California Regional Water Quality Control Board
North Coast Region

Ten Mile River Watershed Chapter

Excerpt of the

DRAFT
Assessment of
Aquatic Conditions in the
Mendocino Coast Hydrologic Unit

by

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4.1 GENERAL BACKGROUND

4.1.1 Basin Plan

The primary beneficial use of concern in the Ten Mile River watershed, as described in the *Water Quality Control Plan, North Coast Region* (Basin Plan), is the cold freshwater fishery which supports coho salmon (*Oncorhynchus kisutch*), steelhead trout (*Oncorhynchus mykiss*), and chinook salmon (*Oncorhynchus tshawytscha*). The Ten Mile River watershed also supports other native and introduced fish and aquatic species including: three-spined stickleback, coast range sculpin, prickly sculpin, several species of lamprey, pacific giant salamander, several species of newt, yellow-legged frog, and tailed frog.

The Basin Plan identifies municipal, industrial, agricultural and recreational uses of the Ten Mile River watershed. As with many of the north coast watersheds, the cold water fishery appears to be the most sensitive of the beneficial uses in the watershed. Accordingly, protection of these beneficial uses is presumed to protect any of the other beneficial uses that might also be harmed by sedimentation.

The Basin Plan identifies the following additional beneficial uses related to the Ten Mile River watershed's cold water fishery:

- Commercial and sport fishing (COMM)
- Cold freshwater habitat (COLD)
- Migration of aquatic organisms (MIGR)
- Spawning, reproduction, and early development (SPWN); and
- Estuarine habitat (EST)

4.1.2 Location

The Ten Mile River watershed drains an area of approximately 31,000 hectares or 120 mi^2 (Ambrose et al., 1996). The watershed is located eight (8) miles north of the City of Fort Bragg, sharing ridges with Pudding Creek and the North Fork of the Noyo River to the south and Wages Creek and the South Fork of the Eel River to the north. Elevations range between 0-977 meters or 0-3205 feet (Ambrose et al., 1996).

4.1.3 Climate

The Ten Mile River watershed experiences a Mediterranean-type climate typified by abundant rainfall and cool temperatures during the winter and dry, hot summers punctuated with cool breezes and fog along the coast (Ambrose et al., 1996). Precipitation occurs primarily as rain with 102 cm or 40 inches in the western and 203 cm or 80 inches in the eastern portions of the watershed (Ambrose et al., 1996). Approximately 90% of the annual precipitation occurs between October and April. Precipitation as fog-drip ranges from 25.4-30.5 cm or 10-12 inches in the open and 18.4-21.6 cm or 7.2-8.5 inches under forested canopy within the western Eel River divide in southern Humboldt County (Azavedo and Morgan, 1974, as cited by Ambrose et al., 1996). These figures may apply to the Ten Mile River watershed, as well.

4.1.4 Vegetation

The Ten Mile River watershed has a dominant overstory consisting of Redwood (Sequoia sempervirens) and Douglas-fir (Pseudotsuga menziesii) (Ambrose et al., 1996). Redwood is the dominant constituent of coastal forest stands while Douglas-fir dominates the more inland sites. Minor conifer components in the area include Grand Fir (Abies grandis) and Western Hemlock (Tsuga heterophylla) (Ambrose et al., 1996).

Hardwood species such as Tanoak (Lithocarpus densiflorus) and Pacific Madrone (Arbutus menziesii) are other common components of conifer stands, though only on xeric sites (Ambrose et al., 1996). Generally, Tanoak and Pacific Madrone constitute a higher percentage of the stands in the inland portions of the watershed (Ambrose et al., 1996). Interior Live Oak (Quercus wislizenii) is a minor component at most xeric sites on inland ridges (Ambrose et al., 1996).

Further inland, near the headwaters of the North Fork and Clark Fork, open grassland dominates with an overstory of California Black Oak (Quercus kelloggii) and Oregon White Oak (Quercus garryana) punctuated with Douglas-fir/Redwood/Tan Oak stands (Ambrose et al., 1996).

4.2 SALMONID DISTRIBUTION AND ABUNDANCE

Short- and long-term trends in abundance are a primary indicator of risk in salmonid populations (Weitkamp et al., 1995). Trends may be calculated from a variety of quantitative data, including dam or weir counts, stream surveys, and catch data (Weitkamp et al., 1995). When data series are lacking, general trends may be inferred by comparing historical and current abundance estimates (Weitkamp et al., 1995).

4.2.1 Historic salmonid abundance

As described in Chapter 2, salmonid abundance has declined dramatically throughout the Mendocino Coast Hydrologic Unit. Coho and chinook salmon have declined sharply in the Ten Mile River watershed as described below. Steelhead trout, however, may be now surpassing the population numbers identified in the 1960s.

4.2.1.1 Coho salmon

In the early 1960's the Ten Mile River was estimated to have a coho run of 6,000 fish according to the California Wildlife Plan, published by the Fish and Game Commission in 1965. The California Wildlife Plan described the fishery habitat conditions in the Ten Mile River to be severely degraded by logging activity. The decline in water quality conditions is related to an over-abundance of sediment.

The California Department of Fish and Game's unpublished records indicate that coho were planted in the Ten Mile River dating back as far as 1955. The effort to restore this run by artificial propagation appears to have been unsuccessful. The Oregon coho stocks may have been inappropriate to this watershed and habitat problems and the limitations that exist may have contributed as well (Maahs, 1994).

Weitkamp et al. (1995) estimates, using data from Brown et al. (1994), that the average coho salmon spawner abundance in Mendocino County includes 160 native coho salmon in the Ten

Mile River. Higgins et al. (1992), as cited by NMFS (1995), characterizes the coho salmon run in the Ten Mile River watershed as one of "special concern."

4.2.1.2 Steelhead trout

In the 1960s, the Ten Mile River was estimated to have a total steelhead trout population of 9,000 fish (Fish and Game Commission, 1965; Busby et al., 1996). More recent data, including; electrofishing, outmigrant, and spawning surveys indicate fairly stable populations of steelhead distributed throughout the Ten Mile River watershed. The electrofishing data collected by G-P, in particular, seems to indicate that the abundance of steelhead may have increased since the 1960's (see Table 3).

According to California Department of Fish and Game (CDFG) hatchery records (CDFG unpublished data), very few steelhead trout have been planted in the Ten Mile River historically (see Table 20).

4.2.1.3 Chinook (king) salmon

Maahs (1990) described chinook (king) salmon as likely an introduced species, first planted into the Ten Mile River basin in 1979. However, Shapovalov (1948) reports Warden Ovid Holmes' findings that chinook spawned in the Noyo and Big Rivers "and somewhat more in the Ten Mile." However, there had not been a "real run" since Holmes' presence in the area, beginning in the mid-1920s.

The United States Fish and Wildlife Service (1960) estimated the total sport catch of king salmon in northwestern California during 1956 at over 44,000 fish. Maahs (1994) concludes that low numbers of chinook introduced into the Ten Mile River watershed, while occasionally productive, may have experienced river conditions unfavorable to continued natural production. This conclusion is based on the estimates of more recent runs, which range from 34-54 fish in 1989-90, 51-154 fish in 1991-92 (Maahs, 1994) and less than 10 fish in 1995-96.Though few, chinook are found widely scattered throughout the Ten Mile River watershed, including: Little North Fork Ten Mile River, North Fork Ten Mile River, Clark Fork Ten Mile River, and South Fork Ten Mile River (Maahs et al., 1994).   Unfortunately, very limited data regarding chinook salmon has been collected over the years. As such, this assessment focuses on coho salmon and its habitat needs and steelhead trout.

4.2.2 Sources of current salmonid distribution and abundance data

There are several good sources of current salmonid distribution and abundance data in the Ten Mile River watershed. The watershed is predominantly owned by Hawthorne Timber Company and is managed by Campbell Timberland Management, Inc. with whom Regional Water Board staff have communicated. Georgia-Pacific West, Inc. (G-P) formerly owned the company. G-P produced numerous documents reporting the results of their surveys and research in the Ten Mile River watershed. G-P established a monitoring network throughout the watershed including 47 stations: 1 station in the lower Ten Mile River subwatershed, 15 stations in the North Fork Ten Mile River subwatershed, 14 in the Clark Fork Ten Mile River subwatershed, and 17 in the South Fork Ten Mile River subwatershed (see Maps 5a, 5b, and 5c and Table 14). Aquatic vertebrate data is available from 26 of the 47 stations (see Map 5a) from 1993 to 1999.

Several other organizations also have studied the basin and reported their findings. Sources of information include:

- G-P and California Department of Fish and Game (CDFG) presence/absence surveys
- Ten Mile River Hatchery and CDFG salmonid release data
- CDFG stream surveys
- Outmigrant studies performed by Salmon Troller's Marketing Association
- Spawning surveys performed by the Salmon Troller's Marketing Association

4.2.3 Current distribution and abundance of spawning salmonids

Spawning surveys were conducted 1) to determine which species are present and their relative abundance, 2) to determine if adults are returning to, and spawning within, a stream reach or basin area, and 3) the relative abundance of the run. Generally speaking, targeted stream reaches were surveyed on a weekly basis if flow and other factors indicated that spawning activity was likely or reasonable to expect. A surveyor recorded all live salmonids, carcasses, and redds encountered. Species of live fish and carcasses were recorded, if identifiable. Coho spawning generally occurs in December and January, while steelhead usually spawn between February and April. Therefore, redds observed after February 1st were assumed to be those of spawning steelhead trout. Redds observed prior to February 1st were assumed to be salmon.

Four separate spawning surveys were conducted in the Ten Mile River watershed: a) 1989-90, b) 1991-92, c) 1995-96, and d) 1996-97. The survey conducted in 1989-90 was the most extensive, covering 409 stream miles. However, the data were tallied from November through February. It is therefore difficult to ascertain whether the redds counted belong to salmon or steelhead trout. It appears that the survey reaches were chosen based on information indicating the presence of salmonids, taking into consideration limited access (weekends only) in most areas of the watershed.

Only sporadic surveys were conducted in 1991-92. Surveyors did not go out on a weekly basis, but only as time allowed. In 1995-1996, 43 miles of stream were surveyed. In 1996-97, the survey included 27 miles in Smith Creek and Campbell Creeks, only. The 1996-97 survey was specifically designed to augment the outmigrant data collected in these same streams.

Table 15 summarizes the results of redd counts, live fish, and coho carcasses in 1989-90 and 1995-96, the two years in which spawning surveys were most extensive. The data are inadequate to compute total number of spawners for individual years or to compare total spawners across years. However, comparisons in individual tributaries are appropriate, where the data exists.

4.2.3.1 1989-90 Survey

The 1989-1990 spawning survey was conducted from November through February. All of the data collected was tallied and reported together. Thus, it is impossible to know if tallied redds were created by salmon or steelhead trout. Redds were seen in: the mainstem Ten Mile River, Mill Creek, the mainstem Little North Fork, Patsy Creek, Clark Fork Ten Mile River, Bear Haven Creek, Little Bear Haven Creek, South Fork Ten Mile River, Campbell Creek, Churchman Creek, Redwood Creek, and Smith Creek. Coho carcasses were found in the Clark Fork Ten Mile River and South Fork Ten Mile River. Steelhead carcasses were seen throughout the survey area. There was no evidence of spawning in Buckhorn Creek, Cavanaugh Creek, Bald Hill Creek, Stanley Creek, Gulch Eleven (11), or North Fork Redwood Creek and no live fish were observed in these reaches. In addition, most live fish were observed in the mainstem reaches, Bear Haven, and Redwood Creek. The greatest number of redds were observed in the Little North Fork, Bear Haven Creek, Little Bear Haven Creek, and Campbell Creek. This does not necessarily correlate with the number of live fish observed.

4.2.3.2 1991-92 Survey

The 1991-1992 spawning survey was conducted from December through April. The data was tallied and reported in two time periods: December through January and February through April. Redds counted in December through January are presumed to be those of salmon, while those seen after January are presumed to be made by steelhead trout. The survey was conducted sporadically, as time allowed. The numbers do not represent total spawners during the spawning season and can not be compared to other years. The 1991-92 data are best used to identify the presence and absence of spawners. These data are not included in Table 15.

There were at total of 98 redds counted in December and January, presumably those of salmon. Coho were observed in the Little North Fork Ten Mile River, lower North Fork Ten Mile River, the lower and middle Clark Fork Ten Mile River, Bear Haven Creek, Campbell Creek, and much of the South Fork Ten Mile River. One redd was found in Bald Hill Creek in late January; but, no live fish or carcasses were seen from which to surmise the species of the spawning pair. Chinook were seen in the Clark Fork above Bear Haven Creek, the South Fork Ten Mile River, and Little North Fork Ten Mile River. Steelhead were seen in each surveyed stream except Smith Creek, where no evidence of spawning whatsoever was observed.

4.2.3.3 1995-96 Survey

The 1995-96 spawning survey was conducted from December through April. The data were tallied and reported in two time periods: December through January and February through April. Presumed salmon redds were observed in Little North Fork, lower and middle Clark Fork Ten Mile River up to Booth Gulch, Bear Haven Creek, South Fork Bear Haven Creek, Campbell Creek, Churchman Creek, and Smith Creek. There was no evidence of salmon spawning in Vallejo Gulch, Buckhorn Creek, Bald Hills Creek, Gulch 11, upper Clark Fork Ten Mile River, or South Fork Ten Mile River from Redwood Creek to the headwaters. However, redds were observed in each of the tributaries except Vallejo Gulch and Bald Hills Creek during the February – April surveys, indicating steelhead spawning. Stanley Creek and North Fork Redwood Creek were not surveyed in 1995-96.

Surveyors found an average of 1.8 redds/mile and 0.7 live fish/mile in the main forks, and 3.3 redds/mile and 0.9 live fish /mile in the tributaries from December through January. Based on this data, it appears that salmon are nearly twice as likely to spawn in the tributaries than in the main forks of the Ten Mile River watershed. The reaches of main fork streams that exceeded the average redds/mile and/or live fish/mile were the Clark Fork Ten Mile River from the confluence to Booth Gulch and the South Fork Ten Mile River from Churchman Creek to Camp 28. The tributaries that exceeded the average redds/mile and/or live fish/mile are Vallejo Gulch, Little North Fork Ten Mile River, Bear Haven Creek, South Fork Bear Haven Creek, and Smith Creek. Bald Hills Creek is the only stream surveyed in which there was no evidence of steelhead spawning. During the February through April surveys, all other streams showed either redds, live fish, or carcasses.

4.2.3.4 1996-97 Survey

The 1996-97 spawning survey was conducted in Smith Creek and Campbell Creek, only. It was designed specifically to augment outmigration data also collected from these tributaries. The 1996-97 data is reported in two time periods: December through January and February through April, to distinguish salmon spawners from steelhead trout spawners.

The 1996-97 survey data indicate that there is indeed spawning in Smith and Campbell Creeks. Though, as compared to the basin wide average in 1995-96, neither creek demonstrated unusually high numbers of redds or live fish in the December to January period. In the period of December through January, there were 2.8 redds/mile, 0.3 live fish/mile and 1 coho carcass found in Smith Creek. There were 2.9 redds/mile and no live or dead chinook or coho found in Campbell Creek. From February to April, there were 15.0 redds/mile, 0.2 live fish/mile and 2 steelhead carcasses found in Smith Creek. There were 8.1 redds/mile, 1 live fish/mile and no steelhead carcasses found in Campbell Creek. There were 2 unidentified carcasses found in Campbell Creek sometime between December and April.

4.2.3.5 Estimate of coho spawners

In his 1996 and 1997 reports, Maahs used the various data collected during the spawning surveys to estimate the size of the spawning coho populations in the streams in which data were collected. Maahs and Gilleard (1994) demonstrated that both live fish- and carcass-based methods of population estimation underestimate the spawning populations while methods using redd counts produced wide ranging estimates. The 1995-96 and 1996-97 data is inadequate to further validate any particular method of population estimation. Thus, a range of possible spawning population sizes is given. Table 16 summarizes the estimates of spawning populations from the 1995-96 and 1996-97 data as derived from each of the data sources. A discussion of the actual models used to estimate population size is given in Nielsen et al. (1990).

From this data we can assess the relative importance of various tributaries for coho spawning. Of the streams surveyed in 1995-96, the South Fork Ten Mile River and the Little North Fork Ten Mile River appear to draw the greatest number of coho spawners with somewhere between 1-83 and 21-101 fish, respectively. If tributary streams are nearly twice as likely as the main forks to support salmon spawning, then the South Fork Ten Mile River must draw the greatest number of coho spawners primarily because of the size of the stream. Churchman Creek draws the fewest coho spawners with an estimated 2-9 fish.

Smith Creek and Campbell Creek are the only two creeks with reliable spawning data for two separate years. The population models estimate in Smith Creek, a population of spawning coho between 10 and 40 fish in 1995-96, and 1 and 16 fish in 1996-97. These ranges overlap and can not show whether spawning escapement improved or worsened from 1995-96 to 1996-97. In Campbell Creek, the population of spawning coho is estimated between 6 and 26 fish in 1995-96 and 0 and 12 fish in 1996-97. In this case, too, the ranges overlap.

Table 16: Estimated Coho Run Size (By Four Different Population Estimation Procedures), as reported by Maahs (1997a)

Stream	**Carcass Retention** (Est. # of spawning coho)		**Live fish** (Est. # of spawning coho)		**Redd Area** (Est. # of spawning coho)		**Redd #** (Est. # of spawning coho)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
North Fork Ten Mile River subwatershed								
Little N. Fork	31	NR	21	NR	47	NR	25-101	NR
Clark Fork Ten Mile River subwatershed								
Clark Fork	5	NR	19	NR	22	NR	9-37	NR
Bear Haven	9	NR	7	NR	35	NR	14-55	NR
South Fork Ten Mile River subwatershed								
South Fork	12	NR	27	NR	52	NR	21-83	NR
Churchman	13	NR	0	NR	7	NR	2-9	NR
Smith	11	1	12	3	14	6	10-40	4-16
Campbell	25	0	18	0	13	6	6-26	3-12
Total	106	1	104	3	190	12	78-351	NR

NR = Not reported

4.2.4 Current distribution and abundance of rearing salmonids

The CDFG's files include a series of historical stream surveys in which field staff walked portions of streams noting their observations. These surveys indicate that steelhead and coho were present in Little North Fork, South Fork, Smith Creek and Campbell Creek in 1961. No coho or steelhead were seen in Booth Gulch in 1961 due to an impassable barrier at the mouth. In 1969, coho and steelhead were seen in Mill Creek. Steelhead were observed in Little Bear Haven Creek in 1961 and again in 1983. No mention of coho salmon was made in this tributary. This data is consistent with the results of more recent spawning surveys; however, it is impossible to derive information on population size from this data.

More recently, CDFG has conducted electrofishing surveys in the Ten Mile River watershed. Their data represents a snap-shot in time, and does not allow for estimates of population size, or trends in abundance or distribution. G-P, on the other hand, has conducted electrofishing surveys at 25 locations in the Ten Mile River from 1993 through 1999. These data are more robust and allow for greater spatial and temporal comparisons. One note of caution; however, is that the locations were chosen in 1993 before much habitat data had been collected. Ambrose and Hines (1997) note that, as a result, the locations may not be truly representative of the watershed as a whole. This should be considered when reviewing the fish density data (Table 17) and the estimated basin wide populations (Dolhoff, 1993 as referenced by Ambrose and Hines, 1997) presented in Table18. G-P, and their current owner, Campbell Timber Management, Inc., chose to continue monitoring these sites in favor of consistency.

The sample sites were selected by G-P to provide uniform coverage of the watershed and an equal distribution of sample locations on the mainstems and tributaries. G-P used a performance curve (described in Brower, et al., 1989, as referenced by Ambrose and Hines, 1996), to determine if the number of monitoring sites was adequate to represent populations trends in the watershed. The results of this analysis indicated that the sample size was adequate for estimating steelhead populations, but not adequate for the less abundant coho due to the variation in their density from year to year (Ambrose and Hines, 1997). G-P noted that coho populations have been sparse and erratic in distribution throughout their sampling and that steelhead appear to be ubiquitous and far more stable in the Ten Mile River than coho. As such, the density data is useful for estimating steelhead population size; but, it is only useful for identifying where in the watershed coho salmon are present or absent.

G-P has nonetheless estimated population size for both coho salmon and steelhead trout in each year that electrofishing was conducted, as depicted in Table 18. Basin wide fish densities for each species were estimated to look at population trends over a five-year period (1993-1997). To accomplish this, the Ten Mile River watershed was broken into segments and the surface area calculated. Fish densities for each species were applied to those stream segments surrounding or adjacent to each sampling location. Tributary and mainstem segments were derived separately to avoid applying estimates to widely differing stream types. All segments were then combined to establish the basin wide estimate (Ambrose and Hines, 1997). An estimate of *total* salmonid population is given as the sum of the estimated populations of coho salmon and steelhead trout. Total salmonid density is estimated by summing the number of fish estimated for the two salmonid species for each year and dividing by the average of the area of surveyed stream. The "total salmonids" figure does not include chinook salmon.

Table 18: Annual Basin-wide Estimates of Salmonid Species, as reported in Georgia Pacific West, Inc., 1997.

Year	**Coho salmon**		**Steelhead trout**		**Total Salmonids***	
	No. of fish (% of total)	Density (fish/m^2)	No. of fish	Density (fish/m^2)	No. of fish	Density (fish/m^2)
1993	10,063 (1.3%)	0.006	781,810	0.439	791,873	0.458
1994	5,149 (0.4%)	0.003	1,192,519	0.670	1,197,668	0.685
1995	1,165 (0.1%)	0.001	907,195	0.510	908,360	0.617
1996	56,356 (6.5%)	0.032	816,672	0.459	873,028	0.493
1997	12,853 (1.5%)	0.007	827,647	0.465	840,500	0.465
5-year Average	17,117 (1.9%)	0.010	905,169	0.509	922,286	0.541

* This figure does not include the presence of chinook salmon.

4.2.4.1 Coho salmon

Coho density data is only available for 1995-1999. CDFG also sampled several stations in the watershed in 1983, 1986, 1991, and 1994. The largest recorded density of coho salmon was in the Little North Fork Ten Mile River in 1983 at 5.8 fish/m.^{2} This number is twice the density of coho found in the South Fork Caspar Creek, an insignificant coho stream, in the 1960s prior to any second growth logging. It is also 155 times as dense as the current coho density in Little North Fork Ten Mile River of 0.037 fish/m.^{2}

The data collected by G-P and the CDFG is summarized in Table 17. Coho salmon have been observed in 14 of the 25 sampling locations throughout the Ten Mile River watershed (see Maps 6a, 6b, and 6c). During that time period, the coho run of 1995-96 was the strongest of the three runs, as indicated by higher summer fish densities in 1996 and greater distribution of juveniles throughout the watershed. Their progeny produced far fewer fry in 1999, however.

Coho densities are estimated to range between 0.004 and 0.35 fish/m^2 from 1995 through 1999. The basin-wide average is 0.016 fish/m^2.

As explained above, the estimates of coho salmon population size are dubious due to annual variation in the data. Nevertheless, if these estimates are used, coho salmon may currently comprise about 2% of the salmonid population in the Ten Mile River watershed.

4.2.4.2 Steelhead Trout

CDFG electrofished several streams in the Ten Mile River watershed in 1983, 1986, 1991, and 1994. G-P also collected fish density data for steelhead from 1993-1999. Steelhead trout were found at every station in every year in which they were sampled. The density of steelhead trout ranged from 0.03 to 2.37 fish/$mi.^2$ The basin-wide average is 0.51 fish/$mi.^2$

The 1993-1999 density data suggests that the summer populations of steelhead trout are relatively stable. Basin-wide density figures vary by no more than 32% around the mean. However, individual sample locations show a varied picture (see Table 3). Some streams appear to support a relatively stable population of summer fish while the population of others has fluctuated widely. The cause(s) of variation, is unknown. The variation may indicate ocean, climate, or other changes as mentioned earlier. It is likely; however, that instream changes, such as will be the subject of a Total Maximum Daily Load (TMDL) for sediment in the Ten Mile River watershed are continually occurring (see Section 4.4, Synthesis).

4.2.5 Current distribution and abundance of outmigrating salmonids

Michael Maahs of the Salmon Troller's Marketing Association conducted outmigrant studies in the Ten Mile River watershed in the 1995-96, 1996-97, and 1997-98. These studies were conducted in the South Fork Ten Mile River, Smith Creek and Campbell Creek (tributaries to the South Fork). Traps were set to capture salmonids migrating downstream during the peak migration season for both coho salmon and steelhead trout (March to June) to determine the number of outmigrants. Other vertebrate species were also captured.

The traps were specifically set to capture outmigrants, not fish migrating upstream. To accommodate migrating adult fish, side channels were kept open during high flow periods. To prevent trap-related mortalities, traps were designed to allow fish to escape. They were also removed occasionally during high flow periods. To estimate the efficiency of the traps, juvenile steelhead were marked with a caudal fin clip and released upstream for recapture and counting (Maahs, 1995, 1996, 1997b). Due to their endangered status, coho were not marked to determine their recovery rates. The average recovery rate for steelhead smolts was utilized to estimate coho smolt trapping efficiency. Combined smolt and parr recovery was used to estimate juvenile steelhead trapping efficiency. The recovery rate for steelhead smolts was much higher in both the Smith and Campbell Creeks, than for steelhead parr. The reverse situation was found in the South Fork (Maahs, 1997b).

In June of 1995 and 1996, the traps captured a large portion of the total numbers of outmigrants. The traps operated in May 1997, but did not operate in June 1997. Thus, to estimate the number of fish that would have migrated in June of 1997, the average number of steelhead trapped per day in 1996 was compared between the months of May and June. The ratio of the rate of May to June captures in 1996 was applied to the rate of capture in May of 1997 to estimate the rate of capture in June 1997 (Maahs, 1997b).

Table 19 depicts the results of the outmigrant studies for 1996 and 1997. In 1995, the outmigrant traps were only set in the South Fork Ten Mile River. They were not set in either Campbell Creek or Smith Creek. The data collected in 1995 does not distinguish between coho and steelhead young-of-the-year. The 1995 results indicate that 5,466 salmonid young-of-year (YOY) were captured in the South Fork Ten Mile River as were 221 one year old or older (Y^+) fish. Further, the 1995 data indicates that there were 10 coho Y^+ fish captured along with 211 steelhead Y^+ fish. Numerous problems with the trap in high flows make developing an accurate estimate of salmonid outmigrants in 1995 impossible.

Table 19: Number of downstream migrating young-of-the-year (YOY) and parr (Y+) trapped in the South Fork Ten Mile River, Campbell Creek, and Smith Creek, as reported by Maahs (1996, 1997b)

		South Fork Ten Mile River		**Campbell Creek**		**Smith Creek**	
		1996	1997	1996	1997	1996	1997
Coho	YOY	42 **1,685**	2 **2**	4,493 **5,493**	205 **206**	2,479 **4,410**	208 **210**
	Y+	29 **493**	411 **1,726**	9 **34**	230 **512**	40 **89**	350 **729**
Steelhead	YOY	5,526 **35,039**	4,313 **6,089**	22,441 **27,189**	19,931 **25,546**	32,812 **41,387**	17,621 **24,058**
	Y+	1,728 **15,795**	601 **3,172**	947 **2,379**	864 **2,367**	1,216 **3,954**	667 **1,700**
Total Salmonids	YOY	5,568 **36,724**	4,315 **6,091**	26,934 **32,682**	20,136 **25,752**	35,291 **45,797**	17,829 **24,268**
	Y+	1,757 **16,288**	1,012 **4,898**	956 **2,413**	1,094 **2,879**	1,256 **4,043**	1,017 **2,429**
	Total	7,325 **53,012**	5,327 **10,989**	27,890 **35,095**	21,230 **28,631**	36,547 **49,840**	18,846 **26,697**

Numbers in **bold**represent the estimated population of outmigrants based on an expansion from a full week of trapping (where necessary) and including the calculated trap efficiency rates.

The total number of outmigrants declined from 1996 to 1997 in each of the study locations (South Fork Ten Mile River, Campbell Creek, and Smith Creek). The decline was most dramatic in the South Fork Ten Mile River from which 53,012 outmigrating salmonids were estimated in 1996 and 10,989 were estimated in 1997. This is a decline of 79%, largely related to a steep decline in the estimated numbers of outmigrating steelhead trout at this location. The decline from 1996 to 1997 in Campbell Creek is 18% and in Smith Creek is 46%.

The estimated total number of Y^+ salmonids outmigrating from Campbell Creek actually increased from 1996 to 1997 by 19%. This is the only trap location from which an increase in the total number of outmigrating Y^+ salmonids was measured, though each location showed an increase in the estimated number of coho Y^+ fish from 1996 to 1997. The percent increase in coho Y^+ fish from 1996 to 1997 was dramatic, but the actual number of fish was modest and did not strongly influence the total number of outmigrating salmonids.

Coho salmon outmigrants account for 4% of the total outmigrating salmonid population in the South Fork in 1996 and 16% in 1997. They account for 16% of the outmigrating salmonid population in Campbell Creek in 1996 and 3% in 1997. Coho account for 9% of the outmigrating salmonid population in Smith Creek in 1996 and 4% in 1997. The changes to the proportion of coho represented in the outmigrant population is related to reductions in coho YOY and steelhead trout from 1996 to 1997.

Coho generally smolt as yearlings. As such, the yearlings trapped in outmigrant traps are likely fish returning to the estuary for smoltification and eventual migration back to the ocean. Their increase in number from 1996 to 1997 suggests that 1996-97 was a more successful spawning season than was 1995-96. The explanation for YOY trapped in outmigrant traps; however, is less clear. Perhaps a reduction in upstream habitat or food forced the movement of YOY downstream. Perhaps competition with steelhead trout forced the downstream movement of coho YOY. Maahs (1996) suggests that the thousands of coho YOY that were outmigrating from Campbell Creek in 1996 indicate that the habitat was fully seeded and unable to support the outmigrating YOY. The same, perhaps, could be said for coho in Smith Creek and steelhead in all three studied streams. Whatever the case, the decrease in YOY downstream migrants suggests that the cause of population redistribution in 1996 was less significant in 1997.

4.2.6 Hatchery Releases

The Salmon Restoration Association (SRA) of California, a non-profit organization comprised of commercial fisherman and other individuals concerned with the declining salmon and steelhead populations in California, at one time operated a fish hatchery on the Ten Mile River. The hatchery, located nine miles north of Fort at the mouth of Vallejo Gulch, began propagating fish in 1975 (Ed Moore, personal communication). The goal of the SRA was restoring salmon and steelhead populations in the Ten Mile River basin. Initially, the target species was chinook salmon. However, sport-caught steelhead were spawned, the eggs hatched and reared to yearlings for release into the Ten Mile River watershed. The first documented release of coho salmon from the facility was in 1987 (Nielsen et al., 1990). The facility was renovated in 1989-90 when a new hatchery and rearing facility, consisting of two rearing-ponds and two rearing tanks (10-foot circular), were constructed. Trapping stations on the South Fork Ten Mile River, Clark Fork Ten Mile River, and Bear Haven Creek operated from 1993 to 1996. These locations were the source of all coho in the hatchery. Operations at the facility ceased in December of 1996, due to the listing of coho as a threatened species by NMFS.

In addition to the releases from the Ten Mile River hatchery, CDFG records indicate releases of coho, chinook, and steelhead dating from 1955 to 1987 (CDFG, unpublished data). Unfortunately, the specific locations of CDFG and SRA releases were not well documented. In most cases, releases to the main stem or to the Ten Mile River in general, were reported. Without data indicating the specific location of releases, it is impossible to make any conclusions regarding the effect of fish plants on the salmonid population in specific tributaries.

CDFG unpublished records indicate that coho were planted in the Ten Mile River, dating back as far as 1955. During the 1960's and 1970's, approximately 270,000 and 400,000 coho were planted in the river, respectively. The records indicate that coho were not planted in the river during the 1980's and between 1994 and 1996, approximately 9,000 coho were planted in the

Ten Mile River (see Table 20). The effort to restore the coho run by artificial propagation appears to have been unsuccessful. The Oregon coho stocks may have been inappropriate to this watershed and habitat problems and the limitations that exist may have contributed as well (Maahs, 1994).

According to California Department of Fish and Game hatchery records (CDFG, unpublished data c), very few steelhead trout have been planted in the Ten Mile River, historically. Beginning in 1955 and continuing through 1959, approximately 90,000 steelhead were planted in the river. Records indicate that between 1960 and 1990, steelhead were not planted in the river. During the 1990's (1991 to 1996), approximately 60,000 steelhead were planted in the Ten Mile River.

Chinook salmon were planted in the Ten Mile River, between 1979 and 1997, in an quantity totaling approximately 750,000 fish.

4.2.7 Summary

This assessment looks at existing data regarding the distribution and abundance of three life stages of salmonids in the Ten Mile River watershed as provided by spawning surveys, summer electroshocking (summer rearing) estimates, outmigrant studies, and estimates of hatchery releases. Each of these data sources has the potential to provide useful information on relative population structure and abundance.

For example, spawner escapement may predict the number of young-of-the-year, assuming adequate aquatic conditions. Similarly, the number of downstream migrants represent successfully reared fish and may predict the number of returning adults, assuming adequate ocean conditions and spawning escapement. Logic follows that with higher rates of survival to smolt and a constant ocean mortality (assumed for sake of discussion), that a larger escapement would result. At some point the spawning and rearing habitat of the stream become limiting and the population is "stable," fluctuating in response to instream and ocean mortality.

Unfortunately, the picture offered by the limited existing data in the Ten Mile River watershed is not that clear. However, the following are general observations made from the synthesis of salmonid distribution and abundance data presented in Table 21 at the end of this report.

4.2.7.1 Steelhead

Steelhead have been found spawning throughout the watershed, except in Cavanough Creek, Bald Hills Creek, Stanley Creek and North Fork Redwood Creek. The data collected during steelhead spawning season (Maahs, 1990, 1996 and 1997) indicates that the mainstem Ten Mile River, the Little North Fork, the North Fork at Patsy Creek, the Clark Fork including Little Bear Haven Creek and Bear Haven Creek, and the South Fork including Campbell and Churchman Creeks, may be the preferred locations for steelhead spawning.

The electrofishing (summer rearing) data that indicates the highest populations of steelhead are located on the South Fork at Camp 28 (Ambrose and Hines, 1998). Other locations where steelhead populations are also consistently higher than others, include the Lower Little North Fork (prior to 1999), Clark Fork at Reynold's Gulch, Upper Bear Haven Creek, and Lower Redwood Creek in the South Fork subwatershed.

Steelhead outmigrants in the South Fork Ten Mile River, Campbell Creek and Smith Creek were significantly higher in 1996 than in 1997. The decrease in steelhead outmigrants was particularly significant in the South Fork Ten Mile River. Neither differences between spawning and/or rearing success between the two years explains the decline in outmigrants since both young-of-year and Y+ fish left the South Fork Ten Mile River in large numbers in 1996 but not in 1997. Premature emigration may have been caused by a decrease in favorable living space upstream (Graves and Burns, 1970), for example, as a result of logging activities in 1995.

4.2.7.2 Coho

The Ten Mile River watershed may be the last refuge for native coho on the Mendocino coast with an estimated population of 160 fish (Weitkamp, et al., 1995).

Coho salmon have been found spawning in the Little North Fork Ten Mile River, Clark Fork Ten Mile River, Bear Haven Creek, South Fork Ten Mile River, Smith Creek, Campbell Creek, and Churchman Creek. The spawning survey data indicate that the Little North Fork, Bear Haven Creek and South Fork Ten Mile River are the best locations for spawning coho. Data collected in Campbell Creek and Smith Creek in both 1995-96 and 1996-97 indicate that the number of spawners was much greater in the 1995-96 season. Maahs (1997) noted that even at very low numbers, the coho smolts appear to survive at a high enough rate to continue a South Fork run of coho.

The density of rearing coho was much greater in 1996 than in any other year between 1993 and 1999. This is consistent with the impression given by the spawning data that 1995-96 was a substantial spawning year. This conclusion is also consistent with other observations throughout the North Coast Region (Ambrose and Hines personal communication with Pete Adams, 1997).

Brown, et al. (1994) and Weitkamp et al. (1995) note some variables affecting populations, which include ocean conditions, stream conditions, and climate. In addition, coho salmon have a three-year life cycle, in which abundance or absence does not relate directly to the next, but to every third year. As noted by Ambrose and Hines (1997), all of these factors act to obscure cause and effect relative to coho declines.

The outmigrant data in South Fork Ten Mile River, Campbell Creek and Smith Creek indicate that YOY coho migrated in significantly larger numbers in 1996 than in 1997. The opposite is true of Y^{+} fish which left in large numbers in 1997. The large migration of coho in1997 corresponds with the large spawning season in 1995-96, and large rearing season in 1996. The large number of YOY coho outmigrants in 1996 suggests, as with steelhead trout, that upstream habitat conditions may have forced a premature migration.

4.3 AQUATIC HABITAT

As described in Chapter 2, salmonids are anadromous fish that live part of their lives in the ocean and part in freshwater. The intent of this section is to evaluate the condition of the freshwater habitat available to salmonids migrating to the Ten Mile River watershed for spawning, rearing, and outmigration to the ocean. While conditions outside of the Ten Mile River watershed certainly have an effect on the success of the salmonid populations that return there to spawn, it is the condition of the freshwater environment that is the focus of this assessment.

4.3.1 Sources of Aquatic Habitat Data

There are several good sources of aquatic habitat data in the Ten Mile River watershed. The watershed is predominantly owned by Hawthorne Timber Company and managed by Campbell Timberland Management, Inc. (CTM). Georgia-Pacific West, Inc. (G-P) formerly owned this land. As an important salmonid fishery on the Mendocino coast, several other organizations also have studied the basin and reported their findings. Sources of information include:

- Substrate composition data collected by G-P/CTM
- Stream temperature data collected by G-P/CTM
- Habitat inventories conducted by G-P
- Habitat inventories conducted by Salmonid Restoration Association, Inc.
- Miscellaneous letters and memorandums from Mendocino County Water Agency, Department of Fish and Game, and Regional Water Quality Control Board files

4.3.2 Gravel mining

According to a letter from the County of Mendocino Department of Planning and Building Services to U.S. EPA dated February 16, 2000 and the files of the Mendocino County Water Agency, there are two permits for gravel mining currently in effect in the Ten Mile River watershed. These are Use Permit and Reclamation Plan #U 27-91 and Vested Right #VR 1-94. Permit #U 27-91 is issued to Watkins Sand & Gravel for the removal of up to 2,500 cubic yards of gravel per year from several sites in the South Fork of the Ten Mile River channel and up to 10,000 cubic yards from a hillside quarry. Permit #VR 1-94 is issued to Baxman Gravel Company for the removal of up to 50,000 cubic yards of rock per year from a hillside quarry. There have been other gravel mining operations in the Ten Mile River watershed prior to those associated with these two permits. However, previous operations were unpermitted. As such, the Mendocino County Department of Planning and Building Services has no record of their location, size or impact.

4.3.3 Sediment Data

Since 1993, G-P has sampled substrate composition of streambed gravels at the pool/riffle juncture of locations throughout the Ten Mile River watershed using a McNeil sampler and following the protocol recommended by Valentine (1995, *in* Taylor, ed. 1996 as cited by Ambrose et al. 1996). G-P has established 23 instream substrate sampling stations: 8 in the North Fork Ten Mile River subwatershed, 6 in the Clark Fork Ten Mile River subwatershed and 9 in the South Fork Ten Mile River subwatershed (see Map 5b). Sampling has been conducted during low flow conditions of late summer or early fall. Samples have not necessarily been extracted from known salmonid redds though some may have been. Data is reported as wet volume. Weighted averages are calculated by dividing sample locations into categories based on channel type and then averaging the percent fines values based on the proportion of each channel type within the subwatershed. The intent of the weighted average is to give each sample site more accurate representation when aggregating the data so that, for example, a sample taken on the mainstem is given greater weight than one taken on a headwater tributary (Hines, 2000).

Table 22: Summary of substrate composition data (% fines <0.85 mm) averaged for each subwatershed as reported by Hines (1999)

Year	Clark Fork		North Fork		South Fork	
	Avg	Wt'd avg	Avg	Wt'd avg	Avg	Wt'd avg
1993	16.7	15.6	19.8	19.1	17.0	17.4
1994	18.3	18.4	20.5	20.6	16.5	16.5
1995	19.1	18.4	22.3	21.3	17.0	17.0
1996	17.4	16.8	19.1	17.5	17.3	17.7
1997	17.6	16.2	18.3	17.7	16.5	17.0
1998	16.8	16.6	18.7	17.9	17.6	18.2
1999	18.5	18.0	16.8	15.8	14.6	14.9
Avg. 1993-99	17.8	17.1	19.4	18.6	16.6	17.0

For comparison purposes, a range of 14-20% fines (<0.85 mm) is used to evaluate sediment composition in the Ten Mile River watershed. An assessment of studies in locations throughout the Pacific Northwest indicate that substrate composed of no more than 14% fines (<0.85 mm) adequately supports successful spawning, incubation and emergence (Mangelsdorf and Lundborg, 1998). Waters (1995) concludes that substrate containing more than 20% fine sediment (<0.85 mm) inadequately supports successful spawning, incubation and emergence. Locations with fine sediment (< 0.8 mm) falling within the range of 14-20% are therefore judged to be less than ideal with respect to sediment composition; but, they may nonetheless allow for at least minimal salmonid spawning, incubation and emergence success.

Using these criteria it appears that each of the three main forks of the Ten Mile River watershed, on average, only minimally support salmonid spawning, incubation, and emergence success. The subwatersheds of the Clark and South forks of the Ten Mile River are essentially identical in the percentage of substrate that is composed of fine sediment (<0.85 mm). The North Fork Ten Mile River subwatershed appears slightly more rich in fine sediment (<0.85 mm) than the other two. Hines (2000) observes that fines in the North Fork Ten Mile River subwatershed are decreasing while those in the South Fork Ten Mile River subwatershed and Clark Fork Ten Mile subwatershed appear relatively stable from 1993-1999. Hines (2000) hypothesizes that since old-growth trees were harvested more recently in the North Fork than elsewhere in the basin, then current sediment data may be picking up a recovery trend from this activity. Sediment data in the other subwatersheds may have missed the downward trend and simply be measuring post-disturbance stabilization (Hines, 2000).

Table 23 contains the fine sediment data for individual sampling locations for individual years from 1995 through 1999. Hines (2000) reports trends in the data using data collected from 1993 through 1999. However, individual data were not provided to Regional Water Board staff for 1993 and 1994.

At 13% of the sample locations, the average percent fines (<.85 mm) over 5 years is less than 14%. These locations are NFT2, SFT9, and SFT13. There are no such locations in the Clark Fork Ten Mile River subwatershed. At 61% of the sample locations, the average percent fines (<0.85 mm) over a 5 year period is between 14-20%. These are the majority of the sampling locations. They are identified in Table 9 and are located throughout the watershed. At 26% of the sample locations, the average percent fines (<0.85 mm) over a 5 year period is greater than 20%. These locations are NFT7, NFT9, NFT10, CFT5, and SFT2. They are located throughout the watershed; but, they concentrated in the North Fork Ten Mile River subwatershed.

Table 23: Substrate composition data as reported by Ambrose et al. (1996), Ambrose and Hines (1997, 1998)

Location		**Percent fines less than 0.85 mm**					
		1995	1996	1997	1998	1999	5-year average
Lower Ten Mile River							
TEN1	Mill Creek	22.6	23.7	17.4	19.1	20.7	20.7
North Fork Ten Mile River subwatershed							
NFT1	NFT at Patsy Creek	20.7	18.4	14.7	23.3	14.4	18.3
NFT2	Bald Hill Creek	16.2	13.7	14.2	12.6	10.7	13.5
NFT5	NFT at Camp 5	20.8	15.5	16.5	16.3	16.6	17.1
NFT6	Lower Little North Fork Ten Mile River	18.9	17.3	17.1	17.6	11.2	16.4
NFT7	Buckhorn Creek	23.7	16.2	20.8	22.5	19.9	20.6
NFT9	NFT at Gulch 9	26.5	20.7	23.9	19.1	19.2	21.9
NFT10	Patsy Creek	28.8	27.1	21.7	19.3	21.8	23.7
Clark Fork Ten Mile River subwatershed							
CFT1	CFT at Reynold's Gulch	17.0	15.1	20.0	19.8	21.1	18.6
CFT2	CFT at Little Bear Haven Creek	16.5	19.7	14.2	8.8	14.4	14.7
CFT3	Lower Bear Haven Creek	18.6	12.9	11.4	23.2	18.1	16.8
CFT4	Lower CFT	20.9	16.9	17.2	15.6	18.5	17.8
CFT5	Booth Gulch	22.2	22.5	26.7	20.6	22.9	23.0
CFT6	Little Bear Haven Creek	19.6	17.4	16.2	12.5	16.1	16.4
South Fork Ten Mile River subwatershed							
SFT1	Smith Creek	14.7	17.2	16.6	21.1	19.1	17.7
SFT2	Campbell Creek	23.1	22.8	22.0	18.7	22.5	21.8
SFT3	SFT at Brower's Gulch	16.5	21.8	18.4	16.1	13.5	17.3
SFT4	Churchman Creek	15.8	19.2	12.4	13.6	16.4	15.5
SFT5	SFT at Buck Mathew's Gulch	16.6	16.9	12.9	28.2	16.1	18.1
SFT6	SFT at Camp 28	18.4	16.2	15.4	20.3	16.9	17.4
SFT8	Upper Redwood Creek	19.5	16.0	22.7	17.1	15.2	18.1
SFT9	Upper SFT	14.0	13.2	13.6	12.0	9.9	12.5
SFT13	SFT at Churchman Creek	14.2	12.4	14.5	11.2	9.2	12.3

G-P conducted a trend analysis and found trends at 10 of the 23 sampling locations (NFT2, NFT5, NFT6, NFT9, NFT10, CFT4, CFT6, SFT1, SFT2, and SFT13). All of these locations are stable or decreasing in percent fines (<0.85 mm), except SFT1, which is increasing. Regression lines for the additional 13 sampling locations are useful in providing a subjective assessment of trends; but are not conclusive (Hines, 2000). Locations where regression lines suggest an increase in the percent fines (<0.85 mm) include CFT1, CFT3, CFT5, and SFT6 (Hines, 2000). There are no stations in the North Fork Ten Mile River subwatershed where an increase in the percent fines (<0.85 mm) is indicated. Locations where regression lines suggest a decrease in the percent fines (<0.85 mm) include NFT7, SFT3, and SFT4 (Hines, 2000). No trends are evident at 6 sampling locations, including TEN1, NFT1, CFT2, SFT5, SFt8, and SFT9.

G-P attempted in 1994 to study gross aggradation/degradation in the South Fork Ten Mile River. The results of this study indicate that the South Fork Ten Mile River is a dynamic system with large local changes in streambed elevation. A change in mean streambed elevation could not be computed due to the loss of numerous benchmarks during the 1994/95 storms (Ambrose et al. 1996).

4.3.4 Temperature Data

G-P installed HOBO temperature data loggers in numerous pools and a few riffles throughout the Ten Mile River watershed beginning in 1993. Temperature data loggers record stream temperature at a regular interval, numerous times a day, for several weeks at a time. From this data, daily temperature statistics can be calculated (e.g., mean, maximum and minimum), as well as weekly or monthly temperature statistics (e.g., maximum weekly average temperature). G-P reported its temperature data for the Ten Mile River watershed for the summers of 1995, 1996 and 1997, in a slightly different way in each year. In 1995, the continuous temperature data is reported in the form of a line graph for each sample site. From this presentation, one can identify the maximum and minimum instantaneous temperatures. One can also estimate the degree to which daily temperatures are within a given range. In addition, the weekly average temperature is reported in the form of a bar graph for each sample site. The weekly average temperature was computed for each calendar week in which there were 7 measurements. From this presentation, one can identify the weeks in which the weekly average temperature exceeded some threshold. In 1996, the average, minimum and maximum daily values are reported in the form of a line graph for each sample site. In addition, a 7-day moving average is reported in the form of a line graph for each sample site. In 1997, only the 7-day moving average is reported for each sample site. The result is that only a weekly average temperature statistic is available for comparison amongst each of the three years.

Bjornn and Reiser (1991) define a short-term maximum summer temperature for rearing coho to be 22 °C. None of the continuous temperature data indicates exceedances of this value. They also define a range of preferred summer temperatures for rearing coho to be 11.8 to 14.6 °C. The continuous temperature data reported by G-P (i.e., 1995 and 1996) indicate that at a few of the monitoring locations the summer temperatures are essentially within this range. These stations are:

- Mill Creek (TEN1)
- Buckhorn Creek (NFT7)
- Upper Little North Fork Ten Mile River (NFT8)
- Bear Haven Creek (CFT3)
- Little Bear Haven Creek (CFT6)
- Upper Bear Haven Creek (CFT7)
- Upper Clark Fork Ten Mile River at Ford Gulch (CFT8)

None of these stations are in the South Fork Ten Mile River subwatershed. All of the other monitoring stations exhibit summer temperatures that fall outside of this range some to most of the time.

A weekly average temperature is a moving average of continuous temperature data over 7 days. When plotted, one can compare the weekly average temperature to a maximum or target. For the purpose of evaluating G-P's temperature data, a maximum weekly average temperature (MWAT) of 16.8°C is chosen. This target is chosen based on the work conducted by David Hines and Jonathan Ambrose for G-P comparing the presence and absence of coho in streams to the weekly average temperatures found there over time. They conclude that a maximum weekly average temperature (calculated as the mean of daily maximums) of 16.8°C predicts whether or not coho will be present in a stream (Ambrose and Hines, 1998). Using a hard copy of the temperature graphs provided by G-P, Regional Water Board staff drew in a target line at 16.8°C and measured the amount of time from June1 to August 31 that the reported weekly average temperature exceeded this target. Table 24 summarizes our measurements (to the closest 5%).

G-P has collected temperature data from 36 pools. Temperature data is available for an additional 9 riffles. Regarding the pool data, 31% of the pools sampled in the North Fork Ten Mile River subwatershed exhibit weekly average summer temperatures regularly below a 16.8°C MWAT. Approximately 45% of the pools sampled in the Clark Fork Ten Mile River subwatershed exhibit suitable weekly average summer temperatures. And, 27% of the pools sampled in the South Fork Ten Mile River subwatershed exhibit suitable weekly average summer temperatures. In total, 36% of the pools sampled in the Ten Mile River watershed exhibit suitable weekly average summer temperatures.

With respect to temperature, then, G-P's data indicate that:
1. Neither the North Fork Ten Mile River, Clark Fork Ten Mile River, nor South Fork Ten Mile River exhibit summer temperature conditions that are lethal to coho salmon (e.g., daily temperatures do not exceed 22 °C at any of the locations).
2. The Little North Fork Ten Mile River subwatershed exhibits continuous daily temperatures and weekly average temperatures that are ideal for coho summer rearing (e.g., daily temperatures at NFT7 and NFT8 are between 11.8 and 14.6 °C and weekly average temperatures are below 16.8 °C).
3. The Middle Clark Fork Ten Mile River subwatershed and the upper reaches of the Upper Clark Fork Ten Mile River subwatershed exhibit continuous daily temperatures and weekly average temperatures that are ideal for coho summer rearing.
4. The continuous daily temperatures in Little Bear Haven Creek and Booth Creek periodically exceed the upper limit of temperatures preferred by rearing coho. However, the weekly average temperatures are adequate to support coho summer rearing.
5. The continuous daily temperatures in the South Fork Ten Mile River subwatershed either periodically or regularly exceed the upper limit of temperatures preferred by rearing coho. However, the weekly average temperatures regularly exhibited in Smith Creek, Churchman Creek, Redwood Creek, and the upper reaches of the Upper South Fork Ten Mile River subwatershed are adequate to support coho summer rearing.
6. Mill Creek exhibits continuous daily temperatures and weekly average temperatures that are ideal for coho summer rearing.
7. All other sampling locations exhibit temperatures that are inadequate to support coho summer rearing.

4.3.5 Habitat Inventories

The Department of Fish and Game has developed a protocol for inventorying the type and quality of habitat available in a given stream reach. The protocol is described in Flosi et al., 1998. The Department of Fish and Game uses the results of its habitat inventories to identify and prioritize habitat restoration opportunities. The data also provides an excellent snap shot of the overall habitat availability in a watershed. The Department of Fish and Game recommends against using the protocol for identifying trends in habitat availability, over time (Cooey, workshop presentation, 1995).

Two habitat inventories have been conducted in the Ten Mile River watershed. One, conducted in 1991, was a cursory assessment looking at selected reaches of individual streams. The other, conducted in 1994 and 1995, was a more extensive assessment looking at the full length of individual streams accessible to anadromous fish. The number of streams selected for inventorying in 1994/95 was more extensive than those selected in 1991. The difference in the number and extent of inventoried streams in the 1991 and 1994/95 assessments prohibits a direct comparison of the findings. As above, the Department of Fish and Game recommends against such a comparison, in any case. Thus, reported here is a summary of the data results of the 1994/95 inventory as reported by Ambrose et al. (1995). (See Map 8).

In 1994 and 1995 G-P surveyed anadromous fish-bearing streams throughout its ownership in the Ten Mile River watershed. A total of 573,711 feet (109 miles) of stream were surveyed and the following measurements collected:

- Flow (Marsh-McBirney Flo-Mate™ Model 2000)
- Channel type (Rosgen, 1985 and revised in 1994)
- Habitat type (Flosi and Reynolds 1994)
- Embeddedness (Ocular estimate of the percent of cobble samples embedded under fine sediment)
- Shelter Rating (Quantitative measure of overhead cover multiplied by a qualitative rating of shelter value)
- Substrate composition (Ocular estimate of dominant and sub-dominant substrate size classes)
- Canopy (Hand-held spherical densiometer readings with ocular estimate of distribution of coniferous and deciduous cover)
- Bank composition and vegetation (Ocular estimate of dominant bank substrate type, vegetation type, and percent of bank covered by vegetation)

Regional Water Board staff have evaluated the data as follows:

- Calculate the miles of stream that based on existing channel type are capable of providing suitable salmonid habitat. A comparison of the population data with the channel type data indicate coho are only present in Ten Mile River watershed streams that have at least some amount of C-type channel. (See Table 25)
- Identify those stream reaches that based on existing habitat type are potentially limiting various salmonid life stages. Lateral scour pools are the most widely used salmonid habitat, followed by backwater pools, mid-channel pools, and pocket water. Edgewater habitat, high gradient riffles, and runs are also important to various salmonid life cycle stages [McCain, Fuller, Decker and Overton (1990) as cited by Flosi et al. (1998)]. (See Tables 26 and 27)
- Identify those stream reaches with a frequency and mean depth of pool that are too little to provide adequate summer rearing habitat for coho salmon. Flosi et al. (1998) report that the better coho streams have 40% of their habitat length in primary pools (e.g., in third and fourth order streams, primary pools have a maximum depth of at least 3 feet, are at least half as wide as the low flow channel, and are at least as long as the low flow channel is wide). (See Tables 26 and 27).
- Identify those stream reaches with a mean shelter rating that is too low to provide adequate protection against predators. A shelter rating is assigned by estimating the percent of a habitat unit's area that offers some form of shelter and multiplying it by a shelter quality

rating of 0 to 3. The maximum possible shelter rating is 300. A shelter quality rating is assigned as follows. If the shelter in a habitat unit consists of 1-5 boulders, bare undercut bank, bare bedrock ledge or a single piece of large wood, then the unit is given a shelter quality rating of 1. This is multiplied by the percentage of the unit's area that is providing the shelter (e.g., 1-100%). If the shelter in a habitat unit consists of 1 or 2 pieces of large woody associated with any amount of small wood, 6 of more boulders per 50 feet, a stable undercut bank with root mass, a single root wad lacking complexity, etc., then the unit is given a shelter quality rating of 2. This is multiplied by the percentage of the unit's area that is providing the shelter (e.g., 1-100%). If the shelter in a habitat unit consists of combinations of large woody debris, boulders and root wads, 3 or more pieces of large woody debris combined with small woody debris, 3 or more boulders combined with large woody debris/small woody debris, etc., then the unit is given a shelter quality rating of 3. This is multiplied by the percentage of the unit's area that is providing the shelter (e.g., 1-100%). Flosi et al. (1998) recommend improving shelter availability through habitat restoration efforts where the shelter rating is less than 80. (See Table 27)

- Identify those stream reaches with gravels that are too few or too heavily embedded to provide adequate spawning habitat. Flosi et al. (1998) indicate that gravels that are less than 25% are preferred for spawning. (See Table 28)
- Identify those stream reaches with canopy cover too little to provide adequate summer shade or too dominated by deciduous species to provide adequate large woody debris. Flosi et al. (1998) indicate that stream canopy should be 80% or more to maintain suitable water temperatures. (See Table 29).

4.3.5.1 Lower Ten Mile River subwatershed

Within the Lower Ten Mile River subwatershed, G-P assessed habitat conditions in Mill Creek, only. As reported by Ambrose et al. (1996), the elevation of Mill Creek ranges from 24 m (40 feet) at the mouth to 488 m (2,200 feet) in the headwaters. A total of 9,606 feet (1.8 miles) of Class I stream were surveyed in Mill Creek from July 14 through June 15, 1994. Table 28 at the end of the report summarizes the lengths of channel surveyed in Mill Creek, as well as the distribution of channel types identified, based on Rosgen (1994). F-type channels predominate (64%) followed by B-type channels (36%).

B-type channels are moderately entrenched, riffle-dominated channels with moderate gradient and infrequently spaced pools. They have a very stable plan and profile as well as stable banks. F-type channels are entrenched, meandering channels with riffle/pool sequences on low gradients with high width/depth ratios. (Rosgen 1994).

Mill Creek is dominated by flatwater units (55% by length). The majority of the flatwater units are step runs, a habitat type used only by young-of-year (YOY) steelhead. Runs, used by 1+ steelhead, make up only 6% of the habitat types while pocket water and edgewater are completely absent. Pools make up only 10% of the habitat units, by length (see Table 26). Mid-channel pools account for 2% while scour pools account for the remaining 8%. Backwater pools are completely absent. In addition, the average pool depth in Mill Creek is 0.7 feet. The mid-channel pools, channel confluence pools, corner pools, and plunge pools have an average depth of 2 feet (see Table 27). Based on these observations, it appears that Mill Creek may be limited as a salmonid stream by an inadequate quantity and quality of rearing and overwintering habitat.

The mean shelter rating for pools in Mill Creek is 44. Shelter in cascades and log-enhanced lateral scour pools exceed a mean rating of 100. But, the shelter in all of the other habitat types is rated at far less than 80 (see Table 27). Based on this information, it appears that Mill Creek does not offer adequate cover to successfully protect young salmonids from predators.

Coho salmon, chinook salmon and steelhead trout build their redds in the gravels found in low gradient riffles such as those seen at the pool tail-outs of mid-channel pools and scour pools, as well as in pocket water (Flosi et al., 1998). Gravel-sized particles dominate the substrate of low gradient riffles found in Mill Creek. However, there is no pocket water habitat in the stream and little mid-channel or scour pool habitat. In addition, substrate particles in Mill Creek are on average more than 50% embedded (see Table 28). As such, the spawning habitat in Mill Creek may be limited.

Finally, the banks of Mill Creek are well vegetated and provide an average of 97% canopy throughout the riparian zone, except in dry stream reaches which are open. Vegetation is primarily deciduous, however, and will not provide long-lasting woody debris to the stream (see Table 29).

4.3.5.2 North Fork Ten Mile River subwatershed

As reported by Ambrose et al. (1996), the elevation of North Fork Ten Mile River subwatershed ranges from 12 m (40 feet) at the mouth to 671 m (2,200 feet) in the headwater areas. It drains approximately 24,967 acres (39 mi^2) and includes the following tributaries:

- Little North Fork Ten Mile River
- Cavanough Gulch
- O'Connor Gulch
- Bald Hill Creek
- Gulch 8
- Gulch 11
- Gulch 19
- Patsy Creek
- Gulch 23

A total of 205,212 feet (38.9 miles) of Class I stream were surveyed in the North Fork Ten Mile River subwatershed from July 27 through November 2, 1995. Table 25 at the end of the report summarizes the lengths of channel surveyed in the mainstem and each tributary, as well as the distribution of channel types identified, based on Rosgen (1994). A total of 183,947 feet of main channel plus 2,957 feet of side channel were surveyed in the North Fork Ten Mile River subwatershed, proper. Within the North Fork Ten Mile River subwatershed, B-type channels predominate (67%) followed by F-type channels (24%). A small proportion of the main channels surveyed were C-type channels (8%) while an even smaller proportion were D-type channels (1%).

B-type channels are moderately entrenched, riffle-dominated channels with moderate gradient and infrequently spaced pools. They have a very stable plan and profile as well as stable banks. C-type channels are low gradient, meandering alluvial channels with point-bars, riffle/pool sequences, and broad, well-defined floodplains. D-type channels are braided with longitudinal and transverse bars. They are very wide with eroding banks. F-type channels are entrenched, meandering channels with riffle/pool sequences on low gradients with high width/depth ratios. (Rosgen 1994).

The mainstem North Fork Ten Mile River is predominated by pools (47%). The same is true of the Little North Fork Ten Mile River. The tributaries, on the other hand, are generally predominated by flatwater units. Two notable exceptions are Barlow Gulch and Cavanough Gulch which are predominated by dry units (38% and 54%, respectively). Gulch 19 and Gulch 23 are predominated by riffle units (42% and 38%, respectively). Only in the mainstem North Fork Ten Mile River do the majority (>50%) of pools have maximum depths that exceed 3 feet. In all the other tributaries the majority of pools have maximum depths no greater than 2 feet (see Tables 26 and 27). Large, deep pools are necessary as rearing habitat for coho salmon. Flosi et al. (1998) have found that primary pools make up more than 40% of the habitat units found in good coho streams. As such, only the mainstem North Fork Ten Mile River is potentially well-suited for coho salmon rearing. The Little North Fork Ten Mile River contains an adequate ratio of pools to riffles/flatwater. But, the pools are shallow. Barlow Gulch and Cavanough Gulch offer poor rearing habitat due to numerous dry reaches that may strand young fish. And the rest of the North Fork Ten Mile River subwatershed is lacking in both an adequate number of pools and pools of adequate depth.

Scour pools make up the largest percentage of the pools in both the mainstem North Fork Ten Mile River and the Little North Fork Ten Mile River followed by main channel pools and very few backwater pools. Five of the tributary watersheds are also predominated by scour pools, including: Cavanough Gulch, O'Connor Gulch, Bald Hill Creek, Gulch 11, and Gulch 19. The others are predominated by main channel pools, including: Blair Gulch, Barlow Gulch, Buckhorn Gulch, McGuire Creek, Gulch 8, Patsy Creek and Gulch 23. Only Cavanough Gulch and Gulch 19 have notable numbers of backwater pools—10% and 8%, respectively (see Table 27). A predominance of scour pools may describe a stream in which there is optimum sediment storage capacity, sediment sorting, and diverse forms of shelter (e.g., large woody debris, undercut banks, white water, etc.). However, a specific relationship between the predominance of scour pools and channel functioning and/or habitat availability is currently unknown. Backwater pools, on the other hand, are commonly thought to be associated with the successful overwintering of young salmonids which would otherwise be washed downstream in the absence of shelter from high, mainstem, winter flows (see Table 27). As such, Cavanough Gulch and Gulch 19 may offer potential overwintering habitat in which young salmonids can successfully find refuge from high winter flows.

In none of the surveyed streams do the mean shelter ratings in pools exceed 80—a target used by Fish and Game when considering habitat restoration. In a majority of the surveyed streams, the mean shelter ratings are no greater than 50 (see Table 27). Based on this information, one can surmise that the North Fork Ten Mile River subwatershed does not generally offer adequate cover to successfully protect young salmonids from predators.

In nearly all of the surveyed streams, gravel is the dominant substrate size class found in low gradient riffles. Coho salmon and steelhead trout build their redds in the gravels found in low gradient riffles such as those seen at pool tail-outs. As such, most of the surveyed streams in the North Fork Ten Mile River subwatershed appear to provide potential spawning habitat for these salmonid species. Gulch 11 and Gulch 23 are the exceptions. The low gradient riffles in these tributaries are dominated by boulder size particles. As such, these tributaries probably do not offer substantial spawning habitat for coho salmon or steelhead trout. Unfortunately, despite the predominance of gravel-sized particles in low gradient riffles, particles appear to be substantially embedded. Particles less than 25% embedded are generally ideal for successful redd-building and incubation/emergence. None of the surveyed streams exhibit spawning substrates where a majority of the substrate is less than 25% embedded. Indeed, more than half of the potential spawning habitat in all of the surveyed streams is more than 50% embedded. In 5 out of 14 surveyed streams, more than 80% of the potential spawning habitat is more than 75% embedded—or essentially fully embedded. (See Table 28)

Finally, the banks of North Fork Ten Mile River subwatershed are dominated by deciduous vegetation. Only in Buckhorn Gulch, McGuire Creek, Gulch 11 and Gulch 19 does coniferous vegetation dominate the stream banks. Indeed, more than 10% of the stream banks are open in the mainstem North Fork Ten Mile River, Bald Hills Creek, Gulch 8, Gulch 11, and Gulch 19. While the distribution of vegetation and open conditions along a stream bank do not directly relate to woody debris production, it does speak to the general capacity of a reach of stream to produce long lasting (e.g., rot resistant) woody debris around which habitat can be formed and sediment stored and sorted. (See Table 29)

4.3.5.3 Clark Fork Ten Mile River subwatershed

As reported by Ambrose et al. (1996), the elevation of the Clark Fork Ten Mile River subwatershed ranges from 140 feet at the mouth to 3,000 feet in the headwater areas. It drains approximately 21,400 acres (33 mi^2) and includes the following tributaries:

- Bear Haven Creek
- Little Bear Haven Creek
- Booth Gulch
- Gulch 27

A total of 154,857 feet (29.3 miles) of Class I stream were surveyed in the Clark Fork Ten Mile River subwatershed from August 17, 1994 through July 18, 1995. Table 25 at the end of the report summarizes the lengths of channel surveyed in the mainstem and each tributary, as well as the distribution of channel types identified, based on Rosgen (1994). Within the Clark Fork Ten Mile River subwatershed, B-type channels predominate (65%) followed by C-type channels (23%). A small proportion of the mainstem channels surveyed were F-type channels (12%) while an even smaller proportion were A-type channels (<1%).

A-type channels are generally found within valley types that due to their inherent channel steepness, exhibit a high sediment transport potential and a relatively low in-channel sediment storage capacity. The influx of large woody debris can play a major role in determining the bedform and overall channel stability of A-type channels. A-type channels are generally steep, entrenched, cascading step/pool streams and are very stable if bedrock or boulder dominated (Rosgen, 1994). A description of the other channel types is given in the discussion of the North Fork Ten Mile River subwatershed habitat data, above.

The mainstem Clark Fork Ten Mile River is predominated by pools (44%). Flatwater units, on the other hand, dominate the tributaries. Only in the mainstem Clark Fork Ten Mile River do the majority (>50%) of pools have maximum depths that exceed 3 feet. In all the other tributaries, the majority of pools have maximum depths no greater than 2 feet. Large, deep pools are necessary are rearing habitat for coho salmon. Flosi et al., (1998) have found that primary pools make up more than 40% of the habitat units found in good coho streams. As such the mainstem Clark Fork Ten Mile River is potentially well-suited for coho salmon rearing. But, the tributaries may offer only marginal rearing habitat. (See Tables 26 and 27)

Scour pools make up the largest percentage of the pools in both the mainstem Clark Fork Ten Mile River and Bear Haven Creek. The other tributaries are predominated by main channel pools. A predominance of scour pools may describe a stream in which there is optimum sediment storage capacity, sediment sorting, and diverse forms of shelter (e.g., large woody debris, undercut banks, white water, etc.). However, a specific relationship between the predominance of scour pools and channel functioning and/or habitat availability is currently unknown. Backwater pools, on the other hand, are commonly thought to be associated with successful overwintering of young salmonids which would otherwise be washed downstream in the absence of shelter from high, mainstem, winter flows. None of the streams within the Clark Fork Ten Mile River subwatershed offer significant backwater pool habitat. (See Table 27)

In none of the surveyed streams do the mean shelter ratings in pools exceed 80—a target used by Fish and Game when considering habitat restoration. In a majority of surveyed streams, the mean shelter ratings are no greater than 50. Based on this information, one can surmise that the Clark Fork Ten Mile River subwatershed does not generally offer adequate cover to successfully protect young salmonids from predators. (See Table 27)

In all but Gulch 27, gravel is the dominant substrate size class found in low gradient riffles. Coho salmon and steelhead trout build their redds in the gravels found in low gradient riffles such as those seen at pool tail-outs. As such, most of the surveyed streams in the Clark Fork Ten Mile River subwatershed appear to provide potential spawning habitat for these salmonid species. Gulch 27 is an exception since low gradient riffles are dominated by small cobble in this stream. (See Table 28)

Unfortunately, despite the predominance of gravel-sized particles, the particles appear to be substantially embedded. Particles less than 25% embedded are generally ideal for successful redd-building and incubation/emergence. None of the surveyed streams exhibit spawning substrates where a majority of the substrate is less than 25% embedded. Indeed, more than half of the potential spawning habitat in all of the surveyed streams is more than 75% embedded. In 2 out of 5 surveyed streams, more than 80% of the potential spawning habitat is more than 75% embedded—or essentially fully embedded. (See Table 28)

Finally, the banks of the Clark Fork Ten Mile River subwatershed are dominated by deciduous vegetation. Only in Bear Haven Creek and Booth Gulch do coniferous vegetation dominant the stream banks. Indeed, more than 15% of the stream banks are open throughout the subwatershed. While the distribution of vegetation and open conditions along a stream bank do not directly relate to woody debris production, it does speak to the general capacity of a reach of stream to produce long lasting (e.g., rot resistant) woody debris around which habitat can be formed and sediment stored and sorted. (See Table 29)

4.3.5.4 South Fork Ten Mile River subwatershed

As reported by Ambrose et al. (1996), the elevation of the South Fork Ten Mile River subwatershed ranges from 20 feet at the mouth to 3,000 feet in the headwater areas. It drains approximately 19,630 acres (31 mi^2) and includes the following tributaries:

- Smith Creek
- Campbell Creek
- Churchman Creek
- Redwood Creek

A total of 213,642 feet (40.5 miles) of Class I stream were surveyed in the South Fork Ten Mile River subwatershed from June 15, 1994 through August 16, 1994. Table 25 summarizes the lengths of channel surveyed in the mainstem and each tributary, as well as the distribution of channel types identified, based on Rosgen (1994). Within the South Fork Ten Mile River subwatershed, B-type channels predominate (74%) followed by C-type channels (25%). A small proportion of the mainstem channels surveyed were F-type channels (1%). A description of the channel types is given in the discussion of the North Fork Ten Mile River subwatershed habitat data, above.

The mainstem South Fork Ten Mile River and each of the surveyed tributaries are predominated by flatwater units. In addition, no where in the South Fork Ten Mile River do the majority (>50%) of pools have maximum depths that exceed 3 feet. In the mainstem South Fork Ten Mile River and all the surveyed tributaries the majority of pools have maximum depths no greater than 2 feet. Large, deep pools are necessary are rearing habitat for coho salmon. Flosi et al. (1998) have found that primary pools make up more than 40% of the habitat units found in good coho streams. As such the South Fork Ten Mile River subwatershed may offer only a marginal coho rearing habitat. (See Tables 26 and 27)

Where pools do exist, scour pools make up the largest percentage of those pools in the mainstem South Fork Ten Mile River and each of the surveyed tributaries. A predominance of scour pools may describe a stream in which there is optimum sediment storage capacity, sediment sorting, and diverse forms of shelter (e.g., large woody debris, undercut banks, white water, etc.). However, a specific relationship between the predominance of scour pools and channel functioning and/or habitat availability is currently unknown. Backwater pools, on the other hand, are commonly thought to be associated with successful overwintering of young salmonids which would otherwise be washed downstream in the absence of shelter from high, mainstem, winter flows. None of the streams within the South Fork Ten Mile River subwatershed offer significant backwater pool habitat. As such, overwintering habitat in the South Fork Ten Mile River subwatershed is sorely lacking. (See Table 27)

In none of the surveyed streams do the mean shelter ratings in pools exceed 80—a target used by Fish and Game when considering habitat restoration. In a majority of the surveyed streams, the mean shelter ratings are no greater than 40. Based on this information, one can surmise that the

South Fork Ten Mile River subwatershed does not generally offer adequate cover to successfully protect young salmonids from predators. (See Table 27)

Gravel is the dominant substrate size class found in low gradient riffles throughout the South Fork Ten Mile River subwatershed. Coho salmon and steelhead trout build their redds in the gravels found in low gradient riffles such as those seen at pool tail-outs. As such, most of the surveyed streams in the South Fork Ten Mile River subwatershed appears to provide potential spawning habitat for these salmonid species. (See Table 28)

Unfortunately, despite the predominance of gravel-sized particles, the particles appear to be substantially embedded. Particles less than 25% embedded are generally ideal for successful redd-building and incubation/emergence. None of the surveyed streams exhibit spawning substrates where a majority of the substrate is less than 25% embedded. Indeed, more than half of the potential spawning habitat in all of the surveyed streams is more than 75% embedded. In 4 out of 5 surveyed streams, more than 80% of the potential spawning habitat is more than 75% embedded—or essentially fully embedded. (See Table 28)

Finally, the banks of the South Fork Ten Mile River subwatershed are dominated by deciduous vegetation. Only in Redwood Creek does coniferous vegetation dominant the stream banks. Indeed, more than 15% of the stream banks are open throughout the subwatershed. While the distribution of vegetation and open conditions along a stream bank do not directly relate to woody debris production, it does speak to the general capacity of a reach of stream to produce long lasting (e.g., rot resistant) woody debris around which habitat can be formed and sediment stored and sorted. (See Table 29)

4.3.5.5 Conclusions

Flosi et al. (1998) identify the habitat types of most benefit to steelhead trout and coho salmon in each of their freshwater life stages. For example, 0+ steelhead trout make use of all habitat types in the summer and fall. The 1+ fish, however, prefer pocket water, later scour pools and high gradient riffles. Juvenile coho salmon use all pool types in the summer and fall months. Mid-channel pools, backwater pools and scour pools provide the predominant spawning habitat for both steelhead trout and coho salmon in the winter and spring (Flosi et al., 1998). The habitat typing data available for the Ten Mile River watershed was collected in the summer and fall months. As such, the data is not particularly well-suited for evaluating winter and spring spawning habitat. But, assuming that the proportion of habitat types, if measured in the winter or spring, would be similar to that found in the summer and fall, then some conclusions can be drawn about the proportion of habitat types with respect to spawning habitat.

<u>Stream channel type</u>

Stream channels are identified by type during a habitat survey so that instream restoration can be designed which is appropriate for the channel type in question. Flosi et al. (1998) do not specifically address the question of whether salmonids prefer one channel type over another or if some habitat types are more common to one channel type than another. But, as will be discussed further in Section 4.4 (Synthesis), it generally appears that the streams with C-type channel are the same as those with coho salmon present. Streams with C-type channel include: Little North Fork Ten Mile River, Bear Haven Creek, Little Bear Haven Creek, mainstem of the South Fork

Ten Mile River, Smith Creek and Campbell Creek. Two exceptions to this observed relationship are Little Bear Haven Creek which has C-type channel but no coho and Churchman Creek which has coho but not C-type channel. As such, the presence of C-type channel may be a reasonable screening tool for identifying streams with potential for supporting coho salmon.

Specific habitat types important to salmonids

Flosi et al. (1998) describes lateral scour pools as the most widely used salmonid habitat. Pools, in general, make up more than 40% of the habitat by length in only three surveyed reaches: mainstem North Fork Ten Mile River, Little North Fork Ten Mile River, and mainstem Clark Fork Ten Mile River. What little pool habitat that does exist throughout the rest of the watershed is predominated by lateral scour pools in the following streams:

- Mill Creek (82% of pools are lateral scour pools)
- Mainstem North Fork Ten Mile River (60%)
- Little North Fork Ten Mile River (61%)
- Cavanough Gulch (51%)
- O'Connor Gulch (63%)
- Bald Hill Creek (53%)
- Gulch 11 (70%)
- Gulch 19 (51%)
- Mainstem Clark Fork Ten Mile River (58%)
- Bear Haven Creek (63%)
- Mainstem South Fork Ten Mile River (71%)
- Smith Creek (78%)
- Campbell Creek (73%)
- Churchman Creek (72%)
- Redwood Creek (58%)

Another important habitat type is backwater pools, which are used by salmonids as overwintering habitat (Flosi et al., 1998). Backwater pools are not prevalent anywhere in the basin. But, they exist in 15 of the 25 surveyed streams and make up ≥5% of pools in the following streams:

- Cavanough Gulch (10%)
- Gulch 19 (8%)
- Little Bear Haven Creek (5%)

Frequency of primary pools

Ambrose et al. (1996) conclude that the North Fork Ten Mile River subwatershed has less than 50% of its length in primary pools. Primary pools are at least two feet deep in first and second order streams and at least three feet deep in third and fourth order streams. The South Fork Ten Mile River subwatershed and Clark Fork Ten Mile River subwatershed, however, each have more than 50% of their lengths in primary pools indicating favorable depths for salmonids. These conclusions are contrary to our own. Based on our reading of the data presented in Ambrose et al. (1996), it appears that only the North Fork Ten Mile River, Little North Fork Ten Mile River, and Clark Fork Ten Mile River have pool frequencies indicating a suitable quantity of rearing habitat for successful coho rearing (e.g., ≥40%). Neither the North Fork, Little North Fork, nor Clark Fork Ten Mile Rivers, however, have adequate pool depths: the average of none of them exceeds 1.6 feet.

Ambrose et al. (1996) further conclude that the South Fork Ten Mile River subwatershed has the highest percentage of pools formed by large woody debris (42%) followed by the Clark Fork Ten Mile River subwatershed (19%) and the North Fork Ten Mile River subwatershed (18%). A possible association was also found between coho sites and the occurrence of pools formed by LWD: the only coho found were in creeks where there was a large percentage of LWD. This suggests that a low percentage of LWD-formed pools could adversely affect juvenile coho populations. The four creeks were coho were found had over 30% of their pools formed by LWD. The association of coho with habitat formed by large woody debris is further discussed in Section 4.4 (Synthesis).

<u>Shelter</u>

Flosi et al. (1998) recommend consideration of instream restoration for stream reaches with a shelter rating of less than 80 (out of a possible rating of 300). The mean shelter rating is below 80 for pools, riffles, and flatwater units in every stream surveyed within the Ten Mile River watershed. As such, shelter in the Ten Mile River watershed can generally be considered a factor potentially limiting the success of salmonids in the basin.

<u>Substrate</u>

Regarding substrate, Ambrose et al. (1996) conclude that there is ample gravel available for spawning throughout the watershed. However, they conclude that the high embeddedness values could hinder the survival of the eggs deposited in the redds. We concur with these conclusions.

<u>Canopy</u>

Flosi et al. (1998) recommend consideration of stream restoration when streamside canopy is less than 80%. Ambrose et al. (1996) conclude that the canopy offered in each subwatershed is on average greater than 80%. Looking more specifically, however, one can see that the mainstems of the North Fork Ten Mile River, Clark Fork Ten Mile River, and South Fork Ten Mile River have less than 80% canopy cover (e.g., 70%, 76%, and 77%, respectively). All the other streams, on the other hand, have an average canopy cover exceeding 80%. Ambrose et al. (1996) observes that in the North Fork Ten Mile subwatershed, deciduous trees occupy a slightly larger portion of the canopy cover than coniferous trees. The canopy found in both the Clark and South Fork Ten Mile River subwatersheds is equally divided between coniferous and deciduous trees (Ambrose et al., 1996). Looking more specifically, one can see that 7 of the 25 streams surveyed are predominated by coniferous streamside canopy. These include:

- Buckhorn Gulch (52% of the streamside canopy is coniferous)
- McGuire Creek (47%)
- Gulch 11 (51%)
- Gulch 19(49%)
- Bear Haven Creek (57%)
- Booth Gulch (54%)
- Redwood Creek (56%)

Ambrose et al. (1996) conclude that wood from alder and other deciduous species deteriorates rapidly potentially leaving less LWD in the stream available for fish cover and LWD formed pools. Further, coniferous streamside canopy left to reach late seral stage would provide significantly better, longer lasting LWD than small, young conifers.

4.3.6 Stream alteration activities

It is generally purported that the removal of migration barriers by the Department of Fish and Game in the 1960s through 1980s resulted in the loss of substantial volumes of large woody debris habitat in Northcoast streams, including the Ten Mile River watershed. Quantified evidence of this has been collected by Mendocino Redwood Company for the Noyo River watershed (Mangelsdorf, 1999). However, no such specific evidence exists for the Ten Mile River watershed.

From 1991-92, the Center for Education and Manpower Resources, Inc. (1993a, 1993b, 1993c, 1995a, and 1995b) conducted stream restoration work in the North Fork, Clark Fork, South Fork, Redwood Creek, and North Fork Redwood Creek in the Ten Mile River watershed. They installed 126 habitat structures (e.g., scour logs and cover logs): 36 in the North Fork, 37 in the Clark Fork and 53 in the South Fork. They also removed 5 barriers from the South Fork Ten Mile River and modified 8 barriers in the Redwood Creek drainage. G-P who funded the Center for Education and Manpower Resources, Inc. in the Redwood Creek drainage estimates that 6.83 km (4.24 mi) of stream were made accessible to salmonids, as a result of their barrier modifications (Ambrose, et al., 1996).

G-P has also conducted a variety of stream restoration and upslope corrections of their own, with the intention of reducing sediment delivery and improving salmonid habitat (Ambrose et al., 1996, Ambrose and Hines, 1997). G-P uses a substrate composition target of 20% fines (<0.85 mm) as the basis for identifying locations requiring sediment-related corrective action. The North Fork Ten Mile River subwatershed was targeted for corrective action due to the number of sites in which fines exceeded this target. Enhancements throughout the watershed, include:

- Approximately 117 km (73 miles) of road were rocked from 1993-1997
- Waterbars were installed at greater frequency than required. Whole mulching and silt barriers were placed, as appropriate.
- On the Ten Mile River, an old failing bridge just below the confluence of the North Fork and the Clark Fork was replaced with a new railcar bridge.
- Sixty-two (62) new and upgraded culverts installed on existing roads in North Fork Ten Mile River drainage. A number of culverts were upgraded elsewhere in the basin.
- Barriers on O’Connor Gulch, Gulch 2 and Gulch 19 in North Fork Ten Mile River drainage were identified. A culvert on O’Connor Gulch was replaced with bridge. Gulch 2 is currently downcutting as a result of newly installed upgraded culvert. A jump pool was installed in Gulch 19.
- In the North Fork Ten Mile River subwatershed, 3 dirt stringer bridges were replaced with railcar bridges; in the Little North Fork Ten Mile River, on North Fork Ten Mile River main haul road in the vicinity of Camp 6 ½ Gulch and on the main haul road elsewhere in the North Fork Ten Mile River subwatershed
- Rip-rap was placed at the toes of three stream bank erosion sites in the North Fork Ten Mile River (i.e., at the 10.5 mile, 14.5 mile, and 17.5 mile markers on the main haul road)

- Vegetation was planted along the stream banks of newly constructed bridges and crossings throughout the North Fork Ten Mile River subwatershed
- Enhancements were made in Patsy Creek, including:
  - ♦ Restoration of old water bars and ditching and/or installation of new water bars, ditches and rolling dips
  - ♦ 5 culverts were upgraded with larger pipe and/or downspouts
  - ♦ A potential landslide area was de-watered with 200'of 10' deep trench
  - ♦ The drainage of 5 existing channels were re-routed into 4 channels which were identified as "original channels"
  - ♦ Springs were de-watered by installing culverts and/or waterbars
  - ♦ 3 stream bank slumps were removed and the associated roadside drainage restored
  - ♦ A stream bank site was rip rapped and a small washout and recent slump were rocked
  - ♦ A drainage swale was constructed to the east of the bridge over the North Fork Ten Mile River
  - ♦ As a result of its habitat typing, G-P concluded that the lower reaches of the South Fork Ten Mile River were substantially aggraded and lacking in habitat complexity. They created 14 scour log sites within a 3 mile reach of the South Fork Ten Mile River from Camp 22 to Blind Gulch.
  - ♦ G-P has also started a conifer release effort in Mill Creek to encourage the growth of suppressed redwoods along the stream for future large woody debris recruitment.
- In the Clark Fork Ten Mile River subwatershed, 3 dirt stringer bridges were replaced with railcar bridges.

G-P, The Timber Company and/or Campbell Timberland Management, Inc. may have conducted additional instream restoration or upslope corrections since 1997. However, they have not been reported to Regional Water Board staff.

4.4 SYNTHESIS

The goal of this section is to identify the factors potentially limiting the success of salmonids in the Ten Mile River watershed. First, the steelhead population data is compared to the sediment data to determine if there is a specific pattern of relationship between the two. Then, the coho salmon presence and absence data is compared to the habitat data to identify those habitat characteristics that may be most critical to coho in the Ten Mile River watershed. Finally, the population and habitat data for each stream is assessed individually to identify the factors that may be limiting the success of salmonids there.

4.4.1 Steelhead population vs. percent fines (<0.85 mm)

The steelhead trout population data and substrate composition data are two of the strongest data sets available for the Ten Mile River watershed. The coho salmon population data allows for an assessment of presence and absence, only. It does not provide unequivocal population numbers for the species. The temperature data set is presumably fairly robust. But, the data were not presented to Regional Water Board staff in a manner (e.g., electronic) supportive of more detailed analysis. A comparison of steelhead trout population data to substrate composition data was conducted. It showed no consistent or statistically significant relationship, indicating that factors in addition to or instead of variation in substrate composition affect the population of steelhead trout in individual tributaries from year to year.

4.4.2 Habitat characteristics critical to coho salmon

As described in Section 4.2, coho salmon are currently present in the following streams:

- Little North Fork Ten Mile River
- Clark Fork Ten Mile River
- Bear Haven Creek
- Smith Creek
- Campbell Creek
- South Fork Ten Mile River
- Churchman Creek

In reviewing the stream channel characteristics of each of the surveyed streams in the Ten Mile River watershed, it is apparent that the above streams constitute all but one of the streams in the basin with C-type stream channel characteristics. Little Bear Haven Creek is the only other stream in the basin with C-type stream channel. (Clark Fork Ten Mile River and Churchman Creek do not have any C-type stream channel; but, coho salmon are present there, nonetheless). This suggests that C-type channel characteristics allow for the creation of habitat most suitable to coho salmon in the Ten Mile River watershed and are in fact preferred by the species. As such, the streams with C-type channel—or channel types that can be modified to increase the amount of C-type channel—may be potentially restorable coho streams.

The streams where coho salmon are present have other habitat parameters in common with one another. For example, if one calculates the mean value associated with a variety of habitat parameters, then those that show a significant difference for coho streams versus non-coho streams can be viewed as potentially critical habitat parameters for the species. These habitat parameters can then be used to predict whether coho salmon are present in streams where population data is unavailable. The habitat parameters that appear to be critical include: percent of pools by area, percent of scour pools by length and area and the percent of large woody debris-formed habitat by length and area. Table 30 identifies the values, derived from the ranges of habitat values seen in the data set, that appear to indicate coho presence or absence. Applying the values for the percent of habitat in pools by length correctly predicts coho presence 80% of the time and coho absence 67% of the time. Applying the values for the percent of habitat in scour pools by length and area correctly predicts coho presence 80% of the time and coho absence 100% of the time. Applying the values for the percent of habitat formed by large woody debris by length and area correctly predicts coho presence 80% of the time and coho absence 100% of the time. As such, the percent of habitat in any given stream that is composed of scour pools and habitat formed by large woody debris appear to be the best indicators of coho presence and absence.

Table 30: Percent values for habitat characteristics that may be good indicators of coho salmon presence and absence.

Habitat characteristics	Coho streams	Non-coho streams
% of habitat in pools (length)	≥21	≤19
% of habitat in scour pools (length)	≥17	≤14
% of habitat in scour pools (area)	≥23	≤19
% of habitat formed by large woody debris (length)	≥11	≤5
% of habitat formed by large woody debris (area)	≥16	≤8

Hines and Ambrose (1998, permission to cite from David Hines) have conducted a similar, but more sophisticated analysis. They have compared combinations of habitat characteristics in search of a good predictor of coho presence and absence. They have found that stream temperature is one of the leading predictive characteristics. Indeed, they have determined that a maximum weekly average temperature of 16.8 °C is a biologically-relevant cut-off between streams that appear to support coho and those that do not.

Table 31 lists the value for each of these "critical" habitat characteristics (e.g., % C-type channel, % scour pools, % LWD-formed habitat, and % summer MWAT exceeds 16.8 °C) in measured Ten Mile River watershed streams. Values that meet the criteria discussed above are highlighted. It is important to note that channel type, scour pool, large woody debris-formed habitat, and temperature data assist in identifying those locations where coho are or are likely to be *present*. But, the criteria identified above are not adequate to determine where habitat characteristics are sufficient to support *sustainable* populations of coho salmon.

The data suggest that the main forks of the Ten Mile River watershed have a sufficient percentage of their habitat in scour pools; they have an insufficient percentage of their habitat formed by large woody debris; and, the instream temperatures are generally too warm. Coho were observed spawning in the lower North Fork Ten Mile River in 1990-91; but, they were not surveyed any other time. Coho were found rearing at Camp 3 in the North Fork Ten Mile River during 1996 (e.g., 0.05 fish/m^2). Spawning surveys in the Clark Fork and South Fork Ten Mile Rivers indicate wide spread coho spawning throughout these forks. Coho were found rearing in the Clark Fork only at Reynold's Gulch during 1996 (e.g., 0.02 fish/m^2). By comparison, coho were found rearing in the South Fork at three locations during 1996 [e.g., Brower's Gulch (0.004 fish/m^2), Buck Mathew's Gulch (0.02 fish/m^2), and Big Cat Crossing (0.01 fish/m^2)]. The South Fork Ten Mile River has only slightly more large woody debris-formed habitat than the other two forks and its instream summer temperatures are comparable to those of the Clark Fork Ten Mile River. But, unlike the other two mainstem channel, the South Fork Ten Mile River has C-type channel.

The Little North Fork Ten Mile River, Bear Haven Creek, and Smith Creek have C-type channel; enough scour pools, large woody debris-formed habitat; and cool enough instream temperatures for coho salmon to be present. Coho salmon have been found spawning in each of these tributaries. Indeed, the Little North Fork Ten Mile River had the largest number of salmon redds in 1995-96 while Bear Haven Creek and Smith Creek had the second and third largest numbers, respectively. Coho were found rearing in the Little North Fork Ten Mile River and Bear Haven Creek in 2 out of 3 years and in Smith Creek 3 out of 3 years.

Table 31: Habitat characteristics that are important to coho salmon of various Ten Mile River watershed streams

Stream	**% C-type channel (length)**	**% Scour pools (length)**	**% Scour pools (area)**	**% LWD-formed habitat (length)**	**% LWD-formed habitat (area)**	**% of summer MWAT > 16.8 °C**
Mill Creek	0	8	10	4	3	0
North Fork Ten Mile River	0	28	39	8	9	65
Little North Fork Ten Mile River	68	27	32	18	19	0
Blair Gulch	0	5	12	1	2	NS
Barlow Gulch	0	3	5	1	2	NS
Buckhorn Creek	0	3	6	0	0	0
McGuire Creek	0	6	19	2	3	NS
Cavanough Gulch	0	4	7	1	2	NS
O'Connor Gulch	0	8	7	0	0	NS
Bald Hill Creek	0	14	19	5	7	5
Gulch 8	0	5	1	1	1	NS
Gulch 11	0	6	7	0	0	NS
Gulch 19	0	9	15	0	0	NS
Patsy Creek	0	7	9	2	3	NS
Gulch 23	0	3	9	0	0	NS
Clark Fork Ten Mile River	0	26	26	7	9	35
Bear Haven Creek	83	21	32	12	19	0
Little Bear Haven Creek	51	14	12	2	2	0
Booth Gulch	0	5	10	0	0	0
Gulch 27	0	8	9	3	4	NS
South Fork Ten Mile River	17	22	23	9	10	35
Smith Creek	79	17	23	11	16	0
Campbell Creek	39	19	25	12	16	25
Churchman Creek	0	6	12	4	9	0
Redwood Creek	0	11	17	5	8	20

Shaded figures are those for which habitat indicators are equal or greater in value than those in coho streams.

Campbell Creek is the only tributary surveyed that has C-type channel; appears to contain enough scour pools and large woody debris-formed habitat; but, whose instream temperatures are slightly warmer than necessary. The number of coho salmon redds in Campbell Creek is lower than the basin wide average (for the year measured). But, rearing fish were observed there in 3 out of the 3 years of sampling. These data suggest that if habitat characteristics are sufficient, instream temperatures can exceed an MWAT of 16.8°C up to 25% of the time and still allow for coho to be present in the stream.

Several tributaries, including Mill Creek, Buckhorn Creek, Little Bear Haven Creek, Booth Gulch, and Churchman Creek have cool summer instream temperatures; but, there are not enough scour pools or large woody debris-formed habitat for coho to be present. Little Bear Haven Creek also has C-type channel. Of these streams, coho are actually present in Churchman Creek, despite pool habitat characteristics. Coho were also observed once in Buckhorn Creek since 1995. But, they are not present in any of the other listed streams, including Little Bear Haven Creek. The data for Churchman Creek are difficult to interpret.

Coho are not predicted to be present in any of the other tributaries due to a lack of C-type channel, insufficient length and area of habitat in scour pools and large woody debris-formed habitat units, as well as elevated summer temperatures. Coho have been observed once in Bald Hills Creek and Redwood Creek since 1995. But, because of their infrequent visits, coho are nonetheless considered to be absent from these tributaries.

4.4.3 Potential Limiting Factors

Limiting factors are those factors that are potentially limiting the success of salmonids within a given stream or watershed. They include such things as fine sediment in gravel limiting the growth or survival-to-emergence of salmonid embryos or elevated summer temperatures limiting the growth or survival of juveniles. For the purposes of this report, potentially limiting factors are identified based on the following data:

- Spawning (dominant substrate, embeddedness)
- Survival to emergence (% fine sediment, embeddedness)
- Summer rearing (temperature, % scour pools, % large woody debris-formed habitat, % pools ≥3 feet, % dry units, % canopy)
- Overwintering (% large woody debris-formed habitat, % backwater pools)
- Channel stability (% scour pools, % large woody debris-formed habitat)

None of the available data shed light on the condition of migration corridors from the ocean to potential spawning grounds. Potentially there are barriers to migration that should be considered a limitation to salmonid success. Their locations, however, are unknown to staff at the Regional Water Board.

4.4.2.1 Mill Creek

Mill Creek is a tributary to the Ten Mile River. There has been evidence of spawning in Mill Creek, as well as juvenile steelhead found. Coho were observed rearing in the stream in 1969, as were steelhead. Since then only steelhead have been found. Spawners were observed in 1989-90, but the species were not identified.

Mill Creek has both F-type (64%) and B-type (36%) channel characteristics with gravel (100%) dominated low gradient riffles and a pool frequency of 10%. The substrate contains an average of 20.7% fines (<0.85 mm) and is highly embedded (e.g., 100% of cobble is >50% embedded). Hines (2000) found no trend from 1995-1999 in the percent fines (<0.85 mm) data. The scour pools and LWD-formed habitat make up only 8% and 4% of the habitat by length, respectively. There are no backwater pools. None of the pools are greater than 3 feet deep. Seven percent of the habitat is dry. Weekly average stream temperatures never exceed an MWAT of 16.8 °C and there is a 97% shade canopy over the stream.

Mill Creek is potentially limited in its ability to support coho salmon as a result of its deep entrenchment, high stream bank erosion rates (e.g., F-type channel), elevated fine sediment, high embeddedness, poor pool frequency, poor scour pool frequency, poor LWD-formed habitat frequency, poor backwater pool frequency, and poor pool depths. Excellent stream temperatures and shade canopy may provide refuge from elevated mainstem temperatures.

4.4.2.2 North Fork Ten Mile River

The North Fork Ten Mile River is a tributary to the Ten Mile River. There is evidence of coho spawning in the lower reaches of the North Fork Ten Mile River. Juvenile coho have been observed once in the lower reaches, as well. Steelhead trout are regularly seen throughout the North Fork Ten Mile River.

The North Fork Ten Mile River is predominantly a B-type channel (100%) with gravel (53%) and small cobble (19%) dominated low gradient riffles and a pool frequency of 47%. The substrate contains an average of 19.1% fines (<0.85 mm) and is highly embedded (e.g., 72% of cobble is >75% embedded). Hines (2000) found no trend in the percent fines (<0.85 mm) data up high in the subwatershed; but, he did determine that sediment conditions have been fairly stable from 1995 to 1999 at points midway and low in the subwatershed. The scour pools and LWD-formed habitat make up 28% and 8% of the habitat by length, respectively. One percent of the pools are backwater pools. Fifty-three percent of the pools are greater than 3 feet deep. None of the stream channel is dry in the summer. Weekly average stream temperatures exceed an MWAT of 16.8 °C 65% of the summer and there is a 70% shade canopy over the stream.

North Fork Ten Mile River is potentially limited in its ability to support coho salmon as a result of its elevated fine sediment, high embeddedness, poor LWD-formed habitat frequency, poor backwater pool frequency, elevated summer temperatures, and poor shade canopy. Good scour pool frequency and pool depths could potentially provide summer rearing habitat if stream temperatures were lower. Coho have been found up to Camp 3 in the North Fork Ten Mile River (just above the confluence with Clark Fork Ten Mile River and below Little North Fork Ten Mile River). Prime habitat indicators suggest that LWD-formed habitat and stream temperatures are critical limiting factors.

4.4.2.3 Little North Fork Ten Mile River

The Little North Fork Ten Mile River is a tributary to the North Fork Ten Mile River. There is evidence of both coho and steelhead spawning in the Little North Fork Ten Mile River. In addition, there is evidence of juvenile rearing of both species going back to 1961.

The Little North Fork Ten Mile River has C-type (68%), B-type (19%), and F-type(13%) channel characteristics with gravel (100%) dominated low gradient riffles and a pool frequency of 44%. The substrate contains an average of 16.4% fines (<0.85 mm) and is highly embedded (e.g., 88% of cobble is >75% embedded). Hines (2000) found a decreasing trend in percent fines (<0.85 mm) from 1995 to 1999. The scour pools and LWD-formed habitat make up 27% and 18% of the habitat by length, respectively. Four percent of the pools are backwater pools. Thirteen percent of the pools are greater than 3 feet deep. None of the stream channel is dry in the summer. Weekly average stream temperatures never exceed an MWAT of 16.8°C and there is a 93% shade canopy covering the stream.

Little North Fork Ten Mile River is potentially limited in its ability to support coho salmon as a result of elevated fines (<0.85 mm), high embeddedness, and poor pool depth. The Little North Fork’s channel form with its low gradient, meandering point-bar, riffle/pool complex and broad, well-defined floodplain may provide some the greatest possibility for coho salmon habitat restoration in the basin. Its pool frequency, scour pool frequency, LWD-formed habitat frequency, backwater pool frequency, and stream temperatures explain why the Little North Fork Ten Mile River currently supports the greatest density of coho spawners in the basin and an above-average density of summer juveniles.

4.4.2.4 Blair Gulch, Barlow Gulch, and Buckhorn Gulch

Blair Gulch, Barlow Gulch and Buckhorn Gulch are tributaries to the Little North Fork Ten Mile River. There is no data regarding salmonid presence for Blair and Barlow Gulches. Data collected from Buckhorn Gulch shows little evidence of steelhead spawning and no evidence of coho spawning. Juvenile steelhead are regularly found in Buckhorn Gulch while coho juveniles have been found only once.

All of these tributaries are F-type channel with gravel (100%) dominated low gradient riffles and pool frequencies ranging from 11-19%. There are no substrate composition measurements in Blair or Barlow Gulches. But, substrate in Buckhorn Gulch contains an average of 20.6% fines (<0.85 mm). Hines (2000) could not confirm an apparent decreasing trend in percent fines (<0.85 mm) from 1995-1999. Cobble in all three streams are completely embedded (e.g., 93-100% of cobble >75% embedded). The scour pools and LWD-formed habitat make up between 3-5% and 0-1% of the habitat length, respectively. Zero to one percent of the pools are backwater pools. Zero to three percent of the pools are greater than 3 feet deep. Blair Gulch is 7% dry while Barlow Gulch and Buckhorn Gulch are 38% and 15% dry, respectively. There are no stream temperature measurements in Blair Gulch or Barlow Gulch. But, Buckhorn Creek never exceeds an MWAT of 16.8 °C. Shade canopy ranges from 93-100%.

Blair Gulch, Barlow Gulch, and Buckhorn Creek are potentially limited in their ability to support coho salmon as a result of their deep entrenchment, stream bank erosion rate (e.g., F-type channel), poor pool frequency, elevated fine sediment, high embeddedness, poor scour pool frequency, poor LWD-formed habitat frequency, poor backwater pool frequency, and poor pool depth. Without substrate composition measurements and/or hillslope erosion rate estimates for Blair and Barlow Gulches, it is difficult to know the degree to which sediment conditions in those streams are impacting the Little North Fork Ten Mile River. One suspects, however, that with little LWD for sediment metering and high cobble embeddedness, there may be significant sediment delivery downstream. Similarly, the elevated fine sediment in Buckhorn Gulch is likely impacting conditions downstream. It is unlikely that Blair Gulch, Barlow Gulch or Buckhorn Gulch are impacting the stream temperatures of Little North Fork Ten Mile River due to their excellent shade canopy.

4.4.2.5 McGuire Creek

McGuire Creek is a tributary to the Little North Fork Ten Mile River. There is not data regarding the presence or absence of salmonids in McGuire Creek. Prime habitat indicators suggest the absence of coho from McGuire Creek.

McGuire Creek has both B-type (84%) and D-type (16%) channel characteristics with gravel (100%) dominated low gradient riffles and a pool frequency of 16%. There is no substrate composition measurements; but, cobble is highly embedded (e.g., majority > 75% embedded). The scour pools and LWD-formed habitat make up 6% and 2% of the habitat length, respectively. Two percent of the pools are backwater pools. Five percent of the pools are greater than 3 feet deep. Thirteen percent of the stream channel is dry in the summer. There are no summer temperature measurements; but, there is a 90% shade canopy covering the stream.

McGuire Creek is potentially limited in its ability to support coho salmon as a result of its poor pool frequency, high embeddedness, poor scour pool frequency, poor LWD-formed habitat frequency, poor backwater pool frequency, poor pool depth and dry summer reaches. Without sediment composition data it is difficult to determine the degree to which sediment delivery from McGuire Creek may be impacting the Little North Fork Ten Mile River. But, with little LWD, moderate gradients, and high embeddedness, one suspects a significant delivery of fines downstream. Good shade canopy suggests that stream temperatures are likely good. A B-type channel has a moderate gradient and is predominated by rapids and scour pools. The poor scour pool frequency and dry area suggest that the stream may be aggraded. Upslope assessment may identify excessive soil movement and delivery.

4.4.2.6 Cavanough Gulch

Cavanough Gulch is a tributary to the North Fork Ten Mile River. Cavanough Gulch is a B-type channel (100%) with small cobble dominated low gradient riffles, and a pool frequency of 7%. There are no substrate composition measurements for Cavanough Gulch; but, cobble is substantially embedded (e.g., majority of cobble greater than 50% embedded). The scour pools and LWD-formed habitat make up 4% and 1% of the habitat by length, respectively. Ten percent of the pools are backwater pools. Three percent of the pools are greater than 3 feet deep. Fifty-four percent of the stream channel is dry in the summer. There are no stream temperature measurements; but, there is a 98% shade canopy over the stream.

Cavanough Gulch is potentially limited in its ability to support coho salmon as a result of it’s large substrate size, poor pool frequency, high embeddedness, poor scour pool frequency, poor LWD-formed habitat frequency, poor pool depth, and large dry area. Though there are no substrate composition measurements, the lack of LWD for sediment metering and the high embeddedness suggest that fines may be high. Though there are no stream temperature measurements, the excellent shade canopy suggests that temperatures are probably fine. A B-type channel has a moderate gradient and is predominated by rapids and scour pools. The poor scour pool frequency and large dry area suggest that the stream is substantially aggraded. Upslope assessment may identify excessive soil movement and delivery. There is no evidence of coho in Cavanough Gulch and the prime indicators suggest they are not present.

4.4.2.7 O’Connor Gulch

O’Connor Gulch is a tributary to the North Fork Ten Mile River. O’Connor Gulch is B-type channel (100%) with gravel-dominated low gradient riffles, and a pool frequency of 12%. There are no substrate composition measurements for O’Connor Gulch; but, cobble is substantially embedded (e.g., majority of cobble is >75% embedded). The scour pools and LWD-formed habitat make up 8% and 0% of the habitat by length, respectively. None of the pools are backwater pools. None of the pools are greater than 3 feet deep. One percent of the stream channel is dry in the summer. There are no stream temperature measurements; but, there is a 99% shade canopy covering the stream.

O’Connor Gulch is potentially limited in its ability to support coho salmon as a result of its poor pool frequency, high embeddedness, poor scour pools frequency, poor LWD-formed habitat frequency, poor backwater pool frequency, and poor pool depth. Though there are no substrate composition measurements, the lack of LWD for sediment metering and high embeddedness suggest that there may be elevated fine sediment. Though there are no stream temperature measurements, the excellent shade canopy suggest that stream temperatures are likely fine. A B-type channel has a moderate gradient and is predominated by rapids and scour pools. The poor scour pool frequency and pool depth suggest that the stream may be aggraded. Upslope assessment may identify excessive soil movement and delivery. There is no evidence of coho in O’Connor Gulch and prime indicators suggest they are not present.

4.4.2.8 Bald Hills Creek

Bald Hills Creek is a tributary to the North Fork Ten Mile River. About half of Bald Hills Creek is a B-type channel while the remaining half is an F-type channel. It has gravel-dominated low gradient riffles and a pool frequency of 26%. The substrate contains an average of 13.5% fines (<0.85 mm) but is moderately to highly embedded (e.g., half the cobble is <50% embedded while the remaining is > 50% embedded). Hines (2000) found a decreasing trend in percent fines (0.85 mm) from 1995-1999. The scour pools and LWD-formed habitat make up 14% and 5% of the habitat length, respectively. One percent of the pools are backwater pools. Eleven percent of the pools are greater than 3 feet deep. Five percent of the stream channel is dry in the summer. Weekly average temperatures exceed an MWAT of 16.8 °C only 5% of the summer and there is a 87% shade canopy covering the stream.

Bald Hills Creek is potentially limited in its ability to support coho salmon as a result of its deep entrenchment and high stream bank erosion rates in the F-type channel reaches, moderate pool frequency, moderate embeddedness, moderate scour pool frequency, poor LWD-formed habitat frequency, poor backwater pool frequency, and moderate pool depth. Its substrate composition and stream temperature are excellent, however. Coho were seen rearing in Bald Hills Creek one summer. One pair may have been observed spawning one year, as well; but, the species was not identified. Prime habitat indicators suggest that coho are not currently present. However, improvements to LWD loading could potentially improve scour pool formation and pool depth to a degree acceptable to coho.

4.4.2.9 Gulch 8, Gulch 11, and Gulch 23

Gulch 8, Gulch 11, and Gulch 23 are tributaries to the North Fork Ten Mile River. Gulch 8, Gulch 11 and Gulch 23 are B-type channels (100%). Gulch 8 has an equal mixture of gravel, cobble and boulder composing its low gradient riffles while Gulch 11 and Gulch 23 are dominated by boulder. Gulch 8 has a pool frequency of 23% while Gulch 11 and Gulch 23 have a pool frequency of 8% and 9%, respectively. There are no substrate composition measurements for these gulches; but, cobble are highly embedded (e.g., majority of cobble are >50% embedded). The scour pools and LWD-formed habitat make up between 3-6% and 0-1% of the habitat length, respectively. Zero to two percent of the pools are backwater pools. Zero to ten percent of the pools are greater than 3 feet deep. Between 0-2% of Gulch 8 and Gulch 11 are dry during the summer which 30% of Gulch 23 is dry. There are no stream temperature measurements for these Gulches. There is a 90% shade canopy over Gulch 23. But, Gulch 8 and Gulch 11 have a 86% and 81% shade canopy, respectively.

Gulch 8, Gulch 11 and Gulch 23 are potentially limited in their ability to support coho salmon as a result of their large substrate size, high embeddedness, pool scour pool frequency, poor LWD-formed habitat frequency, poor backwater pool frequency, and poor pool depths. In addition, a comparison of stream temperature and shade canopy data basin wide indicates that a shade canopy greater than 90% may be necessary to protect stream temperatures. As such, Gulch 8 and Gulch 11 may be limited by moderate stream temperatures. The poor pool frequencies in Gulch 11 and Gulch 23 as well as the extensive dry reaches in Gulch 23 may also be limiting. A B-type channel has a moderate gradient and is predominated by rapids and scour pools. The poor scour pool frequency, poor pool depths and large dry area (in Gulch 23) suggest that these streams may be aggraded. Upslope assessment may identify excessive soil movement and delivery. There is no data indicating the presence or absence of coho in these streams. Prime habitat indicators, however, suggest that they are absent.

4.4.2.10 Gulch 19 and Patsy Creek

Gulch 19 and Patsy Creek are tributaries to the North Fork Ten Mile River. Gulch 19 and Patsy Creek are F-type channels. Gulch 19 has gravel-dominated low gradient riffles (50%) though boulder are subdominant (33%). The low gradient riffles in Patsy Creek are evenly composed of gravel, boulder and cobble. Pool frequencies range from 18-19%. There are no substrate composition measurements for Gulch 19. But, the substrate of Patsy Creek contains an average of 23.7% fines (<0.85 mm), the highest measured in the basin. Hines (2000) found a decreasing trend in percent fines (<0.85 mm) from 1995-1999. Cobble is highly embedded (e.g., majority of cobble are >50% embedded). The scour pools and LWD-formed habitat make up between 7-9% and 0-2%, respectively. Eight percent of the pools in Gulch 19 are backwater pools while none of the pools in Patsy Creek are. Between 7-8% of the pools are greater than 3 feet deep. Between 1-2% of the stream channels are dry in the summer. There are no stream temperature measurements in either stream; but, shade canopy is 87% in Gulch 19 and 92% in Patsy Creek.

Gulch 19 and Patsy Creek are potentially limited in their ability to support coho salmon as a result of their deep entrenchment and high stream bank erosion rate (e.g., F-type channel), moderate availability of gravel, moderate pool frequency, elevated fine sediment, high embeddedness, poor scour pool frequency, poor LWD-formed habitat frequency, and poor pool depth. In addition, Patsy Creek may be limited by poor backwater pool frequency and moderate stream temperatures. The potential value of these streams for coho appears minimal. There is no evidence of coho spawning or rearing in these streams. Indeed, prime habitat indicators suggest that they are absent. Their potential contribution of sediment to the North Fork Ten Mile River, however, appears substantial.

4.4.2.11 Clark Fork Ten Mile River

The Clark Fork Ten Mile River is a tributary to the Ten Mile River. The Clark Fork Ten Mile River is predominantly a B-type channel (91%) with equal proportions of gravel, cobble and boulder in low gradient riffles, and a pool frequency of 44%. The substrate contains an average of 18.6% fines (<0.85 mm) and is highly embedded (e.g., majority of cobble >75% embedded). Hines (2000) found a stable trend in percent fines (<0.85 mm) from 1995-1999 at a point low in the subwatershed. He found no trend at a point midway up the subwatershed and was unable to confirm an apparent increasing trend at a point high in the subwatershed. The scour pools and

LWD-formed habitat make up 26% and 7% of the habitat length, respectively. One percent of the pools are backwater pools. Fifty-two percent of the pools are greater than 3 feet deep. None of the stream channel is dry in the summer. Weekly average stream temperatures exceed an MWAT of 16.8 °C 35% of the summer and there is a 76% shade canopy covering the stream.

The Clark Fork Ten Mile River is potentially limited in its ability to support coho salmon as a result of its moderate availability of gravel, moderately elevated fine sediment, high embeddedness, poor LWD-formed habitat frequency, poor backwater pool frequency, and elevated summer stream temperatures. Good scour pool frequency and pool depths could potentially provide summer rearing habitat if stream temperatures were lower. Coho salmon have been observed both spawning and rearing in the Clark Fork Ten Mile River. Prime habitat indicators suggest that LWD-formed habitat and stream temperatures are critical limiting factors.

4.4.2.12 Bear Haven Creek

Bear Haven Creek is a tributary to the Clark Fork of the Ten Mile River. Bear Haven Creek is predominantly a C-type channel (83%) with gravel dominated low gradient riffles and a pool frequency of 33%. The substrate contains an average of 16.8% fines (<0.85 mm) and is highly embedded (e.g., majority of cobble >75% embedded). Hines (2000) was unable to confirm an apparent increasing trend in percent fines (<0.85 mm) from 1995-1999. The scour pools and LWD-formed habitat make up 21% and 12% of the habitat length, respectively. One percent of the pools are backwater pools. Eleven percent of the pools are greater than 3 feet deep. Six percent of the stream channel is dry in the summer. Weekly average stream temperatures never exceed an MWAT of 16.8 °C during the summer and there is a shade canopy of 91%.

Bear Haven Creek is potentially limited in its ability to support coho salmon as a result of its moderately elevated fine sediment, high embeddedness, poor backwater pool frequency, moderate pool depth, and moderate length of dry stream. Coho have been observed both spawning and rearing in Bear Haven Creek. Indeed the prime habitat indicators suggest their presence in the stream.

4.4.2.13 Little Bear Haven Creek

Little Bear Haven Creek is a tributary to the Clark Fork Ten Mile River. There is evidence of steelhead spawning in Little Bear haven Creek; but, not that of coho salmon. Juvenile steelhead are also found throughout the stream, while coho salmon are not. Prime habitat indicators suggest that coho could be present in the stream.

About half of Little Bear Haven Creek is a C-type channel while the remaining is a B-type channel. Little Bear haven Creek is predominated by gravel in its low gradient riffles (75%) with sand making up the remaining proportion. It has a pool frequency of 33%. The substrate contains 16.4% fines (<0.85 mm) on average and is entirely embedded (e.g., 95% of cobble is >75% embedded). Hines (2000) found a decreasing trend in percent fines (<0.85 mm) from 1995-1999. The scour pools and LWD-formed habitat make up 14% and 2% of the habitat length, respectively. Five percent of the pools are backwater pools. Ten percent of the pools are greater than 3 feet deep. None of the stream channel is dry in the summer. Weekly average stream temperatures never exceed an MWAT of 16.8 °C in the summer and there is a 91% shade canopy over the stream.

Little Bear Haven Creek is potentially limited in its ability to support coho salmon as a result of its moderate levels of fine sediment, high embeddedness, moderate scour pool frequency, poor LWD-formed habitat frequency, and poor pool depths. The availability of C-type channel, the pool frequency, backwater pool frequency, and lack of dry reaches, indicates that Little Bear Haven Creek has the potential to support coho were fine sediment reduced and large woody debris volumes increased.

4.4.2.14 Booth Gulch

Booth Gulch is a tributary to the Clark Fork Ten Mile River There is scant evidence of coho spawning in Booth Gulch though juvenile coho have never been found there. Juvenile steelhead, on the other hand, have been seen there regularly. Prime habitat indicators suggest that coho salmon are absent from Booth Gulch.

Booth Gulch is predominantly an F-type channel (82%) though a small portion is classified as a B-type channel. Gravel (75%) and cobble (25%) are found in the low gradient riffles and the pool frequency is 13%. The substrate contains 23.0% fines (<0.85mm) on average and is highly embedded (e.g., 72% of cobble are >75% embedded). Hines (2000) was unable to confirm an apparent increasing trend in percent fines (<0.85 mm) from 1995-1999. The scour pools and LWD-formed habitat make up 5% and 0% of the habitat length, respectively. One percent of the pools are backwater pools. Thirteen percent of the pools are greater than 3 feet in depth. Sixteen percent of the stream channel is dry in the summer. Weekly average stream temperatures never exceed an MWAT of 16.8 °C in the summer and there is a 91% shade canopy over the stream.

Booth Gulch is potentially limited in its ability to support coho salmon as a result of its high stream bank erosion rates, poor pool frequency, elevated fine sediment, high embeddedness, poor scour pool frequency, poor LWD-formed habitat frequency, poor backwater pool frequency, poor pool depth, and dry stream reaches. The availability of cool water temperatures and good shade canopy may offer cold water refuge from elevated stream temperatures in the Clark Fork Ten Mile River.

4.4.2.15 Gulch 27

Gulch 27 is a tributary to the Clark Fork Ten Mile River. There is no data regarding the presence or absence of coho in Gulch 27. Prime habitat indicators, however, suggest that coho are absent.

Gulch 27 is predominantly a B-type channel (75%) but contains F-type channel (24%) and A-type channel (1%), as well. Gulch 27 is dominated by small cobble (75%) and boulder (25%) in its low gradient riffles and has a pool frequency of 22%. The proportion of fine sediment in Gulch 27 has not been measured. But, embeddedness is high (e.g., 68% of cobble are >75% embedded). The scour pools and LWD-formed habitat make up 8% and 3% of the habitat length, respectively. None of the pools are backwater pools. Twenty-four percent of the pools are greater than 3 feet deep. None of the stream channel is dry in the summer. Stream temperatures have not been measured in Gulch 27; but, there is an 85% shade canopy covering the stream.

Gulch 27 is potentially limited in its ability to support coho salmon as a result of its moderate stream bank erosion rate (e.g., F-type channel), large substrate size, poor pool frequency, high embeddedness, poor scour pool frequency, poor LWD-formed habitat frequency, poor backwater pool frequency, moderate pool depth, and moderate shade canopy. The value Gulch 27 as coho stream appears minimal.

4.4.2.16 South Fork Ten Mile River
The South Fork Ten Mile River is a tributary to the Ten Mile River. There is evidence of both coho and steelhead spawning in the South Fork Ten Mile River. In addition, there is evidence of both species there going back to 1961. The south Fork Ten Mile River is predominantly a B-type channel (82%) with some C-type channel (17%) and F-type channel (1%) also represented. Its low gradient riffles are dominated by gravel (88%) and small cobble (10%) and its pool frequency is 31%. The substrate contains 15.5% fines (<0.85 mm) on average. The range, however, is from 9.2% to 28.2%. Hines (2000) found a decreasing trend in percent fines (<0.85 mm) from 1995-1999 at a point midway up the subwatershed. He found no trend at a point just immediately upstream. Nor did he find a trend at a point in the upper subwatershed. Hines (2000) was unable to confirm an apparent increasing trend in percent fines (<0.85 mm) at a point high in the subwatershed or an apparent decreasing trend at a point in the lower subwatershed. Cobble are highly embedded (e.g., 74% of cobble are >75% embedded). The scour pools and LWD-formed habitat make up 22% and 9% of the habitat length, respectively. None of the pools are backwater pools. Thirty-seven percent of the pools are greater than 3 feet deep. One percent of the stream channel is dry in the summer. Weekly average temperatures exceed a MWAT of 16.8 °C an average of 35% of the summer and there is a shade canopy of 77%.

The South Fork Ten Mile River is potentially limited in its ability to support coho salmon as a result of its moderate level of fine sediment, high embeddedness, poor LWD-formed habitat frequency, poor backwater pool frequency, elevated stream temperatures, and poor shade canopy. The availability of C-type channel, gravel substrate, good scour pool frequency, moderately good pool depths, and absence of significant dry reaches suggest that the stream offers significant potential benefits to coho salmon.

4.4.2.17 Smith Creek and Campbell Creek
Smith and Campbell Creeks are tributaries to the South Fork Ten Mile River. There is evidence of both coho and steelhead spawning in the stream. In addition, there is evidence of juveniles of both species rearing in the both streams. The evidence for Smith Creek goes back to 1961.

Smith and Campbell Creeks have both B-type and C-type channel reaches, through in different proportion: Smith Creek has 21% B-type channel and 79% C-type channel while Campbell Creek has 61% B-type channel and 39% C-type channel. The low gradient riffles of Smith and Campbell Creeks are dominated by gravel (99% and 98%, respectively). Their pool frequencies are 21% and 25%, respectively. The substrate contains 17.7% and 21.8% fines (<0.85 mm), respectively and is entirely embedded (e.g., 84% and 87% of the cobble, respectively, is >75% embedded). Hines (2000) found a stable trend in percent fines (<0.85 mm) from 1995-1999 in Campbell Creek, but an increasing trend in Smith Creek. The scour pools make up 17% and 19% of the habitat length, respectively. The LWD-formed habitat makes up 11% and 12% of the habitat length, respectively. None of the pools in either stream are backwater pools. Seven percent and two percent of the pools in Smith Creek and Campbell Creek are greater than 3 feet deep, respectively. Five percent and three percent of the stream channel is dry in the summer, respectively. Weekly average stream temperatures in Smith Creek never exceed an MWAT of 16.8 °C while they exceed the MWAT in Campbell Creek 25% of the time. The shade canopy in both creeks is 83%.

Smith and Campbell Creeks are potentially limited in their ability to support coho salmon as a result of their poor pool frequency, moderately to highly elevated fine sediment, high embeddedness, poor backwater pool frequencies, poor pool depths, moderate dry reaches, and moderate shade canopy. Campbell Creek may be further limited by its moderate summer stream temperatures. Coho are present in these streams which may be due to the availability of C-type channel, scour pools, and LWD-formed habitat. In addition, there are cool temperatures in Smith Creek. Habitat conditions could potentially be improved by reducing fine sediment loading and improving the sediment metering and scouring functions of the stream channels with an increase in LWD volume.

4.4.2.18 Churchman Creek

Churchman Creek is a tributary to the South Fork Ten Mile River. There is evidence of both coho salmon and steelhead trout spawning and rearing in this stream.

Churchman Creek is a B-type channel (100%) with gravel-dominated low gradient riffles (96%) and a pool frequency of 8%. The substrate contains 15.5% fines (<0.85 mm), on average, and is entirely embedded (e.g., 98% of the cobble is >75% embedded). Hines (2000) could not confirm an apparent decreasing trend in percent fines (<0.85 mm) from 1995-1999. The scour pools and LWD-formed habitat make up 6% and 4% of the habitat length, respectively. Two percent of the pools are backwater pools. Two percent of the pools are greater than 3 feet deep. Twenty percent of the stream channel is dry in the summer. Weekly average temperatures never exceed an MWAT of 16.8 °C and there is a 90% shade canopy over the stream.

Churchman Creek is potentially limited in its ability to support coho salmon as a result of its poor pool frequency, moderate level of fine sediment, high embeddedness, poor scour pools frequency, poor LWD-formed habitat frequency, poor backwater pool frequency, poor pool depths, and large area of dry stream channel in the summer. Indeed, it is unclear why coho salmon are found in this stream at all. What coho are able to spawn here may stay in Churchman Creek simply because of the stream temperatures. Improving sediment metering and scouring ability of the stream would potentially improve habitat conditions for salmonids.

4.4.2.19 Redwood Creek

Redwood Creek is a tributary to the South Fork Ten Mile River. There is evidence of spawning in Redwood Creek; but the species is unknown. There is no evidence of coho rearing; but juvenile steelhead are regularly seen in Redwood Creek.

Redwood Creek is a B-type channel with gravel (89%) and small cobble (10%) dominated low gradient riffles and a pool frequency of 19%. The substrate contains 18.1% fines (<0.85 mm) on average and is entirely embedded (e.g., 88% of cobble is >75% embedded). Hines (2000) found no trend in percent fines (<0.85 mm) from 1995-1999. The scour pools and LWD-formed habitat make up 11% and 5% of the habitat length, respectively. Two percent of the pools are backwater pools. Seventeen percent of the pools are greater than 3 feet deep. Two percent of the stream channel is dry in the summer. Weekly average temperatures exceed an MWAT of 16.8 °C 20% of the summer and there is an 84% shade canopy over the stream.

Redwood Creek is potentially limited in its ability to support coho as a result of its poor pool frequency, moderate level of fines (<0.85 mm), high embeddedness, poor scour pool frequency, poor LWD-formed habitat frequency, poor backwater pool frequency, poor pool depth, elevated stream temperatures, and moderate stream canopy. Redwood Creek is only fundamentally limited in its ability to support coho as result of its location in the headwaters of the South Fork Ten Mile subwatershed. Reductions in sediment delivery and improvements in sediment metering could potentially improve deliver of fine sediment to downstream reaches.

4.5 CONCLUSIONS AND RECOMMENDATIONS

According to Weitkamp (1995), the Ten Mile River watershed harbors the last native coho salmon in Mendocino County. Native coho may spawn in other Mendocino coastal streams, as well. But, their numbers are unknown. As such, protection of the fish and restoration of their habitat in the Ten Mile River watershed is of paramount importance.

4.5.1 Conclusions

The existing data indicate that coho salmon continue to spawn and rear with some regularity in the Little North Fork Ten Mile River, Clark Fork Ten Mile River, Bear Haven Creek, South Fork Ten Mile River, Smith Creek, Campbell Creek, and Churchman Creek. For the most part, these streams have at least some C-type channel; a scour pool frequency of at least 17% (by length), a LWD-formed habitat frequency of at least 11% (by length), and weekly average summer stream temperatures no more than 16.8 °C. Campbell Creek has all of these habitat characteristics except good stream temperatures. The South Fork Ten Mile River is lacking large woody debris-formed habitat. The Clark Fork Ten Mile River has sufficient scour pools, only. And, Churchman Creek has cool stream temperatures, only. Coho salmon have been observed once in the North Fork Ten Mile River, Bald Hill Creek, Buckhorn Creek, and Redwood Creek, as well.

The level of fine sediment (<0.85 mm) in substrate is elevated in reaches throughout the watershed. Fines (<0.85 mm) are particularly elevated (e.g., >20%) in Mill Creek, Buckhorn Creek, the North Fork Ten Mile River at Gulch 9, Patsy Creek, Booth Gulch, and Campbell Creek. They are generally decreasing, however, in the North Fork Ten Mile River subwatershed and holding steady in the Clark Fork and South Fork Ten Mile River subwatersheds. Hines (2000) suggests that the decrease in fine sediment (<0.85 mm) in the North Fork Ten Mile River subwatershed may reflect the fact that old growth logging was completed there far later than in the Clark and South forks. As such, the level of fines (<0.85 mm) in substrate may soon reach a plateau as the subwatershed recovers from the old growth logging.

Other conclusions include:

- Shelter is extremely poor throughout the watershed, including large woody debris.

- Stream temperatures are elevated in the three main forks. They are also elevated in Campbell Creek and Redwood Creek. At these locations, more than 16% of the stream side canopy is open.
- The percentage of habitat in scour pools is extremely poor in all but the main forks and Little North Fork Ten Mile River, Bear Haven Creek, Smith Creek and Campbell Creek.
- The percentage of habitat formed by large woody debris is extremely poor in all but Little North Fork Ten Mile River, Bear Haven Creek, Smith Creek and Campbell Creek.
- The availability of C-type channel is limited to Little North Fork Ten Mile River, Bear Haven Creek, Little Bear Haven Creek, South Fork Ten Mile River, Smith Creek, and Campbell Creek.

4.5.2Potential watershed improvements

Coho salmon habitat in the Ten Mile River watershed could be significantly improved with reductions in sediment delivery, protection and improvement in riparian functions, increases in large woody debris for sediment metering and habitat, and modification of stream channel type. Potential watershed improvements are identified for each of the tributaries of the Ten Mile River watershed, divided by priority. High priority streams are refuge streams or streams tributary to refuge streams. Moderate priority streams are non-coho streams with habitat characteristics that could be improved for coho salmon or streams that are tributary to restorable coho streams. The main forks are low priority streams since improvements in upstream sediment delivery, sediment metering, and stream temperature are necessary before significant instream changes can be expected.

4.5.2.1 High priority streams

- The Little North Fork Ten Mile River is one of the watershed's strongest coho streams. It appears that were sediment delivery rates reduced, habitat conditions could be significantly improved: lower percentage of fines (<0.85 mm) in the substrate, lower embeddedness, and deeper pools. The tributaries to Little North Fork Ten Mile River may be significant sediment contributors.
- Blair Gulch, Barlow Gulch, and Buckhorn Gulch. Only the streamside canopy and stream temperatures of these tributaries favor the presence of coho. None of the other reported habitat characteristics are favorable. These tributaries may be significant sources of sediment to Little North Fork Ten Mile River. As such, they should be a high priority for sediment delivery reduction. A major conversion of channel type from F-type channel to C-type channel might provide greater salmonid habitat. But, the significance of the effort would make this a low restoration priority. Coho salmon have been observed in Buckhorn Creek once before. As such, instream restoration work in Buckhorn Creek may take precedence over the others.
- McGuire Creek does not appear to offer significant potential coho habitat. It does, however, appear to be substantially aggraded and may be contributing to elevated sediment downstream in the Little North Fork Ten Mile River. As such, McGuire Creek should be a high priority for sediment delivery reduction.
- Bear Haven Creek is another of the strongest coho streams in the watershed. With the exception of limited backwater pools, the primary issue of concern in Bear Haven Creek appears to be aggradation. Sediment delivery reductions in the Bear Haven Creek basin

should be a high priority. Improvements to LWD volumes may also improve sediment metering and backwater pool formation.
- Smith Creek and Campbell Creek are two other strong coho streams in the Ten Mile River watershed. Habitat conditions could potentially be improved by reducing fine sediment loading and improving the sediment metering and scouring functions of the stream channels with an increase in LWD volume. Temperatures in Campbell Creek could potentially be improved by increasing the streamside canopy.
- Habitat conditions in Churchman Creek could potentially be improved by reducing fine sediment loading and improving sediment metering and scouring functions of the stream channel with an increase in LWD volume.

4.5.2.2 Moderate priority streams
- Cavanough Gulch, O'Connor Gulch, Gulch 8, Gulch 11, Gulch 19, Gulch 23, and Patsy Creek do not appear to offer significant potential coho habitat. They do, however, appear to be substantially aggraded and may be contributing to elevated sediment downstream in the North Fork Ten Mile River.
- Bald Hill Creek is in many respects similar to the Little North Fork Ten Mile River basin, one of the watershed's best coho streams. One significant difference, however, is the absence of C-type channel in the Bald Hill Creek basin. It may be possible to convert some of the F-type channel found in Bald Hill Creek to C-type channel. But, the C-type channel will not regain access to its former floodplain, which is now defined as terrace. Most significantly, Bald Hill Creek could benefit from LWD placement for improved scouring. Sediment delivery reduction does not appear to be a high priority here. Coho salmon have been observed here once before.
- Habitat conditions in Little Bear Haven Creek could potentially be improved by reducing sediment delivery and improving sediment metering and channel scouring abilities with an increase in LWD volume. Little Bear Haven Creek has C-type channel and thus may have potential as a coho stream.
- Booth Gulch and Gulch 27 do not appear to offer significant potential coho habitat. They do, however, appear to be substantially aggraded and may be contributing to elevated sediment downstream in the Clark Fork Ten Mile River.
- Habitat conditions in Redwood Creek could potentially be improved by reducing sediment delivery and improving sediment metering and channel scouring abilities with an increase in LWD volume. Improvements to streamside canopy may improve instream temperatures, as well. Coho salmon have been observed here once before.

Bald Hill Creek, Little Bear Haven Creek and Redwood Creek are streams in which coho currently appear to be absent but in which coho may have spawned and reared in the recent past. As such, the restoration of these streams as coho streams is an important endeavor.

4.5.3 Additional data needs
The habitat inventories available for the Ten Mile River watershed provide an extraordinary snap shot of habitat conditions. Similarly, the population data, temperature data, and substrate composition data are incredibly useful for understanding conditions and trends in the basin. The availability of each of these data sets in electronic form for each of the years in which they were collected would vastly improve the ability of Regional Water Board staff to analyze it. Some

additional parameters that would help better understand changes in sedimentation in the basin, include:

- Longitudinal profiles
- Cross-sections
- V*
- LWD volume and distribution

Some locations where substrate data could confirm suspected aggradation include:

- Blair Gulch
- Barlow Gulch
- McGuire Creek
- Cavanough Gulch
- O'Connor Gulch
- Gulch 8
- Gulch 11
- Gulch 19
- Gulch 23
- Gulch 27

Continued and improved spawning, rearing, and outmigrant salmonid population studies are necessary to keep close track of the success of the few remaining native coho salmon.

[Insert Maps 1-11 here]

Tables

Assessment of Aquatic Conditions in the Ten Mile River Watershed

Table 14: Sampling stations located by G-P in the Ten Mile River watershed for the purpose of monitoring stream temperature, aquatic vertebrates, and substrate composition.

Station ID	Station location	Stream temperature	Aquatic vertebrates	Substrate composition
Lower Ten Mile River				
TEN1	Mill Creek	X	X	X
North Fork Ten Mile River subwatershed				
NFT1	NFT @ Patsy Creek	X	X	X
NFT2	Bald Hill Creek	X	X	X
NFT3	NFT @ O'Connor Gulch	X		
NFT4	NFT @ Camp 3	X	X	
NFT5	NFT @ Camp 5	X	X	X
NFT6	Lower Little North Fork Ten Mile River	X	X	X
NFT7	Buckhorn Creek	X	X	X
NFT8	Upper Little North Fork Ten Mile River	X	X	
NFT9	NFT @ Gulch 9	X	X	X
NFT10	Patsy Creek		X	X
NFT11	NFT @ property line	X		
NFT12	Bald Hill Creek (riffle)	X		
NFT13	NFT @ Patsy Creek (riffle)	X		
NFT14	NFT @ Camp 5 (riffle)	X		
NFT15	NFT/CFT confluence	X		
Clark Fork Ten Mile River subwatershed				
CFT1	CFT @ Reynolds' Gulch	X	X	X
CFT2	CFT @ Little Bear Haven Creek	X		X
CFT3	Lower Bear Haven Creek	X	X	X
CFT4	Lower CFT	X		X
CFT5	Booth Gulch	X	X	X
CFT6	Little Bear Haven Creek	X	X	X
CFT7	Upper Bear Haven Creek	X	X	
CFT8	CFT @ Ford Gulch	X	X	
CFT9	Lower CFT (riffle)	X		
CFT10	Booth Gulch (riffle)	X		
CFT11	CFT @ Bensi Crossing	X		
CFT12	CFT @ Gulch 18	X		
CFT13	CFT @ Gulch 18 (riffle)	X		
CFT19	Gulch 16	X		
South Fork Ten Mile River subwatershed				
SFT1	Smith Creek	X	X	X
SFT2	Campbell Creek	X	X	X
SFT3	SFT @ Brower's Gulch	X	X	X
SFT4	Churchman Creek	X	X	X
SFT5	SFT @ Buck Mathew's Gulch	X	X	X
SFT6	SFT @ Camp 28	X	X	X
SFT7	Lower Redwood Creek	X	X	
SFT8	Upper Redwood Creek	X	X	X
SFT9	Upper SFT	X	X	X
SFT11	Gulch 11	X		
SFT12	SFT above Gulch 11	X		
SFT13	SFT @ Churchman Creek			X
SFT15	SFT @ Camp 28	X		
SFT16	Lower SFT	X	X	
SFT17	SFT @ Brower's Gulch (riffle)	X		
SFT18	SFT @ Buck Mathew's Gulch (riffle)	X		
SFT19	Lower SFT (riffle)	X		

Table 15: Summary of Salmonid Spawning Survey Results given in the number of redds found per mile of stream surveyed (Maahs, 1995, 1996, 1997a).

Stream		**November 1989-February 1990**			**December 1995-January 1996**			**February – April 1996**		
		Redds/ mile	Live fish/mile	Coho carcasses	Redds/ mile	Live fish/mile	Coho carcasses	Redds/ mile	Live fish/mile	Coho carcasses
Lower Ten Mile River subwatershed										
Lower Ten Mile River		0.78	0	0	NS	NS	NS	NS	NS	NS
Mill Creek		0.1	0	0	NS	NS	NS	NS	NS	NS
North Fork Ten Mile River subwatershed		0.58	0.38	0	NS	NS	NS	NS	NS	NS
Vallejo Gulch		NS	NS	NS	0	2.5	0	0	2.5	0
North Fork Ten Mile River subwatershed										
Little North Fork		2.88	0.26	0	7.6	1.4	10	6.4	0.1	1
Buckhorn Creek		0	0	0	0	0	0	1.7	0	0
Cavanaugh Gulch		0	0	0	NS	NS	NS	NS	NS	NS
Bald Hills Creek		0	0	0	0	0	0	0	0	0
Patsy Creek		0.48	0.12	0	NS	NS	NS	NS	NS	NS
Stanley Creek		0	0	0	NS	NS	NS	NS	NS	NS
Clark Fork Ten Mile River subwatershed										
Clark Fork Ten Mile River (mainstem)	Confluence to Bear Haven Creek	0.48	0.16	4	1.2	1.1	1	2.6	0.07	0
	Bear Haven Creek to Little Bear Haven Creek				1.6	0.8	1	1.9	0.2	0
	Little Bear Haven Creek to Booth Gulch				1.9	0.3	0	3.2	0.1	0
	Booth Gulch to headwaters				0	0	0	4.4	0	0
Bear Haven Creek		2.4	0.16	0	5.9	0.7	4	9.0	0.1	1
SF Bear Haven		NS	NS	NS	2.5	0.9	0	15.0	0	0
Little Bear Haven Creek		3.3	0	0	0	0	0	3.8	0	0
South Fork Ten Mile River subwatershed										
South Fork Ten Mile River (mainstem)	Campbell Creek to Churchman Creek-	0.96	0.33	2	1.4	0.6	5	0.9	0	1
	Churchman to Camp 28				3.9	0.8	1	1.1	0.3	0
	Redwood Creek to headwaters				0	0	0	5.3	1.6	0
Campbell Creek		2.32	0.06	0	1.4	0.7	7	7.1	1.0	0
Churchman Creek		0.2	0.30	0	2.3	0	2	1.5	0	0
Gulch 11		0	0	0	0	0	0	6.9	0	0

Stream	November 1989-February 1990			December 1995-January 1996			February – April 1996		
	Redds/ mile	Live fish/mile	Coho carcasses	Redds/ mile	Live fish/mile	Coho carcasses	Redds/ mile	Live fish/mile	Coho carcasses
Redwood Creek	0.41	0	0	NS	NS	NS	NS	NS	NS
North Fork Redwood Creek	0	0	0	NS	NS	NS	NS	NS	NS
Smith Creek	0.80	0.09	0	4.6	1.2	4	3.9	0.5	0

Redds present between December and January are more likely to be coho or chinook redds. The redds present February through April are more likely to be steelhead.

Table 17: Fish density data for various sampling locations throughout the Ten Mile River watershed as reported by the Department of Fish and Game (unpublished data) and GP (Ambrose et al., 1996; Ambrose and Hines, 1997 & 1998, and Hines, 2000)

Site ID	**Stream**	**Coho salmon density (fish/m^2)**					**Steelhead trout density (fish/m^2)**								
		1995	1996	1997	1998	1999	1983*	1991*	1993	1994	1995	1996	1997	1998	1999
Lower Ten Mile River subwatershed															
TEN1	Mill Creek	0	0	0	0.01	0	NS	NS	0.32	0.32	0.38	0.35	0.37	0.60	0.49
North Fork Ten Mile River subwatershed															
NFT1	NFT below Patsy Creek	0	0	0	0	0.004	NS	NS	0.45	0.47	0.58	0.61	1.05	0.46	0.76
NFT2	Bald Hill Creek	0	0.01	0	0	0	0.20	0.40	0.48	0.47	0.53	0.42	0.41	0.23	0.37
NFT4	NFT @ Camp 3	0	0.05	0	0	0.005	NS	NS	0.36	0.99	0.12	0.12	0.07	0.11	0.08
NFT5	NFT @ Camp 5	0	0	0		0	NS	NS	0.39	0.60	0.04	0.21	0.23	0.09	0.27
NFT6	Lower Little North Fork Ten Mile River*	0	0.18	0.01	0.004	0.02	0.60	NS	NS	1.50	0.57	0.62	0.77	0.92	0.02
NFT7	Buckhorn Creek	0	0.22	0	0	0	0.30	0.22	0.50	0.72	0.75	0.49	0.26	0.36	0.26
NFT8	Upper Little North Fork Ten Mile River	0	0.15	0.01	0	0	NS	NS	0.38	0	0.85	0.75	0.16	0.20	0.59
NFT9	NFT @ Gulch 9	0	0	0	0	0	NS	NS	0.32	0.64	1.63	0.29	0.50	NS	0.47
Clark Fork Ten Mile River subwatershed															
CFT1	CFT @ Reynold's Gulch	0	0.02	0	0	0	NS	NS	0.74	0.44	0.78	0.61	0.57	0.46	1.02
CFT3	Lower Bear Haven Creek	0	0.01	0.03	0	0	2.37	0.62	0.83	1.20	0.61	0.52	0.56	0.41	0.28
CFT5	Booth Gulch	0	0	0	0	0	0.93	NS	0.45	0.13	0.74	1.00	0.41	0.20	0.74
CFT6	Little Bear Haven Creek	0	0	0	0	0	0.45	0.32	0.28	0.40	0.36	0.44	0.42	0.25	0.32
CFT7	Upper Bear Haven Creek	0	0.01	0.14	0	0.005	NS	NS	0.48	0.58	0.71	0.61	0.64	0.45	0.31
CFT8	CFT @ Ford Gulch	0	0	0	NS	NS	NS	NS	0.20	0.15	0.28	0.11	0.18	NS	NS
South Fork Ten Mile River subwatershed															
SFT1	Smith Creek	0.01	0.15	0.04	0	0	NS	NS	0.53	0.67	0.36	0.50	0.32	0.23	0.17
SFT2	Campbell Creek	0.02	0.35	0.01	0	0.01	NS	0.13	0.30	0.61	0.74	0.85	0.56	0.53	0.42
SFT3	SFT @ Brower's Gulch	0	0.004	0	0	0.004	NS	NS	0.08	0.66	0.19	0.33	0.33	0.25	0.71
SFT4	Churchman Creek	0	0.05	0.10	0.004	0.02	NS	NS	0.42	1.20	0.37	0.34	0.48	0.30	0.21
SFT5	SFT @ Buck Mathews Gulch	0	0.02	0	0	0.01	NS	NS	0.23	0.83	0.57	0.30	0.52	0.27	0.32
SFT7	Lower Redwood Creek	0	0	0	0	0	NS	0.34	NS	0.89	0.77	0.57	0.77	0.55	0.97
SFT8	Upper Redwood Creek	0	0	0	0	0	NS	NS	0.25	0.70	0.25	0.33	0.42	0.66	0.34
SFT9	Upper SFT	0	0	0	0	0	NS	0.21	0.17	0.35	0.34	0.07	0.03	0.66	0.07
SFT15	SFT @ Camp 28	0	0	0	NS	NS	NS	NS	0.85	2.30	1.74	1.33	1.35	0.91	1.14

* The Department of Fish and Game collected data at a few locations in the Ten Mile River watershed in 1983, 1986, 1991, and 1994. 1983, the Department of Fish and Game only recorded coho salmon in Little North Fork Ten Mile River in a density of 5.89 fish/m^2. In 1991, coho were reported only at Bear Haven Creek at a density of 0.08 fish/m^2 & at Bald Hill Creek 0.008 fish/m^2. The steelhead data collected in 1983 and 1991 is reported above. In 1986, the Department of Fish and Game found 0.38 steelhead/m^2. In 1994, they found 0.88 steelhead/m^2, a figure in perfect agreement with that reported by G-P for the same year and place.

Table 20: Ten Mile River Fish Plants from CDFG unpublished data (c)

Year	**Coho salmon (A)**	**Steelhead trout (B)**	**Chinook salmon (C)**	**Approximate number of fish planted**	**Planting location**	**Entity responsible for planting**
1950's						
1955	A	B		A) 1,475; B)1,168	TMR	CDFG
1956		B		B) 68,702	TMR	CDFG
1957		B		B) 20,576	TMR	CDFG
1958		B		B) 1,485	TMR	CDFG
1959	A	B		A) 72; B) 168	TMR	CDFG
1960's						
1964	A			A) 70,000	TMR	CDFG
1965	A			A) 60,240	TMR	CDFG
1966	A			A) 60,006	TMR	CDFG
1967	A			A) 80,034	TMR	CDFG
1970's						
1971	A			A) 20,004	TMR	CDFG
1972	A			A) 222,206	TMR	CDFG
1973	A			A) 20,002	TMR	CDFG
1974	A			A) 121,114	TMR	CDFG
1975	A			A) 10,007	TMR	CDFG
1976	A			A) 10,013	TMR	CDFG
1979	A		C	A) 9,988; C) 350,000	TMR	A) CDFG; B) SRA
1980's						
1980			C	C) 199,000	TMR (main)	SRA
1981			C	C) 20,000	TMR (main)	SRA
1982			C	C) 95,000	TMR (main)	SRA
1983			C	C) 75,000	TMR	CDFG
1985			C	C) 1,845	TMR	CDFG
1986			C	C) 5,000	TMR (main)	SRA
1987			C	C) 7,134	TMR	CDFG
1990's						
1991		B		B) 10,000	TMR (main)	SRA
1994	A	B		A) 503; B) 13,396	A) CFT; B) CFT & NFT	SRA
1995	A	B		A) 5,389; B) 14,850	TMR (main)	SRA
1996	A	B		A) 3,510; B) 22,500	A) SFT, Big Bear Creek (CFT); B) TMR (main)	SRA

Table 21: Summary of Salmonid Distribution and Abundance Findings

Stream	Spawning Surveys	Summer Electroshocking Survey	Outmigrants	Fish Plants
Ten Mile River Watershed—General Observations				
Ten Mile River Watershed	a. 6,000 spawning coho est. in early 1960s b. 9,000 spawning steelhead estimated in early 1960s c. Habitat described as "severely damaged" in early 1960s. d. 1995 spawning coho estimated at 78-351 fish. e. 1996 spawning coho estimated at 1-28 fish.	a. 1994 and 1995 greatest steelhead summer population of record (1993-99) b. 1996 greater coho year of record (1995-97) c. Steelhead population estimated as average of 905,169 from 1993-97	None	a. Coho released to Ten Mile River watershed in 1955, 1959, 1964-67, 1971-76 and 1979 b. Chinook released in 1979-1987 c. Steelhead released 1955-59
Lower Ten Mile River Subwatershed				
Mill Creek	a. 1989-90 salmonid spawners b. 1990-91 no survey c. 1995-96 no survey d. 1996-96 no survey	a. 1969 coho and steelhead b. 1993-99 steelhead c. 1995-97 no coho	No data	No data
Vallejo Gulch	a. 1989-90 no survey b. 1990-91 no survey c. 1995-96 coho and steelhead d. no surveys	No data	No data	No data
Ten Mile River	a. 1989-90 salmonid spawners b. 1990-91 no survey c. 1995-96 no survey d. 1996-97 no survey	No data	No data	a. 1980-82 and 1986 chinook b. 1991, 1995-96 steelhead c. 1995 coho
North Fork Ten Mile River Subwatershed				
North Fork Ten Mile River	a. 1989-90 no survey b. 1990-91 coho and steelhead c. 1995-96 no survey d. 1996-97 no survey	a. 1996 coho b. 1993-99 steelhead. Greater than avg. in upper watershed	No data	a. 1994 steelhead
Little North Fork Ten Mile River	a. 1989-90 salmonid spawners b. 1990-91 coho, steelhead and chinook c. 1995-96 coho and steelhead (21-101 coho spawners est.) d. 1996-97 no survey	a. 1961 coho and steelhead b. 1983 coho and steelhead (5.89 fish/m^2) c. 1996-97 coho: 0.17 fish/m^2 (1996); 0.01 fish/m^2 (1997) d. 1993-99 steelhead. Greater than avg. in lower watershed	No data	No data

Stream	Spawning Surveys	Summer Electroshocking Survey	Outmigrants	Fish Plants
Buckhorn Creek	a. 1989-90 no salmonid spawners b. 1990-91 no survey c. 1995-96 no coho; steelhead present d. 1996-97 no survey	a. 1996 coho b. 1983, 1991, 1993-99 steelhead	No data	No data
Cavanough Gulch	a. 1989-90 no salmonid spawners b. no other surveys	No data	No data	No data
Bald Hill Creek	a. 1989-90 no salmonid spawners b. 1990-91 salmonid spawners c. 1995-96 no salmonid spawners d. 1996-97 no survey	a. 1996 coho b. 1983, 1991, 1993-99 steelhead	No data	No data
Gulch 11	a. 1989-90 no salmonid spawners b. 1990-91 no survey c. 1995-96 no coho; steelhead present d. 1996-97 no survey	No data	No data	No data
Stanley Creek	a. 1989-90 no salmonid spawning b. no other surveys	No data	No data	No data
Patsy Creek	a. 1989-90 salmonid spawners b. No other surveys	No data	No data	No data
Clark Fork Ten Mile River Subwatershed				
Clark Fork Ten Mile River	a. 1989-90 coho and others b. 1990-91 coho, steelhead and chinook c. 1995-96 coho and steelhead (5-37 coho spawners est.) d. 1996-97 no survey	a. 1996 coho b. 1993-99 steelhead. Greater than avg at Reynold's Gulch	No data	a. 1994 coho and steelhead
Bear Haven Creek	a. 1989-90 salmonid spawners b. 1990-91 coho and steelhead c. 1995-96 coho and steelhead (7-55 coho spawners est.) d. 1996-97 no survey	a. 1996-97 coho b. 1983, 1991, 1993-99 steelhead. Greater than avg. in lower watershed	No data	No data
Little Bear Haven Creek	a. 1989-90 salmonid spawners b. 1990-91 no survey	a. 1961 and 1983 steelhead. No coho mentioned	No data	No data

Stream	Spawning Surveys	Summer Electroshocking Survey	Outmigrants	Fish Plants
	c. 1995-96 no salmonid spawners d. 1996-97 no survey	b. 1983, 1991, 1993-99 steelhead		
Booth Gulch	a. 1961 impassable barrier at mouth b. no surveys	a. 1983, 1993-99 steelhead	No data	No data
South Fork Ten Mile River Subwatershed				
South Fork Ten Mile River	a. 1989-90 coho and others b. 1990-91 coho, steelhead and chinook c. 1995-96 coho and steelhead. (12-83 coho spawners est.; 0.9-5.3 redds/mi; 0-1.6 live fish/mi; 1 coho carcass). NO coho in headwaters d. 1996-97 no survey	a. 1961 coho and steelhead b. 1996 coho (0.01 fish/m^2) c. 1993-99 steelhead: 0.67 fish/m^2 (1995); 0.48 fish/m^2 (1996). Greater than avg. at Camp 28.	a. 1996 coho: 1,985 YOY and 493 Y+ b. 1996 steelhead: 35,039 YOY and 15,795 Y+ c. 1997 coho: 2 YOY and 1,726 Y+ d. 1997 steelhead: 6,089 YOY and 3,172 Y+	a. 1996 coho (3,510 est.)
Smith Creek	a. 1989-90 salmonid spawners b. 1990-91 no salmonid spawners c. 1995-96 coho and steelhead (10-40 coho spawners est; 3.9 redds/mi; 0.5 live fish/mi; 0 carcasses) d. 1996-97 coho and steelhead	a. 1961 coho and steelhead b. 1995-97 coho: 0.01 fish/m^2 (1995), 0.15 fish/m^2 (1996) c. 1993-99 steelhead; 0.36 fish/m^2 (1995); 0.50 fish/m^s (1996)	a. 1996 coho: 4,410 YOY and 89 Y+ b. 1996 steelhead: 41,387 YOY and 3,954 Y+ c. 1997 coho: 210 YOY and 729 Y+ d. 1997 steelhead: 24,058 YOY and 1,700 Y+	No data
Campbell Creek	a. 1989-90 salmonid spawners b. 1990-91 coho c. 1995-96 coho and steelhead (6-26 coho spawners est.; 7.1 redds/mi; 1.0 live fish/mi; 0 carcasses0 d. 1996-97 coho and steelhead	a. 1995-97 coho: 0.02 fish/m^2 (1995); 0.35 fish/m^2 (1996) b. 1991, 1993-99 steelhead: 0.61 fish/m^2 (1995); 0.74 fish/m^2 (1996)	a. 1996 oho: 5,493 YOY and 34 Y+ b. 1996 steelhead: 27,189 YOY and 2,379 Y+ c. 1997 oho: 206 YOY and 512 Y+ d. 1997 steelhead: 25,546 YOY and 2,367 Y+	No data
Churchman Creek	a. 1989-90 salmonid spawners b. 1990-91 no survey c. 1995-96 coho and steelhead (0-13 coho spawners est.) d. 1996-97 no survey	a. 1996-97 coho b. 1993-99 steelhead	No data	No data
Redwood Creek	a. 1989-90 salmonid spawners. No spawners in North Fork. b. No other surveys	a. 1991, 1993-99 steelhead. Greater than avg. in lower watershed	No data	No data

Table 24: Summary of G-P's temperature data collected from 1995-1997 in the Ten Mile Creek watershed

Site ID		**Estimated % of time (to closest 5%) from June through August that weekly average temperature exceeded 16.8°C**[1]		
		1995	1996	1997
Lower Ten Mile River				
TEN1	Mill Creek	0	0	0
North Fork Ten Mile River subwatershed				
NFT1	NFT @ Patsy Creek	50	NR	85
NFT2	Bald Hill Creek	0	0	15
NFT3	NFT @ O'Connor Gulch	15	75	80
NFT4	NFT @ Camp 3	15	70	90
NFT5	NFT @ Camp 5	40	75	90
NFT6	Lower Little North Fork Ten Mile River	0	NR	0
NFT7	Buckhorn Creek	0	0	0
NFT8	Upper Little North Fork Ten Mile River	0	0	0
NFT9	NFT @ Gulch 9	15	NR	80
NFT11	NFT at property line	NS	45	100
NFT12	Bald Hill Creek (riffle)	0	NR	NR
NFT13	NFT @ Patsy Creek (riffle)	NS	85	NS
NFT14	NFT @ Camp 5 (riffle)	NS	100	NS
NFT15	NFT/CFT confluence	NS	100	95
Clark Fork Ten Mile River subwatershed				
CFT1	CFT @ Reynold's Gulch	0	35	45
CFT2	CFT @ Little Bear Haven Creek	25	NR	80
CFT3	Lower Bear Haven Creek	0	0	0
CFT4	Lower CFT	0	35	85
CFT5	Booth Gulch	0	0	0
CFT6	Little Bear Haven Creek	0	0	0
CFT7	Upper Bear Haven Creek	0	0	0
CFT8	CFT @ Ford Gulch	0	0	0
CFT9	Lower CFT (riffle)	15	75	NS
CFT10	Booth Gulch (riffle)	0	0	NS
CFT11	CFT @ Bensi Crossing	NS	45	60
CFT12	CFT @ Gulch 18	NS	75	NR
CFT13	CFT @ Gulch 18 (riffle)	NS	80	NS
CFT19	Gulch 16	NS	NS	0
South Fork Ten Mile River subwatershed				
SFT1	Smith Creek	0	0	0
SFT2	Campbell Creek	0	30	50
SFT3	SFT @ Brower's Gulch	15	75	45
SFT4	Churchman Creek	NS	0	0
SFT5	SFT @ Buck Matthews Gulch	50	90	90
SFT6	SFT @ Camp 28	15	75	85
SFT7	Lower Redwood Creek	0	55	40
SFT8	Upper Redwood Creek	0	0	10
SFT9	Upper SFT	0	NR	0
SFT11	Gulch 11	NS	0	0
SFT12	SFT above Gulch 11	0	40	0
SFT15	SFT @ Camp 28	15	65	NS
SFT16/19	Lower SFT	NS	0	0
SFT17	SFT @ Brower's Gulch (riffle)	NS	65	NS
SFT18	SFT @ Buck Matthew's Gulch (riffle)	NS	100	NS

NR = Not reported. G-P provides a table in the monitoring report for each year that lists the stations from which data was collected. If a station was listed as a monitoring location for a given year but the data was not presented, then it was listed here as NR.
NS = Not sampled. If a station was not listed as a monitoring location for a given year then it was listed here as NS.
[1] An MWAT of 16.8°C was chosen as a reporting metric because of the results of the work conducted by David Hines and Jon Ambrose comparing summer temperature data to coho presence data

Table 25: Length of channel surveyed in each stream throughout the Ten Mile River watershed as well as the stream channel-type identified for each reach based on Rosgen (1994).

Stream	**A-type channel** Feet (%)	**B-type channel** feet (%)	**C-type channel** feet (%)	**D-type channel** feet (%)	**F-type channel** feet (%)	**Total main channel** feet	**Total side channel** feet (side/main)
Lower Ten Mile River subwatershed							
Mill Creek		3,479 (36)	0	0	6,127 (64)	9,606	0
North Fork Ten Mile River subwatershed							
Mainstem North Fork Ten Mile River	0	82,612 (100)	0	0	0	82,612	1,299 (0.02)
Little North Fork Ten Mile River	0	3,990 (19)	14,578 (68)	0	2,854 (13)	21,422	62 (0.00)
Blair Gulch	0	0	0	0	5,236 (100)	5,236	0 (0.00)
Barlow Gulch	0	0	0	0	3,633 (100)	3,633	0 (0.00)
Buckhorn Gulch	0	269 (2)	0	0	11,121 (98)	11,390	1,403 (0.12)
McGuire Creek	0	8,248 (84)	0	1,622 (16)	0	9,870	19 (0.00)
Cavanough Gulch	0	5,691 (100)	0	0	0	5,691	0 (0.00)
O’Connor Gulch	0	3,488 (100)	0	0	0	3,488	0 (0.00)
Bald Hill Creek	0	6,656 (47)	0	0	7,555 (53)	14,211	174 (0.01)
Gulch 8	0	5,455 (100)	0	0	0	5,455	0 (0.00)
Gulch 11	0	5,021 (100)	0	0	0	5,021	0 (0.00)
Gulch 19	0	0	0	0	5,455 (100)	5,455	0 (0.00)
Patsy Creek	0	0	0	0	8,009 (100)	8,009	0 (0.00)
Gulch 23	0	2,454 (100)	0	0	0	2,454	0 (0.00)
North Fork Ten Mile River subwatershed	0	123,884 (67)	14,578 (8)	1,622 (1)	43,863 (24)	183,947	2,957 (0.02)
Clark Fork Ten Mile Rive subwatershed							
Mainstem Clark Fork Ten Mile River	0	81,325 (91)	0	0	7,957 (9)	89,282	1,131 (0.01)
Bear Haven Creek	0	5,847 (17)	29,533 (83)	0	0	35,380	409 (0.01)
Little Bear Haven Creek	121 (1)	5,879 (48)	6,286 (51)	0	0	12,286	0
Booth Gulch	0	1,869 (18)	0	0	8,669 (82)	10,538	0
Gulch 27	79 (1)	4,380 (75)	0	0	1,372 (24)	5,831	0
Clark Fork Ten Mile River subwatershed	200 (0)	99,300 (65)	35,819 (23)	0	17,998 (12)	153,317	1,540 (0.01)

Stream	**A-type channel** Feet (%)	**B-type channel** feet (%)	**C-type channel** feet (%)	**D-type channel** feet (%)	**F-type channel** feet (%)	**Total main channel** feet	**Total side channel** feet (side/main)
South Fork Ten Mile River subwatershed							
Mainstem South Fork Ten Mile River	0	76,748 (82)	16,030 (17)	0	1,216 (1)	93,994[1]	2,101 (0.02)
Smith Creek	0	6,802 (21)	26,044 (79)	0	0	32,846[2]	0
Campbell Creek	0	11,623 (61)	7,408 (39)	0	0	19,031	162 (0.01)
Churchman Creek	0	23,050 (100)	0	0	0	23,050	0
Redwood Creek	0	26,402 (100)	0	0	0	26,402	276 (0.01)
Total South Fork Ten Mile River	0	144,625 (74)	49,482 (25)	0	1,21 (1)	195,323	2,539 (0.01)

[1]Ambrose et al. (1996) report a total of 111,369 feet of surveyed stream. However, they only report a channel type for 93,994 feet of stream.
[2]Ambrose et al. (1996) report a total of 33,352 feet of surveyed stream. However, they only report a channel type for 32,846 feet of stream.

As taken from Rosgen (1994):

- A-type channels are steep, entrenched, cascading, step/pool streams. They have high energy and debris transport capacity and area associated with depositional soils. They are very stable if the channel is bedrock or boulder dominated.
- B-type channels are moderately entrenched, riffle-dominated channels with moderate gradient and infrequently spaced pools. They have a very stable plan and profile as well as stable banks.
- C-type channels are low gradient, meandering alluvial channels with point-bars, riffle/pool sequences, and broad, well-defined floodplains.
- D-type channels are braided with longitudinal and transverse bars. They are very wide with eroding banks.
- F-type channels are entrenched, meandering channels with riffle/pool sequences on low gradients with high width/depth ratios.

Table 26: The mean length and distribution of habitat units in each surveyed stream as reported by Ambrose et al. (1996)

Stream name	**Riffle Units**		**Flatwater Units**		**Pool Units**		**Dry Units**	
	Mean length (ft)	% of total	Mean length (ft)	% of total	Mean length (ft)	% of total	Mean length (ft)	% of total
Lower Ten Mile River subwatershed								
Mill Creek	51	28	95	55	20	10	328	7
North Fork Ten Mile River subwatershed								
Mainstem North Fork Ten Mile River	53	16	86	37	79	47	92	0
Little North Fork Ten Mile River	28	15	54	41	32	44	0	0
Blair Gulch	18	15	42	59	14	19	56	7
Barlow Gulch	20	17	47	34	13	11	171	38
Buckhorn Gulch	35	25	65	49	16	11	238	15
McGuire Creek	23	15	72	56	15	16	101	13
Cavanough Gulch	33	12	61	28	12	7	305	54
O’Connor Gulch	36	28	86	59	14	12	17	1
Bald Hill Creek	29	22	62	47	23	26	100	5
Gulch 8	30	27	69	48	20	23	103	2
Gulch 11	33	36	71	56	12	8	0	0
Gulch 19	30	42	36	39	15	18	80	1
Patsy Creek	33	33	46	45	22	19	85	2
Gulch 23	32	38	48	23	15	9	244	30
Clark Fork Ten Mile River subwatershed								
Mainstem Clark Fork Ten Mile River	51	16	112	40	85	44	179	0
Bear Haven Creek	35	16	73	45	35	33	90	6
Little Bear Haven Creek	21	13	70	55	26	33	0	0
Booth Gulch	31	22	60	49	18	13	578	16
Gulch 27	39	32	68	47	28	22	0	0
South Fork Ten Mile River								
Mainstem South Fork Ten Mile River	54	14	143	55	61	31	68	1
Smith Creek	42	21	101	53	29	21	72	5
Campbell Creek	38	19	94	53	33	25	99	3
Churchman Creek	42	11	141	62	21	8	226	20
Redwood Creek	50	13	154	66	36	19	64	2

Table 27: Maximum pool depths and mean shelter ratings in pools as reported by Ambrose et al. (1996)

Stream name	**Distribution of pool types as percent of total length**			**Maximum pool depth as % of all pools**		**Mean shelter rating in pools**
	Main channel pools	Scour pools	Backwater pools	<2 feet	≥3 feet	
Lower Ten Mile River subwatershed						
Mill Creek	18	82	0	80	0	44
North Fork Ten Mile River subwatershed						
Mainstem North Fork Ten Mile River	40	60	1	16	53	36
Little North Fork Ten Mile River	35	61	4	55	13	44
Blair Gulch	72	27	1	66	3	42
Barlow Gulch	73	27	0	97	0	22
Buckhorn Gulch	73	27	1	77	3	48
McGuire Creek	57	41	2	77	5	42
Cavanough Gulch	39	51	10	79	3	65
O'Connor Gulch	37	63	0	66	0	75
Bald Hill Creek	46	53	1	58	11	68
Gulch 8	76	22	2	61	10	63
Gulch 11	30	70	0	70	6	40
Gulch 19	41	51	8	71	8	58
Patsy Creek	66	34	0	69	7	73
Gulch 23	70	30	0	87	0	40
Clark Fork Ten Mile River subwatershed						
Mainstem Clark Fork Ten Mile River	41	58	1	10	52	43
Bear Haven Creek	36	63	1	59	11	31
Little Bear Haven Creek	53	42	5	60	10	42
Booth Gulch	58	41	1	54	13	35
Gulch 27	64	36	0	27	24	51
South Fork Ten Mile River subwatershed						
Mainstem South Fork Ten Mile River	29	71	0	23	37	41
Smith Creek	22	78	0	56	4	31
Campbell Creek	27	73	0	65	7	29
Churchman Creek	27	72	2	75	2	39
Redwood Creek	40	58	2	44	17	31

Table 28: Cobble embeddedness in pool tail-outs and substrate composition of low gradient riffles as reported by Ambrose et al. (1996)

Stream name	Mean % of each cobble particle that is embedded by fine sediment				Substrate composition of low gradient riffles (% of all class sizes)	
	0-25%	26-50%	51-75%	76-100%	Dominant	Sub-dominant
Lower Ten Mile River subwatershed						
Mill Creek	0	0	70	30	Gravel (100%)	None
North Fork Ten Mile River subwatershed						
Mainstem North Fork Ten Mile River	2	9	16	72	Gravel (53%)	Sm. cobble (19%)
Little North Fork Ten Mile River	0	0	12	88	Gravel (100%)	None
Blair Gulch	0	0	0	100	Gravel (100%)	None
Barlow Gulch	0	0	0	100	Gravel (100%)	None
Buckhorn Gulch	0	0	7	93	Gravel (100%)	None
McGuire Creek	0	0	15	85	Gravel (100%)	None
Cavanough Gulch	4	4	54	39	Sm. Cobble (75%)	Gravel (25%)
O'Connor Gulch	0	10	17	72	Gravel (67%)	Boulder (33%)
Bald Hill Creek	12	35	34	19	Gravel (75%)	Lg. Cobble (17%)
Gulch 8	3	31	29	36	Gravel (33%) Sm. Cobble (33%) Boulder (33%)	None
Gulch 11	0	24	45	30	Boulder (75%)	Gravel (25%)
Gulch 19	5	8	23	64	Gravel (50%)	Boulder (33%)
Patsy Creek	11	24	11	54	Gravel (33%) Boulder (33%)	Sm. Cobble (17%) Lg. Cobble (17%)
Gulch 23	0	7	20	73	Boulder (100%)	None
Clark Fork Ten Mile River subwatershed						
Mainstem Clark Fork Ten Mile River	2	12	31	55	Gravel (38%)	Sm. Cobble (29%) Boulder (29%)
Bear Haven Creek	0	1	17	82	Gravel (86%)	Sand (5%) Lg. Cobble (5%) Boulder (5%)
Little Bear Haven Creek	0	0	5	95	Gravel (75%)	Sand (25%)
Booth Gulch	0	4	24	72	Gravel (75%)	Sm. Cobble (25%)
Gulch 27	0	13	19	68	Sm. Cobble (75%)	Boulder (25%)
South Fork Ten Mile River						
Mainstem South Fork Ten Mile River	0	0	26	74	Gravel (88%)	Sm. Cobble (10%)
Smith Creek	0	0	16	84	Gravel (99%)	Sm. Cobble (1%)
Campbell Creek	0	0	13	87	Gravel (98%)	Sand (1%) Sm. Cobble (1%)
Churchman Creek	0	0	2	98	Gravel (96%)	Sm. Cobble (2%)
Redwood Creek	0	0	12	88	Gravel (89%)	Sm. Cobble (10%)

Table 29: Percent of stream banks on surveyed streams that are covered by coniferous and deciduous vegetation or are open as reported by Ambrose et al. (1996)

Stream name	**Percent of stream banks covered by vegetation**		
	Coniferous	Deciduous	Open
Lower Ten Mile River subwatershed			
Mill Creek	10	87	3
North Fork Ten Mile River subwatershed			
Mainstem North Fork Ten Mile River	15	55	30
Little North Fork Ten Mile River	44	49	7
Blair Gulch	46	54	0
Barlow Gulch	48	51	1
Buckhorn Gulch	52	41	7
McGuire Creek	47	43	10
Cavanough Gulch	23	75	2
O'Connor Gulch	23	76	1
Bald Hill Creek	37	50	13
Gulch 8	35	51	14
Gulch 11	51	30	19
Gulch 19	49	38	13
Patsy Creek	38	53	9
Gulch 23	35	55	10
Clark Fork Ten Mile River subwatershed			
Mainstem Clark Fork Ten Mile River	25	51	24
Bear Haven Creek	57	34	9
Little Bear Haven Creek	45	46	9
Booth Gulch	54	37	9
Gulch 27	19	66	15
South Fork Ten Mile River subwatershed			
Mainstem South Fork Ten Mile River	36	41	23
Smith Creek	36	47	17
Campbell Creek	31	52	17
Churchman Creek	36	54	10
Redwood Creek	56	28	16

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