SECTION F

FISH HABITAT ASSESSMENT

INTRODUCTION

The anadromous fish species inhabiting the Garcia WAU are coho salmon (*Oncorhynchus kisutch*), steelhead trout (*Oncorhynchus mykiss*), chinook salmon (*Oncorhynchus tshawytscha*) and pacific lamprey (*Lampetra tridentata*). Other non-salmonid species include the three spine stickleback (*Gasterosteus aculeatus*), Sacramento sucker (*Catostomus occidentalis*), and sculpin (*Cottus spp.*). Other non-salmonid species include the three spine stickleback (*Gasterosteus aculeatus*), Sacramento sucker (*Catostomus occidentalis*), and sculpin (*Cottus spp.*). A fish habitat assessment was conducted in the Garcia WAU in 1997 to identify the present habitat conditions and areas of special concern regarding the life history stages of salmonids.

Field surveys were conducted to evaluate the quality and quantity of salmonid habitat in the Garcia WAU. Surveys included salmonid habitat typing and assessment, stream gravel permeability measurements and bulk gravel samples. The fish habitat assessment evaluated spawning, rearing and overwintering habitats based on targets derived from scientific literature (Bilby and Ward, 1989; Bisson et al., 1987; CDFG, 1998; Montgomery et al., 1995; Washington Forest Practices Board, 1995) and professional judgment. The habitat data are combined into indices of habitat quality for the different life history stages.

Aquatic species distribution surveys were conducted by the previous landowners (Louisiana-Pacific Corp.) from 1994-1996, and were repeated by MRC from 2000-2002 (MRC 2002). The study consisted of single pass electrofishing or snorkeling surveys in the summer months to assess aquatic species distribution and composition in the Garcia WAU. All organisms observed were identified to the lowest possible taxonomic level.

Permeability and bulk gravel samples were taken in select fish bearing reaches of the Garcia WAU to determine an index of spawning gravel quality. Permeability and gravel particle size distributions are stream substrate parameters, which affect survival of incubating salmonid embryos. Salmonid eggs buried under up to a foot of gravel depend on sufficient intragravel water flow for their survival and development. Fine sediment within spawning gravel can impede intragravel 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.

METHODS

Fish Habitat Evaluation

Stream segments based on gradient and confinement were delineated in the Stream Channel Condition assessment of this watershed analysis. A map of gradient and confinement was generated using measurements taken from topographic maps and aerial photos of the area (Map E-1). Field verification of slope and confinement was conducted at all field sites. Channel segments were later grouped into geomorphic units based on their response to processes which form the condition of the channel. These geomorphic units were used to compare fish habitat conditions in the Garcia WAU.

The primary focus in choosing areas to sample for fish habitat was stream channel gradient. Data on fish habitat and channel morphology was needed for the Garcia WAU. Because the minor tributaries in the Garcia WAU were likely non-fish bearing, high gradient Class II watercourses, we concentrated on the mainstem and major tributaries when assessing fish habitat. Channel slope categories were broken up into increments of zero to four percent slope, four to eight percent slope, eight to twenty percent slope and greater than twenty percent slope. Confinement (flood plain width/ channel width) was broken into three categories; confined (<2), moderately confined (2-4) and unconfined (>4). Sites were chosen so that the full range of slope and confinement combinations and known fish use in the Garcia WAU were considered. Data from the Louisiana-Pacific fish distribution surveys (1994-1996) were also utilized during the site selection process.

The fish habitat evaluation was conducted during low flow conditions, July through October 1997. A minimum survey length of twenty bankfull widths or 100 meters (328 feet) was observed. Data collected during the fish habitat/ stream channel surveys provided information on pool frequency, pool spacing, large woody debris (LWD) frequency, LWD condition and future recruitment, spawning gravel quantity and quality, cover quantity and quality, and stream temperature. The objective was to evaluate fish habitat conditions as poor, fair and good in the context of anadromous salmonid species. Table F-1 displays the indices used for rating measured parameters. To combine the measured parameters into a rating for individual life history stages (spawning habitat, summer rearing, and overwintering habitat) a subset of the parameters for each life history stage was weighted and used to develop a rating score. The parameters were scored as follows: 1 (poor), 2 (fair), or 3 (good) for each habitat condition. Parameter weights developed in Louisiana-Pacific's Watershed Analysis Manual were applied to the total score calculated as shown below, with parameter numbers in bold and weights in parentheses:

<u>Spawning Habitat</u>

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

<u>Summer Rearing Habitat</u>

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

<u>Overwintering Habitat</u>

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

Table F-1. Habitat Condition Indices For Measured Parameters

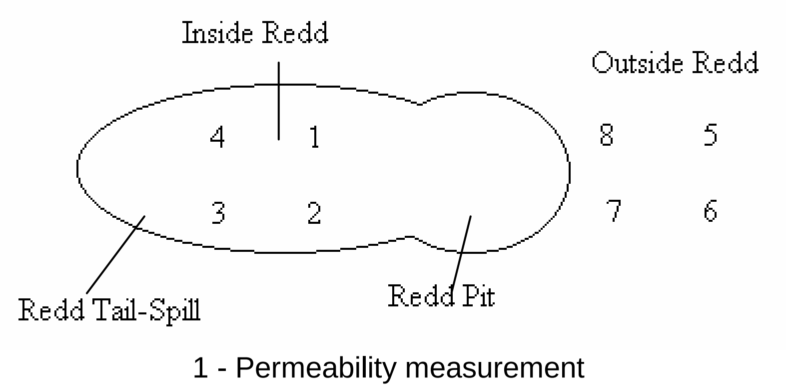
Habitat Parameter	Feature	Habitat Quality: Poor	Habitat Quality: Fair	Habitat Quality: Good
Percent Pool (of survey site length) **(A)**	Anadromous Salmonid Streams	<25%	25-50%	>50%
Pool Spacing (reach length/bankfull/#pools) **(B)**	Anadromous Salmonid Streams	<15%	15-30%	>30%
Shelter Rating (shelter value * % 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 Dominated

As stated in Louisiana-Pacific's Watershed Analysis Manual (1996), weightings for the habitat parameters was based on professional judgment. The methodology for collecting fish habitat information is defined in the Watershed Analysis Manual (Version 4.0, WFPB), Louisiana Pacific's Watershed Analysis Manual, and California Salmonid Stream Habitat Restoration Manual (Flosi and Reynolds, 1991).

Stream Spawning Gravel Quality (Permeability and Bulk Gravel Samples)

The stream gravel permeability was conducted using a stand-pipe as discussed in Terhune (1958) and Barnard and McBain (1994). An electric pump was used to create the water suction in the stand-pipe. The permeability measurements were taken at a depth of 25 centimeters, the maximum depth of coho and steelhead spawning. In 1997 the permeability measurements were taken at identified redd sites to attempt to determine the difference in permeability between stream gravels that have been built into a redd by spawning salmonids versus non-redd areas. Permeability measurements were taken during low flow conditions at identified redd sites following hatching of salmonid eggs (in this case during the summer). Four separate permeability measurements were taken each time the standpipe was inserted into the gravels. This was repeated four times in the redd and four times outside the redd (Figure 1). The mean of the permeability measurements inside the redd and outside the redd (non-redd) were reported as permeability values for the respective sites.

Figure 1. Sampling Locations for Permeability Measurements Inside and Outside of Redd Sites in the Garcia River, 1997.



A total of 15 redd sites and 15 non-redd sites were sampled. Of these sites 3 of the redd and non-redd sites were excluded from the analysis. The 3 sites excluded were all located in the same tributary of the Garcia River, Mill Creek. The sites were excluded due to poor substrate conditions (i.e. angular rocks suggesting substrate that has been deposited from streamside sources rather than fluvial sources) and lack of defined pool tail-outs making it impossible for the sampling protocol to be followed.

In the year 2000, a total of 26 permeability measurements were taken in each of the 5 long term stream channel monitoring segments (see Stream Channel Condition module for description). The measurements were evenly distributed among all pool tail-outs in the segments, with any additional measurements taken in tail-outs behind the deepest pools. The measurement location in each tail-out was randomly selected from an evenly selected 12-point grid in the tail-out. At each measurement location permeability repetitions were taken until the permeability readings no longer were increasing.

The 1997 permeability data of redd versus non-redd gravels was analyzed by taking the mean of permeability measurements inside the redd and comparing them to the mean of permeability measurements otuside of the redd. A relationship was developed based on linear regression between the redd and non-redd permeability measurements. For the 2000 data, the median permeability measurement for each permeability site in the monitoring segment was used as representative of the site. To characterize the entire monitoring segment the natural log of the geometric mean of the median permeability measurements was determined. The natural log of the permeability is used because of a relationship developed from data from Tagart (1976) and McCuddin (1977) (Stillwater Sciences, 2000) was used to estimate survival to emergence from permeability data. This relationship equates the natural log of permeability to fry survival ($r^2 = 0.85$, $p<10^{-7}$). This index needs further improvements, but is currently all we have for interpreting permeability information and biological implications. This relationship is:

$$\text{Survival} = -0.82530 + 0.14882 * \ln \text{permeability}$$

It is important to understand that the use of this survival relationship is only an index of spawning gravel quality in the segment. The permeability measurements are taken randomly in pool tail-outs and are not indicative of where a salmon may select to spawn. Furthermore, spawning salmon have been shown to improve permeability in gravel where a redd was developed (MRC, 2000). The survival percentage developed is only indicative of the quality of potential spawning habitat and not as an absolute number.

The measurement techniques varied from 1997 to 2000 for permeability in the Garcia WAU. The objective of the 1997 measurements was to determine permeability for gravels in redds versus non-redds. In 2000 the objective was to determine an index of the quality of the spawning habitat. Future permeability surveys will focus on this protocol to track the index of spawning habitat quality over time.

Aquatic Species Distribution

A hierarchical framework was used to select the initial locations of survey sites in each stream. Major streams were broken into lower, middle and upper reaches. Smaller streams were divided into lower and upper reaches. One site is surveyed in each reach, resulting in 3 sites in larger streams, and 2 sites in smaller streams. Additional sites are added directly downstream and upstream of potential migration barriers to determine which salmonid species these barriers are impacting.

A survey site contains a minimum of two consecutive habitat sequences (pool-riffle sequences) and has a minimum length of ninety feet. The survey method used to determine the aquatic species present is single pass electro-fishing or snorkeling. The effort put forth at each survey site is not sufficient to delineate the absence of a species.

Prior to initiating surveys water quality is measured using a Horiba™ U-10 Water Quality Checker. Measurements taken are water temperature (°C), conductivity (microS/cc), dissolved oxygen (mg/L), and pH. Air temperature is measured with a pocket thermometer and water visibility is estimated. Stream discharge is estimated or measured with a Swoffer™ Model 2100 flow meter. The actual physical parameters measured at each site vary depending on equipment availability. Horiba™ U-10 Water Quality Checkers were not used prior to the surveys in 2000.

The primary survey method is electro-fishing using a Smith-Root™ Model 12 (Smith-Root Inc., Vancouver, WA) backpack electro-fisher. One person operates the backpack electro-fisher while one or two other individuals use dip nets to capture the stunned species. The captured specimens are placed into a five-gallon bucket containing aerated stream water. The aquatic species are anesthetized then enumerated, measured to fork length (fish) or snout-vent length (amphibians) and released back into the units from which they were captured, after they have recovered. All vertebrate species are identified to the lowest possible taxonomic level.

Diving (snorkeling) is used to assess species presence when stream conditions are considered adequate or when elevated stream temperatures have the potential to adversely impact the health of the animals being electro-fished. The basic survey unit for diving consists of a minimum of two pools, however if riffles are deep enough to allow underwater observation these units are sampled. Depending on the channel width, one to four divers are used for the field surveys. The diver(s) enters the survey unit from the downstream end and waits approximately one-minute before proceeding upstream to observe species. If the water velocity is too fast for divers to proceed upstream, the unit is surveyed by floating downstream. Dive slates are used to record data underwater. During the survey, salmonid species are enumerated by size class according to pre-determined size class categories (<70mm, 70–130mm, >130mm). All other vertebrate species observed during the field surveys are identified to the lowest possible taxonomic level.

RESULTS

Fish Habitat Evaluation

A total of 22 stream segments were between zero and eight percent gradient in the Garcia WAU. These are considered potential fish habitat. Of the 22 segments, 16 were field evaluated. Three stream segments with predicted gradients greater than eight percent gradient were also surveyed. Two of the nineteen total stream segments visited in the field for fish habitat proved to be non-fish bearing (segments 121 and 149) due to high gradient (>15 percent). Table F-2 summarizes the habitat parameters measured during field surveys. Information from Table F-2 was used to compute ratings for various life stages of salmonids in Table F-3. There were five geomorphic units as defined by the channel module that were associated with fish habitat.

Geomorphic unit I is the alluvial mainstem of the Garcia River. Segments associated with this geomorphic unit are 1, 2, 3, 4, 5, and 6. Four of the five segments received a ‘Good’ rating (Table F-3) for spawning habitat conditions. Table F-2 shows that the gravel quantity and quality were good with very little embeddedness (<50 percent), and observations of fine sediments were negligible. The rating for rearing habitat within the segments of geomorphic unit I was 67 percent ‘Fair’ and 33 percent ‘Good’. The pool spacing and pool depth were excellent in these segments, however, the lack of LWD lowered the habitat cover complexity and respective rearing habitat rating. Overwintering habitat was rated ‘Fair’ for these segments. The overwintering habitat rating was affected by the lack of LWD and gravel being the dominant substrate. The lack of roughness elements provided by LWD and larger substrate affects the usefulness of the deep pools of segments as overwintering habitat within the unit.

Geomorphic unit II is the low gradient depositional segments of v-shaped valleys. This area is the South Fork of the Garcia River segments 83, 84, 85, 86, 101, and 111. Ratings for spawning habitat were: three segments ‘Good’, two segments ‘Fair’, and one ‘Poor’ (Table F-3). Segment 83 is the lowest downstream segment of the South Fork of the Garcia River. It received a ‘Poor’ rating because of high aggradation in that reach, spawning gravels had a high degree of embeddedness (> 50 percent) and percent fines in gravels. The high aggradation had an affect on all segments upstream until segment 85. Evidence of aggradation at segment 85 was absent and habitat quality showed signs of improvement. Rearing habitat within the unit were rated as follows: one segment ‘Good’, four segments ‘Fair’, and one segment ‘Poor’. Aggradation in rearing habitat played a major role in determining ratings. With the exception of segments 83 and 84, LWD quantity was rated ‘Good’. The lower segments of the South Fork of the Garcia River were so aggraded that most LWD was completely buried. Pool depth and frequency were low to moderate as a result of the aggradation, lowering the rating for segments in this unit. Overwintering habitat was rated as follows: four segments ‘Fair’ and two ‘Poor’. LWD provided a roughness element for overwintering, but the dominant substrate was gravel. Pools affected the rating because pool depths due to aggradation were ‘Poor to Fair’ for a majority of segments which lowered the overall rating of overwintering habitat for this geomorphic unit.

Table F-2. Fish Habitat Parameters Summary

	General Information					Pool Habitat											Large Woody Debris											Substrate									
Segment	Geomorphic Unit	% Gradient	Channel Confinement	Sampled Length (ft)	Bankfull Width (ft)	Pool % by Stream Length	Rating (Poor/Fair/Good)	Pool Spacing (reach length/bankfull width/# of pools)	Rating (Poor/Fair/Good)	% Pools >3 ft Depth	Rating (Poor/Fair/Good)	Mean Pool Shelter Rating	Rating (Poor/Fair/Good)	Wood Forced	Boulder Forced	Free Forced	# of Key LWD In Stream (Survey Area)	In Stream Key LWD per 328 ft	Rating (Poor/Fair/Good)	Pieces Needed per 328 ft for 'Good' Rating	# LWD in Bankfull Within Survey Area	# LWD Eminent To Deliver	# of Large Debris Accumulations	% Key LWD Deciduous	% Key LWD Coniferous	% LWD Active	% LWD Relic	Dominant Substrate	Spawning Gravel Quanity	Rating (Poor/Fair/Good)	Percent Embeddedness(1<25%,2 25-50%,3 >50%)	Rating (Poor/Fair/Good)	Subsurface Fines	Rating (Poor/Fair/Good)	Gravel Quality	Rating (Poor/Fair/Good)	Substrate For Over-wintering (Poor/Fair/Good)
1	1	0-1	C	3094	144	80	G	3	F	71	G	62	F	7	1	3	23	2.4	P	7.7	12	5	0	35	65	10	90	Gr	3	G	2	F	1.3	G	3	G	P
2	1	0-1	MC	3028	144	75	G	1.8	G	67	G	51	P	8	1	2	33	3.6	P	6.5	18	23	1	30	70	5	95	Gr	3	G	1	G	1.2	G	3	G	P
3	1	0-1	C	2647	141	70	G	2.6	G	83	G	48	P	1	3	4	5	0.6	P	9.5	11	12	0	25	75	5	95	Gr	3	G	2	F	1.7	F	2.5	G	P
4	1	0-1	MC	3204	144	81	G	2.4	G	75	G	65	F	3	2	4	27	2.8	P	7.3	12	18	0	46	54	5	95	Gr	3	G	1	G	1.2	G	3	G	P
5	1	0-1	C	2288	131	69	G	1.9	G	100	G	84	F	3	2	4	15	2.2	P	7.9	10	9	0	9	91	1	99	Gr	3	G	1	G	1.1	G	3	G	P
6	1	0-1	C	2853	117	79	G	3	F	63	G	45	P	2	4	2	16	1.8	P	8.3	6	3	0	36	64	1	99	Gr	3	G	2	F	1.7	F	2.4	F	P
19	3	4-8	C	1058	42.2	24	P	4.2	F	0	P	39	P	3	0	3	11	3.4	P	6.7	7	25	2	14	86	10	90	Gr	1.5	F	2	F	2	F	1.7	F	P
20	3	8-20	C	805	35.6	52	G	3.8	F	33	F	73	F	2	1	3	16	6.5	F	0.3	10	6	1	13	87	10	90	Gr	1.5	F	1	G	2	F	1.9	F	P
53	3	4-8	C	1206	33	23	P	3	F	0	P	41	P	8	2	0	16	4.4	F	2.4	9	9	2	35	65	10	90	Gr	3	G	2	F	2.1	F	2.2	F	P
83	2	2-4	MC	1463	63.3	20	P	3.8	F	0	P	25	P	5	0	1	9	2	P	8.1	8	13	3	30	70	10	90	Gr	2	F	3	P	2.5	P	1.4	P	P
84	2	1-2	C	1073	46.7	45	F	2.9	G	0	P	70	F	6	1	1	12	3.7	P	6.4	17	4	3	36	64	10	90	Gr	3	G	2	F	2.4	P	2.3	F	P
85	2	2-4	C	993	32.5	66	G	1.9	G	0	P	45	P	13	1	2	29	9.6	G	NA	28	12	5	23	77	10	90	Gr	3	G	2	F	2.3	F	2.4	G	P
86	2	1-2	C	1032	35.4	59	G	2.7	G	9	P	72	F	7	1	1	38	12.1	G	NA	28	6	1	8	92	20	80	Gr	3	G	2	F	1.7	F	2.5	G	P
90	6	8-20	MC	735	18.3	8	P	8.2	P	0	P	70	F	2	1	0	12	5.4	F	1.4	12	4	1	23	77	10	90	Gr	3	G	3	P	2.4	P	1.6	P	P
101	2	2-4	C	1093	26.4	22	P	4.6	F	0	P	75	F	6	0	0	18	8.7	G	NA	11	9	1	18	82	5	95	Gr	3	G	2	F	2	F	2.4	G	P
102	4	4-8	C	865	19	20	P	7.6	P	0	P	78	F	6	0	0	24	9.1	G	NA	10	8	2	7	83	20	80	Gr	3	G	2	F	2.3	F	2.4	G	P
111	2	2-4	C	1093	26.4	29	F	3.8	F	0	P	45	P	10	0	1	29	8.7	G	NA	15	14	0	14	86	5	95	Gr	3	G	2	F	2	F	2.3	F	P
121	4	8-20	C	510	21	7	P	24.3	P	0	P	20	P	0	0	1	60	38.6	G	NA	9	2	1	0	100	2	98	Gr	1.5	F	2	F	2.1	F	1.4	P	P
149	4	4-8	C	800	27.5	41	F	3.2	F	0	P	68	F	6	3	0	20	8.2	G	NA	23	5	4	0	100	5	95	SC	1.7	F	2	F	2.2	F	1.5	P	G

Table F-3. Summary of Fish Habitat Life History Stages

Habitat Ratings For Various Life Stages							
Segment	Geomorphic Unit	Spawning Habitat Score	Spawning Rating (Poor/Fair/Good)	Rearing Habitat Score	Rearing Rating (Poor/Fair/Good)	Overwintering Habitat Score	Overwintering Rating (Poor/Fair/Good)
1	1	2.75	Good	2.15	Fair	1.9	Fair
2	1	3	Good	2.15	Fair	1.75	Fair
3	1	2.5	Good	2	Fair	1.9	Fair
4	1	3	Good	2.45	Good	2.05	Fair
5	1	3	Good	2.45	Good	2.05	Fair
6	1	2.25	Fair	2	Fair	1.9	Fair
19	3	2	Fair	1.3	Poor	1.6	Poor
20	3	2.25	Fair	2.35	Good	2.1	Fair
53	3	2.25	Fair	1.5	Poor	1.4	Poor
83	2	1.25	Poor	1.15	Poor	1.2	Poor
84	2	2	Fair	1.8	Fair	1.7	Fair
85	2	2.5	Good	2.25	Fair	2.15	Fair
86	2	2.5	Good	2.4	Good	2.3	Fair
90	6	1.5	Poor	1.35	Poor	1.4	Poor
101	2	2.5	Good	1.85	Fair	1.75	Fair
102	4	2.5	Good	1.7	Fair	1.6	Poor
111	2	2.25	Fair	1.9	Fair	1.8	Fair
121	4	1.75	Fair	1.55	Poor	1.45	Poor
149	4	1.75	Fair	2.05	Fair	2.35	Good

Geomorphic unit III is the moderate gradient depositional segments of v-shaped valleys. The fish-bearing segments (19, 20, and 53), were the Garcia River tributaries Rolling Brook and No Name Creek. They were rated ‘Fair’ for spawning habitat. Little spawning habitat existed in these segments. Rearing habitat was rated ‘Good’ for the upper segment in Rolling Brook (segment 20) and ‘Fair’ for No Name Creek (segment 53) and the lower segment of Rolling Brook (segment 19) (Table F-3). The lower segment (19) of Rolling Brook is degraded and lacking LWD. This creates poor pool frequency, depth, and habitat shelter value. No Name Creek (segment 53) shows signs of degradation as well. Segment 53 is rated ‘Fair’ for LWD, but ‘Poor’ for pool frequency, depth, and shelter values. Upper Rolling Brook (segment 20) is rated ‘Good’ for pool frequency and ‘Fair’ for depth, shelter value, and LWD. The effect of degradation in this unit affects the overall habitat rating for this geomorphic unit. Overwintering habitat was ‘Poor to Fair’ for segments of geomorphic unit III. Low pool and LWD ratings suggest a situation where overwintering habitat is not optimal.

Geomorphic unit IV is the moderate gradient transport segments of v-shaped valleys. Field surveyed segments of this unit are 102, 121, and 149. Segments 121 and 149 are non-fish bearing streams. Spawning habitat in segment 102 was rated ‘Good’. Gravel quantity and quality was rated ‘Good’ (Table F-3), and embeddedness of fines are within an acceptable range. Rearing habitat for the segment was rated ‘Fair’. The rating was affected by pool frequency, depth, and LWD quantity. Overwintering habitat was ‘Poor’ for segment 102. Pool values caused the overall rating of overwintering habitat to be low for this segment.

Geomorphic unit VI is the moderate gradient segments of moderately sloped valleys. Segment 90, an unnamed tributary to South Fork Garcia River, is the only fish-bearing segment in this unit. Spawning habitat is rated as ‘Poor’ (Table F-3). This tributary flows into segment 83 and is effected by the aggradation in the South Fork of the Garcia River. Documentation of a coho redd in this segment was made during field evaluation. Rearing habitat was rated ‘Poor’. Aggradation has led to pool filling which reduced the number of pools available for rearing. The field survey found that the first half of the segment had sub-surface flow in the summer. Lack of pools, limited cover, and gravel dominant substrate gave a ‘Poor’ rating for overwintering habitat.

Stream Spawning Gravel Quality (Permeability and Bulk Gravel Samples)

Field measurements and calculations of bulk gravel samples and permeability sampling from 1997 are shown in Table F- 4. The results were highly variable; however, the measurements show that there is highly permeable spawning habitat in the Garcia WAU. Percentage of fine particles less than 0.85 mm is low and the Fredle Indices and Geometric means are moderate to high, which is preferred. Gravels are moderate to highly permeable as well.

Redd sites are observed to be more permeable than non-redd stream substrate in the 1997 Garcia River data. This is an expected response to salmonid redd construction. When a redd is constructed fine particles are cleaned from the site likely creating the more porous and thus permeable substrate. Furthermore the shape and location of a redd possibly creates hydraulic conditions conducive to increased permeability.

The percentage of fine particles < 0.85 mm and < 6.3 mm observed in the Garcia WAU are lower inside the redds compared to outside redds. This demonstrates how spawning salmonids clean finer substrate particles when building redds. For some sites, the amount of finer particles cleaned during the redd construction was substantial. Site 4 had 16% difference in percentages of fine particles < 0.85 mm inside the redd compared to outside the redd.

The 1997 permeability measurements from the Garcia River showed a strong relationship (r^2 = 0.93, p<0.0001) between redd and non-redd permeability, with permeability in the redd sites approximately 30% greater than non-redd sites (Figure 2). When Garcia River redd versus non-redd data is combined with similar data from the Albion and North Fork Navarro River a similar relationship was observed. Good relationships for stream substrate permeability between redds and non-redds, with redd sites being more permeable than non-redd sites were observed. The Albion/North Fork Navarro data set showed a higher percentage difference for redd to non-redd permeability, redd sites showed a 77 percent increase in permeability from the linear regression relationship, than the Garcia River data set which showed a 30% increase. Collectively (Garcia, Albion and North Fork Navarro data) the redd versus non-redd data showed redd permeability 53% greater than non-redd permeability.

Figure 2. Redd versus Non-Redd Permeability for the Garcia River, 1997

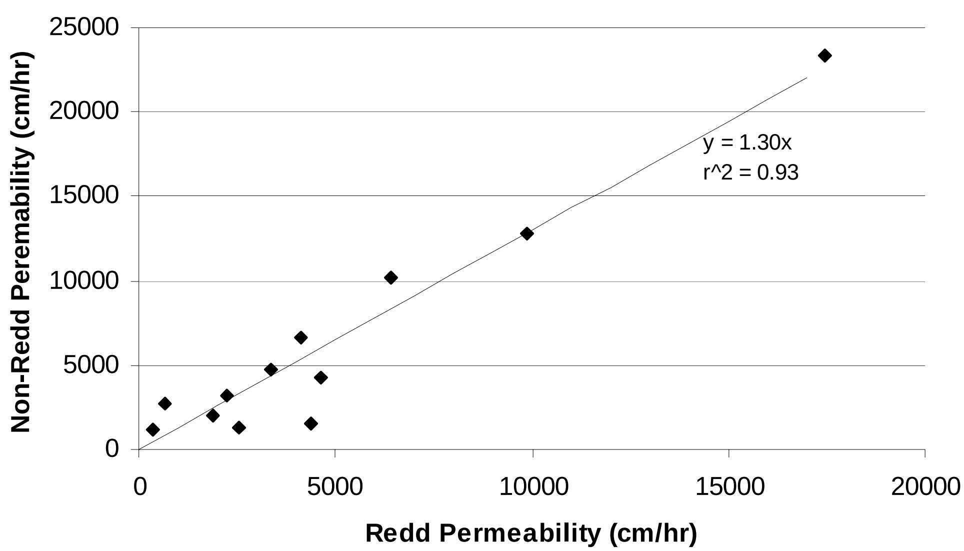


Table F-4. Permeability and Gravel Composition Results for Garcia WAU, 1997.

Redd Site	Watercourse	Channel Segment No.	Permeability (cm/hr)	Fine Percentage < 0.85mm	Fine Percentage < 6.3mm	Geometric Mean	Fredle Index
1 in	Garcia River	1	1518	3%	29%	11.7	6
1 out	Garcia River	1	4363	12%	56%	5.5	2.5
2 in	Garcia River	1	23318	8%	41%	9.3	4.1
2 out	Garcia River	1	17462	6%	24%	14.2	2.5
3 in	Garcia River	1	4291	5%	25%	18.5	5.5
3 out	Garcia River	1	4644	5%	40%	8.9	4
4 in	Garcia River	2	2052	6%	28%	10.3	5.1
4 out	Garcia River	2	1872	22%	55%	4.5	1.3
5 in	No Name Creek	53	17834	3%	17%	25.2	9.4
5 out	No Name Creek	53	1799	5%	22%	25.5	8.6
6 in	No Name Creek	53	4132	2%	17%	23.5	11
6 out	No Name Creek	53	13627	6%	36%	11.5	4.3
7 in	No Name Creek	53	17360	2%	18%	19.7	9.2
7 out	No Name Creek	53	4261	9%	31%	11.1	4.9
8 in	South Fork	84	1321	7%	25%	13	5.7
8 out	South Fork	84	2548	7%	25%	16.6	6
9 in	South Fork	84	1188	13%	40%	9.7	3.3
9 out	South Fork	84	369	10%	41%	12.5	4.4
10 in	South Fork	84	10214	5%	27%	15.5	5.9
10 out	South Fork	84	6437	13%	43%	7.4	2.1
11 in	Rolling Brook	19	6598	2%	20%	18.9	8.4
11 out	Rolling Brook	19	4135	6%	31%	15.8	5.3
12 in	Rolling Brook	19	4797	4%	27%	19.6	5.9
12 out	Rolling Brook	19	3380	5%	30%	15.9	5.3
13 in	Rolling Brook	19	3177	6%	28%	15.2	5.5
13 out	Rolling Brook	19	2252	6%	29%	19.2	5.3
14 in	Garcia River	6	2780	5%	23%	16.3	7
14 out	Garcia River	6	680	9%	27%	19.6	5.5
15 in	Garcia River	5	12828	1%	15%	21.5	10.9
15 out	Garcia River	5	9878	3%	21%	15.2	7.2

Permeability measurements observed in 2000 are fair in segments 7 (Garcia River) and 83 (lower South Fork Garcia) and poor in segments 101 (upper South Fork Garcia), 19 (Rolling Brook) and 86 (South Fork Garcia at Fleming Creek) (Table F-5). There is room for improvement, however considering that these values are indices of spawning habitat quality and not necessarily indicative of where a fish will actually spawn the results are fairly good.

Table F-5. Permeability and Survival Indices for Long-Term Channel Monitoring Segments in the Garcia River WAU, year 2000.

Stream	**Segment ID #**	**Permeability (cm/hr)**	**Survival Percent Index**	**Survival Standard Error**
Garcia River	7	4,868	44%	27%
South Fork Garcia	83	9,229	53%	29%
South Fork Garcia	86	2,262	32%	29%
South Fork Garcia	101	343	4%	21%
Rolling Brook	19	1,601	27%	1%

Aquatic Species Distribution

Data from six years of fish distribution surveys are located in the appendix. Map F-1 illustrates the distribution of steelhead trout, coho salmon and other non-salmonid fish species (California roach, sculpin, and stickleback) in the Garcia WAU. Chinook salmon were not detected during fish distribution surveys due to the timing of surveys and the chinook salmon's life history. Chinook most likely will have migrated to the estuary or near-shore coastal waters prior to survey effort. Adult chinook salmon are caught infrequently by anglers in the Garcia River.

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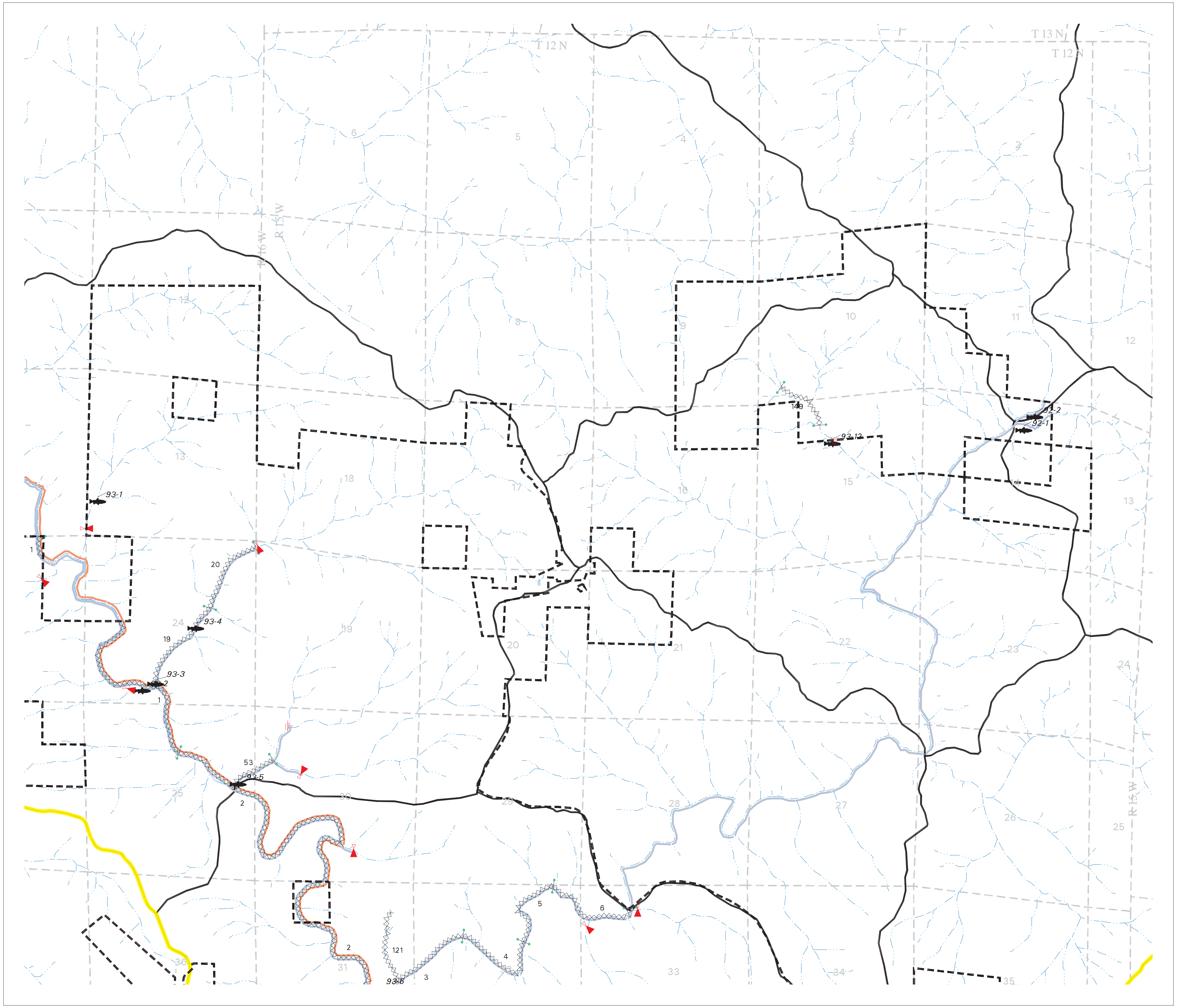
APPENDIX F



Garcia River Watershed Analysis Unit

Map F-1
Salmonid Distribution

This map illustrates the distribution of coho salmon and steelhead trout in the Garcia WAU. It is based on distribution surveys conducted by MRC in 2000-2002 and the previous landowner Louisiana-Pacific Corporation in 1994-1996.

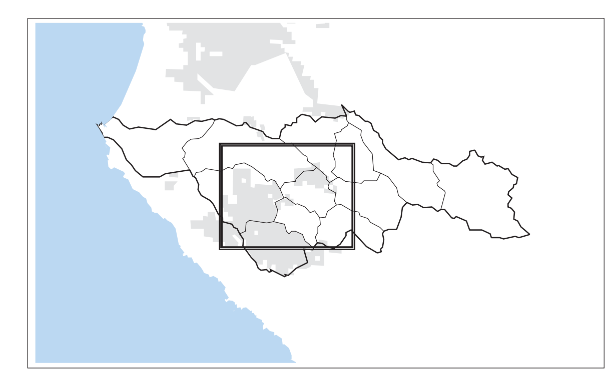
Potential Salmonid Distribution
- Coho Salmon Distribution
- Steelhead Distribution
- Habitat Survey Segments
- Fish Distribution Sampling Locations

Barriers to Adult Salmonid Upstream Migration
- Gradient
- Waterfall

- MRC Ownership
- Planning Watershed Boundary
- Garcia River Watershed Boundary

Flow Class
- Class I
- Class II
- Class III

Sheet 1



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September 2003