CALIFORNIA DEPARTMENT OF FISH AND GAME
STREAM INVENTORY REPORT
Willow Creek
Report Revised April 14, 2006
Report Completed 2000
Assessment Completed 1994

INTRODUCTION

A stream inventory was conducted during the summer of 1994 on Willow Creek to assess habitat conditions for anadromous salmonids. The inventory was conducted in two parts: habitat inventory and biological inventory. The objective of the habitat inventory was to document the amount and condition of available habitat to fish, and other aquatic species with an emphasis on anadromous salmonids in Willow Creek. The objective of the biological inventory was to document the salmonid and other aquatic species present and their distribution. After analysis of historical information and data gathered recently, stream restoration and enhancement recommendations are presented.

WATERSHED OVERVIEW:

Willow Creek is tributary to the Russian River, located in Sonoma County, California. Willow Creek's legal description at the confluence with the Russian River is T 7N R 11W S 13. Its location is 38°26'25" N. latitude and 123°05'42" W. longitude. Willow Creek is a second order stream and has approximately 5.9 miles of blue line stream, according to the USGS Duncan Mills 7.5 minute quadrangle. Willow Creek drains a watershed of approximately 7.88 square miles. Elevations range from about 4 feet at the mouth of the creek to 2,900 feet in the headwater areas. Douglas Fir, Redwood, Alder, Willow and Oak dominate the watershed, and the drainage is a typical coastal V shaped canyon. The upper section is a steep sided canyon with redwoods and mixed conifers. The mid-section is similar, however, the gradient is more gradual and the canopy is more open. The lower section opens to a wider U shaped valley, containing a marsh which is subject to tidewater influence daily. Summer habitat conditions in the marsh area are poor to non-existent for salmonids due to high water temperatures.

Willow Creek was first logged in the 1860's. A sawmill was built around the lower meadow area later that decade. Narrow gauge rail was constructed in the stream channel and ran to the headwaters which facilitated steam donkey engines for log extraction (Figure 2). The rail system was later used to move finished lumber products over the top of the watershed to Bodega Bay for loading on schooners to San Francisco (Dave Raff, pers. comm.). In the 1950's and 60's a second logging occurred of much of the remaining old growth and any second growth trees that were large enough to be merchantable.

The lower watershed is now part of the State Parks system, and a primitive campground exists on the southern edge of the valley. The rest of the watershed is privately owned. A large ranch consisting of rangeland and agriculture production exists in the mid-watershed area with smaller private parcels dispersed in the headwaters. Louisiana-Pacific Corporation (L-P) owns most of the upper watershed and manages it for timber production.

Vehicle access exists at the confluence with the Russian River via Willow Creek Road from State Highway 1 approximately 3 miles south of the town of Jenner, or at the headwaters via Willow Creek Road from Coleman Valley Road west of Occidental.

STREAM SURVEYS:

The Department of Fish and Game conducted stream surveys in the summer months of 1962, 1965, 1970, and in the spring of 1982. The surveyed area covers the mouth of Willow creek to the upper forks, approximately 6.0 miles. A general description of the watershed is summarized as follows:

Early surveys indicate that there was good to excellent pools throughout. Larger, deeper pools were found in the mid section, and smaller, shallower pools were found in lower areas. Pools averaged 20 ft. in length, 6 ft. in wetted width, and 2 ft. in depth. Later surveys indicated pool depth and width decreased, particularly in the lower section. Good to excellent instream shelter was found in the early surveys, on the entire length of the stream and consisted of small log jams and undercut banks.

In 1970 a noticeable decline in canopy was noted particularly in the upper section. This was attributed to land use practices which created many log jams from high amounts of "slash" in the upper portion of the drainage. A recommendation was made to have Black Mountain Conservation Camp work on a project to clear the stream of such jams. The lower section still held fair shelter composed of willows and undercut banks.

By 1982 the riparian canopy in the upper section of Willow Creek had improved to a second growth alder/bay forest. In the lower section where the stream meanders, shelter still consisted of a thin strip 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. A rock water fall about 100 yards up the north branch from the main fork at approximately mile 5 was noted and thought to be created by channel downcutting. A heavy load of fine grained sediments in the stream was also noted and thought to have come from massive slides that occurred during January 1982 storms. Early logging was likely to have contributed to the severity of these slides as well. However, large numbers of fish were found in all suitable habitats. The overall reach of the stream surveyed (L-P property) was rated as excellent habitat for salmonids.

METHODS

The biological and habitat inventory conducted in Willow Creek follows the methodology presented in the California Salmonid Stream Habitat Restoration Manual (Flosi and Reynolds, 1991). The Trout Unlimited volunteers and CCC seasonal Technical Advisors that conducted the inventory were trained in standardized habitat inventory methods by the DFG and CCC in May 1994. This inventory was conducted by a two-three person team under the supervision of Bob Coey, DFG's Russian River Basin Planner.

HABITAT INVENTORY COMPONENTS

A standardized habitat inventory form was used in Willow Creek to record measurements and observations. There are nine components to the inventory form.

1. Flow:

Flow is measured in cubic feet per second (cfs) at the bottom of the stream survey reach using standard flow measuring equipment, if available. In some cases flows are estimated. Flows were also measured or estimated at major tributary confluences.

2. Channel Type:

Channel typing is conducted according to the classification system developed by David Rosgen (1985). This methodology is described in the California Salmonid Stream Habitat Restoration Manual. Channel typing is conducted simultaneously with habitat typing and follows a standard form to record measurements and observations. Each new "channel type" encountered corresponds to a new "Reach" number. There are four measured parameters used to determine channel type: 1) water slope gradient, 2) channel confinement, 3) width/depth ratio, 4) substrate composition.

3. Temperatures:

Both water and air temperatures are taken by handheld thermometers and recorded at each tenth unit typed. The time of the measurement is also recorded. Temperatures are taken in Fahrenheit at the middle of the habitat unit and within one foot of the water surface. Temperatures are also recorded using remote data loggers which log temperature every two hours, 24 hours/day.

4. Habitat Type:

Habitat typing uses the 24 habitat classification types defined by McCain and others (1988). Habitat units are numbered sequentially and assigned a type identification number selected from a standard list of 24 habitat types. Dewatered units are labeled "dry". Willow Creek habitat typing used standard basin level measurement criteria. These parameters require that the minimum length of a described habitat unit must be equal to or greater than the stream's mean wetted width. Channel dimensions were measured using hip chains, range finders, tape measures, and stadia rods. Unit measurements included mean length, mean width, mean depth, and maximum depth. Pool tail crest depth at each pool unit was measured in the thalweg. All measurements were taken in feet to the nearest tenth.

5. Embeddedness:

The depth of embeddedness of the cobbles in pool tail-out reaches is measured by the percent of the cobble that is surrounded or buried by fine sediment. In Willow Creek, embeddedness was visually estimated. The values were recorded using the following ranges: 0 - 25% (value 1), 26 - 50% (value 2), 51 - 75% (value 3), 76 - 100% (value 4).

6. Shelter Rating:

Instream shelter is composed of those elements within a stream channel that provide salmonids protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition. The shelter rating is calculated for each habitat unit by multiplying shelter value and percent cover. Using an overhead view, a quantitative estimate of the percentage of the habitat unit covered is

made. All cover is then classified according to a list of nine cover types. In Willow Creek, a standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) was assigned according to the complexity of the cover. Thus, shelter ratings can range from 0-300, and are expressed as mean values by habitat types within a stream.

7. Substrate Composition:

Substrate composition ranges from silt/clay sized particles to boulders and bedrock elements. In all habitat units, dominant and sub-dominant substrate elements were visually estimated using a list of seven size classes. Mechanical substrate sampling is also conducted to quantify the percentage of fine sediment within riffle gravels.

8. Canopy:

Stream canopy is estimated using handheld spherical densiometers and is a measure of the water surface shaded during periods of high sun. In Willow Creek, an estimate of the percentage of the habitat unit covered by canopy was made from the center of each unit. The area of canopy was further analyzed to estimate its percentages of coniferous or deciduous trees, and the results recorded.

9. Bank Composition:

Bank composition elements range from bedrock to bare soil. However, the stream banks are usually covered with grass, brush, or trees. These factors influence the ability of stream banks to withstand winter flows. In Willow Creek, the dominant composition type in both the right and left banks was selected from a list of eight options on the habitat inventory form. Additionally, the percent of each bank covered by vegetation was estimated and recorded.

DATA ANALYSIS

Data from the habitat inventory form are entered into Habitat Runtime, a dBASE 4.1 data entry program developed by the California Department of Fish and Game (DFG). This program also processes and summarizes the data.

The Habitat Runtime program produces the following tables:

- Riffle, flatwater, and pool habitat types
- Habitat types and measured parameters
- Pool types
- Maximum pool depths by habitat types
- Dominant substrates by habitat types
- Mean percent shelter by habitat types

Graphics are produced from the tables using Lotus 1,2,3. Graphics developed for Willow Creek include:

- Riffle, flatwater, pool habitats by percent occurrence
- Total habitat types by percent occurrence
- Pool types by percent occurrence

BIOLOGICAL INVENTORY

Biological sampling during stream inventory is used to determine fish species and their distribution in the stream. Biological inventory is conducted using one or more of three basic methods: 1) stream bank observation, 2) underwater observation, 3) electrofishing. These sampling techniques are discussed in the California Salmonid Stream Habitat Restoration Manual.

SUBSTRATE SAMPLING

Substrate sampling was conducted using a 12 inch diameter standard McNeil gravel sampler. Sample sites were identified numerically beginning at the most downstream site in the stream, and stratified by channel type.

Ten substrate samples were taken in potential spawning riffles between December 2-9, 1994. The samples were stratified by channel type reaches (1-3). Each reach had 3-4 subsamples (consisting of one 12" McNeil sample), which when combined made one sample to characterize each reach. Each of the subsamples consisted of 3-4 samples taken at low gradient riffles randomly selected from the habitat database for Willow Creek. Riffles selected were not actual redds. Locations were selected on the basis of their potential use by spawners.

The samples were placed through a series of sieves with diameters of .85mm, 2.37mm, 4.7mm, 12.5mm, 25.4mm, 75mm and 150mm. Displacement volumes were measured for particles in each size classification. Finally, the remaining sample <0.85mm was placed in Imhoff cones for 1 hour with the volume of fines settled out measured.

RESULTS

HABITAT INVENTORY RESULTS

* ALL TABLES AND GRAPHS ARE LOCATED AT THE END OF THE REPORT *

The habitat inventory of June 7 through August 19, 1994, was conducted by Dave Raff, Katie Etiene, Mike Swaney (all Trout Unlimited volunteers) with assistance by California Conservation Corps (CCC) Technical Assistants, under supervision by DFG. The total length of the stream surveyed was 29,700 feet, starting at the second bridge crossing (Figure 1). The stream channel below Bridge 2 (approximately 4000 feet), was not surveyed, because the survey methods used are not designed for streams subjected to tidewater. The stream below Bridge 2 is composed of a complex marsh system, and not surveyed due to depth and impassable by foot due to dense vegetation in many areas.

Flow was measured at the bottom of the survey reach with a Marsh-McBirney Model 2000 flowmeter at 0.5 cfs on Aug. 20, 1995.

Willow Creek is a F5 channel type for the first 3,925 feet; and has been artificially channelized in the lower area. It is an F4 for the next 7,745 ft; a B4 for the next 15,418 ft; and a B3 for the final 1,968 feet of stream reach surveyed. **Each new "channel type" encountered corresponds to a new "Reach" number.**

F5 channels are entrenched meandering riffle/pool channels on low gradients with high width/depth ratio; and are sand dominated. F4 channels are similar but are gravel dominated

B4 channels are moderately entrenched, moderate gradient, riffle dominated channels, with infrequently spaced pools; very stable plan and profile; stable banks; and are gravel dominated. B3 channels are similar but are cobble dominated.

The stream channel below the start of our survey is most characteristic of a D6 channel type. D6 channels are braided with longitudinal and transverse bars. They are very wide channels with eroding or non-existent banks where entrenchment is lacking and are predominantly silt/clay. Recently during the 1995 winter storms, this channel type has migrated upstream, due to aggradation in the lower portion of Reach 1.

Water temperatures measured with handheld thermometers ranged from 54 to 60 degrees Fahrenheit, and air temperatures ranged from 59 to 74 degrees Fahrenheit. Figure 2 depicts water temperatures collected with remote data loggers from State Park property in the marsh section. The range between the two horizontal dashed lines represent optimal stream temperatures for salmonids. The range above the solid horizontal line represents the temperatures considered to be lethal. Data shows temperatures in mid-summer increased to levels above optimal, and climbed to levels near lethal by late August.

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. By percent **occurrence**, RIFFLES made up 24%, FLATWATER types 30%, and POOLS 38% (Graph 1). FLATWATER habitat types made up 45% of the total survey **length**, RIFFLES 19%, and POOLS 29%. Six percent of the survey length was DRY.

TWENTY-ONE Level IV habitat types were identified. The data are summarized in Table 2. The most frequent habitat types by percent **occurrence** were GLIDE, 26%; LOW GRADIENT RIFFLES, 23%; and LATERAL SCOUR ROOTWAD ENHANCED POOLS, 16% (Graph 2). By percent total **length**, GLIDES made up 41%, LOW GRADIENT RIFFLES 19%, and LATERAL SCOUR ROOTWAD ENHANCED POOLS 13%.

TWO HUNDRED AND FIFTY SEVEN pools were identified (Table 3). SCOUR POOLS were most often encountered at 80%, and comprised 83% of the total length of pools.

Table 4 is a summary of maximum pool depths by pool habitat types. Depth is an indicator of pool quality. SEVENTY-FIVE of the 257 pools (29%) had a depth of two feet or greater .

Table 6 summarizes the dominant substrate by habitat type. GRAVEL was the dominant substrate observed in 115 of the 157 low gradient riffles (73%). Small cobble was the next most frequently observed dominant substrate type, and occurred in 14% of the low gradient riffle .

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 257 pool tail-outs measured; 94% of the pools in Reach 1 had an embeddedness rating of 4; 53% in Reach 2 had an embeddedness rating of 1 or 2; 58% in Reach 3 had an embeddedness rating of 1 or 2; and 64% in Reach 4 had an embeddedness rating of 1 or 2 (Appendix A). On this scale, a value of one is the best for fisheries.

Substrate samples were taken in the field by Raff, Fort, Higgins, Maggi, Close, Etienne and Coey. Further analysis

was done by Craig Mesman (CCC) and Kyle Young (Americorps) between May 16-22, 1995 in Fortuna. The data was then summarized and analyzed with a computer program written by Dwain Goforth, NPS.

The analysis showed sample 1 (reach 1) averaged 20.0% fines (<0.85 mm), with subsamples ranging from 17-24% fines. Sample 2 (reach 2) averaged 19.4% fines with subsamples ranging from 17-22%. Sample 3 (reach 3) averaged 18.0% fines with subsamples ranging from 10-24%. The combined summary of all three samples averaged 18.94% fines. The combined summary showed 75% of the substrate to be less than 15mm, 50% to be less than 5mm and 25% to be less than 1.34mm. No stratification in fines was evident by channel type, however the sample with the lowest percent fines was the furthest upstream.

A shelter rating was calculated for each habitat unit and expressed as a mean value for each habitat type within the survey using a scale of 0-300. POOLS had the highest rating at 29, FLATWATER followed with a rating of 13 (table 1). Of the pool types, the SCOUR POOLS had the highest mean shelter rating at 31, and backwater rated 27 (table 3).

Table 5 summarizes mean percent cover by habitat type. ROOTMASS are the dominant cover type in Willow Creek in nearly all habitat types, with LARGE AND SMALL WOODY DEBRIS following.

Only 9% of the entire stream lacked shade canopy. Of the 91% of the stream covered with canopy, 80% was composed of deciduous trees, mostly willow, alder and bay, and 20% was composed of coniferous trees (redwood and fir).

Table 2 summarizes the mean percentage of the right and left stream banks covered with vegetation by habitat type. For the entire stream reach surveyed, the mean percent right bank vegetated was 78% and the mean percent left bank vegetated was 79% (Appendix B). The dominant elements composing the structure of the stream banks consisted of 78% silt/clay, and 19% cobble/gravel. Additionally, 77% of the banks were covered with deciduous trees and 13 % with coniferous trees, including downed trees, logs, and root wads .

BIOLOGICAL SURVEYS

Juvenile Surveys:

In 1962, juvenile coho salmon and steelhead were found throughout the mid-lower, mid and upper sections up to the rock falls. The lower section was nearly absent of salmonids, but had roach and suckers. Coho salmon were found in schools of 15-20 in pools throughout, with the exception of the upper section.

In April 1963, a test was conducted by DFG on Willow Creek to determine the effectiveness of Composol (a cresylic acid base disinfectant) as a guiding agent for salmonids. The test was inconclusive as only stress and mortality was observed. Both salmonid fry and yearlings were discovered down stream from the initial point of the chemical application.

In 1965 three-spined sticklebacks or sculpin were found to be most abundant with steelhead and coho salmon less abundant. Later surveys estimated the abundance of the salmonids to be even lower, although Coho salmon (1+), were most numerous of those found. Steelhead, trout, Sacramento squawfish, western sucker and sculpin were also

found.

The 1970 stream survey indicated spawning gravels were extremely compacted for the whole length of the stream due to large amounts of detritus and silt.

In February, March, and May 1982 only young of year (YOY) steelhead were observed near the forks. Coho were not found.

L-P has been conducting juvenile surveys in the basin along 2 reference stream reaches within their ownership since 1990. Species were identified and enumerated and relative density information collected. Both YOY and 1+ fish were found in all
L-P surveys. Table 1 below includes L-P's data to date along with information collected during DFG surveys.

Table 1. Summary of Salmonids found in Juvenile Surveys

YEAR	SPECIES	SOURCE	DENSITY #/M^2
1962	SHD,SS	DFG	
1963	SHD,SS	DFG	
1965	SHD,SS	DFG	
1982	SHD	DFG	
1990	SHD,SS	L-P	0.2-0.4
1991	SHD	L-P	0.1-0.5
1992	SHD	L-P	0.2
1993	SHD	L-P	0.2-0.4
1994	SHD	L-P	0.6

SHD = Steelhead SS = Coho (Silver) Salmon

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. The rock falls located on the upper fork was identified as a complete barrier. Many log jams were also noted as incomplete barriers to fish.

The 1970 survey indicated the spawning habitat was poor due to high silt concentration in the major portion of the stream below the forks. Redds were observed above the forks in the North fork, however, and spawning gravels were more plentiful and less silted, due to storms flashing out debris and loosening the gravel.

By 1980 the numbers of barriers were more abundant as well as more complete. In December, 1980, the Sonoma County Water Agency and the Department of Fish and Game noted ten log jams on Willow creek. All jams were causing erosion and all were located above the second bridge. At a large horseshoe bend (at stream mile 2.8) a large log jam was noted to be trapping debris and deflecting stream flow into the bank. The deflecting of the stream caused a large mud slide and completely blocked the original stream channel which caused the stream to alter it's course and run out over adjacent fields. Sharp turns in the new channel caused high erosion. However, YOY steelhead were seen above this area.

In 1980 it was recommended that the log jam near mile 5 be removed due to being considered a fish barrier. The remainder of the jams were recommended to be monitored. No other stream improvement projects have been indicated prior to our survey other than the restoration plan involving the lower Willow Creek channel by DPR.

A recent spawning\carcass survey was conducted February 14, 1995 on Willow creek, beginning at habitat unit 356, near the "Redwood grove" and continued upstream to the end of the survey. At habitat unit #356 a female and male steelhead, were observed in a small root wad formed pool. At the same location several redds were sighted, and gravel quality appeared good. At habitat units #495, 500 and 504, redds were also observed in fair to good gravel. At habitat unit #405 a large wood jam 10'H,15'W,60L was sighted 150' above the old culvert. It did not appear to be a barrier to migration however.

The spawning\carcass survey was continued February 23, 1995 on the lower reach of Willow Creek. The survey began at habitat unit #165 downstream of the cattle ranch and continued upstream to unit #296 at the "Redwood grove". At unit #296 an adult steelhead 18"-20" was sighted, and just upstream another adult steelhead (20"-22") was observed. One 1+ steelhead carcass was also found, sex unknown. Large quantities of fine sediment (some 2' high) on the inside edge of gravel bars were observed. High bank erosion was encountered at a large bend and numerous signs of cattle crossing the creek were observed.

SUBSTRATE SAMPLING

Analysis of historic activities of Willow Creek has enabled an evaluation of present channel substrate conditions. Landslides and early management practices resulted in severe aggradation occurring in the upper watershed of Willow Creek. This was primarily due to mass wasting, and the removal of trees which armored the banks and within the stream channel, and railroad and road development.

The buildup of sediments at various points along the watercourse where the railroad crossed the stream or where logging debris existed, later resulted in downcutting on the downstream end, extending to the next grade stabilization. Over time as the stream worked against these obstructions, high flows aggravated existing natural landslide areas and resulted in debris torrents and erosion. Stream clearing activities conducted by several agencies exasperated these conditions further.

Over time, the upper slopes of the watershed are mending and the upper and mid channel areas are downcutting, establishing a former grade as evidenced by rail ties found during the survey. This is expected to continue as the sediment load to the system has been markedly reduced from that of the 1960's and 70's. However, there is still significant amounts of sediments in storage upstream in the active channel from these historic activities.

Many sediments from the eroding streambanks and bottom were carried by debris torrents and deposited in the lower gradient section of Willow Creek downstream. These land use activities in the upper watershed and channelization below has resulted in severe aggradation of the lower stream channel for at least a mile.

A Department of Parks and Recreation (DPR) study indicates that channelization took place on the lower sections around the turn of the century for agricultural purposes and more recently for bridge construction. In the early 1980's channel excavation was initiated to improve channel capacity and a levee was built from these sediments. In the late 1980's the DPR identified sedimentation problems along the reach of the channel that bordered the levee, extending from the second bridge upstream 2,500 feet. After determining that the levee was eroding and constituted a source of sedimentation in the stream, the levee was removed.

Observations indicate that, in spite of the levee removal and channelization activities, Willow Creek has continued to aggrade near the second bridge. Aggradation has created a wide, shallow channel with little cross-sectional area and low water-conveyance capacity. The bridge structure itself may be attributing to the sediment deposition.

The inability of Willow creek to scour sediments and thereby maintain channel capacity near the second bridge has been recognized by the DPR, and reconstruction of the channel as a solution for restoring the creek has been examined in a 1994-95 study by Trihey and Associates, Inc. under a DPR funded grant. The purpose of the study was to obtain a basic understanding of geomorphic and hydrologic processes in the whole watershed and to evaluate sediment supply and transport on State Park property. Results of the study are summarized:

1) Sediment delivery from landsliding and surface erosion along the inner gorge appears to have substantially decreased compared with conditions prevailing from the 1960's through mid 1980's.

2) The estimated annual bedload delivery to lower Willow Creek is indicative of a disturbed watershed.

3)Stream bank erosion and erosion of in-channel deposits in the upper watershed, represent a significant sediment source to lower Willow Creek. The long term contribution of other sediment sources such as the county road, logging roads, and headwater tributaries, has not yet been determined.

4) Sediments which have aggraded lower Willow Creek are not mobilized and transported to the Russian River by present day flood events.

5) Given that high sediment delivery is expected to continue, and that transport rates are relatively low, channel bed aggradation is expected to occur in lower Willow Creek and will likely progress further upstream.

6)Given the observed conditions in the watershed, restoration of lower Willow Creek remains feasible.

7) It is likely that restoration plans will require some degree of direct intervention to attenuate bedload deposition in lower Willow Creek.

To date no channel reconstruction work has been scheduled or funded.

Recently, during the 1995 winter storms, the lower portion of Reach 1 has aggraded to the point where base flows

are no longer within the stream channel and flow is wandering out across the meadow above the second bridge for several hundred yards. Conditions upstream of the second bridge, now resemble conditions downstream, except riparian canopy exists throughout the existing multiple channels downstream. Flow is artificially directed to the "old channel" at the second bridge by the levee which the road is built on, except where culverts exist through the levee. At culverts, flow spills into the flood plain below the levee. Adult fish access upstream is available only during much higher flows and both upstream and downstreamers must migrate out through the open floodplain.

The gravel program analyzed the 1995 substrate sample data for egg to emergence survival rates for steelhead and coho. The survival rates are based on a 95% confidence interval and used the FredleIndex. Based on this index and the data on Willow Creek, the mean egg to emergence survival rate would be 24% for steelhead and 2.2% for coho.

DISCUSSION

The un-surveyed stream channel below Bridge 2 (approximately 4000 feet), is most characteristic of a D6 channel type. The surveyed section of Willow Creek has four channel types: from the second bridge to 3,925 feet an F5; next 7,745 ft. an F4; next 15,418 ft. a B4; and the upper 1,968 feet a B3.

D6 channels are rated as fair for single and opposing wing-deflectors, or channel constrictors. They are poor for low- and medium-stage weirs, boulder clusters, and log cover. F5 channels are rated as good for bank-placed boulders, fair for low-stage weirs, single and opposing wing-deflectors, channel constrictors, and log cover. They are poor for medium-stage weirs, and boulder clusters due to being sand dominated channels that have a high erosion potential. Any instream structures designed in the lower unsurveyed section and in Reach 1 must take into account the instability of these areas associated with the aggradation problems. Instream structures are not recommended at this time however.

F4 channels are similar in fish habitat improvement suitability in that they are also low gradient areas with high bank erosion potential, however, bank placed boulders, bank cover, overhead log cover and shelter structures in straight reaches are often appropriate. Any structures must be selected with care in these two reaches because of the high stream energy which can create problems with stream bank erosion and structure stability. Any work considered will require careful design, placement, and construction that must include protection for the unstable banks.

The B3 channel types exhibited in the upper reaches are excellent for many types of low and medium stage instream enhancement structures. These channels have suitable gradients and the stable stream banks that are necessary for the installation of instream structures designed to increase pool habitat, trap spawning gravels, and provide protective cover for fish. Well placed and engineered structures that constrict the channel to form pool habitat or cover structures are usually appropriate and have a good chance of success in these channel types.

Specifically, the B4 channel types are excellent for low-stage plunge weirs, boulder clusters and bank placed boulders, single and opposing wing-deflectors; and for log cover. They are rated as good for medium-stage plunge weirs. The B3 channels are excellent for low-stage plunge weirs, boulder clusters and bank placed boulder, single and opposing wing-deflectors, and log cover. They are good for medium-stage plunge weirs. There are a total of 11,670 feet of this type of channel form in Willow Creek, along with a plenitude of LOD either in or nearby the stream. Many site specific projects can be designed within this channel type, especially to increase pool frequency,

volume and pool cover.

The water temperatures recorded by handhelds on the survey days from June 9 to August 19, 1994 ranged from 54° F to 60° F, and air temperatures ranged from 59° F to 74° F. The warmer water and air temperatures were recorded in the lower survey reaches. These warmer temperatures, are above the optimum levels but are well below the threshold stress level for salmonids. Figure 2 depicts water temperatures collected with remote data loggers from State Park property in the marsh section, below our survey area. Data shows temperatures in mid-summer increased to levels above optimal, and climbed to levels near lethal by late August. These temperatures suggest that the lower marsh area is unsuitable for habitat use by salmonids.

Flatwater habitat types comprised 45% of the total **length** of this survey, riffles 19%, and pools 29%. In coastal coho and steelhead streams, it is generally desirable to have "primary pools" comprise approximately 50% of total habitat. In first and second order streams a primary pool is defined by DFG to have a maximum depth of at least two feet, occupy at least half the width of the low flow channel, and be as long as the low flow channel width. The pools in Willow Creek are relatively shallow with only 71 of the 257 pools (28%) having a maximum depth greater than 2 feet. These pools were likely historically deeper, but are now buried in substrate and sediments. Therefore, eventually installing structures that will increase or deepen pool habitat is recommended for locations where their installation will not be threatened by high stream energy, cause streambank erosion. However, installing structures that will increase pool habitat is not recommended at this time due to the large quantity of sediment stored in the system that must be processed.

Reach 4 appears to hold fair spawning habitat (50% of pool tailouts rated level 1), where the gradient is a little steeper to flush fines from the better quality cobble/gravel substrate. Level 1 (0-25% embedded), is considered best for the needs of salmon and steelhead. Reaches 2 and 3 have only fair gravel quality, and reach 2 lacks the capacity to flush since it is a lower gradient depositional area. Reach 1 has poor gravel quality for spawning due to severe aggradation of fines.

The mean shelter rating for pools was LOW with a rating of 29. The shelter rating in the flatwater habitats was lower at 13. A pool shelter rating of approximately 100 is desirable. Log cover structure provides rearing fry with protection from predation, rest from water velocity, and also divides territorial units to reduce density related competition. The relatively SMALL amount of cover is currently being provided primarily by LARGE WOODY DEBRIS AND ROOT MASS in all habitat types. Additionally, SMALL WOODY DEBRIS AND UNDERCUT BANKS contribute a large amount. A larger amount of cover exists in the stream, but is under-utilized by fish due to being buried by the large quantity of substrate in the stream.

ONE HUNDRED AND THIRTY SEVEN of the 157 low gradient riffles had either GRAVEL OR SMALL COBBLE as the dominant substrate. This is generally considered good for spawning salmonids.

The mean percent canopy for the survey reach was 91%. This is a very GOOD percentage of canopy, since 80 percent is generally considered desirable. Elevated water temperatures in isolated reaches downstream could be reduced by increasing stream canopy however. Water temperatures in the marsh area (which was not surveyed) of Willow Creek are not suitable for salmonid rearing. However, this area provides beneficial habitat conditions for many other desirable aquatic and terrestrial wildlife species and waterfowl.

In areas of stream bank erosion, planting endemic species of coniferous and deciduous trees, in conjunction with bank stabilization, is recommended.

GENERAL MANAGEMENT RECOMMENDATIONS

Willow Creek should be managed as an anadromous, natural production stream.

Large conifers within the LOD (Large Organic Debris) recruitment zone should not be removed to ensure recruitment of instream shelter elements. LOD accumulations should be carefully evaluated before modification to preserve cover elements as well.

Winter storms often bring down large trees and other woody debris into the stream, which increases the number and quality of pools. This woody debris, if left undisturbed, will provide fish shelter and rearing habitat, and offset channel incision. Landowners should be sensitive about the natural and positive role woody debris plays in the system, and encouraged not to remove woody debris from the stream, except under extreme buildup and only under guidance by a fishery professional.

PRIORITY FISHERY ENHANCEMENT OPPORTUNITIES

1) Identified sites from the road survey conducted in the summer of 2000 should be treated to reduce the amount of fine sediments entering the stream. Near-stream riparian planting along Reach 2 should also be encouraged to provide bank stability and a buffering against agricultural, grazing and road surface runoff.

2) After careful study restoration efforts should be initiated to increase processing of the increased sediment load. Cooperation and input by other landowners is essential and should be encouraged and sought out through this process.

3) Where feasible, increase woody cover in the pool and flatwater habitat units in reaches 2-4. Adding high quality complexity with larger woody cover is desirable. Combination cover/scour structures constructed with boulders and woody debris would be effective in many flatwater and pool locations. This must be done where the banks are stable (reaches 3 and 4) or in conjunction with stream bank armor to prevent erosion (reach 2). In many areas the material is at hand. Eventually, instream cover/scour structures may be considered for Reach 1, and possibly below. Efforts should follow recommendations outlined for the proper channel type.

4) Monitor fish passage, distribution and presence in this stream for index of coho usage/abundance.

RESTORATION IMPLEMENTED

1) There is one section (in Reach 2) where the stream is being impacted from cattle trampling the riparian zone, eroding the banks and defecating in the water. Alternatives for limiting cattle access and improving the riparian should be explored with the landowner, and developed if possible.

2) Map sources of upslope and in-channel erosion, and prioritize them according to present and potential

sediment yield.

3) Active and potential sediment sources related to the county road system need to be mapped, and treated according to their potential for sediment yield to the stream and its tributaries. Failing culverts and landslides below the road surface are common. Culverts draining small tributaries which cross the State Park road leading into the Park should also be cleaned out and increased in size where needed. Roads and trails related to the L-P hunting camp should be improved and erosional areas corrected.

4) The State Park funded studies to establish restoration goals and alternatives in the lower reaches should be continued. To accomplish this, upstream and upslope sediment sources must be mapped and controlled as noted previously.

5) Increase the canopy on Willow Creek by planting willow, alder, redwood, and Douglas fir along the stream where shade canopy is not at acceptable levels (in erosional areas of reaches 1, 2). In many cases, planting will need to be coordinated to follow bank stabilization, cattle exclusion, and upslope erosion control projects, and eventual restoration of the lower channel reach.

6) Garbage, debris and waste facilities related to the L-P hunting camp which are stored in the flood plain, should be moved or disposed of to decrease potential impacts to water quality during flood events, and to increase the esthetics and enjoyment for all users of the Willow Creek resource. This project was completed by MRC.

Biological comments, landmarks and problem sites

STREAM LENGTH (ft)	COMMENT (*******HABITAT UNIT #)
290	FOUND BEDLOAD TRAP AT BEGINNING OF UNIT. SECONDARY CHANNELS CREATED BY DOMINANT DISCHARGE.
1221	RT BANK LOOSE BARS.
2222	LFT BANK - CLAY ERODING. CHANNELIZED SECTION SCWA 1976.
3270	BEDLOAD TRAP, COVER ON. LFT BANK.
3724	RT BANK ERODED BY RUNOFF. LFT BANK LOAD ALLUVIUM.
4542	EROSION AT BASE OF ROAD. ********** UNIT 077
4542	NOT OBSERVED- ESTIMATED BY EXPERIENCE W/SNAGS.
4578	SUBTERRANEAN FLOW. EROSION ON RT BANK. MASSIVE LOG JAM- COUNTY ROAD THREATENED********** UNIT 080
4612	Lots of 2" steelhead.
4830	Log jam and woody debris
4845	RESIDENT 10" FAT STEELHEAD.
4970	1100 FT FROM BRIDGE 3.********** UNIT 090
5162	6" STEELHEAD, CRAYFISH
5442	BANK 5 FT ABOVE BURIED REDWOOD PLANK AT 13 FD INCISED
5535	Twelve 5" stlhd, crayfish . photo of undercut bank.

5846 sheep litter.
6519 sub flow only
6900 some depressions up to 21 ft
6925 bed load sampler. ********** UNIT 135
7305 POM0 creek. confluence on lft bank. ********** UNIT 135
8188 0.3% grade, large gravel bars
8886 4.5 UNDERCUT BANK
9530 SOME COWS IN THE CREEK. SOME GRAVEL REMOVING MAY BE OCCURING. ********** UNIT 175
9793 ALDER IN CREEK HAS BEEN TOPPED.
9924 CLEARED BRUSH AND UNDERSTORY FROM BANKS.
10248 GRAVEL/POINT BAR ERODING, BANK AT LEFT.
10347 POIN DEXTER RANCH RD ENTERS CREEK
11047 REDWOOD (OLD) LOG ON LEFT BANK OUT OF WATER.
11143 CATTLE PATH ON RIGHT, POSSIBLE WATER COURSE.
11271 CATTLE TRAIL IN /OUT. ********** UNIT 203
11527 COBBLE DEPOSITS ON BAR
11623 TRIB LFT BANK. ********** UNIT 207
11750 BANK EROSION ON RT UP STREAM OF ROOT WAD SIDE.
11767 STREAM ENTERS CREEK.
11812 VERY LITTLE RIPRARIAN ON RT BK.
12177 LFT BNK SPRING FEEDING POOL
12208 TWO COWS IN CREEK
12861 6" STEELHEAD AND OTHERS
13101 A LOT OF STEELHEAD. COW THOROUGHFARE. ********** UNIT 236
13148 L-P BLUE TAG DATED 5-26-94 ON TREE. HOBO TEMPMETER?
13450 CLAY NOT BEDROCK
13591 CLAY NOT BEDROCK
14183 TRAIL ON LFT BANK INTO CREEK.
14296 CATTLE TRAIL FROM BOTH BANKS.********** UNIT 261
14461 COW DROPPINGS
14761 PATH ON LEFT WIDE ENOUGH FOR JEEP RD
14951 HUNTING CAMP, BRIDGE BOTTOM SILL IS 6.1 FT ABOVE THE THALWEG OF CHANNEL. ********** UNIT 268
14981 TRAIL ON LFT
15046 SUB-TERRAINIAL FLOW
15356 FISH MONITORING STATION.********** UNIT 277
15636 CAMP TRAIL ON LFT
15696 RUN OFF OR TRAIL ON LFT BANK
15713 UNDERCUT REDWOODS 2% GROWTH, CONTAIN CHANNEL.
15771 EXPOSED RT BANK
15801 TRAILS FROM CAMP ON LEFT.
15863 LEFT -5 LWD AND ROOTS
15883 2400 FT LOOSE SAND, GRAVES BEING ERODED. COW TRAILS BEING

ERODED.********** UNIT 307
16156 THREE LARGE LOGS IN CHANNEL DEFLECTING FLOW, WILL FORM 2 CHANNELS.
16449 CONSTRICTION BY 4 FT REDWOOD RT MASSES EACH 5-8 FT IN DIAM.
16495 DRAINAGE TRIB, RT BANK.********** UNIT 313
16572 LOG ACROSS CREEK 4' HIGH
16933 steelhead
16999 cow crossing
17180 REDWOODS ON BANK
17371 WHERE CONFLUENCE WAS, ALDER HAS NOW TAKEN OVER.
17418 REDWOOD GROVE
17462 CONFINED CHANNEL; SWD, LOGS AND BEDROCK
17546 HUNT CAMP/LOG RD ON LEFT BANK
17628 LOGS ARE BEING UNDERCUT CAUSING THE PLUNGE POOL TO CHANGE
17648 REDWOOD CROSSES CREEK(PLUNGE POOL CHARACTERISTICS) NOT A POOL NOW.
17996 CADDIS FLIES, FALLEN LOG CROSSING CREEK COLLECTING GRAVEL ERODING BK
18006 STICKLEBACK
18045 RT BANK TRIB CARRYING LG COBBBLE.********** UNIT 353
18095 RT BK DOWNCUTTING UNDER LOG FORMING CASCADE HOLDING SM COBBLE GRAVEL
18123 RT BK TRIB CARRYING LG COBBLE- BUILDING BAR
18194 SM DEBRIS IN CREEK FROM ERODED CROSSING OF OLD LOGGING RD
18533 RD ON RT BK 20 FT FROM WETTED CHANNEL
19187 COUNTY RD ON RT, COWS ON LFT
19229 COUNTY RD ON RT, TRAIL OR PATH ER0SION
19265 COUNTY RD ON RT, TRAIL OR PATH EROSION
19308 OPEN TO RT RD ON RT RD OBSERVATION
19333 COW PATH THROUGH CREEK FROM RD
19372 FEEDER STREAM OM RT BANK AT HEAD OF POOL
19558 3 FT DROP AT PLUNGE, BED LOAD DAM
19590 COW PATH ON LFT
19620 COW PATH FEEDER ON RT AT HEAD
21098 ROCKS! CHANGE IN GRADIENT, TRIB ON RT W/ LOW FLOW
********** UNIT 428
21390 LFT BANK SMALL PLUNGE FROM RUN-OFF
21455 LG SEDIMENT L0AD LFT BANK WITH OLD CHANNEL BEHIND BANK
21576 RAIL FROM OLD TIMBER C0.
21616 LEFT BANK-SKID ROAD
21747 CHANNEL TYPE UNIT. ********** UNIT 448
21767 JAM COLLECTING SEDIMENT, NOT A BARRIER-75% FILLED APP. 2 FT
21786 TRANSECT #3.********** UNIT 450
21937 3000 FT TO WATERFALL
22001 STONE FLY LARVA

22113 PACIFIC SALAMANDER
22163 COW
22248 LFT BANK LOGGING TRAIL
22313 TRIB CONFLUENCE ON LFT BANK.**********UNIT 470
22363 ANOTHER DRY TRIB DUMPS LOAD ONNTO LFT BANK, DRY CONFLUENCE RT BK-DRY
22464 8 FT BANK CROSSOVER-DRAG TRAIL AND DEBRIS EXPOSED
22722 LOOSE AGGREGATE ON LEFT BANK, GULLY ON RT BANK
22756 FISH
22872 MAJOR CONFLUENCE ON LEFT BANK-DEWATERED.
********** UNIT 485
23176 DRAG RD CROSSOVER
23261 LFT BANK-OLD STREAM CROSSING, RT BANK OLD K DEGREE CHANNEL
23298 SIGNIFICANT EROSION. 10AM 8-10-94 60 F AIR, 54F WATER.
********** UNIT 498
23331 STEELHEAD
23623 SIDE CHANNEL ON RT BANK
24023 EXPOSED SLUCE, STEEP BANKS BOTH SIDES, YOUNG ALDERS
24321 TRIB ON LFT BANK, "Y" ON TOPO.********** UNIT 532
24377 TRIB LFT BANK
24618 STEELHEAD
24991 PLENTY OF STELHEAD
25144 JAM POTENTIAL, DOWNED ALDERS ON CURVE OF BEDROCK CONSTRICTION
25305 WATERFALL
25361 RT BANK 2 DEGREES CHANNEL ERODING AROUND CASCADE 23'W ROTTING DEBRIS. ELEV .07 ABOVE CHANNEL
25407 PAMPAS GRASS
25482 IRON OXIDE IN WATER FROM RAILS
25736 BFD-6FT ABOVE CHANNEL PROBABLY 1986-BY SIZE OF ALDERS, WIDTH 40 FT
25807 RAIL
25860 ROOT-MASS POOL
26067 GOOD SPAWNING GRAVEL. STICKLEBACK,SALAMANDER. ERODING STEEP RT BNK. ********** UNIT 584
26147 RAIL
26389 TRIB ON LFT BNK, STEEP VALLEY FILLED W/ SLUGE
26560 CULVERT
26640 (CULVERT) RT BNK-EXTREME EROSION AVOVE LOG JAM.
********** UNIT 601
26682 COHO 4" 2PLUS, 2 STIKLEBACK, 1 RBT 2"
26707 TRANSECT GRADIENT CHANGE
26807 FISH
26936 CLAY EXPOSED IN BED
26978 SERIOUS EROSION ON RT BNK? OR LOG CUTTING?
27146 FEEDER LFT SIDE

27179 LOOSE RT BNK
27372 SOME CHANGE IN GRADIENT
27908 LWD PILE
28219 HABITAT TYPED THE YEAR BEFORE , COMPARE
28285 TRNSCT NO.#4.********** UNIT 652
28792 TRIB ON LFT BNK, STEEP CONFINED BANKS.
********** UNIT 664
28860 6 FT WATERFALL W/ WOODY DEBRIS 0 PLUS FISH ABOVE
28960 CYN LFT BNK TO WEST. **END SURVEY. DEWATERED ABOVE NEXT JAM**