was high, but the percentage of pool volume with cover elements was low. Ninety percent of the pools had cover in less than 30% of the pool volume and although there are not targets for the percentage of cover in certain habitat types, a multilevel variety of cover types in pools allows for higher densities of fish (Allouche, 2002).

While pools are used for juvenile rearing and resting adults, the pool tail crests or the glides at the downstream end of the pools can be utilized for spawning. Those pool tail crests that consisted of gravel (0.08 to 2.25 inches diameter) and/or small cobble (2.5 to 5 inches diameter) were considered to be potential spawning sites. If large cobble (5.25 to 10 inches diameter) was also present, the site was still considered to be potential spawning habitat; however if the site consisted exclusively of large cobble the site was not considered useable for spawning. In addition to the size of substrate particles another attribute of spawning habitat that is measured is embeddedness or the percentage of fines surrounding the gravel and cobble. Excessive embeddedness hampers substrate movement by adult steelhead during spawning; decreases spawning success by

preventing or decreasing aeration and waste removal from eggs within redds; and impedes fry emergence from the gravels.

Forty-four of the pool tail crests had the appropriate substrate for spawning, but only eleven were embedded less than 25%. The remainder were heavily embedded with twenty-seven crests embedded up to 50% and another six embedded up to 75%. Embeddedness was generally higher in the lower watershed as were those pool tail crests that could not be used because the substrate was sand. Most of the embeddedness may have been caused by excessive sand (decomposed granite) that was eroded into the system after the Basin Complex Fire.

From mid- to upper river many of the pool tail crests could not be used because of boulder substrate. However, directly upstream of many of the boulder crests spawning substrate was present and found to be used by adult steelhead during subsequent redd surveys. In addition to the pool tail crests, riffles, runs and pocket water areas that had the appropriate sized substrate could also be used for spawning if intra gravel water velocities were sufficient to adequately aerate eggs and remove metabolic waste from the redd.

The pool habitat that has been described is essential rearing habitat for larger juvenile steelhead, but riffle and run habitat are critical rearing areas for steelhead fry and fingerlings and for benthic macro invertebrate production. Prime substrate conditions for optimum benthic macro invertebrate production include streambed particle sizes ranging from 1.25 inches to 12 inches in diameter (e.g. gravel, small cobble, large cobble and small boulders) with low embeddedness (Reiser, 1979). Most of the riffles (99%) and runs (98%) consisted of optimal particle sizes for invertebrate production and these sites were located throughout the watershed.

Canopy, riparian condition, non-native plant species, bank erosion, and bank revetment are also noted during the habitat typing survey. The average canopy density over Big Sur River was 54% which is fairly low. The areas where canopy closure was highest were in those sections where the channel was narrower and trees such as alder spanned over the

channel. Low canopy closure tended to occur in those areas of the river where the riparian was dominated by willow or where bar formation or wide channels prevailed. Shade that is provided by topography is not captured in the habitat typing methods used, but it can be significant in providing shade to the river especially those sections that are running east-west. In spite of the low canopy closure water temperatures at the time of the survey were well within the optimal range; however the extensive temperature data logger information that extended from June 3 through November 2 will be more telling.

The riparian zone on one or both banks along 4.54 miles of the river was impacted by either trails, roads, campsites, beaches, or development. In many areas the riparian width was one tree thick with little to no understory. The lack of riparian vegetation has led to bank failure in some instances and has eliminated any sort of buffering ability to filter pollutants. In many cases, the stream banks and upslope areas were denuded or actively eroding thereby directly delivering fine sediment (e.g. silt) to the river. In other previously eroding areas, bank revetment was placed on banks for armoring which precluded vegetation growth.

Non-native plant species in some locations also precluded native vegetation from growing. Cape ivy (*Delairea oderat*a) was the most significant non-native species growing over the vegetation in the riparian zone and higher up on the floodplain. It was intermittently dispersed and confined to the lower 3.4 miles of the river and where it was growing on State Park property; staff were aggressively treating the ivy. Other areas of non-natives were located in the back yards of stream side residents or businesses where the vegetation extended down the banks.

In many of those same areas where stream banks were altered significant instream modification of bed material was also occurring. Cobble and boulders from the stream or point bars were stacked to create dams, chutes, and side channel pools. This instream activity began in early spring during the adult steelhead and lamprey migration and spawning season and extended into the fall. Boulder/cobble dams span the channel in various locations to increase the water depth upstream. Several were constructed at pool tail crests and had chutes extend downstream in the riffles. In two locations, the chutes

were constructed where redds were created six weeks before, thereby trampling any eggs or alevins that may still have been in the gravel. Several of the dams that spanned the channel effectively prohibited juvenile (and adult) fish movement downstream. If several dams were placed across the channel in close proximity fish were trapped between structures. Several of the side channel pools that were created were in shallow sunny areas trapping newly emerged steelhead fry and exposing them to excessive temperatures and predation.

In addition to the seasonal migration barriers that are constructed every year, a permanent ford crossing located at river mile 4.5 prevents or impedes adult and juvenile steelhead upstream movement. At high flows the structure is inundated and is not an impediment to upstream adult migration. However, at some mid-range flow all stream flow is passing through the culverts creating a velocity barrier to migrating adults. There is an optimal flow where adults would be able to swim across the apron and through the culverts, but it is unknown how often this occurs. In addition to the structure being a barrier to fish movement it is also preventing downstream movement of bed material creating an extensive point bar along the left bank just upstream of the structure. It is unknown how frequent of what type of maintenance (e.g. clearing culverts, removing instream wood) needs to occur to keep the culverts clear and open.

Although Juan Higuera Creek had a robust juvenile steelhead population in the 1990's when last sampled the significant rain events after the Basin Complex fire created a debris flow through the channel which modified the habitat dramatically. The culvert is undersized for the watershed area and debris filled the channel upstream requiring removal by heavy equipment. In its current state steelhead habitat is limited but over time habitat will be recovered.

One of the most significant variables in quantifying and qualifying spawning and rearing habitat and barriers is stream flow. The high winter/spring flows experienced after storm events are natural and beyond intervention; however the low flow conditions experienced in the summer and fall are altered be instream and groundwater extraction. The cumulative impact of extraction and the diminished rearing capacity can have dire

consequences for multiple generations of steelhead since juvenile steelhead can rear instream for two to three years before smolting and going to sea. With this in mind instream diversions and well heads along the river were noted.

In summary, rearing and spawning habitat is abundant but experiences localized frequent disturbance from spring to late fall, a time that is already critical for steelhead migration, egg incubation, emergence, and rearing. Excessive fine sediment was found frequently surrounding spawning gravels which could lower spawning success and have negative consequences on year class strength. Encroachment into the riparian corridor was pervasive and led to bank stability issues in some areas and chronic sources of sediment. Non-native vegetation (primarily cape ivy) was found in the lower 3.5 miles of the watershed and was actively managed on State property. Other areas of non-natives were on private parcels in backyards. One permanent impediment/barrier was located at r.m. 4.5 that could adversely affect passage

Recommendations in Priority Order

1) Remove or modify the concrete ford crossing and the apron at river mile 4.5 to allow for unimpeded adult and juvenile steelhead movement upstream and bedload movement downstream. If modification is the preferred alternative (as opposed to removal), designs need to assure that not only does the structure pass adult and juvenile steelhead upstream, but adult lamprey as well.

2) Replace the culvert on Juan Higuera Creek with a free span bridge or half round culvert to allow for hydrologic and geomorphic processes to occur unimpeded and to facilitate upstream habitat recovery.

3) Work with landowners/managers to stop instream manipulation of the boulders and cobbles. Whether this occurs cooperatively with an educational component or via a streambed alteration agreement the widespread manipulation of bed material is resulting in take of juvenile steelhead. If the activity cannot cease altogether, it could be directed away from sensitive areas and during a less vulnerable time that would reduce the mortality associated with the activity. Since 2001, State

Parks staff in Pfeiffer Big Sur State Park have worked aggressively to stop the instream manipulation of cobbles and although the situation requires monitoring, they have been successful in curtailing the activity.

4) Given the number of instream diversions and wells within the watershed a cumulative impacts analysis of summer/fall diversions should be done to fully understand the effects. Depending on the outcome of the analysis it may be necessary to develop operational guidelines for diversions or bypass flow requirements at several locations along the river.

   Another option would be to explore the development of offstream storage of high winter flows for use during the summer and fall. For this to be beneficial, the water savings during low flow conditions would need to be significant and last throughout the dry season. This analysis would also need to assess and provide for those peak flows that are needed for sediment and wood movement downstream as well fish habitat needs.

5) Improve riparian conditions by increasing the width of the corridor, removing exotic species and planting a diversity of native plant and tree species. Denuded, eroding banks and upland camp areas are a chronic source of fine sediment. Increasing the filtering capacity and decreasing surface erosion by adding understory to the stream banks and top of bank would diminish the quantity of fine sediment entering the system. In addition to restoring understory on denuded stream banks, planting native trees will increase bank integrity alleviating the stress of high flow events and abate the need for bank revetment. Here again, State Parks has developed a plan whereby they are directing or concentrating activities to a few areas along the river and planting and fencing those areas that they want to reclaim for a functioning riparian zone.

6) In larger river systems such as the Big Sur River, large wood does tend to deposit out on flood plains; however there may be instances where wood is actively removed from the stream channel. It would be worthwhile exploring the need for

a woody debris management plan for the watershed.

COMMENTS AND LANDMARKS

The following comments and landmarks were noted during the habitat mapping survey. All distances are approximate and were taken from the beginning of the survey.

Distance (feet)	Habitat Unit	Comments
174	001	Because the survey was started at a low tide, some of the estuary/lagoon was mapped. The habitat downstream is a split channel with glides on both sides and sandy gravel substrate. Directly downstream on the left bank side is a transverse riffle. This unit is a split channel with a pool on one side of the bar and a glide on the other. The bar consists of sand and gravel and is approximately two-thirds of the channel width. The left bank side has cattails and bulrush, but most of the cover (terrestrial vegetation) is confined towards the right bank and extends half way across the channel. The lower 39 feet of the glide consists of spawning gravel.
360	002	This unit is a split channel with a riffle on one side of the bar and a run on the other side. The lower 75 feet of the riffle is small cobble. The overall width of this channel is 68 feet. The width of the bar is approximately 12 feet wide and 111 feet long. The left bank has a trail at the top of it and the bank under the trail is actively eroding. The terrestrial vegetation consists of willow only. The cover in the side channel consists of overhanging and submerged vegetation. There is no cover in the main channel.
529	003	The log scour refers to terrestrial vegetation, roots and logs. The lower 37 feet of this pool is a spawning glide.
624	004	This unit is a split channel with a glide on one side of the bar and a pool on the other side. Both sides have 3 4 foot wide cover over the channel consisting of willow. The right side of the channel has a gravel bar that is 18 feet wide and 95 feet long. Behind this bar is an isolated pool.
912	005	The lowermost 25 feet of the right bank side channel is a riffle and has glide and run sections upstream. This side channel is 21 feet wide with a maximum depth of 1.3 feet. There is very little cover in the side channel.
1023	006	The substrate is embedded in this unit. Most of the cover is confined to the left side of the channel and consists of willow and undercut bank.
1158	007	A cottonwood tree has fallen across the channel at the pool tail crest. The pool starts out as a log scour pool, but turns to a mid-channel pool further upstream. The lower 66 feet of the pool is a glide with only a 10 foot by 15 foot patch of spawning gravel
1407	010	Most of this unit is a run, but a pool is confined to one-third of the channel on the left bank.
1835	011	The lower 65 feet of this pool is a glide. The pool goes from being a lateral scour root pool to a lateral scour log pool to a mid-channel pool at the upper end. Most of the cover is confined to the edges of the stream. This unit is the beginning of a confined channel type (F channel type).
1928	012	A seventy foot long cobble bar has deposited upstream of the log jam. The cobble bar in new since 2009. The log jam is confined to the right side of the channel only.
1941	013	This unit has a transverse riffle on the right side of the channel and a run on the left side.
2103	014	Most of the cover and scour is on the left bank side of the channel.

Distance (feet)	Habitat Unit	Comments
2159	015	A 12 foot wide run is on the left bank but the remainder of the channel width is a riffle.
2223	017	Observed one adult and several age 1+ and 2+ steelhead in this pool. The pool starts out as a mid-channel pool and morphs into a root scour pool. A log jam is on the left bank (out of the channel). A eucalyptus in off the right bank (away from the channel).
2587	019	The lower 60 feet of this pool is a glide with sandy substrate. The log jam is still on the left bank. Channel switches back to a "C" channel type.
3058	020	This unit was the lower redd site in 2009. The unit starts as a root scour pool and morphs into a mid-channel pool.
3241	021	The upper end of this unit is a root scour pool; the middle portion is a mid-channel pool and the lower 30 feet is a sandy glide. No spawning gravel.
3310	022	A 15 to 20 foot wide cobble bar is along the left bank. This is a deeper riffle with the cover towards the right bank.
3463	023	The lower 33 feet of this unit is a deep glide with a spawning patch towards the left bank that is 10 feet wide by 21 feet long. A log jam on the right bank (that is above the water line) is providing some edge water cover.
3615	024	The lower 90 feet of this unit is a deep glide with no spawning gravel.
3822	026	First redwood tree on left bank.
3969	027	At 51 feet, the first redwood on the right bank. The lower 78 feet of this unit is a glide without spawning gravel.
4084	028	A ditch which drains Andrew Molera State Park campground enters from the right bank. Substrate is armored.
4411	031	Embedded and armored substrate throughout this unit. Lower 68 feet is a glide without spawning substrate.
4526	032	Substrate is sandy and armored.
4844	035	Redwood trees are on both banks. Cape ivy covers the riparian vegetation.
5176	037	Substrate is embedded and armored. At 170 feet, a tributary enters from the right bank. This area is adjacent to the parking lot. Trail is up the slope on the right bank.
5598	040	This unit is the 90 degree bend by the parking lot. The channel is confined by a 5 -6 foot high cobble bar on the left bank and a slope leading up to the parking lot on the right bank. The lower 107 feet of this unit is a deep glide with cobble substrate on the right bank and sand on the left bank. The substrate is sand upstream of the bend.
5676	041	This unit is a high gradient riffle just downstream of a foot bridge.
5967	043	Gravel and cobble substrate is somewhat embedded with sand.
6129	044	The lower 49 feet of this unit is a glide with embedded and sandy gravel and cobble. The remainder of the unit is just sand.
6387	045	This unit has embedded cobble throughout. Large cobble is prevalent in the upper 30 feet.
6466	046	At 25 feet a foot bridge crosses the creek. First road/horse crossing.
6574	047	Substrate continues to be sandy cobble that is heavily embedded (>75%). Cut vegetation is piled on the bank.
6655	048	Start of a cobble bar on the left bank.
6763	049	This pool unit has swift flow throughout. Left bank cobble bar continues.
6853	050	Substrate is embedded with 3 inches of sand. Left bank cobble bar continues.

Distance (feet)	Habitat Unit	Comments
6943	051	The next 12 units have multiple channels with stream flow switching between channels. The cause of the multiple channels is a log jam that used to be located here and although large wood is still present, the log jam itself is gone. Two of the three channels had flow and were both habitat typed. Gravel bar continues on the left bank.
6943	051.1	Pool tail crest consists of boulders. Right bank channel.
6963	052	Middle channel. Forty feet wide in this location.
7021	053	At the top of the unit, a dry side channel enters from the left bank over a cobble bar. Large woody debris crosses over the channel
7021	053.1	Cape ivy covers the vegetation on both banks.
7040	054.1	A short riffle at the top of the unit has embedded spawning gravel.
7126	055	Large woody debris crosses 3 feet over the channel.
7126	055.1	Large woody debris crosses 4 feet over the channel. All the substrate is embedded.
7309	057	Upper 30 feet is run-like due to the narrow channel, but the unit is a pool.
7309	057.1	Some spawning gravel at the pool tail crest. Two fry observed.
7336	058.1	Dry side channel on the left side.
7418	059	The lower 40 feet is more like pocket water than pool with deep, swift flowing water. Large wood debris is piled up on the left bank.
7418	059.1	A large woody debris jam is in the center of the unit with flow under and around towards the left bank.
7481	060	Lower 9 feet is a riffle. A 10 – 5 foot wide cobble bar runs along the right bank for the length of the unit
7481	060.1	Large woody debris jam over this unit is 50 feet wide x 30 feet long and is 7 feet high. No aggradation occurs upstream of this jam. Flow is under the log jam. The pool upstream of this log jam is shallow.
7532	061	At the start of the unit, a channel on the left bank enters but deposited cobble blocks the flow.
7532	061.1	The unit has spawning gravel and cobble throughout, but is embedded up to3 inches
7688	063	The lower 29 feet is a glide with small cobble substrate. The unit has
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7532	061.1	The unit has spawning gravel and cobble throughout, but is embedded up to3 inches
7688	063	The lower 29 feet is a glide with small cobble substrate. The unit has
7688 cont'	063	higher velocities, but is a well scoured out pool. Large woody debris is accumulated on the right bank at the top of the unit.
7760	064	This unit is a low gradient transverse riffle that is scoured out 2 – 3 feet along the left bank. Entire unit consists of spawning gravel. This unit is the end of the log jam area.
7984	065	Unit has changed from the 2009 survey due to accumulated wood on the lower left bank side of the channel and low terrestrial vegetation (willow) at the bottom of the unit. Now an exposed gravel bar in the center of the unit is creating two runs on either side of the bar. The bar begins at78 feet and is 135 feet long by 5 – 15 feet wide. Substrate in the unit is gravel and small cobble, but is embedded 50% - 75%.
8362	066	Large woody debris and terrestrial vegetation is slumping off the shallow banks into the stream channel. Some scour on left bank caused by large woody debris. At 223 feet, terrestrial vegetation (willow) is creating a dam across the channel that is approximately 30 feet long. There are an increasing amount of redwoods on the banks along with willow, alder,

Distance (feet)	Habitat Unit	Comments
		ferns and sedges. The right bank has very little understory aside from dead cape ivy.
8474	067	The unit begins with what used to be the side channel (2009) flowing around vegetation in the middle. What used to be the side channel along the right bank is now the main channel (has the only flow) although it still looks like a side channel. The main channel flows over to the left bank channel adding some water to that side. Fingerlings observed.
8518	068	At 15 feet, a split channel begins. The side channel goes behind/around a vegetated cobble bar along the left bank.
8677	069	The lower 36 feet of this unit is a glide with sandy gravel and small cobble. Some higher quality gravel is at the pool tail crest. In the upper half of this unit, the scour is only on the left bank (as opposed to mid-channel).
8788	070	Behind the willow vegetation along the left bank, a denuded cobble bar extends for 30 feet upstream.
8860	071	The velocities in this pool are higher than usual due to water plunging into to the top of the unit over boulders that are in the middle of the channel. The scour in the pool is due to roots, terrestrial vegetation and wood along the right bank.
8915	072	Some bedrock on the left bank. A fallen redwood with numerous branches in the creek is on the left bank.
9015	073	The lower 18 feet of this unit is a glide with gravel and small cobble substrate.
9189	075	At 60 feet, a horse trail crosses through the creek.
9287	076	Boulders at the pool tail crest. Exposed wood along left bank and a silt/sand/gravel bar extends the length of the unit along the right bank. Sandy gravel throughout the unit.
9353	077	Lower 17 feet is a glide with sandy spawning gravel at the pool tail crest.
9542	079	Highway 1 is at the top of the right bank.
9731	081	Highway 1 continues at the top of the right bank. Hiking trail also on the right bank. Lower 20 feet is scoured around boulders (pocket water). At 56 feet a tributary with minor flow enters on the right bank. Gravel bar along the left bank.
9911	083	Lower 19 feet is a glide with small and large cobble. A cobble bar runs the length of the unit plus 30 feet into unit 084.
10055	084	Embedded substrate (up to 75%) with sand.
10265	085	Lower 156 feet is a glide that is primarily sand. Several fingerlings and a 12 – 14 inch steelhead observed.
10523	087	Decreasing overhanging riparian vegetation from the right bank due to a cobble bar that has formed. The cobble bar extends upstream through to unit 090.
10601	088	Fingerlings observed.
11177	093	This entire glide unit consists of spawning gravel, but is embedded 50% - 75%.

Distance (feet)	Habitat Unit	Comments
11380	094	This entire riffle (203 feet long by 24 feet wide) consists of spawning gravel.
11548	095	This is 2009 habitat unit 74. Woody debris is still on both banks. Spawning gravel is throughout the unit.
11868	099	A small tributary enters at 50 feet from the left bank. One 6 inch steelhead observed. The lower 50 feet of this unit is a glide with spawning gravel.
11936	100	At 34 feet, large wood debris crosses 10 feet over the channel. Most of the flow is through boulders and low hanging vegetation.
12015	101	Low vegetation over the creek continues. Large woody debris is on the right bank.
12186	103	A horse trail crosses the creek at the beginning of this unit. Lower 23 feet is a glide with spawning gravel and cobble.
12246	104	The top of the left bank is piled high with sand and silt (another trail crosses just upstream of the deposited sediment.
12589	108	At 68 feet, an unnamed tributary with good flow enters off the right bank across a trail
12819	111	This was habitat unit 85 in 2009.
12853	112	This unit is a transverse riffle that starts on the left bank and extends to the right bank at the top. A gravel bar in on the left side and extends to the top of the unit.
12967	113	The lower 30 feet of this unit is a glide with gravel and small cobble. Piled up woody material at the top of the unit is causing flow to go beneath the material. Substrate is aggraded to a depth of 1 foot upstream.
13456	117	An extensive gravel bar runs along the left bank. It extends upstream and downstream of this unit. Pool tail crest in this unit is not very obvious.
13507	118	The end of the left bank gravel bar is at the top of this unit. A man-made crossing of wood and boulders is at the top of this unit.
13573	119	A trail crosses the creek at the beginning of the unit. The lower 20 feet is a glide with spawning gravel (sandy). This is habitat unit 90 from 2009
13698	121	A dry tributary enters at the top of the unit. A small cobble bar runs along the right bank for the entire unit. There is scour around a large boulder, but the velocities are high (for a pool). This is unit 92 from 2009.
13811	123	The lower 45 feet is a glide with small and large cobble. Most of the scour is around the bedrock on the left bank. The pool extends further up on the left bank side because of a transverse riffle.
14069	126	The lower 48 feet is a spawning glide with small coble and gravel. Pool tail crest is not distinct. The scour in this pool is only at the top of the unit where the large woody debris is located. The velocities in this unit are high (for a pool). Large woody debris on the left bank as well. This is unit 95 from the 2009 typing.
14233	128	Recently cut branches deposited in the channel.
14840	135	The pool tail crest consists of wood; however there is a 10 x 4 foot patch of spawning gravel just upstream. The river makes a 90° bend to the left (looking upstream) in this unit. A cobble bar is along the right bank.

Distance (feet)	Habitat Unit	Comments
14945	137	Lower 10 feet is a run. The left bank is a terrace that is approximately 7 feet high, vertical, denuded and eroding. Large woody debris with a root was is on the right bank side of the channel.
15173	140	At the beginning of this unit, a fallen alder clump with 5 trunks has fallen into the channel from the left bank. There is a trail at the top of this unit.
15350	143	At 10 feet, the start of a right bank side channel begins. Both the main channel and side channel are riffles. In 2009, this was habitat unit 105.
15410	144	Highway 1 is close to the right bank. This site in next to the "mushroom" sycamore tree pullout. The main channel unit is a run, but the adjacent side channel unit is a secondary channel pool.
15461	145	Large woody debris is throughout the channel at the top of the unit. The main channel unit is a riffle and the secondary channel pool continues in the side channel.
15763	146	At 75 feet, the side channel changes from a secondary channel pool to a shallow riffle. The side channel ends at the top of the unit. The main channel unit is a run. At 170 feet, several fallen willows span the channel. In 2009, this was habitat unit 107.
15910	147	A 20+ foot wide sandy gravel bar runs along the right bank in this unit and the lower 27 feet of unit 148.
16060	148	The lower 27 feet is a glide with spawning gravel.
16095	149	At 19 feet, a drain pipe for Highway 1 runoff extends off the top of the right bank.
16270	150	Highway 1 continues to be at the top of the right bank. At 31 feet, a sand/gravel bar begins on the left side and extends half way across the channel.
16507	155	A fallen sycamore from the right bank spans the channel.
16971	159	95 feet upstream. Large woody debris is deposited on the right side of the channel at the top of the unit.
17175	160	Large woody debris is deposited along the right bank toe, but is not scouring.
17250	161	Trail crossing with a sign on the right bank at the top of the unit (Gate 10). A dry tributary also enters on the right bank. A cobble bar runs along the left bank.
17335	162	Flag from 2009 survey has this as habitat 115. At 60 feet, a side channel goes around a cobble bar that has deposited in the middle of the channel. The left side is a boulder scour pool. The right side is a run.
17362	163	This area experiences a lot of human activity. Parts of the cobble bar and stream channel are dammed up with boulders. There are several small woody debris "bridges" in the creek. The channel splits around a boulder in the middle of the channel. The lower 10 feet of the left bank side is a boulder scour pool, but the remainder of the unit is a riffle.
17554	164	A cobble bar on the left bank begins and extends through unit 169.
17991	170	The lower 75 feet is a glide with small cobble and gravel. A 15- 25 foot wide cobble bar runs along the right bank. Four steelhead 4 – 6 inches in

Distance (feet)	Habitat Unit	Comments
		length observed. A dry tributary enters from the left bank.
18153	172	At 25 feet, a left bank side channel that is separated from the main channel with a vegetated cobble bar begins. The bar is 5 – 20 feet wide and extends upstream to unit 174.
18411	174	The lower 45 feet is a glide with sandy gravel substrate.
18447	175	Several fallen alders are along the left bank and large woody debris is deposited at the top of the unit.
18559	176	Several fingerlings observed. The pool tail crest is embedded wood. This unit is the beginning of a significant log jam along the right bank side of the channel (does not span the channel).
18697	177	This pool curves around the log jam on the right side, but does not flow under the log jam. This area is the "sycamore pools" area.
18982	179	The lower 147 feet of this pool is a glide. For the lowermost 54 feet, the glide has excellent spawning gravel. In the next 93 feet, the gravel is sandy.
19294	181	A right bank cobble bar begins. Highway 1 is at the top of the right bank through unit 192.
19590	183	This entire unit (225 feet in length) has high quality spawning substrate.
19686	184	The right bank is rip rapped. A culvert extends from the top of the right to drain runoff from Highway 1. This unit marks the beginning of the community of Big Sur.
20124	188	A pump house is at the top of the left bank.
20351	191	A large paved parking area is at the top of the right bank. This unit is a transverse riffle.
20582	192	At 110 feet, a bridge crosses over the creek. The right bank is rip rapped.
20608	193	This transverse riffle is wider than it is long, but was called out as a separate unit. The left side of the river flows through vegetation. The riffle extends upstream of the bend.
20835	195	Parking area and buildings start on the right bank and extend to unit 198.
21552	197	From 84 feet through 225 feet, chairs are throughout the channel. At 177 feet, a man-made cobble dam spans the channel causing minor dewatering below. A shorter cobble dam is upstream.
21646	198	At 10 feet, Pheneger Creek enters on the right bank. A gravel bar runs along the left bank.
21705	199	Entire unit consists of spawning gravel. A bedrock outcrop is on the left bank.
21915	200	This pool has filled with sand. The lower 120 feet is a glide with small cobble.
21965	201	A vegetated cobble bar runs along the left bank.
22206	204	Campground area. The flow through this run unit is channelized because of a man-made cobble weir along the right bank.
22428	205	A cobble/sand bar runs along the left bank and extends into the next unit. A tributary with minor flow enters on the left bank at 123 feet. Man-made weirs throughout.

Distance (feet)	Habitat Unit	Comments
22626	207	Man-made cobble/boulder dam at the downstream end of this unit.
22771	208	The pool tail crest is a man-made cobble/boulder dam. Gravel is upstream of the dam and fry were observed. The left bank is a bedrock outcrop. Most of the left bank is denuded because of foot traffic.
22871	210	Cobble dams/weirs have been constructed parallel to the flow to create chutes. A 10 – 15 foot wide cobble bar is along the right bank..
23035	211	At 15 feet, a campground bridge crosses to the campground located on the left bank. Bedrock outcrop on right bank. Fingerlings observed.
23479	214	The left bank is armored with large concrete blocks (approximately 3 feet by 4 feet and 8 inches thick).
23540	215	A man-made boulder/cobble dam spans the channel at the top of the unit. Cabins are at the top of the left bank. The left bank is also denuded.
23612	216	Rip rap (concrete slabs) covers the left bank.
23747	217	A cobble/gravel bar runs along the right bank through unit 218
23854	219	A man-made cobble dam spans the channel at the pool tail crest. At the upper end of the unit, there is a 6 inch plunge off of a concrete apron. The apron is approximately 11 feet in length and is attached to the downstream end of a concrete ford that crosses the channel. The ford is approximately 3.5 to 4 feet high and has five culverts that pass through the base of the ford. Sand and cobble is accumulating on the left side of the apron on the downstream end. See pictures.
23959	221	An extensive gravel bar has built up behind the left side of the concrete ford.
24079	222	At 37 feet, a man-made cobble dam spans the channel. The lower 62 feet of the unit is a spawning glide consisting of gravel and small cobble.
24116	223	Several man-made cobble dams throughout the unit.
24191	224	A man-made cobble dam spans the channel at the top of the unit.
24305	225	The lower 48 feet is a spawning glide with small cobble substrate. The left bank is stabilized with concrete blocks and cable from the start of the unit. See pictures.
24349	226	Left bank stabilization continues.
24412	227	Metal structures are used to stabilize the left bank starting in this unit. See pictures.
24534	228	The lower 38 feet is a spawning glide with gravel. A man-made dam spans the pool tail crest.
24711	230	Cabins are on the right bank from unit 215. A private residence is on the left bank. Campgrounds have been on either the right and/or left bank since habitat unit 204.
24877	232	Cabins and private residences continue on banks. A man-made dam spans the channel at the beginning.
25153	233	At 126 feet, a bridge for a private residence crosses over the creek.
25588	235	A building is up on the right bank starting in this unit and continuing into unit 238. The lower 75 feet of the unit is a spawning glide with small cobble and gravel.

Distance (feet)	Habitat Unit	Comments
25678	238	Juan Higuera Creek enters steeply off the right bank. Private residence on right left bank.
25911	240	Private residences are on the right bank through habitat unit 254.
26016	242	Lower 21 feet is a spawning glide with gravel and small cobble.
26197	244	The creek makes a 90° bend to the left (looking upstream). The right bank has a pump house with a diversion line running over the creek and up to the ridge on the left bank. Left bank is bedrock.
26452	247	A boulder/cobble bar towards the left bank forms a backwater pool area.
26682	249	The lower 35 feet is a spawning glide with sand and gravel.
26724	250	A black diversion line crosses over the creek. Private residences on both banks.
26911	251	At 87 feet, there is an instream diversion on the left bank. At 133 feet, there is a second diversion on the left bank.
27144	254	A dirt road crosses through the creek at the start of the unit. A foot bridge crosses overhead at 63 feet.
27188	255	A road is at the top of the right bank
27362	256	At 50 feet, a wooden retaining wall starts on the right bank. Fry observed.
27460	257	The creek makes a bend to the right (looking upstream).
27542	258	Both banks have point bars.
27595	259	Left bank point bar continues through unit 260.
27667	260	A backwater pool has formed behind the point bar on the left side.
27700	261	Buildings are on the right bank through unit 264.
27797	262	Creek makes a bend to the left (looking upstream). Left bank is unstable and is slumping.
27926	263	A vegetated cobble bar extends down the center of the channel.
28211	264	Buildings are on the right bank. A retaining wall at river mile 5.3 on the right bank consists of concrete blocks and metal lattices (see pictures). English Ivy covers the right bank. The lower 114 feet is a spawning glide with gravel. At 130 feet, a foot bridge crosses over the creek.
29010	265	Beginning of a campground on the right bank. At 315 feet, a man-made cobble dam spans the channel.
29366	268	The creek flows through several man-made boulder/cobble/wood weirs that either span the channel or are built parallel to flow.
29599	270	Concrete slabs cover the right bank.
29710	271	At 30 feet, a campground bridge crosses over the creek.
30004	274	Start of Pfeiffer State Park property on the left bank. Highway 1 is at the top of the right bank. The lower 84 feet is a spawning glide with small cobble and gravel. A retaining wall along the right bank begins at the start of the unit and extends 415 feet upstream.
30213	275	At 148 feet, a culvert draining runoff from Highway extends off the bank.

Distance (Feet)	Habitat Unit	Comments
30306	276	At 15 feet, the retaining wall ends and the right bank riprap begins.
30452	278	The lower 32 feet is a spawning glide with gravel although the pool tail crest consists of boulders.
30749	280	This unit is a high gradient reach. At 200 feet, a right tributary enters from the right bank.
30890	281	The lower 42 feet is a spawning glide with gravel and small cobble. A sandy gravel bar is on the left bank. Large woody debris spans the creek with a root wad on the right side. Substrate is aggraded behind the root wad and flow is underneath.
31832	286	The lower 72 feet of this unit is a spawning glide with small and large cobble. At the top of the unit, a historic flash board dam structure (without the boards) spans the creek. The bottom of the structure is flush with the stream bottom upstream, but there is a one foot jump at the downstream end. Large woody debris is scouring out small pools just downstream of the dam.
32030	287	The lower 105 feet is a spawning glide with sandy gravel.
32396	289	The lower 51 feet is a spawning glide with sandy gravel. A defunct metal pipe is above on the left bank. The redwood root mass and trees are causing extensive scour and providing excellent cover. This pool is bending left toward Highway 1. At 129 feet, a large woody debris jam that is 17 feet long x 50 feet wide x7 feet high spans the channel. Flow is under the log jam. Parr observed.
32519	290	At the top of this unit a 9 foot long concrete road crosses the creek to one of the Pfeiffer Big Sur campgrounds. The road is flush with the upstream and downstream stream bed. The campground extends up through unit 300 on the left bank.
32892	293	Lower 45 feet is a glide with boulders and gravel (pocket water). Cut logs are on the right bank. At 96 feet, an over flow channel enters on the left bank.
32972	294	Cal-trans is stabilizing the right bank with rip rap and vegetation. This extends for approximately 108 feet.
33249	299	A two inch diameter pipe crosses the creek at 26 feet. Pump is not located here.
33562	301	Lower 117 feet is a spawning glide with small and large cobble. Ten 4-5 inch long trout observed.
33850	303	The lower 33 feet is a spawning with gravel, small cobble and large cobble.
33950	304	Scour along the left bank wall which is severely undercut. Next unit comes in at an angle with this pool extending further upstream on the left side.
34052	305	This unit is a transverse riffle at the downstream end. Within this unit is the beginning of a large cobble bar on the left bank. The State Park trail starts on the left bank as well.

Distance (Feet)	Habitat Unit	Comments
34145	306	At 72 feet, a historic boulder cobble wall begins on the left bank and extends to the end of unit 310.
34466	310	The lower 90 feet is a spawning glide with small cobble. A gravel bar runs down the center of the channel. The boulder/cobble wall ends at 116 feet. There are two boulder wing deflectors on left bank that serve to protect the well (pump) that is on the left bank by the State Park trail. An electric line crosses over the creek to the pump. The scour in the pool is caused by bucked up wood and the boulders that are used in the wing deflectors. Parr observed.
34521	311	A historic short boulder/cobble wall runs along the left bank through the end of unit 312.
34584	312	Large woody debris and sand are deposited on the left bank.
34868	316	At 13 feet, Highway 1 crosses over the creek and extends for 42 feet. Upstream of the bridge in the beginning of Pfeiffer Big Sur State Park (PBSSP) on both sides of the river. The remainder of the survey in within PBSSP.
34997	317	The lower 72 feet is a spawning glide with small cobble. At 5 feet into the unit, Redwood Creek enters from the right bank over a steep bank.
35224	319	The campground bridge crosses over this unit at the beginning.
35439	321	A foot bridge crosses the river at 14 feet into the unit.
35436	322	A large woody debris jam is backing up water on the left bank side of the channel.
36274	226	A small scoured out section around roots on the left bank is at the top of the unit. One third of the channel is exposed cobble.
36322	227	This unit has the unfinished bridge with concrete abutments at the top of both banks.
36625	330	The lower 62 feet of this unit is a glide with gravel. Most of the unit is glide-like with only the upper one-third scoured out around a boulder.
36673	331	Campsites are on the left bank and a road which leads to the east end of the park is on the right bank.
36781	332	Most of the unit consists of high quality spawning gravel.
37329	336	Some boulder and log cover is confined to the margins of the stream. There is excellent spawning substrate in the lower 92 of this glide.
37440	337	Some minor scour along roots on the left bank. A culvert high on the right bank drains a steep tributary.
37653	339	Two large boulders in the channel at the top of the unit are causing scour.
38222	343	At 92 feet, the abutments from an unfinished bridge are on both banks. The road on the right bank is veering away from the top of the right bank. At 358 feet concrete chunks are in the channel.
38405	344	Gabion bank revetment covers the right bank.

Distance	Unit	Comments
38921	347	Starting at 54 feet, one third of the channel on the left side is scour by bedrock. The road is right on top of the left bank. At 129 feet, a riffle continues up the right side of the channel and a glide is on the left bank side.
39059	348	Large woody debris covers the pool tail crest. This pool unit is located on the right side of the channel. The cobble/gravel bar in previous units extends upstream creating an angled pool tail crest. A vegetated gravel bar continues up the center of the channel creating a side channel run along the left bank side. Upstream of the main channel pool, there is a backwater area that is formed as the transverse upstream enters the pool The width of the channel that was typed was 22 feet, but the overall channel width (including the cobble bars) was 60 feet.
39087	349	This unit is a transverse riffle.
39353	351	A large cobble/ gravel bar runs along the right bank. Road continues on left bank.
39435	352	At 45 feet a seasonal foot bridge crosses the creek.
39544	355	This run extends up the left bank side of the channel with a backwater along the right bank.
39732	357	Increasing amounts of green filamentous algae. Campsites are right above the left bank.
39888	359	Partial boulder dam at the top of the unit.
40164	362	At the beginning of the unit is the start of a right bank overflow channel. A small/large woody debris pile is on the left bank.
40262	363	At 85 feet, large woody debris spans the channel 2 – 4 feet over the surface. Exposed roots are along both banks.
40462	367	Sand is deposited on both banks. A log jam is on the left bank flood plain. Excessive amounts of filamentous green algae are still present.
40540	368	The log jam on the left bank continues through to the top of the unit. Start of dry overflow on the left bank.
40651	369	The soil on the left bank is eroded leaving exposed sycamore roots.
40693	370	Denuded left bank continues. The snack bar is up on the left bank and back a hundred feet.
40744	371	Seventy-five percent of the left bank is an eroded wall with exposed roots and cobble.
40862	373	A dry tributary enters at the start of the unit. A short riffle section is at the top.
41016	374	At 14 feet, Post Creek enters on the left bank.
41242	376	The lower 66 feet is a spawning glide with small cobble. The scour in this pool is only on the left bank side due to wood and boulders upstream. This unit marks the beginning of a denuded right bank.
41344	377	The lower 18 feet on the left bank side is a riffle. The denuded right bank ends at the top of the unit.

Distance (Feet)	Habitat Unit	Comments
41545	378	A gabion wall is up on the left bank with sand deposited in front of it.
41613	379	This unit flows mostly on the right bank side because of a mid-channel gravel bar that forces most of the flow to the lower elevation.
41664	380	The lower 10 feet of this unit is a transverse riffle.
41801	381	Downstream end of a side channel on the right bank.
42319	384	High quality spawning gravel throughout the unit. At 183 feet, a historic bridge with boulder/cobble abutments used to cross the river here. The abutments remain, but the running surface has been removed. There is scour around the abutment on the right bank. The upper end of the right bank abutment is where the USGS gage is located. At 228 feet, a seasonal foot bridge crosses the creek. At the upper end of the unit there is some scour around boulders.
42630	386	At 138 feet, large boulders are now the dominant substrate and the gradient increases somewhat.
43038	392	The beginning of this unit is the start of the gorge area with substantial changes in gradient and the size of boulders. A "B" channel type begins here. A large wood debris pile is on the right bank behind and between boulders.
43165	393	There are two small pool sections among the boulders, but most of the unit is a run. Sand is deposited on the left bank.
43226	394	A trail from the campground enters on the left bank. Start of canyon with bedrock walls.
43323	395	The pool tail crest consists of boulders, but there is a 23 foot long glide with spawning substrate upstream of the crest. The jump over boulders at the top is 3 feet high.
43400	396	The jump over the boulders at the top of the unit is 4 feet high.
43495	398	Several springs are flowing from the right bank. The jump over boulders at the top of the unit is 4 feet high. A Large woody debris jam is up on the left bank between boulders. The jam is approximately 18 feet high and is used as a trail.
43550	399	Upstream of the boulders at the pool tail crest, there is 23 feet of glide with small cobble.
43707	401	A landslide is on the left bank. The jump at the top is 7 feet high.
43805	404	Two to three feet elevation change at this high gradient riffle. A boulder/ cobble dam is at the top of the unit. Because it is tied into the existing boulders, the dam is approximately 5 feet high.
43913	405	At the upper end of this pool is a series of waterfalls over boulders and large woody debris. The pool at the base is 70 feet wide and greater than 8 feet deep. End of survey. Questionable end of anadromy.

References

Allouche, S. 2002. Nature and Function of Cover for Riverine Fish. Bulletin Fr Pêche Piscic: 297 – 324.

Flosi, G., Downie, S., Hopelain, J., Bird, M., Coey, R., and Collins, B. 1998. *California Salmonid Stream Habitat Restoration Manual*, 3rd edition. California Department of Fish and Game, Sacramento, California.

Reiser, D.W., and T.C. Bjornn. 1979. Habitat Requirements of Anadromous Salmonids. *In:* Meehan, W.R., Technical Editor. Influence of Forest and Rangeland Management on Anadromous Fish Habitat in the Western United States and Canada. USDA Forest Service GTR PNW-96. 54 pp.

Reiser, D.W. and R.G. White. 1988. Effects of two sediment-size classes on steelhead trout and Chinook salmon egg incubation and juvenile quality. North American Journal of Fisheries Management 8:432-437.

Rosgen, D.L., 1994. A Classification of Natural Rivers. Catena, Vol. 22: 169-199, Elsevier Science, B. V. Amsterdam.

Appendix A

Level III and Level IV Habitat Types

RIFFLE			
Low Gradient Riffle	(LGR)	[1.1]	{ 1}
High Gradient Riffle	(HGR)	[1.2]	{ 2}
CASCADE			
Cascade	(CAS)	[2.1]	{ 3}
Bedrock Sheet	(BRS)	[2.2]	{24}
FLATWATER			
Pocket Water	(POW)	[3.1]	{21}
Glide	(GLD)	[3.2]	{14}
Run	(RUN)	[3.3]	{15}
Step Run	(SRN)	[3.4]	{16}
Edgewater	(EDW)	[3.5]	{18}
MAIN CHANNEL POOLS			
Trench Pool	(TRP)	[4.1]	{ 8 }
Mid-Channel Pool	(MCP)	[4.2]	{17}
Channel Confluence Pool	(CCP)	[4.3]	{19}
Step Pool	(STP)	[4.4]	{23}
SCOUR POOLS			
Corner Pool	(CRP)	[5.1]	{22}
Lateral Scour Pool - Log Enhanced	(LSL)	[5.2]	{10}
Lateral Scour Pool - Root Wad Enhanced	(LSR)	[5.3]	{11}
Lateral Scour Pool - Bedrock Formed	(LSBk)	[5.4]	{12}
Lateral Scour Pool - Boulder Formed	(LSBo)	[5.5]	{20}
Plunge Pool	(PLP)	[5.6]	{ 9 }
BACKWATER POOLS			
Secondary Channel Pool	(SCP)	[6.1]	{ 4 }
Backwater Pool - Boulder Formed	(BPB)	[6.2]	{ 5 }
Backwater Pool - Root Wad Formed	(BPR)	[6.3]	{ 6 }
Backwater Pool - Log Formed	(BPL)	[6.4]	{ 7 }
Dammed Pool	(DPL)	[6.5]	{13}
<u>ADDITIONAL UNIT DESIGNATIONS</u>			
Dry	(DRY)	[7.0]	
Culvert	(CUL)	[8.0]	
Not Surveyed	(NS)	[9.0]	
Not Surveyed due to a marsh	(MAR)	[9.1]	