State of California
The Resources Agency
Department of Water Resources

SP F-10, TASK 2B REPORT 2003 LOWER FEATHER RIVER STEELHEAD (*ONCORHYNCHUS MYKISS*) REDD SURVEY

Oroville Facilities Relicensing FERC Project No. 2100

JULY 10, 2003

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REPORT SUMMARY

Thirteen weekly redd surveys were performed between January 6 and April 3, 2003. A total of 108 steelhead and 75 redds were observed during the sampling period.

Redd construction likely began sometime in late December, peaked in late January and was essentially complete by the end of March. In the months of January, February and March, steelhead constructed, at minimum, 45, 26 and 4 redds, respectively.

The surveys revealed that nearly half (48%) of all redds were constructed in the uppermost mile of river (between RM 66 and 67), between the Table Mountain Bicycle Bridge and Lower Auditorium Riffle. This section of river maintained 36 redds per mile, over ten times greater than any other section of river. Hatchery Ditch alone had 26 redds constructed within it, five times more redds than were constructed in any other location.

No attempt was made to estimate the number of adult steelhead spawning. Difficulties associated with identifying all steelhead redds convinced us to determine only the minimum number of spawning steelhead for the 2002-2003 spawning period. Assuming one female per redd and a male to female ratio of 1.2:1, the minimum number of males and females expected to have spawned was 88 and 75, respectively, for a total of 163 steelhead.

Physical characteristics of constructed redds in both the HFC (High Flow Channel) and LFC (Low Flow Channel) appeared suitable for successful spawning and egg incubation. High flows in the HFC during three weeks in February may have reduced HFC spawning or forced steelhead to spawn near the river margin. There was no evidence that any redds were dewatered after the flow reduction. It is unknown whether a flow of 8000 cfs (experienced on February 20, 21 and 22) would scour recently constructed redds in the HFC.

Future work must focus on determining the actual number of steelhead entering and spawning in the river proper. Redd surveys can only provide a sense of where spawning occurs and the physical attributes of individual redds. Redd surveys cannot accurately determine the number of steelhead actually spawning, nor can they determine the origin of the steelhead building them (hatchery or naturally spawned). A weir or other counting mechanism would be necessary to accurately determine the number of steelhead spawning in the Feather River. This would also allow individual counts of wild and hatchery steelhead, providing better data for long-term management goals.

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1.0 INTRODUCTION

Completion of Oroville Dam in 1967 (and its associated barriers) blocked all passage above the town of Oroville for migrating steelhead (*Oncorhynchus mykiss*). It is assumed that prior to the construction of Oroville Dam most steelhead spawned in the upstream reaches. As mitigation for Oroville Dam the CDWR and CDFG have been operating the Feather River Fish Hatchery (FRH) since 1967. Adult counts have ranged from a low of 78 in 1971 to a high of 2999 in 2003 (Table 1.1-1). As part of the original FERC license a study was performed (Painter et al., 1977) to evaluate the impact of the Oroville project on fish populations. Angler creel data, interim fish facility counts and subsequent FRH counts were used to assess the success of steelhead in the first eight years after construction. Their research determined that FRH operations were maintaining pre-project abundance levels of steelhead (interim fish facility counts from1963 to 1966 averaged 582 adult steelhead per year while FRH counts averaged 565 the first eight years after project construction).

Although the FRH has long-term records of hatchery activities, little is known about the success of hatchery origin or wild spawning steelhead in the river. Adult abundance and spawning distribution have never been well documented in the Feather River below Oroville Dam. Department of Fish and Game Angler Surveys (DFG, 2002) report that 2892 steelhead and/or rainbow trout were caught and released between January and June of 2001. However, the data combines all steelhead caught between Sunset Pumps and the Feather River Hatchery, a distance of 28 river miles. Therefore, we cannot distinguish more localized catch (for the LFC spawning population, for example) or determine how many times an individual was re-caught (and therefore counted twice). The data does indicate that steelhead fishing is generally good, somewhat indicative of a healthy fishery (of hatchery steelhead, primarily). Furthermore, because angler surveys are conducted sporadically (funding problems), consistent long-term angler data is probably unavailable for evaluation. This data is therefore limited in relevance to the status of naturally spawning steelhead.

Recent snorkel studies performed by DWR have documented that most newly emerged steelhead fry are rearing in the uppermost portions of the LFC (DWR, 2003). Since newly emerged steelhead fry prefer calm shallow water and are incapable of swimming large distances upstream, this information would strongly indicate that spawning is occurring in nearby areas. As part of the Oroville Relicensing SP F-10, Task 2B, we conducted steelhead redd surveys to identify the location, timing and magnitude (if possible) of steelhead spawning in the Feather River between the Fish Barrier Dam (RM 67.1) (the Fish Barrier Dam is the entrance to the FRH fish ladder and the end to upstream migration) and Honcut Creek (RM 44) (Honcut Creek is thought to be near the downstream end of steelhead spawning habitat).

Table 1.1-1. Number of steelhead returns at the Feather River Fish Hatchery, 1967 to present.

YEAR	Number of steelhead
1967	--
1968	1,005
1969	361
1970	--
1971	78
1972	288
1973	1,000
1974	715
1975	758
1976	573
1977	163
1978	153
1979	189
1980	238
1981	414
1982	537
1983	1,238
1984	783
1985	1,721
1986	1,553
1987	1,018
1988	2,587
1989	1,106
1990	1,193
1991	1,025
1992	1,028
1993	297
1994	1,594
1995	877
1996	1,058
1997	2,113
1998	1,023
1999	633
2000	1,742
2001	2,161
2002	1,431
2003	2,999

Source: CDFG-FRH unpublished

2.0 NEED FOR STUDY

Our current knowledge of steelhead spawning distribution suggests that steelhead spawning activity appears to be concentrated in the LFC, between the Fish Barrier Dam and the Thermalito Afterbay Outlet. In this river segment, flows remain relatively constant (approximately 600 cfs year round) and thus negative flow-related effects on steelhead spawning should be minimized. Our current lack of detailed information on steelhead spawning locations and abundance curtails any attempt to test for the effects of flow or other environmental factors. Hence, the current priorities were: 1) to obtain detailed information on the distribution of spawning steelhead, 2) to obtain basic data on the physical characteristics of steelhead redds, and 3) to provide a basis for the development of a long-term plan to monitor the abundance and distribution of steelhead spawning in the Feather River.

3.0 STUDY OBJECTIVE(S)

Adult abundance and spawning distribution of wild or hatchery origin steelhead have never been well documented in the Feather River below Oroville Dam. However, some information on the distribution of spawning steelhead can be inferred from observations collected during snorkel surveys performed by DWR between 1999 and 2002 (DWR 2003). Most steelhead spawning activity appears to have been concentrated between the Fish Barrier Dam and the Thermalito Afterbay Outlet, because 91%, 77% and 84% of all the young-of-the-year steelhead observations in 1999, 2000 and 2001 occurred within one mile downstream of the Fish Barrier Dam. Since newly emerged steelhead fry prefer calm shallow water and are incapable of swimming large distances upstream, this information would strongly indicate that spawning is occurring in nearby areas. As part of the Oroville Relicensing SP F-10, Task 2B, we conducted steelhead redd surveys to identify the location, timing and magnitude (if possible) of steelhead spawning in the Feather River between the Fish Barrier Dam (RM 67.1) and Honcut Creek (RM 44).

4.0 METHODOLOGY

4.1 STUDY DESIGN

In general, steelhead begin entering the FRH facilities in December, with the peak of the run returning in January, tapering off to just a few fish in April and May (Table 1.1-1 or -2). The FRH run timing and previous DWR snorkel data were used as a baseline for determining when to begin and end the redd survey.

The entire river from the Table Mountain Bicycle Bridge (RM 67) to Long Glide (RM 45) was surveyed once a week from January 6 to April 3, 2003. Two different survey methods were employed to ensure that small areas of expected high use and larger areas of lower potential spawning use were both examined.

4.1.1 Transect Surveys

Transect surveys were employed to sample redds present in areas of expected high use. Each transect was roughly 30 m x 30 m square, depicted on aerial photographs by a straight line bisecting the transect (Figure 2.1-1). Each of the 41 transects (23 LFC, 18 HFC) was pre-selected based on the expectation that steelhead would likely use the transect if they were to spawn in the general area (i.e. appropriate depth and velocity. By selecting the most likely areas for steelhead spawning (in both the LFC and HFC), we were expecting to gain the most information on the physical attributes (size, substrate composition) of steelhead redds in the Feather River with the least amount of effort (see Appendix A for a list of all Transect and Roving sites).

Sampling each transect involved wading the entire transect area. Because the transect sites were waded, any redds constructed deeper than 1.5 meters were not sampled or identified (primarily due to visibility constraints beyond 1.5 meters). Two to four people would wade the area looking for steelhead and steelhead redds (in any fashion deemed most effective and least impactful for each transect site). Care was taken to identify redds with as little disturbance as possible to spawning or holding steelhead.

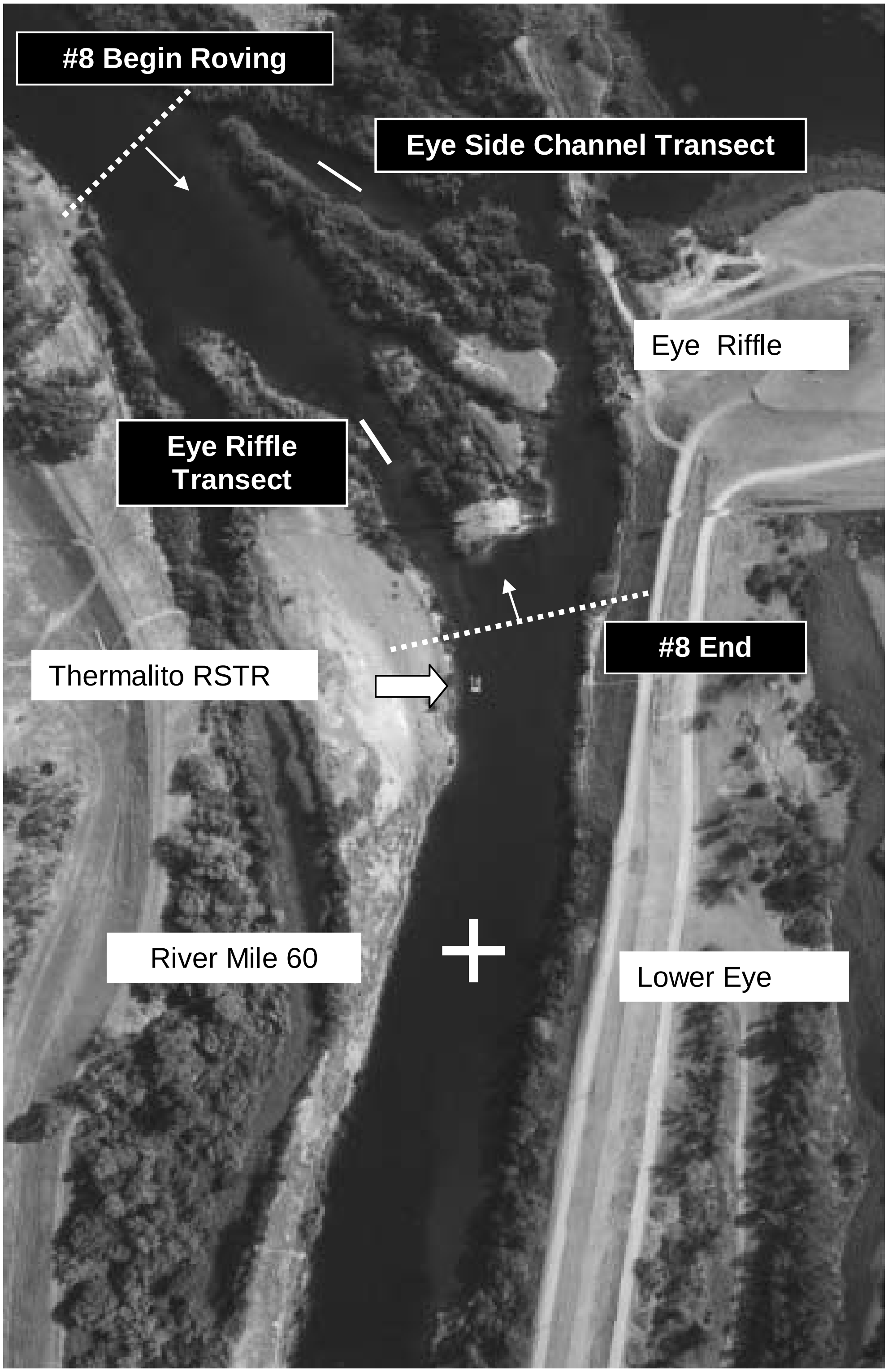


Figure 4.1-1. Transect and roving map of Eye Riffle.

4.1.2 Roving Surveys

The roving surveys were used to sample most of the spawning habitat (riffles/glides) from the FRH to Honcut Creek without using a tremendous level of effort. This was done to ensure that no area would be overlooked simply because it was not chosen as a transect site. It was also done to ensure that the HFC was adequately sampled for spawning activity. Each roving section was numbered and covered at least one riffle-pool river segment (See Figure 4.1-1). All suitable (riffles, runs or glides) habitat was searched for steelhead and steelhead redds.

Sampling roving sections involved drifting a boat through and/or around spawning areas looking for steelhead and steelhead redds (wading was used in cases where it was too shallow to drift a boat). If a redd was spotted in a roving area, the same physical data collected for transect area redds was collected.

4.1.3 Steelhead Redd Microhabitat Data Collection

If a redd was identified the following data was collected or determined.

- Were steelhead present? If yes, how many?
- Was the redd constructed closer to the head, middle or tail of the riffle or glide?
- How far from the riverbank was it?
- Water depth and velocity at the front of the redd
- Redd length and width
- Substrate type within the disturbed area (see Table 4.1-1)
- Cover type within 1 meter of the disturbed area, except for canopy (See Table 4.1-2)
- GPS coordinates: using a Garmin GPS model 76

Water velocity was collected by placing a Price AA current meter at 60% depth at the front of the redd (beginning of the pit) for 40 seconds. If the water depth was greater than .75 m, a velocity reading would be taken at both 20% and 80% depth. This value would then be averaged to determine the velocity to be recorded for the redd.

Substrate and cover characteristics at each redd were recorded according to the descriptions provided below. Substrate and cover (instream and overhead) recorded at each site were reduced to percent occurrence to qualitatively assess the relative significance of each.

Table 4.1-1. Substrate descriptions used to describe steelhead redds.

Code	Substrate Description (choose no more than two)
1	Organic Fines, Mud (0-0.05mm)
2	Sand (0.05-2mm)
3	Small gravel (2-50mm)
4	Large gravel (50-150mm)
5	Cobble (150-300mm)
6	Boulder (> 300 mm)

Table 4.1-2. Instream and overhead cover descriptions used to describe the immediate area surrounding steelhead redds.

Code	Instream Cover Description (choose no more than two)
A	No apparent cover
B	Small instream objects/small-medium woody debris
C	Large instream objects/large woody debris
D	Overhead Objects
E	Submerged aquatic vegetation
F	Undercut bank
Code	**Overhead Cover Description (circle all that apply)**
0	No apparent cover
1	Overhanging vegetation < .5m above water surface
2	Overhanging vegetation .5-2m above water surface
3	Surface turbulence, bubble curtain

4.1.4 Steelhead and Salmon Carcass Collection

Any steelhead carcass found during redd surveys was processed in the following manner. Fork length, sex (if possible), location, life stage and life history (adipose fin clipped or not) data were all collected. If the fish was adipose fin clipped, the head was removed and a Coded Wire Tag (CWT) head tag label was attached (heads of CWT fish are temporarily kept frozen at the Oroville Field Division and eventually shipped to the CDFG Ocean Harvest Laboratory in Healdsburg, CA). If the steelhead was not clipped, the head was removed and placed in a bag with an appropriate head tag label and kept frozen at the Oroville Field Division for future otolith removal. Also, non-clipped steelhead carcasses had a large (1 cm x 1 cm) piece of caudal fin tissue removed for genetic analysis. Tissues were sent to the CDFG Tissue Archive for inclusion in the ongoing Central Valley Steelhead Genetic Study. Adipose fin clipped salmon encountered during steelhead redd surveys were processed the same as steelhead.

4.1.5 Discerning Steelhead Redds From Other Species

Differentiating between steelhead redds and those of Sacramento sucker (*Catostomus occidentallis*) and pacific lamprey (*Lampetra tridentata*) was initially a concern because all three species clean the gravel during spawning. Fortunately, suckers do not typically spawn until late March and April and are generally very visible during their spawning period. Furthermore, because steelhead usually create a noticeable pit and tail spill in the gravel during redd construction, it was generally easy to distinguish them. However, many possible redds were likely ignored due to the inability of the survey crew to positively identify the constructing species as steelhead, pacific lamprey or Sacramento sucker (many species digging in the same area can confuse the surveyors). DeHaven often found it difficult to distinguish pacific lamprey from steelhead (2002). Very few salmon spawn after January 1, making the distinction between salmon and steelhead redds almost irrelevant. The size of substrate used by salmon is generally much larger than that used by steelhead, accentuating the differences between the two. Furthermore, female salmon generally spend a few days to a week guarding their redds, making the distinction uncomplicated. Additionally, the entire survey crew (two to three individuals) had to agree on the identity of each spawning nest, therefore greatly eliminating the chance of calling a spawning nest a steelhead redd when it was actually created by another species. This method certainly reduced the overall number of steelhead redds identified, but also provided a more accurate estimate of the minimum number of spawning steelhead.

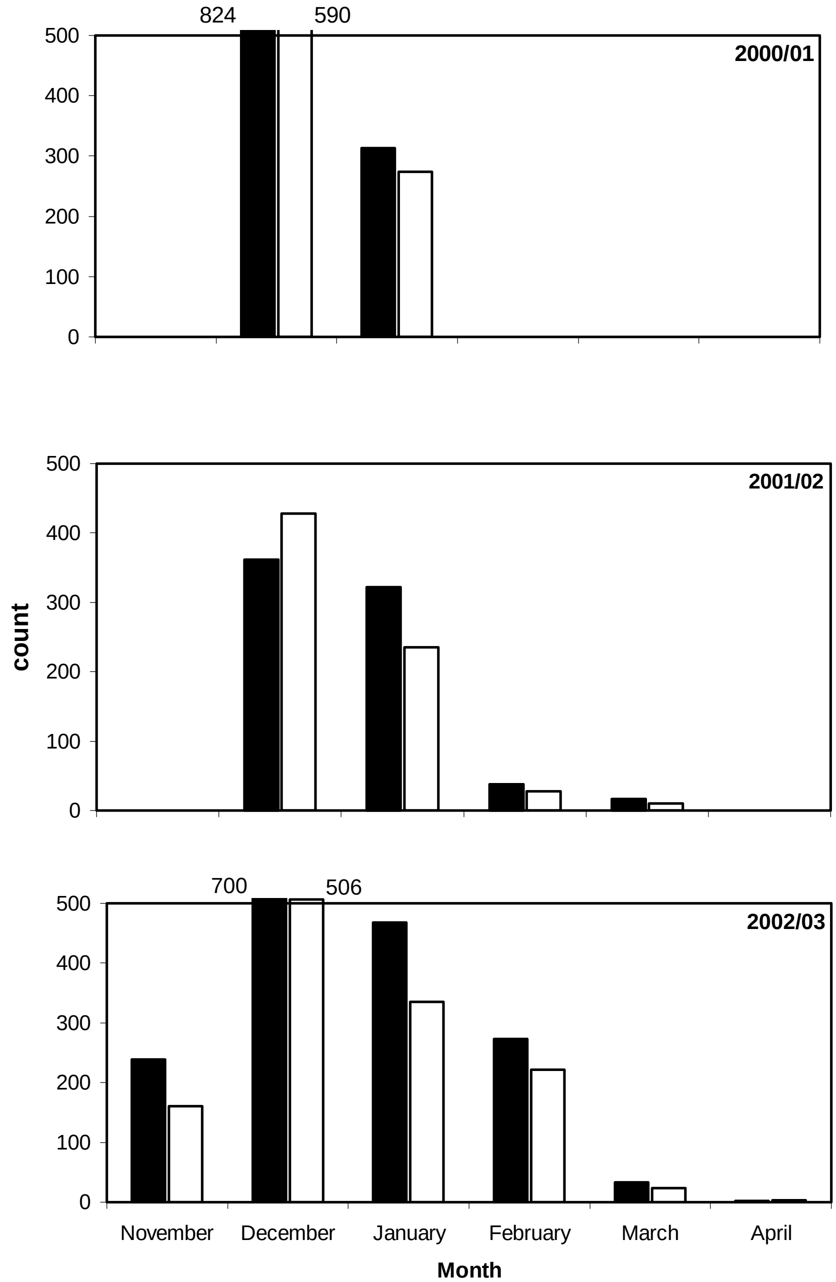
4.1.6 Differentiating Steelhead Redds From Week to Week

In areas of fairly high redd density and clean gravel substrate, washers with flagging were placed in the center of steelhead redds to avoid counting the same redd twice in successive weeks. In all other areas, most redds could not be positively identified in subsequent weeks due to rapid growth of epilithic algae (algae growing on rocks) and colonization of aquatic invertebrates. The presence of case building caddisflies (primarily caddisflies of the families Sericostomatidae, Helicopsychidae and Leptoceridae) on the redd substrate generally indicated that the redd had been built at least a week prior. Although the potential existed, these three indicators helped eliminate the potential of counting a single redd twice.

5.0 STUDY RESULTS

5.1 REDD SURVEY RESULTS

Thirteen weekly redd surveys were performed between January 6 and April 3, 2003. A total of 108 steelhead and 75 redds were observed during the sampling period. No attempt was made to estimate the number of adult steelhead spawning. We are certain that redds were missed due to the strict identification protocols and the fact that no spawning activity deeper than 1.5 meters was surveyed (visibility issues). Therefore, the number of redds identified in this study should be considered the minimum number of steelhead redds constructed in the Feather River in the 2002-2003 spawning season. Likewise, the steelhead spawner estimate is intended to be the minimum number expected to have spawned. Assuming one female per redd (Hannon and Healey, 2002) and a male: female ratio of 1.2:1 (Figure 5.1-1; DFG, 2003), the minimum number of males and females expected to have spawned was 88 and 75, respectively (163 total).



Source: CDFG, unpublished

Figure 5.1-1. Monthly count of male (black) and female (white) adult steelhead from the Feather River Hatchery in 2000/01, 2001/02 and 2002/03.

Steelhead redd surveys on the lower Feather River revealed that nearly half of all redds identified (n=36, 48%) were constructed in the one mile immediately below the Fish

Barrier Dam (Table 5.1-1). Hatchery Ditch alone had 26 redds (35% of all redds), ten times more redds per mile than any other section of river (Table 5.1-1 and Figure 5.1-2).

Table 5.1-1. Summary of steelhead redd occurrence between the Table Mountain Bicycle Bridge and Honcut Creek.

Selected River Sections	River Section	River Miles	Number of redds identified during transect and (roving) surveys	Number of Redds/Mile	Percent of all Redds Constructed
Auditorium Riffle to Table Mountain Bridge (includes Hatchery Ditch)	1	66.0-67.0	16 (20)	36.0	0.48
Aleck Riffle to Auditorium Riffle	2	63.5-66.0	3 (0)	1.2	0.04
Afterbay Outlet to Aleck Riffle	3	59.0-63.5	9 (6)	3.3	0.20
Keister Riffle to Afterbay Outlet	4	55.0-59.0	2 (1)	0.8	0.04
Gridley Riffle to Keister Riffle	5	50.0-55.0	2 (9)	2.2	0.15
Honcut Creek to Gridley Riffle	6	44.0-50.0	6 (1)	1.2	0.09

Redd construction likely began sometime in late December, peaked in late January and was essentially complete by the end of March (Figure 5.1-3). In the months of January, February and March, steelhead constructed 45, 26 and 4 redds, respectively.

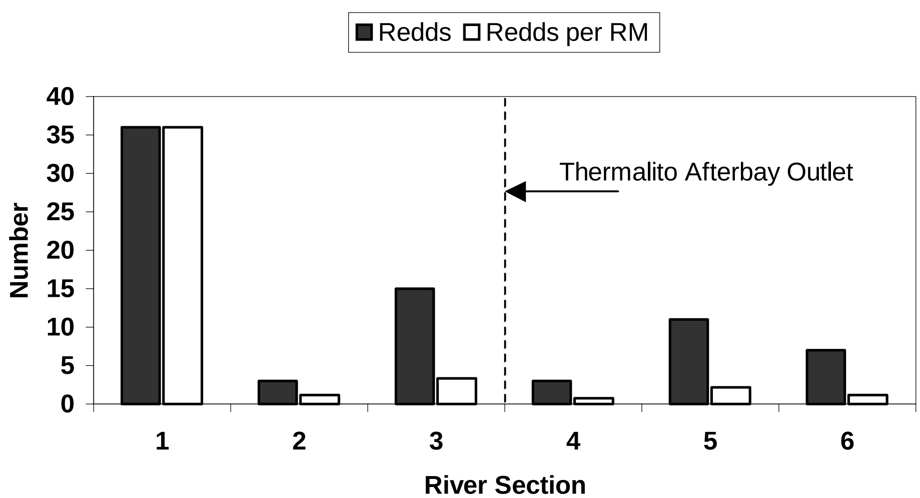


Figure 5.1-2. Total number of redds, as well as the total number of redds per mile.

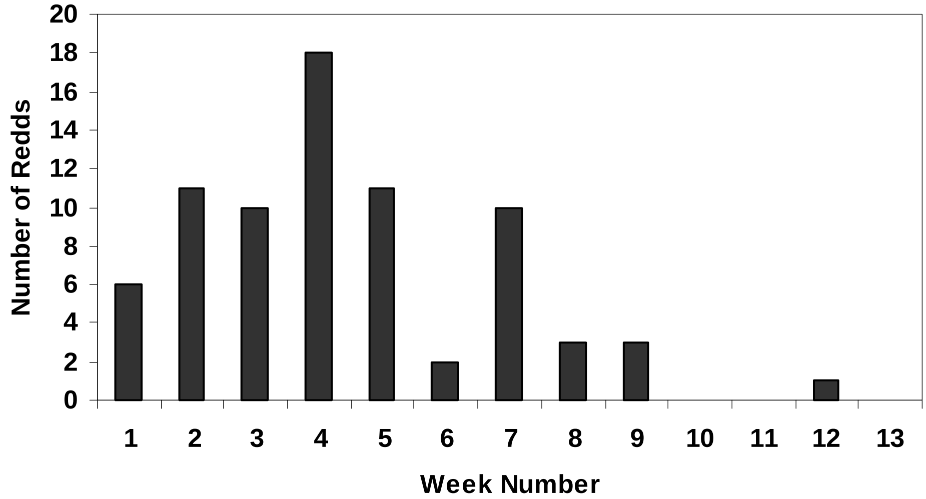


Figure 5.1-3. Total number of redds found during each survey week between January 6th (week 1) and April 3rd (week13).

5.2 REDD PHYSICAL DATA

Microhabitat data collected at each redd is presented in Tables 5.2-1, 5.2-3 and 5.2-4. Substrate selected by steelhead generally fit into the small gravel category, a size suitable for proper redd construction and egg development. Large gravel and sand were also well represented, although occurring much less. As expected, organic fines, cobbles and boulders were not found to be part of any steelhead redd.

Table 5.2-1. Microhabitat data collected at 75 steelhead redds during the 2002-2003 survey.

Parameter	Mean	Maximum	Minimum	1 Standard Deviation
Water Depth (m)	0.35	0.92	0.12	0.19
Water Velocity (ft/s)	1.56	2.80	0.44	0.55
Redd Length (m)	1.20	2.50	0.34	0.50
Redd Width (m)	0.75	1.80	0.22	0.34
Redd Area (m^2)	0.96	3.5	0.12	0.65

Table 5.2-2. Substrate characteristics of all redds sampled during the 2002-2003 survey.

Substrate Size	Percent Occurrence
Sand (.05-2mm)	0.15
Small Gravel (2-50mm)	0.55
Large Gravel (50-150mm)	0.29

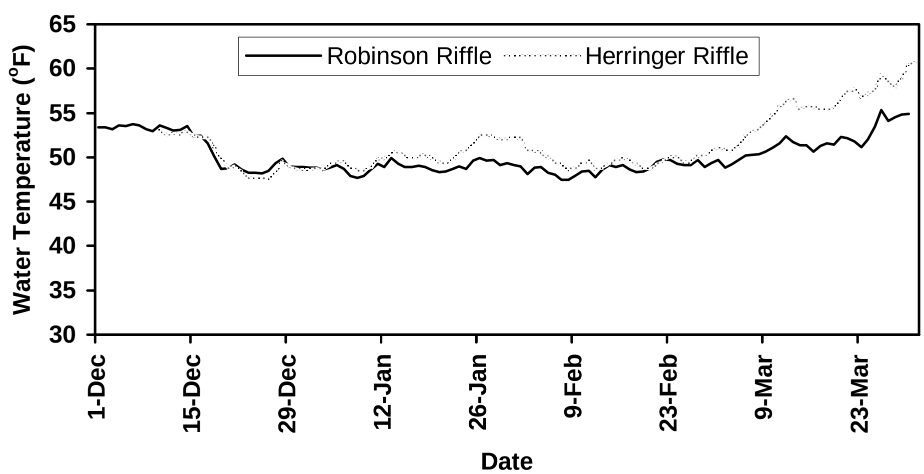
Cover, especially instream, did not appear to be important for steelhead when selecting a spawning location. Overhead cover only occurred 21% of the time, while instream cover was identified only 5% of the time.

Table 5.2-3. Cover characteristics of all redds sampled during the 2002-2003 survey.

Cover Parameter	Percent Occurrence	
	No Cover	Mix of all other cover types
Overhead Cover	0.79	0.21
Instream Cover	0.95	0.05

5.3 FEATHER RIVER TEMPERATURE DATA

Feather River temperature data for the 2002-2003 steelhead spawning season is presented below in Figure 5.3-1. Due to their consistency with other sampling programs, Robinson Riffle and Herringer Riffle were chosen as representative sites for the LFC and HFC temperature data, respectively. Water temperatures were within the range for spawning steelhead during the entire survey.



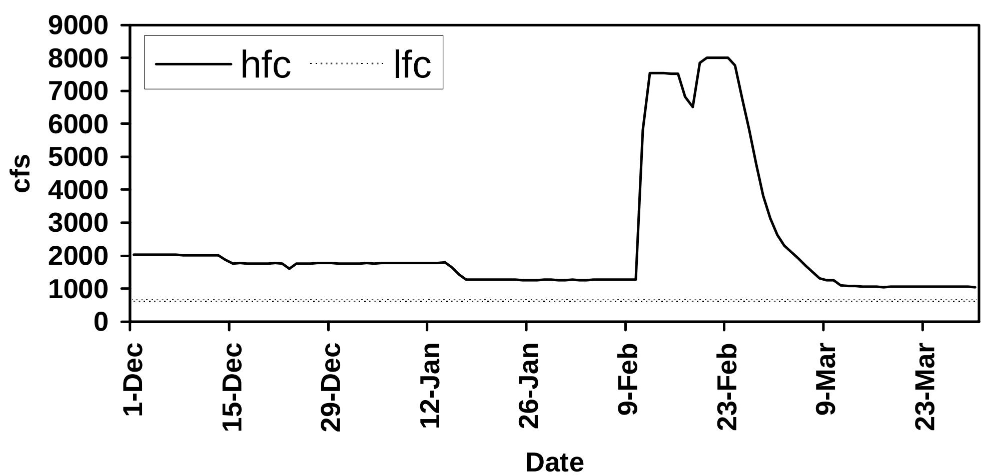
Source: Robinson Riffle Temperature Data: DWR unpublished; CDEC
Source: Herringer Riffle Temperature Data: DWR unpublished

Figure 5.3-1. Water temperature (°F) at Robinson Riffle (RM 61.6), in the LFC, and Herringer Riffle (RM 46.0), in the HFC, December 2002 to April 2003.

5.4 FEATHER RIVER FLOW DATA

Feather River flow data for the 2002-2003 steelhead spawning season is presented below in Figure 5.3-1. Flow data for the low flow channel (LFC) was calculated by adding the Feather River flow at Oroville (USGS gauge #11406999) to the Feather River Fish Hatchery flow (USGS gauge # 11406930). High Flow Channel (HFC) flow was calculated by adding the LFC flow to the flow record for the Thermalito Afterbay Outlet (USGS gauge # 11406920).

Flows in the HFC ranged from a low of 1200 cfs to a high of 8070 cfs on February 21. When flows increased from 1200 cfs to approximately 6000 cfs, spawning activity may have been curtailed or forced toward the river margins. When flows were reduced to 2300 cfs on April 3, no redds were identified as recently constructed or stranded. However, a flow change of this magnitude would make it extremely difficult to identify a fresh redd or one that had been recently stranded. It is unknown whether an 8000 cfs event would scour steelhead redds created in the HFC.



Source: DWR unpublished

Figure 5.4-1. Feather River discharge for the high flow channel (HFC) and low flow channel (LFC) between December, 2002 and March, 2003.

6.0 ANALYSES

Steelhead redd surveys on the lower Feather River revealed that nearly half of all redds identified (48%) were constructed in the one mile immediately below the Fish Barrier Dam. Additionally, the number of redds per mile (36) identified in this area is over 10 times greater than any other section of river. The highest redd density found on the American River by Hannon and Healey (2002) in 2001/02 was16.1 redds per mile. Clearly, this small section of river plays an integral part in determining the success of natural origin steelhead in the Feather River. There are several factors that potentially make this section of river particularly suitable for Feather River steelhead. First, the combination of braided main channel (mid-channel islands) and side channel habitat may produce the type of cover and substrate that is more suited for successful steelhead spawning. Second, the proximity of this area to the FRH makes it an excellent location for hatchery steelhead to select based on intrinsic homing behavior. For example, Hatchery Ditch source water flows directly from the FRH effluent settling ponds, creating an attraction that could be very difficult for a steelhead to ignore. Third, because this section of the river is the last available for spawning (last upstream area), the physical location alone may make this a prime spawning site after a long migratory journey. Fourth, heavy spawning activity from Chinook salmon may provide many suitable sites (increased upwelling or downwelling and loosened substrate) for steelhead to exploit that may otherwise go unused to due the larger substrate sizes generally found in many spawning riffles of the Feather River.

Of other notable interest is the large gap in steelhead spawning in river Section two. Section two spans 2.5 miles from Bedrock Park (RM 66) to Robinson Riffle (RM 63.5). There were only three redds identified in this reach during the entire survey (1.2 redds/mile), two of which were within five meters of one another at Aleck Riffle. This section of river is lacking side channels and mid-channel islands. Additionally, many of the riffles contain heavily armored substrate. There are, however, small pockets of quality spawning gravel that are likely being used but were not identified as having active spawning in the study. However, areas like this are extremely limited in this portion of river, hence the low number of redds identified. Immediately downstream (Section 3), between Upper Robinson Riffle and the Afterbay Outlet, spawning activity appears to increase, if only slightly, to 3.3 redds/mile (15 redds observed in this section during the survey). Three prominent side channel complexes, each of which contains adequate spawning habitat for steelhead, characterize this section of river.

There is no way to determine if redds constructed in the LFC are easier to detect than those in the HFC. It is likely that due to the inherently larger size (and of course, flow) of the HFC some redds were missed. However, during reduced flow conditions (below 3000 cfs in the HFC and 600 cfs in the LFC) visibility and subsequent identification of redds is comparable. Furthermore, transect and roving sections were well searched at all locations, eliminating any substantial bias toward LFC redd detection. However, during even moderate flow events (3000 to 6000 cfs) redd detection would likely fall considerably. Water quality measurements such as secchi depth or turbidity were not measured to compare visibility differences in the LFC and HFC. The period between February 11 and March 2 was a period when redd detection in the HFC was significantly compromised (Figure 5.4-1). At all other times, visibility was generally sufficient in the LFC and HFC to allow redd detection, based on visibility alone. During this period, 15 redds were identified in the LFC, while none were identified in the HFC. After March 3, only four more redds were identified in the entire survey, all in the LFC. February 5 was the last time a redd was identified in the HFC. It is possible that high flow conditions that began on February 11 caused most steelhead to move into the LFC to spawn, thereby eliminating any potential observations in the HFC. It is possible that in many years, higher flows in the HFC (potentially above 6000 cfs) force steelhead to move into the LFC to spawn. Although likely, at this time there is no data to indicate that such a trend exists. Furthermore, there is no information to indicate that additional steelhead spawning (the total number of HFC spawners plus the current amount of LFC spawners) in the LFC is detrimental to the fishery. In fact, considering the constant flow regime and temperature profile (among other attributes) in the LFC, steelhead are most likely better off spawning in the LFC.

Although cover does not appear to have a large impact on where steelhead choose to spawn, locations such as Hatchery Ditch (and other side channels), which do maintain a high overhead canopy, appear to be heavily favored. Steelhead spawning site selection is probably driven by several factors (as mentioned above), many of which may be undetectable (a hatchery scent and/or upwelling/downwelling for instance). Cover, water depth, water velocity, temperature and substrate used in the LFC all appeared to be generally suitable for successful spawning and egg incubation. All physical attributes except for flow (during high flow events only) appeared suitable in the HFC. Flows in the HFC ranged from a low of 1200 cfs to a high of 8070 cfs on February 21. When flows increased from 1200 cfs to approximately 8000 cfs, spawning activity may have been curtailed or forced toward the river margins or upstream areas. Considering the typical locations steelhead choose for redd construction, redds could have been constructed in marginal areas that would be subject to dewatering after a reduction in flow. When flows were reduced, no redds were identified as recently constructed or stranded. However, as previously mentioned, identifying redds (new or dewatered) is very difficult after a flow change of this magnitude.

Redd surveys as described in this report should be considered short-term efforts to qualitatively evaluate redd distribution and microhabitat features of steelhead redds. Long-term efforts to quantify the number of natural spawners must rely on a more rigorous system of in-river weirs/counters and FRH counts to accurately evaluate population trends of both hatchery and wild origin steelhead. Poor visibility, identification of redds and the lack of a rigorous means of quantifying the spawning population are all reasons to strongly consider in-river weirs or counters. Currently, hatchery operations probably play a large role in maintaining the Feather River population. Adipose fin-clipped steelhead dominate counts of steelhead entering the FRH. In many years, nearly all steelhead entering the FRH are adipose clipped (pers. comm., Kastner 2003). Without the ability to accurately determine the number of wild and hatchery spawners, it will be impossible to set even short-term management goals. The federal listing of steelhead as “threatened” greatly increases the need to understand their basic life history on the Feather River. Gravel restoration, side channel creation and hatchery operational changes may all be needed to sustain adequate natural and hatchery production in the future.

7.0 REFERENCES

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Appendix A

List of Transect and Roving Survey Areas

LFC Transect Locations	River Mile	HFC Transect Locations	River Mile
Table Mtn	66.9	Vance East	58.6
Upper Hatchery	66.8	Vance West	58.7
Hatchery	66.7	Lower Big Hole East	57.9
Cottonwood	66.6	G-95 Main Channel	57.2
Upper Auditorium	66.5	G-95 West SC	57.3
Lower Auditorium	66.4	G-95 East SC	57.1
Upper Hatchery Ditch	66.6	Lower Hour	56.3
Lower Hatchery Ditch	66.5	Hour Bars East	56.0
Bedrock Park	65.8	Keister	55.0
Trailer Park	64.3	Goose	54.7
Upper Matthews	64.1	Big	54.0
Lower Matthews	64.0	Lower Big	53.3
Aleck	63.5	Lower MacFarland	52.0
Upper Robinson	61.9	Gridley East	49.4
Robinson	61.5	Junkyard	48.8
Upper Robinson SC	61.6	Cox	47.7
Lower Robinson SC	61.4	Upper Herringer	46.3
Steep	61.0	Long Glide	44.9
Steep SC	61.1		
Weir	60.8		
Eye	60.2		
Eye SC	60.3		
Gateway	59.7		

Low Flow Channel Roving Locations	**Section Number**	**Approximate River Mile(s)**
Hatchery Ditch	0	66.6
Table Mtn. Riffle to Auditorium	1	66.9-66.4
Upper Bedrock Pool	2	66.1
Bedrock Park	3	65.8
Trailer Park to Matthews	4	64.3-64.0
Aleck Riffle	5	63.5
Robinson Riffle	6	61.8-61.5
Weir Riffle	7	60.8
Eye Riffle	8	60.2
Gateway to Thermalito	9	59.7-59.4

High Flow Channel Roving Locations	**Section Number**	**Approximate River Mile(s)**
Vance Ave. West Channel	10	58.7-58.5
Vance Ave. East Channel	11	58.7-58.5
Big Hole West Channel	12	57.9
Big Hole East Channel	13	57.9
G-95 West and Main Channel	14	57.2-56.9
G-95 East Channel	15	57.1-56.9
Hour Bars	16	56.1-55.0
Goose Riffle	17	54.8
Big Riffle	18	54
Lower Big Riffle	19	53.7
Big Bar	20	53.4-53.2
Lower MacFarland Riffle	21	52.4-51.9
Gridley Riffle	22	49.1-49.5
Junkyard to Cox Riffle	23	48.8-47.6
Herringer Riffle	24	46.4-46.0
Herringer Pool	25	45.5-45.3

Appendix B

Microhabitat Data for All Redds Identified During the 2002-03 Redd Survey

Date Identified	Location	Instream Cover	Water Depth (m)	Water Velocity (ft/s)	Redd area m^2	Survey Type	Number of Steelhead	Riffle Position	Distance from bank	GPS Coordinates	Overhead Cover	Instream Cover	Substrate Code
01/06/2003	1	None	0.32	0.44	1.62	Roving	0	Tail	6	N 39.30.958 W 121.33.638	3	None	2,3
01/06/2003	Upper Hatchery Ditch	None	0.20	0.56	0.56	Transect	0	Middle	2	N 39.30.998 W 121.33.400	3	None	3,4
01/06/2003	Upper Hatchery Ditch	E	0.22	0.54	0.70	Transect	0	Middle	0.5	N 39.31.009 W 121.33.420	1,3	E	2,3
01/06/2003	Upper Hatchery Ditch	None	0.12	1.65	0.56	Transect	0	Middle	1	N 39.31.009 W 121.33.420	1,3	None	2,4
01/07/2003	6	None	0.34	1.67	1.20	Roving	0	Middle	75	N 39.30.511 W 121.30.285	None	None	3
01/07/2003	Steep SC	None	0.42	1.95	1.04	Transect	0	Head	4	N 39.28.007 W 121.35.686	None	None	3
01/14/2003	0	None	0.15	1.12	1.20	Roving	0	Middle	1	N 39.31.010 W 121.33.441	1,3	None	3,4
01/14/2003	0	None	0.23	1.34	2.16	Roving	0	Middle	4	N 39.30.996 W 121.33.424	3	None	3,4
01/14/2003	0	None	0.21	1.68	0.88	Roving	0	Middle	4	N 39.31.000 W 121.33.423	3	None	3,4
01/14/2003	1	None	0.20	1.00	1.80	Roving	0	Middle	1	N 39.30.942 W 121.33.607	none	None	3,4
01/14/2003	Cottonwood	None	0.41	2.32	1.20	Transect	0	Head	4	N 39.30.999 W 121.33.352	None	None	3
01/14/2003	Lower Auditorium	None	0.31	1.06	0.70	Transect	0	Middle	0.5	N 39.30.948 W 121.33.584	none	None	3,4
01/14/2003	Upper Hatchery	None	0.20	1.48	0.60	Transect	0	Middle	5.5	N 39.30.978 W 121.33.151	3	None	3
01/14/2003	Upper Hatchery	None	0.30	0.58	0.84	Transect	2	Middle	3.5	N 39.30.980 W 121.33.148	3	None	3
01/16/2003	20	None	0.32	0.66	0.99	Roving	0	Middle	6	N 39.23.161 W 121.37.715	None	None	3

Date Identified	Location	Instream Cover	Water Depth (m)	Water Velocity (ft/s)	Redd area m^2	Survey Type	Number of Steelhead	Riffle Position	Distance from bank	GPS Coordinates	Overhead Cover	Instream Cover	Substrate Code
01/16/2003	Hour Bars East	None	0.28	0.71	0.44	Transect	0	Middle	10	N 39.24.959 W 121.34.579	None	None	3
01/16/2003	Lower Big	None	0.27	1.36	1.56	Transect	0	Tail	30	N 39.23.402 W 121.37.418	None	None	3
01/20/2003	0	None	0.25	1.06	0.99	Roving	0	Middle	0.5	N 39.30.995 W 121.33.430	1	None	3
01/20/2003	0	None	0.22	1.45	0.90	Roving	0	Middle	3.5	N 39.30.995 W 121.33.430	None	None	3
01/20/2003	Aleck	None	0.23	1.18	0.18	Transect	0	Head	0.25	N 39.29.057 W 121.34.742	none	None	2,3
01/20/2003	Aleck	None	0.36	1.73	1.32	Transect	0	Head	2	N 39.29.061 W 121.34.739	none	None	3
01/20/2003	Upper Hatchery Ditch	None	0.20	2.00	1.10	Transect	0	Tail	4	N 39.30.995 W 121.33.421	None	None	3
01/20/2003	Upper Hatchery Ditch	None	0.23	1.12	1.00	Transect	0	Tail	1.5	N 39.30.995 W 121.33.420	None	None	3
01/21/2003	Steep SC	None	0.20	1.84	0.50	Transect	0	Tail	1.5	N 39.27.786 W 121.36.194	None	None	3
01/21/2003	Steep SC	None	0.28	2.17	0.90	Transect	0	Head	0.5	N 39.27.765 W 121.36.199	None	None	3
01/22/2003	Lower MacFarland	None	0.30	1.32	0.23	Transect	0	Middle	5	N 39.22.385 W 121.38.073	None	None	3
01/23/2003	Upper Herringer	None	0.30	2.00	0.52	Transect	0	Middle	10	N 39.19.101 W 121.37.197	None	None	3
01/27/2003	7	F	0.36	2.50	0.64	Roving	0	Middle	0	N 39.27.692 W 121.36.475	1	F	3
01/27/2003	7	None	0.39	2.44	1.00	Roving	0	Middle	1.5	N 39.27.692 W 121.36.475	None	None	3
01/27/2003	Steep SC	None	0.39	1.89	0.53	Transect	0	Middle	1	N 39.27.766 W 121.36.203	None	None	3

Date Identified	Location	Instream Cover	Water Depth (m)	Water Velocity (ft/s)	Redd area m^2	Survey Type	Number of Steelhead	Riffle Position	Distance from bank	GPS Coordinates	Overhead Cover	Instream Cover	Substrate Code
01/27/2003	Upper Robinson	None	0.31	0.51	1.21	Transect	0	Middle	40	N 39.27.999 W 121.35.707	None	None	3
01/28/2003	0	None	0.27	1.18	1.32	Roving	0	Middle	4.5	N 39.30.966 W 121.33.551	None	None	3
01/29/2003	15	None	0.26	1.83	0.56	Roving	0	Middle	40	N 39.25.797 W 121.37.797	None	None	3
01/29/2003	21	None	0.76	2.06	0.56	Roving	0	Middle	35	N 39.22.465 W 121.38.292	None	None	3
01/29/2003	21	None	0.77	2.06	1.10	Roving	0	Middle	30	N 39.22.464 W 121.38.299	None	None	3
01/29/2003	21	None	0.77	1.95	0.42	Roving	0	Middle	40	N 39.22.459 W 121.38.272	None	None	3
01/29/2003	21	None	0.74	1.95	0.40	Roving	0	Middle	35	N 39.22.451 W 121.38.267	None	None	3
01/29/2003	21	None	0.90	1.31	1.05	Roving	0	Middle	50	N 39.22.460 W 121.38.260	None	None	3
01/29/2003	G-95 East SC	None	0.27	1.95	1.40	Transect	0	Middle	30	N 39.25.852 W 121.37.742	None	None	3
01/30/2003	23	None	0.54	1.28	1.14	Roving	0	Middle	25	N 39.20.835 W 121.37.642	None	None	3
01/30/2003	Cox	None	0.50	1.28	0.29	Transect	0	Head	32	N 39.20.216 W 121.37.894	None	None	3
01/30/2003	Gridley East	None	0.36	1.53	0.15	Transect	0	Middle	15	N 39.21.298 W 121.37.773	None	None	3
01/30/2003	Long Glide	None	0.92	2.17	0.50	Roving	0		16	N 39.18.555 W 121.37.637	None	None	3
01/30/2003	Long Glide	None	0.76	2.22	0.21	Roving	0		18	N 39.18.554 W 121.37.643	None	None	3
01/30/2003	Upper Herringer	None	0.24	1.40	0.12	Transect	0	Middle		N 39.19.102 W 121.37.197	None	None	3

Date Identified	Location	Instream Cover	Water Depth (m)	Water Velocity (ft/s)	Redd area m^2	Survey Type	Number of Steelhead	Riffle Position	Distance from bank	GPS Coordinates	Overhead Cover	Instream Cover	Substrate Code
02/03/2003	0	None	0.29	1.76	1.13	Roving	0	m	2	N 39.30.991 W 121.33.486	2,3	None	2,3
02/03/2003	0	B	0.20	0.83	1.30	Roving	0	Middle	0.5	N 39.30.971 W 121.33.531	1,3	B	2,3
02/03/2003	Lower Auditorium	None	0.30	0.91	0.85	Transect	0	Middle	0.5	N 39.30.948 W 121.33.588	non	None	2,3
02/03/2003	Lower Auditorium	None	0.37	1.61	1.32	Transect	0	Middle	9	N 39.30.939 W 121.33.953	none	None	2,3
02/03/2003	Lower Auditorium	None	0.35	1.09	1.20	Transect	2	Head	1	N 39.30.994 W 121.33.577	1	None	2,3
02/03/2003	Lower Hatchery Ditch	None	0.26	1.98	1.43	Transect	0	Middle	2	N 39.30.971 W 121.33.539	2,3	None	2,3
02/03/2003	Lower Hatchery Ditch	None	0.20	1.24	0.45	Transect	0	Middle		N 39.30.965 W 121.33.539	3	None	2,3
02/03/2003	Upper Matthews	None	0.48	1.66	0.35	Transect	0	Head	15	N 39.29.552 W 121.34.754	none	None	3,4
02/05/2003	21	None	0.76	2.01	0.90	Roving	0		12	N 39.22.456 W 121.38.284	none	None	3,4
02/05/2003	21	None	0.36	1.12	0.56	Roving	0		6	N 39.22.451 W 121.38.283	none	None	3,4
02/05/2003	21	None	0.80	1.26	0.52	Roving	0		15	N 39.22.466 W 121.38.294	none	None	3,4
02/11/2003	Steep	None	0.16	2.80	0.42	Transect	1	Head	5	N 39.27.797 W 121.36.297	none	None	3,4
02/12/2003	Lower Hatchery Ditch	None	0.16		0.20	Transect	0	Middle	0.7	N 39.30.979 W 121.33.486	none	None	3,4
02/19/2003	0	None	0.36	1.40	3.50	Transect	0	Middle	0.6	N 39.30.989 W 121.33.456	none	None	2,3
02/19/2003	0	None	0.36	2.30	2.64	Roving	0	Middle		N 39.30.884 W 121.33.458	none	None	2,3

Date Identified	Location	Instream Cover	Water Depth (m)	Water Velocity (ft/s)	Redd area m^2	Survey Type	Number of Steelhead	Riffle Position	Distance from bank	GPS Coordinates	Overhead Cover	Instream Cover	Substrate Code
02/19/2003	0	none	0.38	2.20	1.47	Roving	0	Middle	3	N 39.31.991 W 121.33.447	none	none	2,3
02/19/2003	0	None	0.22	1.40	1.54	Roving	0	Middle	0.3	N 39.31.006 W 121.33.418	none	None	3
02/19/2003	0	None	0.28	1.72	2.55	Roving	1	Middle	0.1	N 39.30.986 W 121.33.537	1,2,3	None	2,3
02/19/2003	0	None	0.26	1.81	1.12	Roving	0	Middle	0.25	N 39.30.281 W 121.33.500	1,2	None	2,3
02/19/2003	6	None	0.18	2.30	1.19	Roving	0	Middle	0.2	N 39.28.045 W 121.35.635	none	None	2,3
02/19/2003	6	None	0.26	1.70	2.20	Roving	0	Head	1	N 39.28.026 W 121.35.877	none	None	2,3
02/19/2003	Lower Auditorium	None	0.36	1.34	1.98	Transect	1	Middle	5		none	None	2,3
02/19/2003	Steep	None	0.39	2.53	1.89	Transect	0	Middle	1.3	N 39.27.750 W 121.36.271	none	None	4
02/25/2003	0	None	0.16	1.40	0.23	Roving	0	Middle	0.5	N 39.27.741 W 121.36.271	3	None	3
02/27/2003	Steep SC	None	0.23	2.20	0.25	Transect	0	Middle		N 39.27.787 W 121.36.198	none	None	2,3
02/27/2003	Upper Robinson	None	0.22	1.65	0.19	Transect	0	Middle	15	N 39.28.017 W 121.35.677	none	None	3,4
03/07/2003	0	None	0.16	0.85	0.60	Roving	0	Middle	2	N 39.31.005 W 121.33.393	none	None	3,4
03/07/2003	0	B	0.26	1.12	0.74	Roving	0	Middle	2	N 39.30.994 W 121.33.422	none	B	3,4
03/07/2003	0	None	0.20	1.40	0.84	Roving	2	Middle	0.75	N 39.30.978 W 121.33.523	none	None	3,4
03/20/2003	6	None	0.28	2.22	0.14	Roving	2	Middle	15	N 39.28.032 W 121.35.639	none	None	3,4