Section F

Fish Habitat Assessment

Introduction

The Anadromous fish species inhabiting the Willow/Freezeout Creeks WAU are steelhead trout (*Oncorhynchus mykiss)* and coho salmon (O. kisutch). Other non-salmonid species include northern pikeminnow (*Ptychocheilus grandis*), sculpin (*Cottus* spp.), three-spine stickleback (Gasterosteus *aculeatus),* California Roach (*Lavina symmeticus),* Sacramento Sucker (*Castomus occidentalis)* and pacific lamprey (*Lampetra tridentata)*. A level II fish habitat assessment was conducted in the Willow/Freezeout Creeks WAU to identify the current habitat conditions and areas of special concern regarding the three life stages of salmonids: spawning, summer rearing, and overwintering.

Willow Creek drains a watershed of approximately 8.8 square miles. Elevation ranges from about 4 feet at the mouth of the creek to 2,900 feet in the headwater area (CDFG 1995). The upper to mid sections of Willow Creek are in steep-sided canyons. The lower section opens into a wide U shaped depositional valley comprised of a marsh-like environment. This habitat is subject to tidewater influence daily. High water temperatures in this marshy lowland create poor summer rearing habitats for salmonids.

Field surveys conducted to evaluate the quality and quantity of fish habitat in the Willow/Freezout Creek WAU include fish habitat assessment, stream temperature monitoring, stream gravel permeability measurements, and bulk gravel samples. The evaluation of fish habitat conditions is based on target conditions presented in the Watershed Analysis Manual (Version 4.0, Washington Forest Practice Board), the Louisiana–Pacific Watershed Analysis Manual, the California Salmonid Stream Restoration Manual and on inherent geomorphic characteristics of the stream. The target conditions for pools, wood, and fine sediment defined in these manuals are based on research of unmanaged drainages, technical studies, and professional judgement by fisheries biologist.

Stream temperatures were monitored to obtain average temperature conditions. Stream temperature monitoring has been conducted in Willow/ Freezeout Creek WAU since 1990 and sites were monitored through 2000. Relevant to fish, stream temperature regimes are an important aspect to consider when evaluating salmonid summer rearing habitat. A primary assumption for stream temperature monitoring is that increases in stream temperature conditions are associated with streamside shade canopy conditions. Streamside shade canopy affects local air temperature, solar radiation, and relative humidity. Stream temperature information is summarized in the riparian module of this watershed assessment.

Permeability and bulk gravel composition samples were taken in a fish bearing reach of the Willow/Freezeout Creeks WAU, SW1, to establish baseline quality of spawning gravel and to monitor overtime. Permeability and gravel particle size distributions are stream substrate parameters, which affect survival of incubating salmonid embryos. Salmonid eggs buried under as much as a foot of gravel depends on sufficient intra-gravel water flow for their survival and development. Fine sediment within spawning gravel can impede intra-gravel water flow, reducing the delivery of dissolved oxygen to eggs, which can increase mortality in the egg to emergence stage. Forest management practices may increase the delivery of fine sediment to the stream channel, potentially impacting spawning gravel. The assessment of substrate permeability and composition are useful in monitoring the effects of increased sediment delivery on salmonid spawning and incubation conditions.

Aquatic species distribution surveys were conducted within the Willow/Freezeout Creeks WAU conducted from 1994-1996 and repeated in the summer of 2000. Surveys were conducted in the summer months to assess present juvenile salmonid distribution and composition as well as collecting information on other fish species and stream dwelling amphibians.

Steelhead Trout

Steelhead (*Onchorhynchus mykiss)* migrate upstream to spawn during the winter. Steelhead begin entering spawning streams in October and November and continue through February and March. The mainstem and major tributaries of Willow Creek and Freezeout Creek provide the primary portion of steelhead spawning and rearing habitat. Smaller tributaries were observed inaccessible to fish because of waterfalls and characterized by steep gradient and high confinement limit the availability of habitat for anadromous fish.

After completing their upstream migration, adult females construct redds for spawning by excavating gravel four to twelve inches deep and fifteen inches in diameter (Needham and Taft 1934; Shapovalov and Taft 1954). Redds are oval-shaped depressions excavated by the tail of a female. Suitable gravel for steelhead spawning ranges in size from one quarter of an inch to five inches in diameter (Barnhart 1991). Eggs are deposited in excavated depressions. Gravel that has been cleaned and sorted through the excavation process is used to cover the eggs. Male steelhead fertilize the eggs during the redd construction process and aggressively defend the area against other males. Redd construction takes place in pool tail-outs or riffle heads where water is the most oxygenated. Incubation time for eggs is temperature dependent and ranges between twenty and 100 days (Roelofs 1985: Barnhart 1991). Adult steelhead are capable of returning to the ocean and spawning again in subsequent years, although some die after the first year of spawning.

Fry emerge at approximately 25 to 30mm from egg pockets with egg sacks on their ventral surface. During this time, areas of low velocity (shallow water habitats such as stream margins and low gradient riffles) are preferred. Foraging takes place in open areas lacking instream cover (Hartman1965; Everest et al. 1986; Fontaine 1988). In the late summer and fall, fry increase in size and habitat preference changes to higher velocity, deeper mid-channel pools (Hartman 1965; Everest and Chapman 1972;Fontaine 1988). Juvenile steelhead, also called parr, rear in freshwater from one to four years before migrating to the ocean as smolts. Parr show a preference for habitat with rocky substrates (Hartman 1965; Fausch 1993). Foraging typically occurs in scour and plunge pools where there is more cover and higher velocity. Steelhead are opportunistic feeders, utilizing the roughness element provided by boulders and log clusters to rest and pick off food as it drifts in the current (Fontaine 1988; Bisson et al. 1988).

During the winter, steelhead prefers pool habitats; especially deeper low velocity pools with rocky substrate and LWD for cover (Hartman1965; Fontaine 1988). The size of substrate preferred differs, depending on age class. Fry are able to make use of small to large cobble substrate for cover while parr tend to use large cobbles and boulders (Everest et al. 1986). During the winter months deeper pools with cover are preferred because they prevent displacement of fish during high flows.

Coho Salmon

Coho Salmon (*O. kisutch*) begin entering streams in mid-December and continue through mid-February. Similar to steelhead, the mainstem and major tributaries provide a majority of the habitat for coho because steep channel gradients and high channel confinement limit habitat in smaller tributaries. Lack of LWD, high summer stream water temperatures and low structural complexity are factors that can limit the ability of coho to maintain viable populations.

Females arriving on spawning grounds select redd sites and defend the area against other females. Like other salmonids, females excavate a depression in the gravel by using their tail. The preferred spawning locations for coho are low gradient (<3%) tributary streams. Egg pockets in coho redds are 20 to 47 in. wide and 4 to 9 in. deep (Tautz 1977, van den Berghe and Gross 1989). Optimum gravel particle size is 1.3 to 10.2 cm (Stilllwater 1998). Females continue to guard the redd against other females until they are too weak to maintain their position in the current (Briggs 1953). Males and females die soon after spawning. Coho salmon eggs incubate from 35 to 50 days at temperatures of 9°C to 11° C (Shapovalov and Taft 1954).

Juvenile coho salmon select habitat primarily based on water velocity, although light intensity and depth are also considerations (Shirvell 1990). After emergence, fry disperse upstream and downstream into areas of suitable habitat. Usually, side channels and backwaters or other areas of slow velocity and low light intensity are utilized during the rearing period (Stillwater 1998). Coho juveniles typically use woody debris as cover, rather than rock and other substrate, which is primarily used as cover by steelhead parr (Bugert 1985).

One of the primary components of rearing habitat for coho is LWD. In addition to providing shelter, LWD promotes scour, which lead to deeper pools. In coastal northern California streams, the presence or absence of LWD has an overwhelming influence on the suitability of the stream for rearing coho. McMahon and Reeves (1989) have suggested that LWD is a “keystone” feature for salmonids because of its dominating influence on stream morphology (e.g. bank condition, pool creation), sediment and organic matter retention, water velocity and shelter (Stillwater 1998).

Deep pools are an important habitat feature for juvenile coho salmon during the summer months. These pools provide cold water refugia. In the winter months, deep pools prevent displacement of young fish. The ideal pools for coho have slow areas with woody cover, logs, rootwads and flooded brush. Deep pools, which are structurally complex, offer juveniles the most protection from predation and displacement in swiftly moving current.

Historic Perspective

The oldest stream survey on record for Willow Creek is a survey done in the summer months of 1962, by the California Department of Fish and Game (CDFG). The CDFG also conducted stream surveys in the summer months of 1965, 1970, 1982 and 1995. According to the 1995 CDFG Stream Inventory Report, CDFG has surveyed areas covering the mouth to the upper forks, a total area of 6.0 miles from 1962 to 1995. Juvenile fish census data indicate coho and steelhead were present in the watershed between 1962 and 1990 (CDFG, 1995).

Early surveys (1962,1965) results showed good to excellent pool rating. Larger, deeper pools were found in lower areas. Pools averaged 20 feet in length, 6 feet in wetted width, and 2 feet in depth. These early surveys recorded good to excellent instream cover for its entire length, with small logjams and undercut banks predominating. The 1962 stream survey reported steelhead trout and silver salmon throughout most of the watershed.

CDFG’s later surveys (1970, 1982) indicated pool depth and width decreased, particularly in the lower section. In the 1970 stream survey, surveyors observed a decline in canopy particularly in the upper reaches. CDFG attributed the cause of decline to the land use practices, which created many logjams from high amounts of “slash,” introduced into the upper portion of the drainage. By the 1982 stream survey, the riparian canopy in the upper section had improved to a second growth alder/bay forest. Shelter in the lower section of Willow Creek consisted of thin strips of willows and alders with blackberries on either side of the creek.

In February 1988, DFG, Trout Unlimited and L-P representatives walked the stream to look at the impacts of pre L-P ownership logging practices. Here, it was decided that the storm of 1982 was responsible for the massive slides that introduced a heavy load of fine-grained sediment into the stream. Early logging was also noted as contributing to the severity of these slides (CDFG 1995).

It is believed that logging in Willow Creek started in the 1850's. In 1890, narrow gauge railroad was constructed in the stream channel and ran to the headwaters. In order to construct the rail system, it was likely that large trees that had naturally fallen into and "obstructed" the channel were removed. Sections of the narrow gauge rail can be found in the streambed today. Steam donkey engines were used to facilitate the extraction of logs. Logging occurred again starting in the 1950's and progressing through the 1970's. Aerial photographs illustrate the interconnecting network of skid trails; landings and roads were common to tractor logging of that era. Logging occurred in extensive areas of the watershed, including the inner gorge. Roads were developed for ranch access and general transportation in addition to logging purposes. The unimproved Willow Creek road, which provides the only access through the valley remains in a high state of erosion. This road is unpaved. Sonoma County maintains the Willow Creek road.

Juvenile Surveys

In 1962, juvenile coho salmon and steelhead were found throughout the mid-lower, mid and upper sections up to the rock falls (CDFG 1995)(end of Segment SW3). The rock falls reach a height of approximately 50 feet, presenting an obvious barrier for fish passage. CDFG, in 1962, reported the lower section to contain low concentrations of salmonids while containing abundant numbers California roach and Sacramento sucker. Here, pools contained coho in schools of fifteen to twenty (CDFG 1995). A 1965 survey conducted by CDFG resulted in the most abundant residence of three-spined stickleback and less abundant numbers of steelhead and coho presence. Of the coho salmon found, the (1+) size-class was most numerous. Northern pikeminnow (*P. grandis*) and Sacramento sucker (*C. occidentalis*) presence was also noted by CDFG in 1965. The 1970 stream survey indicated spawning gravels to be extremely embedded for stream length entirety. This embeddedness was thought to consist of heavy deposition by detritus and silt. The 1982 CDFG Stream Inventory Report detected no coho in Willow Creek. Young of the Year (YOY) steelhead were the only salmonid species observed here by CDFG in that years survey effort.

Louisiana-Pacific Corporation conducted multi-pass depletion electrofishing surveys. An Upper and Lower site were electrofished from 1990-1994 (Map F-1). In 1990,1992 and 1993 the Willow Creek watershed had almost equal numbers of steelhead represented in the 0+ and 1+ age classes. The only year that had many more fish in the 0+ age class was 1991. Steelhead biomass at the Willow Creek-Lower site increased from 1.4 g/m2 in 1990 to 2.8 g/m2 in 1993. This site was not monitored in 1994. At the Willow Creek-Upper site, steelhead biomass decreased from 3.1g/m2 in 1990 to 0.8g/m2 in 1993. In 1994, biomass was up to a high of 4.3g/m2. Coho were found at the Willow Cr.- Upper site in 1990 only. Seventeen coho with lengths ranging from 52-70mm were found. Biomass was calculated as 1.3g/m2. A note should be made that although this watershed was surveyed for five years, coho were last found in 1990 at the upper monitoring site. In this case, fish from 1990 would be returning in 1993 and none were detected at either Willow Creek site during this year.

Adult Surveys:

In the 1960's surveys, the spawning area of Willow Creek was estimated as good to excellent throughout, with the exception of the upper forks where the rock falls created a fish barrier. The 1970 survey resulted in poor ratings for spawning habitat due to high silt concentrations in the stream below the forks. However, redds were observed above the forks in the North Fork where spawning gravels were more plentiful and less embedded. In December 1980, the Sonoma County Water Agency and the Dept. of Fish and Game noted ten logjams on Willow Creek. All jams were causing erosion and all were located above the second bridge. A particular log jam (stream mile 2.8) caused a large mud slide and completely blocked the original stream channel causing the stream to alter it's course and run out over adjacent fields. However, YOY steelheads were still observed, by CDFG, above this area. In 1995, CDFG conducted a spawning/carcass survey in the upper and lower reaches of Willow Creek. The Upper site, resulted in findings of several redds and gravel quality was rated as fair habitat. In the lower site, large quantities of fine sediment were observed on the inside edge of gravel bars. High bank erosion was encountered at a large bend and numerous cattle crossing the creek was observed (CDFG 1995).

Methods

The habitat inventory method used to evaluate the habitat condition of the Willow/Freezeout Creeks WAU is a modified version of survey methods in the California Salmonid Stream Habitat Restoration Manual (Flosi et. al.) Stream segments were created based on stream gradient and channel confinement (see Stream Channel Condition module). Other factors included the presence of fish, accessibility, stream channel type (response, transport or source reach), and representative segments that were likely to respond similar to other stream channel types within the watershed. Since high gradient streams were likely to be non-fish bearing, survey efforts were concentrated on low gradient reaches of the streams.

A survey was conducted in seven stream segments of Willow/Freezeout Creeks WAU. SW1, SW2, SW2 (2) and SW3 were located in the mainstem of Willow Creek. SW20 was located in the North Fork of Willow Creek. SW23 was located in the Unnamed Tributary to Willow Creek SF10 was located in an Unnamed Tributary to Freezeout Creek. Habitat inventory methods were surveyed for 100% of the wetted width, a distance of 20-30 bankfull widths in length to ensure that at least two meander bends of the stream channel were observed. In addition to survey length, the length of the channel (beyond the designated survey length) was walked, taking note of any change in habitat. Data collected during the fish habitat and stream channel surveys provided information on pool frequency, pool spacing, spawning gravel quantity and quality, overwintering substrate, shelter complexity, and large woody debris (LWD) frequency, condition and future recruitment.

Stream gravel permeability and bulk gravel samples were collected on one stream monitoring segment in the Willow Creek watershed (SW1, similar segment for thalweg profile and cross section surveys). The stream gravel permeability was measured using a 1 inch diameter stand-pipe similar to the stand-pipe discussed in Terhune (1958) and Barnard and McBain (1994) with the exception that our stand-pipe is smaller in diameter. We used the smaller diameter stand-pipe because we hypothesize that it will create less disturbance to the stream gravels when inserted. Bulk stream gravel samples were taken with a 12 inch diameter sampler as described in Platts, Megahan and Minshall (1983).

The monitoring segment for permeability had a total of 7 pool tail-outs and was approximately 20-30 bankfull channel widths in length. Permeability measurements were taken in all 7 pool tail-outs and bulk gravel samples were taken in the first 4 pool tail-outs. At each pool tail-out permeability was measured at 6 sites randomly selected from a grid of 12 sample points. Permeability measurements were taken at a depth of 25 cm. A bulk gravel sample was taken on the permeability site closest to the thalwag of the channel (the deepest spot). The bulk gravel sample was taken to a depth of 33 cm to ensure collection of gravel below typical salmon spawning depths.

After the bulk gravel samples were collected the gravel is dried and sieved through 7 different size-class screens (45, 22.4, 11.2, 5.6, 4, 2, 0.85 mm). The weight each gravel size class was determined for each of the bulk gravel samples using a commercial quality scale. From the sieved bulk gravel samples the fredle index, geometric mean and percent fine particles less than sieve size classes were determined. The survival index for steelhead trout was calculated from the bulk gravel samples using the method described in Tappel and Bjorn (1983). An index calculated from data from Tagart (1976) and McCuddin (1977) (Stillwater Sciences, 2000) was used to estimate survival to emergence from permeability data.

The primary survey method for aquatic species distribution surveys was electrofishing using a Smith-Root Model 12 (Smith-Root Inc., Vancouver, WA) backpack electrofisher. One person operated the backpack electrofisher while one or two other individual(s) used dip nets to capture the stunned species. The captured specimens were placed into a five-gallon bucket containing stream water. When the survey time ended, aquatic species were enumerated, measured to fork length (salmonids) or total length, or snout vent length for amphibians and released back into the units from which they are captured. If stream water temperature was in excess of 70° Fahrenheit (21° Centigrade) the units were snorkeled. All fish and vertebrate species were identified to the lowest possible taxonomic level.

Snorkeling was used to assess species presence at stream segments where the channel was large enough to preclude electrofishing or where elevated stream temperatures had the potential to adversely impact the health of the animals being electrofished. The basic survey unit for snorkeling consisted of a minimum of three pools, however if riffles were deep enough to allow underwater observation these units were sampled. Depending on the channel width, one to four divers were used for the field surveys. The diver(s) entered the survey unit from the downstream end, and waited approximately one-half to one-minute at the downstream end of the survey unit before proceeding upstream to observe species. If the water velocity is too excessive for diver(s) to proceed upstream, then the survey unit would be snorkeled by floating downstream. Dive slates are used to record data underwater. During the survey time, salmonid species were enumerated by age-class according to pre-determined size-age class categories (0 = <70mm, 1+ = 70 – 140mm, 2+ = >140mm). All other fish and vertebrate species observed during the field surveys were identified to the lowest possible taxonomic level, recorded and enumerated.

Table F-1 displays the indices used for rating measured parameters. Measured fish habitat parameters were weighted and given a numeric scale to develop a quality rating for individual life history stages. Parameters were divided into subsets that correspond with individual life history stages (spawning, summer rearing, and overwintering habitat). Parameters were scored as follows: 1 (poor), 2 (fair), and 3 (good). Parameter weights were applied to the total score calculated as shown below. The parameter numbers are in bold and the weights in parentheses.

The overall score would be rated as follows:

Spawning Habitat

E (0.25) + **F** (0.25) + **G** (0.25) + **H** (0.25)

Summer Rearing Habitat

A (0.20) + **B** (0.15) + **C** (0.15) + **D** (0.15) + **F** (0.15) + **I** (0.20)

Overwintering Habitat

A (0.20) + **B** (0.15) + **C** (0.15) + **D** (0.10) + **I** (0.20) + **J** (0.20)

The overall score would be rated as follows:

1.00 - 1.66 = Poor
1.67 - 2.33 = Fair
2.34 - 3.00 = Good

TableF-1. Fish Habitat Condition Indices for Measured Parameters

Fish Habitat Parameter	Feature	Fish Habitat Quality Poor	 Fair	 Good
Percent Pool (Of survey site length) **(A)**	Anadromous Salmonid Streams	<25%	25-50%	>50%
Pool Spacing (Reach length/bankfull/#pools) **(B)**	Anadromous Salmonid Streams	≥ 6.0	3.0 - 5.9	≤ 2.9
Shelter Rating (Shelter value x % Of habitat covered) **(C)**	Pools	<60	60-120	>120
% Of Pools that are ≥3 ft. residual depth **(D)**	Pools	<25%	25-50%	>50%
Spawning Gravel **(E)**	Pool Tail-outs Quantity	<1.5%	1.5-3%	>3%
Percent Embeddedness **(F)**	Pool Tail-outs	>50%	25-50%	<25%
Subsurface Fines (L-P watershed analysis manual) **(G)**	Pool Tail-outs	2.31-3.0	1.61-2.3	1.0-1.6
Gravel Quality Rating (L-P watershed analysis manual) **(H)**	Pool Tail-outs	2.31-3.0	1.61-2.3	1.0-1.6
Key LWD +Rootwads / 328 ft. Of Stream **(I)**	Streams≤40 ft. BFW	<3.3	3.4-6.7	>6.8
	Streams ≥40 ft. BFW	<5	5.1-10	>10.1
Substrate for Over-wintering **(J)**	All Habitat Types	<20% of Units Cobble or Boulder Dominated	20-40% of Units Cobble or Boulder Dominated	>40% of Units Cobble or Boulder Units

Results

Tables F-2, F-3 and maps F-1, F-2 summarize the 2000 fish habitat assessment data. Map F-1 displays the current fish distribution for the Willow/Freezeout CreeksWAU with barriers to anadromy marked. Map F-2 illustrates the potential anadromous fish use by life history stage. Table F-2 presents the scores and ratings for each fish habitat parameter. A weighted average of physical parameters was used to develop the rating for each segment's current condition for the three life stages; spawning, summer rearing and overwintering listed in Table F-3.

Spawning Habitat

All seven segments contained the exact same ratings for spawning indices E, F, G and H. Spawning gravel scored >3% and quality rated as "Good." Embeddedness scored as >50% with a habitat rating of "poor." Quality of gravel was rated and scored as being "fair." Subsurface fines were scored and rated as "fair" habitat for spawning.

The four segments surveyed in the mainstem of Willow Creek (SW1, SW2, SW2(2), and SW3) ranged between 0-3% slope. Spawning habitats rated "fair" in all four segments. The remaining three segments (SW20, SW23 and SF10) also rated as "fair."

Owl Creek, SW20, was given an overall spawning score of 2.0 and an overall rating of "fair." The stream gradient of this site was 7-12%.

For the unnamed tributary to Willow Creek, SW23, an overall rating of "fair" was calculated. The stream gradient of this site was between 3-7%.

For the unnamed tributary to Freezeout Creek, SF10, an overall rating of 'fair" was also applied to the segment evaluation. The stream gradient of this site ranged from 3-7%.

Summer Rearing

Of the seven segments surveyed none were rated as "good" habitats for summer rearing. Four of the total seven segments were given "fair" ratings. The remaining three segments were given "poor" ratings. The summer rearing indices for embeddedness was continually given a score of >50% resulting in a "poor" rating for all seven segments. The indices for % pools with residual depth greater than or equal to 3 feet was also rated as "poor" for all seven segments as there were virtually no pools found in Willow Creek greater than 3 foot in depth. Key LWD per 328 ft. rated "poor" for six of the seven segments. The remaining segment, SW2(2) was rated "good" for Key pieces of LWD. These three indices factored into the six variable equations for summer rearing.

SW1 and SW2 were calculated with scores that gave them overall ratings of "fair" for summer rearing. SW1 was also the only segment to contain a pool with a residual depth greater than 3 feet in depth. This did not affect overall rating; it just reconfirms the lack of deep pool depths in Willow Creek.

SW2(2) was given an overall rating of “fair.” SW2(2) had the only “good” rating for Key LWD loading (6.8 pieces/100 meters) of any of the segments surveyed.

SW3 was given a summer rearing habitat score of 1.15, the lowest of any segment surveyed. The overall rating is “poor.” Percent pool and pool spacing was inadequate in this reach, any restoration in this segment should focus on pool development.

Segment SW20 was given an overall rating of “fair.” SW20 only received a “good” rating for pool spacing.

Segment SW23, unnamed tributary to Willow Creek, received an overall rating of ”poor.” Pool spacing was “good” but percent pools by length were very low. Key LWD was rated “poor” as no wood was recorded for this segment.

Segment SF10 was rated as “poor” habitat for summer rearing.

Overwintering Habitat

Of the seven segments surveyed for overwintering habitat, SW3 was given a “poor” habitat rating. All other segments received an overall rating of “fair” overwintering habitat.

SW2 (2) and SW3 each had no overwintering substrate in the channel. SW2 (2) and SW3 also did not have any pools with a residual depth greater than 3 feet. SW2 (2) had a shelter rating of “poor.” SW2(2) received the only “good” rating for presence of Key LWD. This “good” rating for large woody debris allowed SW2(2) to receive an overwintering score 1.80, higher than SW3, resulting in its “fair” not “poor” rating. SW3 in addition to not having good instream shelter did not have high percentage of pools per segment length. SW3 was a confined channel containing long sections of riffles. Of the few pools present, spacing was poorly rated with a score of 6.2.

SW20 was rated as “fair” habitat for overwintering. SW20 had no overwintering substrate. SW20 also did not have the presence of more than 3.1 pieces of Key LWD’s in the stream channel. SW20 was rated as having a “fair” % of pools by stream length with “good” pool spacing. Shallow pools and lack of wood for pool scours inhibited this section from having the conditions needed to be a “good” habitat.

SW23 had an abundance of overwintering substrate with a score of 100%. SW23 also had a “good” amount of pool spacing within its segment length. However, SW23 did not have any Key LWD nor did it contain any pools with a residual depth greater than three feet. SW23 was rated as having “fair” habitat conditions for overwintering.

Table F-2. Summary of Fish Habitat Parameters, with Scores and Corresponding Ratings. Willow/Freezeout Creeks Watershed Analysis Unit, Sonoma county, CA, Summer, 2000.

Segment	**A.** % Pool by stream length		**B.** Pool Spacing		**C.** Shelter rating		**D.** % of all pools with residual depth ≥3 ft.		**E.** Spawning gravel quantity		**F.**% Embeddedness		**G.** Sub-surface fines		**H.** Gravel Quality		**I.** Key LWD + rootwads / 328 ft.		**J.** % Over-wintering substrate	
	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating
SW 1	78	Good	1.7	Good	84	Fair	7.7	Poor	>3	Good	3	Poor	2	Fair	2	Fair	1.3	Poor	15	Poor
SW 2	54	Good	1.9	Good	53	Poor	0	Poor	>3	Good	4	Poor	2	Fair	2	Good	2.6	Poor	7	Poor
SW 2 (2)	46	Fair	3.0	Fair	59	Fair	0	Poor	>3	Good	3	Poor	2	Fair	2	Good	7.2	Good	0	Poor
SW 3	20	Poor	6.2	Poor	78	Fair	0	Poor	>3	Good	3	Poor	2	Fair	2	Good	2.8	Poor	0	Poor
SW 20	35	Fair	2.7	Good	64	Fair	0	Poor	>3	Good	3	Poor	2	Fair	2	Good	3.1	Fair	0	Poor
SW 23	20	Poor	2.3	Good	72	Fair	0	Poor	>3	Good	3	Poor	2	Fair	2	Fair	0.0	Poor	100	Good
SF 10	42	Fair	4.8	Fair	81	Fair	0	Poor	>3	Good	3	Poor	2	Fair	2	Good	2.6	Poor	23	Fair

Table F-3. Summary of Fish Habitat Ratings for Three Life History Stages.
Willow/Freezeout Creeks Watershed Analysis Unit, Sonoma county, CA. 2000.

Segment	Slope gradient class (percent)	Spawning habitat score	Spawning habitat rating	Rearing habitat score	Rearing habitat rating	Over-wintering habitat score	Over-wintering habitat rating
SW 1	0-3%	2.00	Fair	1.85	Fair	1.85	Fair
SW 2	0-3%	2.25	Fair	1.70	Fair	1.70	Fair
SW 2 (2)	0-3%	2.25	Fair	1.70	Fair	1.80	Fair
SW 3	0-3%	2.25	Fair	1.15	Poor	1.15	Poor
SW 20	7-12%	2.25	Fair	1.85	Fair	1.85	Fair
SW 23	3-7%	2.00	Fair	1.45	Poor	1.85	Fair
SF 10	3-7%	2.25	Fair	1.50	Poor	1.70	Fair

SF10 received a "poor" rating for indices D, F, I, and J. SF10 was rated as a "fair" habitat for the indices A, B, and C. Thus, SF10 was rated as an overall "poor" habitat for overwintering.

SW1 and SW2 were the only two segments to receive "good" ratings for both pool spacing and % pool by stream length. However, SW1 and SW2 rated as "fair" habitats for overwintering due most likely to the lack of LWD and shallow pools.

The results from the bulk gravel samples and permeability measurements are presented in Table F-4. Percent survival-to-emergence indices for spawning gravel were calculated from the bulk gravel samples and permeability samples. The Tappel/Bjorn index (1983) was used to calculate survival-to-emergence from the bulk gravel samples. The index for percent survival of steelhead was used because Tappel and Bjorn (1983) only present two survival indices for chinook salmon and steelhead trout. The steelhead index was used because it more closely approximates the fishery in the Noyo WAU, coho salmon and steelhead trout. Chinook salmon are larger fish than coho or steelhead and can spawn in larger substrate making the index based on Chinook salmon impractical for Willow Creek. An index calculated from data from Tagart (1976) and McCuddin (1977) (Stillwater Sciences, 2000) was used to estimate survival to emergence from permeability data. This index is not robust and additional work is needed, but it is useful for interpreting permeability information.

The estimated percent survival of emerging steelhead, from Tappel and Bjorn (1983), varied from 62% to 83% with one sample being calculated at 0% (Table XX-1). The survival-to-emergence index calculated for the permeability data showed survival rates that ranged from 37% to 55% (Table F-4). The mean survival to emergence rate for all tail-outs from permeability data is 49%. These survival indices reflect conditions at pool tail-outs where a spawning fish has not worked the gravel into a redd. Therefore they reflect the relative quality of stream gravels that a spawning fish has to work with. Areas of stream gravels with a high survival percentage would likely be preferred by spawning fish and likely have better survival success for emerging fish. Areas of stream gravels with a low survival index percentage may not be completely poor quality, particularly because they will have permeability and gravel quality improved following redd development, but likely will not be the preferred condition.

Generally, the percentage of fine sediment (<0.85 mm) was not found to be high in the Willow Creek tail-outs except for 1 tail-out. Three bulk gravel samples had percent fine particles less than 0.85 mm under 8 percent, which is considered within a properly functioning range, especially considering that when a fish spawns a significant portion of these fines will be cleaned. However one tail-out had 16% fine particles less than 0.85 mm, which is not desirable for spawning. Fredle indices and the geometric means for the sampled locations were low, however, when a spawning fish works stream gravels these values will change.

We feel the use of permeability as the indicator of current stream gravel quality is the better indicator of conditions necessary for developing fish embryos. In most of the laboratory studies of fish emergence from incubating eggs, survival is related to the proportion of fine particles or the size class distribution of the gravel fish embryos are developed in. These measures are used to indicate the ability of water borne nutrients and dissolved oxygen to reach the embryos. Therefore, measures of fine particles or size class distribution indices, etc. are surrogates for gravel permeability. Direct measure of the permeability conditions that occur in the stream gravels is the best indication of this quality. When using permeability as an indicator of spawning gravel quality in Willow Creek, the results suggest improvement needed for the quality of spawning gravels.

Table F-4. Bulk Gravel Sample and Permeability Measurements for Willow Creek Monitoring Segment (SW1).

Pool Tail-out Number	Percent <0.85 mm	Geometric Mean	Fredle Index	Percent Survival (Tappel/Bjorn)	Mean Permeability (cm/hr)	Percent Survival (from permeability)
1	5%	4.8	0.7	85%	10,518	55%
2	7%	2.8	0.4	70%	10,358	55%
3	16%	3.0	0.2	0%	6,202	47%
4	8%	3.6	0.3	62%	5,523	46%
5	-	-	-	-	8,059	51%
6	-	-	-	-	3,263	38%
7	-	-	-	-	3,098	37%

Discussion

A fish habitat assessment is intended to evaluate stream reaches for the presence and overall health of three types of anadromous salmonid habitats: spawning, summer rearing and overwintering. Habitat limitations on production during the freshwater portion of their life history are typically found in one of these habitat types (CDFG 1994). No single component of habitat quality can effectively reflect overall habitat conditions because different life stages use different types of microhabitats. Integration of the quality of many habitat components provides a better understanding of overall habitat conditions. The seven survey segments (SW1, SW2, SW2 (2), SW3, SW20 SW23 AND SF10) will be discussed in the following text according to these three respective life history stages.

Spawning Habitat

A good habitat for spawning is dependent on variables such as: sufficient number of gravels, quality of gravel (size and distribution in the tailout of a pool), amount of fines predominating and the amount at which the present gravels are embedded in sediment. If fines and sediment are depositing at a fast rate, cementation of spawning gravels occurs. Cementation confines the gravels to anoxic conditions, no longer filtering dissolved oxygen through multiple layers of gravel and cobble.

In the Willow/Freezeout Creeks WAU, all segments exhibited an abundance of spawning gravel with high levels of embeddedness and a moderate amount of fine sediment. In each case, the habitat was rated as a “fair” habitat for spawning. Willow Creek contains many segments with pools moderately to heavily filling in with fines. It is believed that this is due in part, to erosional activity occurring along the banks of Willow Creek. However, in each case, cementation was not yet a problem, as gravels were still loose and aerated. These gravels are thought to remain aerated due to the abundant presence of spawning gravels still remaining in pool tail-outs. In the unnamed tributary to Freezeout Creek, SF10, the gradient and good cobbles were thought to aid in the filtering out of sediment but the channel was still moderately filling in with fines. Thus, it had fair habitat for spawning.

In segment SW2 (2,) two consecutive slides had resulted, exposing predominately sandy soil, continually introducing fines and sediment to the channel below. In segment SW23, a slide located on the left bank of the survey segment has introduced gravel, cobble and fines into the channel below. The rock falls were located in survey segment SW23 and reached a height of approximately 50 feet, thus creating an obvious barrier for fish passage and spawning any further along this section of the creek.

Summer Rearing Habitat

Summer rearing habitat conditions for salmonids are evaluated on the availability of pools, sizes of pools, embeddedness of gravels and the complexity and quantity of cover (particularly large woody debris) in the channel.

The limiting factors for providing a “good” habitat for summer rearing involve embeddedness, Key LWD and pool depth greater than 3 ft. For all seven segments, embeddedness was greater than 50%. As fine sediment rises, spaces between cobbles fill in, smoothing out the floor of the streambed. Filling of the streambed eliminates cobble surface area. This eliminates spaces between cobbles. This results in loss of habitat for macro-invertebrates, a food source for rearing salmonids and loss of instream shelter for small parr avoiding predation.

Six of the seven segments received “poor” ratings for Key pieces of LWD. Key LWD with debris jams only exceeded more than 3 key pieces in one segment. LWD provides instream shelter and refuge from predation. LWD also creates scour thus providing depths to pools for further shelter and refugia. The scouring process also helps to clean and sort gravels improving quality of salmonid spawning habitat. LWD has the potential to provide the stream with much needed nutrients by introducing detritus and/or capturing detritus in its porous cambium and providing habitat for larval stages of macro-invertebrates. Of the 68 total pools surveyed in all seven segments only one pool exceeded 3 ft in residual depth. This result is directly related to lack of wood creating scours and the influx of sediment embedding and filling in pool depth.

Rearing habitats in segments SW1, SW2, SW20 and SW2(2) rated “fair,” while SW3, SW23 and SF10 rated “poor.” Segments SW1 and SW2 have a high frequency of pools, which increased their rating to “fair.” However, all segments lacked pool depth, Key LWD and high % embeddedness, which prevented any ratings from being “good”. SW2 (2) was the only segment to exhibit a “good” amount of Key LWD however, this did not affect its pool depth and shelter rating from being “poor.” It is believed that erosional activity has contributed to the “filling in” of pools. This is supported by the fact that only segment SW1 has a singular pool exceed 3 feet at its residual depth and overall subsurface fines for all seven segments were rated as fairly depositing.

Overwintering Habitat

Overwintering habitat is evaluated on the availability of deep pools, pool cover, the presence of backwater and side channels, proportion of habitat units with cobble-or boulder-dominated substrate and the presence of riparian vegetation. Riparian vegetation can provide water velocity refugia during overbank flow events in moderately confined to confined channels. Riparian vegetation can also introduce much-desired nutrients from insects to detritus matter. Fish cannot overwinter in the main current of the channel with out objects that provide a roughness element that can break up the flow of the direct current. Fish will overwinter off-channel where water velocity is less vigorous and large boulders and trees are most likely to sit thus creating back water eddies for refugia to help prevent displacement.

In Willow Creek, the limiting factors inhibiting a “good” habitat rating were the lack of overwintering substrate, key LWD and pool depth.

Overwintering habitats in segments SW1, SW2, SW2(2), SW20, SW23, and SF10 rated “fair,” while SW3 rated as “poor” habitat. Thus Willow/Freezeout Creeks WAU provides a better overwintering than a summer rearing habitat for salmonids.

Segment SW23 contained the only “good” rating for overwintering substrate. An abundant piling of LWD at the confluence with Mainstem Willow Creek was thought to be the result of a massive slide ~ 200ft above the confluence. Although this slide introduced a fair amount of fines and poorly embedded gravels, it also introduced rootwads, LWD and significant amounts of cobble and boulders. Overall, SW23 was rated “fair” due in part to LWD not being of “Key” size and sediment loading decreasing pool presence and pool depth.

The presence of backwater eddies in the root scour pools of SW1 and SW2 provided key locations for overwintering. However, fine deposition kept the pools from having any depth for fish utilize as sanctuary from wintertime flows. SW1 was also impacted with a “poor” rating for instream shelter. SW1 and SW2 remained “fair” habitats for overwintering.

Segment SW2 (2) also rated “fair” for overwintering. SW2 and SW2 (2) were the only segments to receive “poor” ratings for shelter. However, SW2(2) was the only segment to receive a “good” rating for the presence of Key LWD. A slide on the Right Bank ~445 ft above the confluence with SW23 introduced fallen trees and sediment into the channel. A second slide, ~150 above the first slide also occurred. Shallow pools, moderately filling with fines could be a result of this slide. These two consecutive slides could be the distinguishing factors affecting the “good” rating for wood loading. However, these two slides could also be the distinguishing factors hindering SW2(2)’s overall rating from being “good” wintering grounds.

SF10 is a cobble/boulder dominated stretch of the watercourse with LWD littered throughout. High gradient and lack of deep pools may deter potential of this segment for fish utilization for overwintering.

SW3 was rated “poor” for every indices but shelter rating. SW3 was a confined channel with no off channel habitat. There was little wood loading for cover and long riffle sections did not allow for a break in water velocity. These resulting factors deterred the surveyor from rating the segment as “good” or even “fair” habitat for overwintering.

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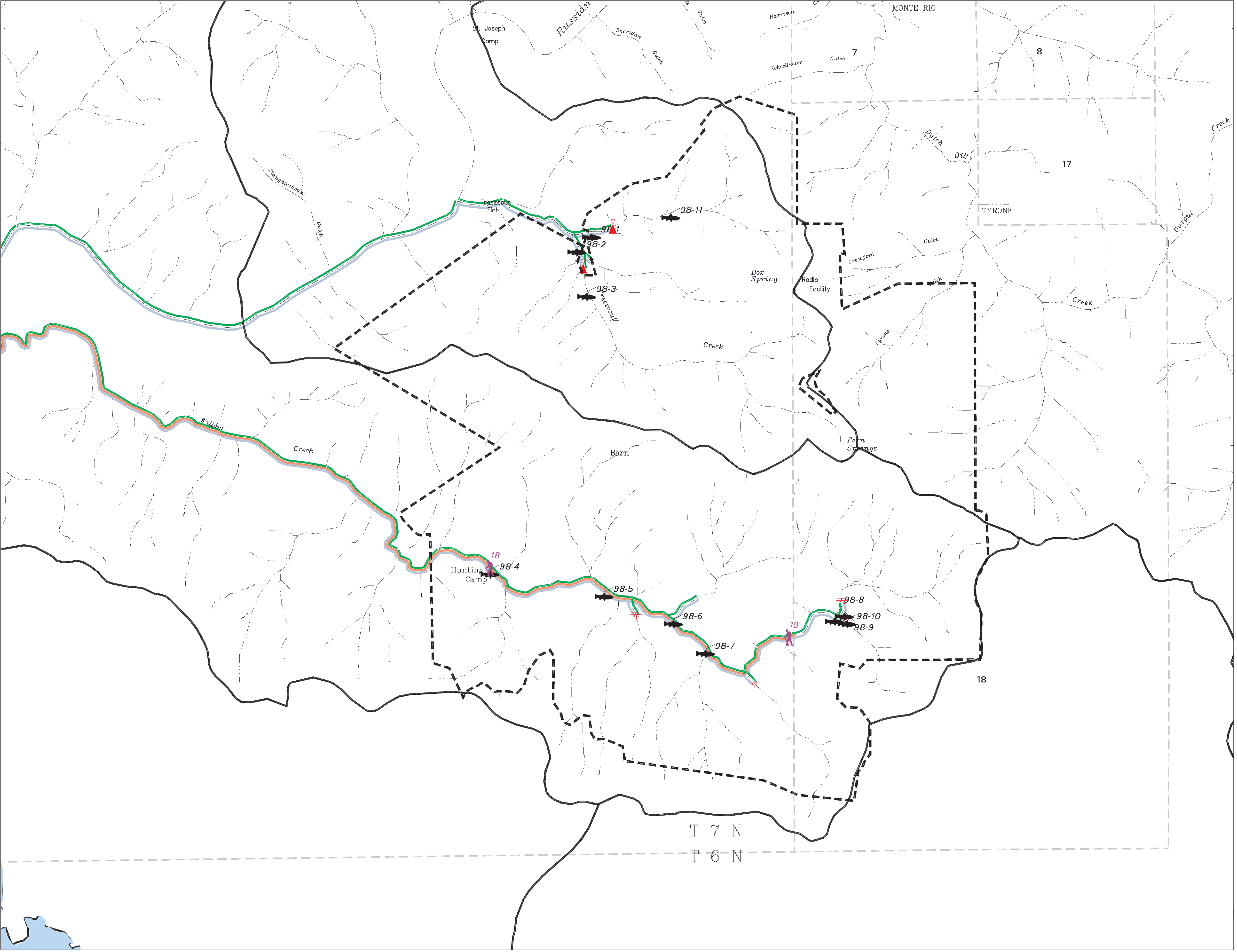
Willow Creek / Freezeout Creek Watershed Analysis Unit

Map F-1 Potential Fish Distribution



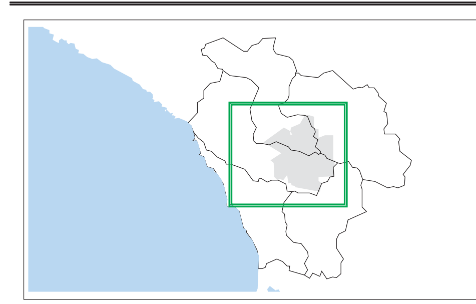
Potential Fish Distribution
- Coho Salmon Distribution
- Steelhead Distribution
- Non-Salmonid Fish Distribution

- Fish Distribution Sampling Locations
- Fish Index Monitoring Sites

Barriers to Adult Migration
- Gradient
- Waterfall

Flow Class
- Class I
- Class II
- Class III

- MRC Ownership
- Planning Watershed Boundary



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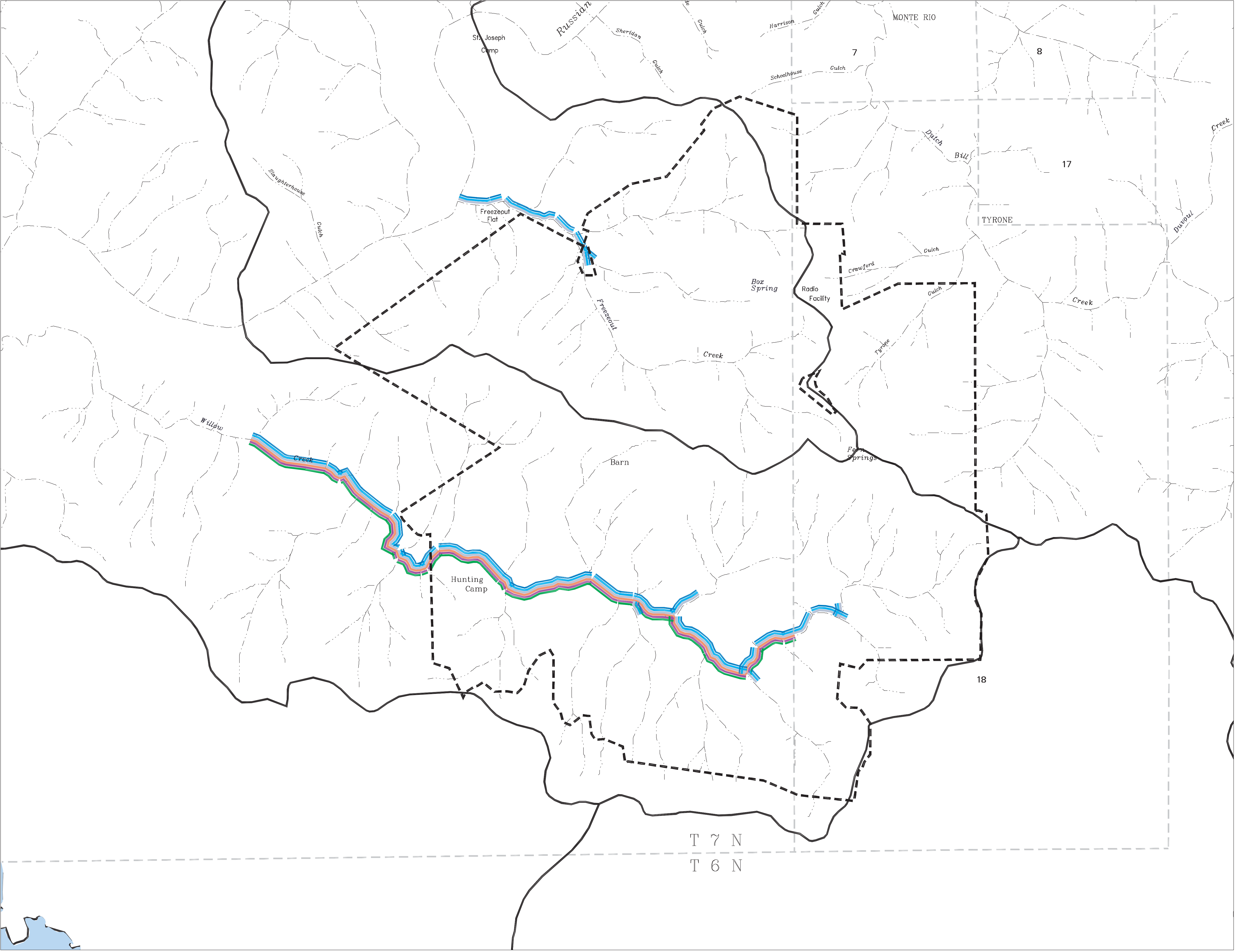
February 16, 2001



Willow Creek / Freezeout Creek Watershed Analysis Unit

Map F-2 Potential Anadromous Fish Habitat and Life History

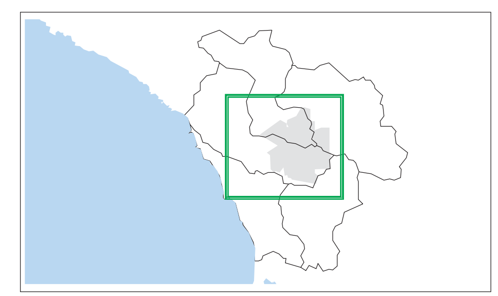
Present Habitat Usage by Salmonid Life History Phases

- Coho Spawning
- Coho Rearing
- Coho Over-Wintering
- Steelhead Spawning
- Steelhead Rearing
- Steelhead Over-Wintering

Flow Class

- Class I
- Class II
- Class III

- MRC Ownership
- Planning Watershed Boundary



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February 16, 2001