Fish Passage

Appendix 5

FIELD SURVEYS AND VISUAL ASSESSMENTS
OF THE FEASIBILITY OF
HANDWORK TO RESTORE FISH PASSAGE TO TRIBUTARIES IN THE SOUTH FORK OF THE TRINITY RIVER WATERSHED, TRINITY COUNTY, CA

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EXECUTIVE SUMMARY

The Karuk Tribe and Mid Klamath Watershed Council have demonstrated success with improving salmonid passage into high value tributary habitat with handwork to remove sediment accretion at tributary mouths. The Watershed Research and Training Center (WRTC) wanted to examine the feasibility of implementing similar work in the South Fork of the Tributary River. Thirteen streams were examined to quantify habitat quality and biotic community composition. One site, Crystal Creek, was determined to be an orthofluvial pond on the South Fork of the Trinity River floodplain and therefore restoration of fish passage is not applicable. Two tributary mouths (Corral Creek and Rattlesnake Creek) were found to have sufficient passage at baseflow and do not warrant restoration. Five sites, Big Creek, Kerlin Creek, Mill Creek, Olsen Creek, and Pelletreau, did have impaired fish passage but it was determined that handwork would be insufficient to restore fish passage at this time. Five sites, Eltapom Creek, East Fork of Hayfork Creek, Madden Creek, Potato Creek, and Plummer Creek were determined to be good candidates for handwork to restore fish passage at the mouth. These sites were prioritized for restoration based on available habitat, habitat quality, species composition, and passage potential. Restoration design recommendations were drafted for each priority site.

Josh Smith of the Watershed Research and Training Center (WRTC) visually inspected an additional eleven sites. Eight sites (Duncan Gulch, Miner's Creek, Red Mountain Creek, Bear Creek, Big Creek, Carr Creek, Olsen Creek, and Smokey Creek) were determined to have sufficient passage at the tributary mouth during observed flows. Three sites, Rough Gulch, Little Bear Wallow, and Grouse Creek, were found to be a good candidates to improve fish passage at the tributary mouth by handwork.

INTRODUCTION

The South Fork Trinity River (SFTR) watershed is approximately 932 square miles. The SFTR is the longest undammed river remaining in California. 56 miles of the SFTR river are protected by the California Wild and Scenic Rivers Act and large portions of the basin are designated as Roadless and Wilderness management prescriptions by the United States Forest Service (Foster Wheeler Environmental Corporation, 2001; Truman et al 1996). Eighty-two percent of the basin is under federal ownership (NOAA, 2012). In 1964, with industrial logging activity at its peak, the watershed experienced its largest recorded flood, causing mass wasting of epic proportions. Numerous reports describe the 1964 flood and resultant sedimentation in detail and most identify it as the primary cause to loss in fisheries and habitat. There is evidence that the system is recovering. In 1970 only five deep summer holding pools existed; by 1999, 48 holding pools had re-formed in the same section of river (USFS, Dept. of Ag, 1999). The SFTR is presently Total Maximum Daily Load (TMDL) listed for sediment and 303(d) listed for temperature impairment.

The SFTR holds vast potential as habitat for anadromous fisheries. A number of factors contribute to the watershed's suitability to support fisheries including high intrinsic potential, limited human population, land designations supporting the area's wild character, and the relative healthy condition of the watershed. The SFTR, in particular Hayfork Creek, with its side channels, low gradient, and comparatively limited human influence, is well-suited coho habitat. According to 2008 studies by Everest and Boberg, "The lower part of Hayfork Creek has the greatest extent of high IP habitat and with increased water quality; this section of Hayfork Creek could serve as the major seat of recovery for coho salmon in the South Fork Trinity River basin. Other important tributaries where coho salmon have recently been found include Butter Creek, Eltapom Creek, Olsen Creek, and Madden Creek" (NOAA, 2014).

Numerous reports have identified the need to identify, prioritize, and implement fish passage projects to increase access to rearing and refuge habitats. The Southern Oregon and Northern California Coast (SONCC) Coho Salmon Recovery Plan (NOAA, 2014) emphasizes the need to protect access to cold water tributary streams to ensure that thermal refugia are available for hot summer periods. The Pacific Watershed Associates (PWA) Action Plan for the Restoration of the South Fork Trinity River and Fisheries (1994) calls for identification and implementation of improved fish passage as well as a juvenile rescue program. Recent research in the SFTR indicates that both summer and winter refugia associated with the lower reaches of tributaries are critical for the survival of juvenile salmonids. Fisheries surveys have identified consistently high numbers of juvenile salmonids in habitats that function both as summer and winter refugia (NOAA, 2014).

The identification of a series of manual, non-invasive projects that would offset sediment aggradation due to historic land use and improve fish passage at tributary mouths is an important restoration opportunity. Relatively little investment and disturbance can create large gains for fish populations as they gain access to large areas of cool water and high quality habitat. The Watershed Research and Training Center (WRTC) assessed numerous tributaries within the SFTR to identify chronic barriers to anadromous fish passage at the mouths of tributaries. A stream summary report was prepared for each stream outlining the results of the biotic and habitat surveys as well as restoration recommendations. This report compares the stream surveys and visual assessments results for different streams and discusses overall restoration opportunities for tributary mouth work in the SFTR watershed.

METHODS

Tributary mouth assessments determine whether aquatic vertebrates have sufficient passage at tributary mouths to gain access to upstream habitat. Surveys quantify fish habitat quality and fish assemblage characteristics (diversity, age structure, and density) in the lower tributaries as well as in the mainstem streams. Survey results allowed managers to understand what populations may be available to utilize habitat made available by improved passage conditions as well as infer potential impacts to tributary populations from impaired fish passage at tributary mouth accretions. Thirteen streams (Big Creek (Hyampom), Corral Creek, Crystal Creek, East Fork of Hayfork Creek, Eltapom Creek, Kerlin Creek (Hyampom), Madden Creek, Mill Creek (Hyampom), Olsen Creek, Pelletreau Creek (Hyampom), Plummer Creek, Potato Creek, and Rattlesnake Creek) were surveyed by Samantha Chilcote. Josh Smith (WRTC) conducted visual assessments of eleven additional streams (Duncan Gulch, Miner's Creek, Red Mountain Creek, Rough Gulch, Bear Creek (Hayfork Creek), Big Creek, Carr Creek, Grouse Creek, Olsen Creek, Little Bear Wallow, and Smokey Creek). The findings are summarized and reported herein.

Survey timing

The goal was to have surveys conducted as close to historic base flow (65-70 cubic feet per second (cfs)) based on average from period of record at the USGS SF Trinity gauge below Hyampom (USGS, 2014). Base flow was used to standardize hydrologic conditions between sites and through time due to extreme drought conditions in Northern California. This assumes that the tributaries were also at historical base flow conditions. Results should characterize average conditions in any given year and the degree of handwork to modify fish passage at tributary mouths will not be overestimated due to low flows caused by drought conditions. However, due to this historic drought, some surveys had to be conducted opportunistically and flows were significantly below the 65-70 cfs target. These surveys were conducted at flows ranging from 14-18 cfs. Reduced flows were qualitatively incorporated into the analysis of results and considered in subsequent restoration recommendations.

The visual assessments were opportunistically conducted. Therefore, they occurred across a range of flow. Flows at the USGS SF Trinity gauge below Hyampom ranged from 14-866 cfs during these assessments.

Reach determination

At each confluence site, two reaches were surveyed for habitat and snorkel surveys, the mainstem reach and the tributary reach. Reach locations and extents were determined by 1) stream structure (confluence), 2) ideal reach length of 100-150 m, and 3) hydrogeomorphic structure of the water body (changes in geologic confinement, pool riffle structure, etc). For every reach, a Global Positioning System (GPS) point and 2 photos (looking upstream and looking downstream) were taken at the beginning and end of the survey reach. These were recorded as Universal Transverse Mercator (UTM) coordinates using a GPS so they could be associated with photos and descriptions to characterize survey reaches.

Reaches were not surveyed for the visual assessments. Only observations at the confluence of the tributary and the mainstem were included in the visual assessments. A photo was taken at the mouth and it was noted whether current conditions allowed fish passage into the tributary and if restoration by handwork would be sufficient to improve passage conditions at the current flow. No further work was conducted. The following methods apply only to survey reaches.

Biotic surveys

Once the start and end point of each reach were determined, snorkel surveys were conducted before there was any instream disturbance. The snorkeler started at the downstream end of the reach and pulled themselves upstream against the current. This allowed a more accurate count of fish because they are usually oriented upstream for feeding from the current (Fausch, 1984). When both banks of the stream were not visible from the thalweg due to stream width or reduced visibility, the snorkeler worked back and forth from bank to bank, moving in a zigzag fashion upstream to the reach end. Areas that were shallower than 0.10 m were not surveyed by snorkel because the water depth precluded sufficient mask submersion. In these areas counts were completed using overhead visual surveys and fish were noted.

Each fish was identified by species and size class, less than 2.5 cm (young of the year, YOY), 2.5-7.6 cm, 7.6-12.7 cm, 12.7-17.8 cm, 17.8-22.9 cm, and 22.9-27.9 cm. Size classes were used to infer age class structure of fish and other amphibians utilizing the reach. The stream dimensions were used to calculate stream area and convert the abundance numbers to density measurements for reach comparisons.

Habitat surveys

Habitat conditions in each survey reach were characterized by visually estimating average conditions of various habitat elements throughout survey reaches. Data was collected on reach length and width, percent cover riparian vegetation, and substratum size. Reach width was estimated from the average wetted width of the channel. Reach length was estimated in the field and verified with Google Earth pathway measurements later in the office.

Available cover elements were also characterized in the field. Cover elements were defined as being areas of potential protection or refugia for aquatic vertebrates, such as undercut banks, aquatic vegetation, overhanging vegetation, and large wood. Undercut banks were defined as areas within the wetted channel that have been scoured by stream flows, causing concave areas under the bank. Overhanging vegetation was defined as terrestrial grasses and low bushes. Riparian vegetation cover was defined as canopy cover. Percent area of vegetation was only estimated over the wetted portion of the stream which had overhanging or riparian vegetation hanging over it. Aquatic vegetation was categorized as algae and any plants which were rooted underwater. Percent cover by large wood was also recorded. Large wood was defined as pieces greater than six feet long and at least three inches in diameter which were at least partially associated with the wetted channel. Substrate type was visually estimated as the amount of bottom area of each pool with a particular substrate type or percent cover. Substrate types were defined as fine/sand (< 2mm), gravel (2 – 64 mm), cobble (64 – 256 mm), and boulder/bedrock (>256 mm) (Bain, Finn, and Booke, 1985).

Supplemental Measures

There were additional metrics taken at sites which appeared appropriate for the restoration of fish passage by handwork. If a tributary was disconnected in the proximity of its confluence with the main channel, additional metrics were used to quantify the degree and type of hand work for each potential restoration project. Supplemental measures included the distance where the stream goes subsurface (the length of dry streambed blocking fish passage) and the depth of sediment aggradation (the change in elevation from the main channel to the usable portion of the tributary). The length and height measurements gave an approximate slope that restoration measures must obtain to connect the two reaches. This allowed the feasibility of restoration activities to be evaluated and supported the development of modification design standards.

ANALYSIS

Data was entered into a Microsoft Excel 2013 spreadsheet and basic statistical summaries were conducted. Surface area was calculated for each reach. This assumed each pool was rectangular, with surface area being calculated as the width multiplied by the length. Although this did not account for the heterogeneity of banks, it allowed some relative comparison of fish density across sites. Volume was not calculated because of the tight correlation of this metric to surface area. The total number of fish as well as total vertebrates by species and size class was also calculated for each reach. The density of fish and vertebrates was calculated by dividing the number of individuals by the reach surface area for all species and size classes in each reach, yielding a number of individuals per square meter. Average, maximum, minimum, and standard deviation values are calculated for habitat measures. The size class density for each species was calculated and species richness was determined for each site. A summary was written for each tributary surveyed.

RESULTS

The following results are based on the data gathered and analyzed from the survey reaches described above.

Abiotic Conditions

Abiotic surveys were conducted in all tributaries and mainstem reaches where the stream channel was not dry. Big Creek, Mill Creek, and Olsen Creek were dry so no data was collected. Survey data was collected on a total of 10 tributaries; Rattlesnake Creek, Corral Creek, Eltapom Creek, Kerlin Creek, Potato Creek, East Fork of Hayfork Creek, Pelletreau Creek, Madden Creek,and Plummer Creek. Data was collected on the mainstem waterbody directly below the confluence with each respective tributary. The exception to this was Rattlesnake Creek, where no mainstem data was collected. Five sites are tributaries to the SFTR; Eltapom Creek, Kerlin Creek, Pelletreau Creek, Madden Creek, and Plummer Creek. Three sites are tributaries to the mainstem of Hayfork Creek; East Fork of Hayfork Creek and Corral Creek. One site, Potato Creek, is a tributary of the mainstem East Fork of Hayfork Creek.

Habitat metrics were stream length (L), stream width (W), survey area (A), percent large wood debris (LWD), percent riparian canopy (RIP), percent overhanging vegetation (O VEG), percent aquatic vegetation (A VEG), and percent undercut banks (UB).

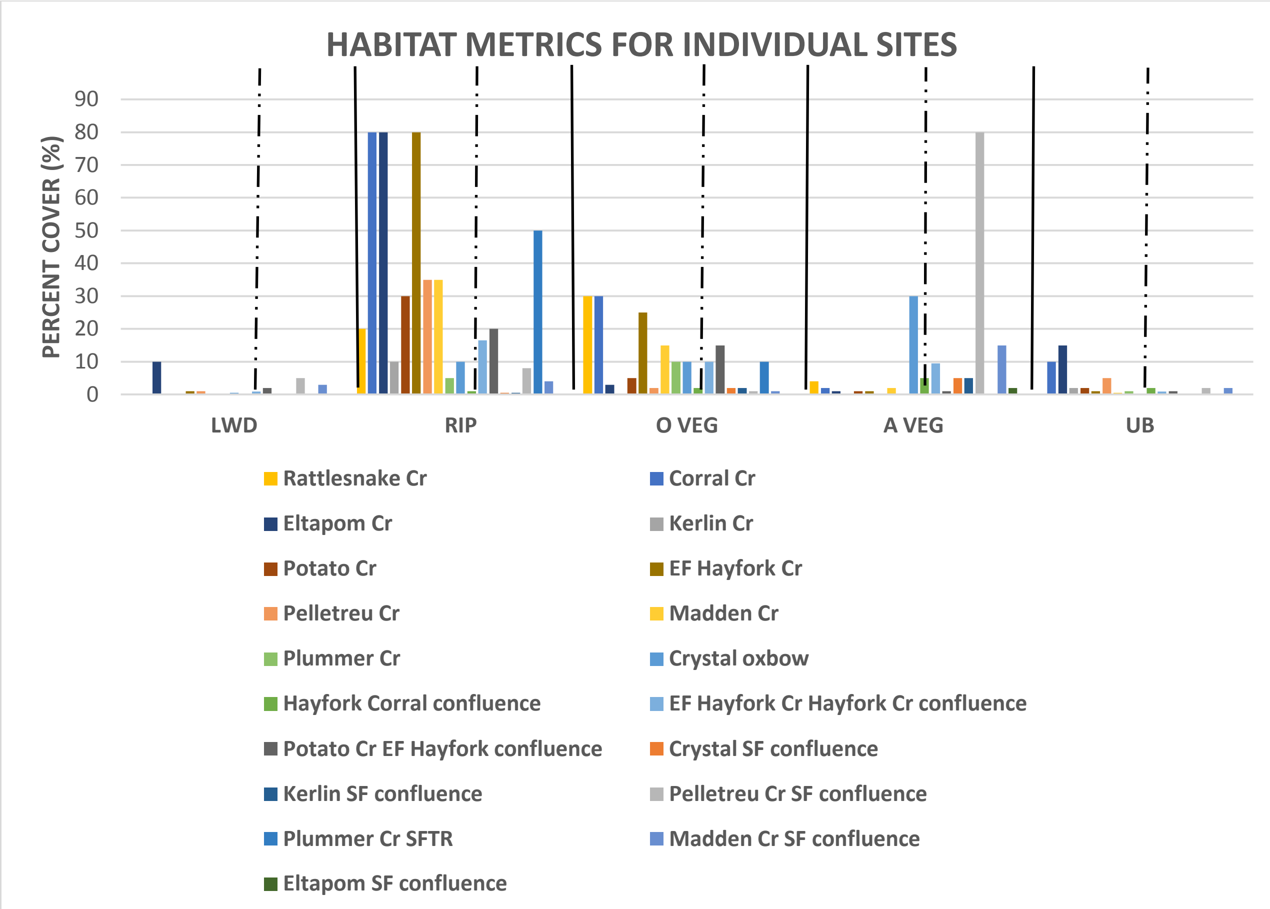


Figure 1. Habitat metrics for each survey site. Tributaries are to the left of the dashed line. Mainstem areas are on the right side of the dashed line. Solid lines separate the habitat metrics LWD, RIP, O VEG, A VEG, and UB.

Percent cover by refugia elements were higher in tributaries than the main channel. The exception to this was percent cover by aquatic vegetation (A VEG). This was primarily due to high levels of algae in the main channel. Although this does represent cover for salmonids, it also can be associated with increased nutrient concentrations and decreased flow. These conditions are not favorable for salmonids (Zedonis, 2007; Bjornn and Resier, 1991).

Substrate composition was also measured at all sites and represented as percent bedrock (BD), percent boulder (BO), percent cobble (CO), percent fines (FI).

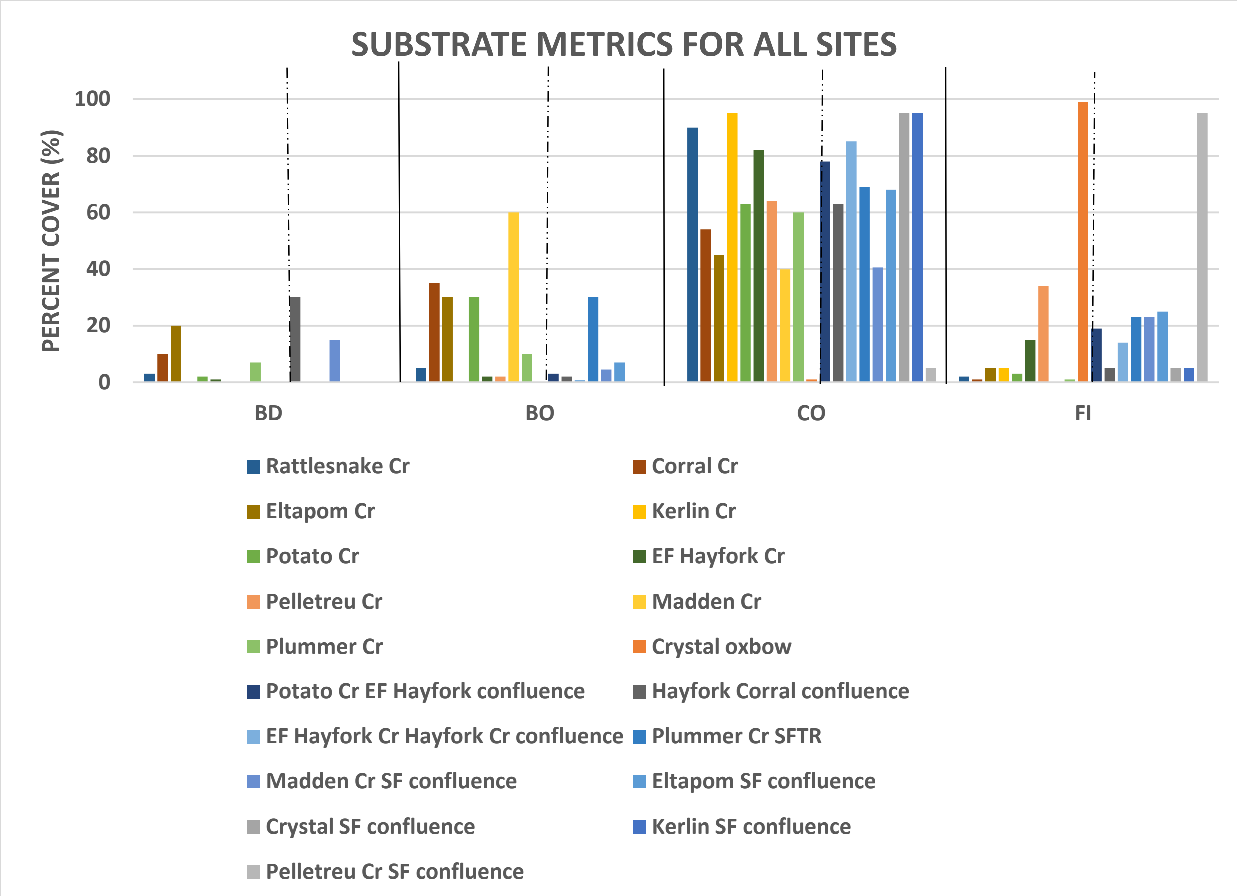


Figure 2. Substrate metrics for each survey site. Tributaries are to the left of the dashed line. Mainstem areas are on the right side of the dashed line. Solid lines separate the habitat metrics BD, BO, CO, and FI.

Trends in substrate composition were not as distinct as refugia elements between tributaries and main channel sites. There was a tendency toward more boulder (BD) and less fines (FI) in tributary sites relative to main channel sites. Boulder substrate is indicative of higher flow velocities and fines are indicative of less stream power. This can be associated with either stream gradient or high flow events.

Summary statistics, Average (Avg), Standard deviation (SD), Maximum (Max), and Minimum (Min) values were calculated for all habitat metrics for tributaries, the mainstem South Fork of the Trinity River, and the other “mainstem” sites. These summary statistics reinforce the visual trends of increased refugia cover elements (riparian vegetation (RIP), overhead vegetation (O VEG), and undercut banks (UB)) in tributary sites relative to main channel sites. Although the average large wood percent cover (LWD) was slightly higher in mainstem sites, the maximum large wood cover was higher in tributary sites. Lastly, the summary statistics indicate a distinct trend toward larger substrate types in the tributaries relative to main channel sites. Tributary mainstem sites were separated from mainstem sites in the SFTR so that summary statistic data would not be skewed.

Table 1. Statistical summary of habitat metrics for tributary survey sites.

	LWD (%)	RIP (%)	O VEG (%)	A VEG (%)	UB (%)	BD (%)	BO (%)	CO (%)	FI (%)
Avg	1.25	38.50	13.00	4.10	3.65	4.30	17.40	59.39	16.51
SD	3.10	30.46	11.54	9.18	5.02	6.48	20.36	27.44	30.77
Max	10.00	80.00	30.00	30.00	15.00	20.00	60.00	95.00	99.00
Min	0.00	5.00	0.00	0.00	0.00	0.00	0.00	1.00	0.10

Table 2. Statistical summary of habitat metrics for SFTR mainstem survey sites.

	LWD (%)	RIP (%)	O VEG (%)	A VEG (%)	UB (%)	BD (%)	BO (%)	CO (%)	FI (%)
Avg	1.35	10.50	2.68	17.83	0.67	2.50	6.92	62.08	29.33
SD	2.15	19.59	3.66	30.89	1.03	6.12	11.68	34.57	33.45
Max	5.00	50.00	10.00	80.00	2.00	15.00	30.00	95.00	95.00
Min	0.00	0.00	0.10	0.00	0.00	0.00	0.00	5.00	5.00

Table 3. Statistical summary of habitat metrics for tributary mainstem abiotic survey sites. Data includes Hayfork Creek at Corral Creek and the East Fork of Hayfork Creek at Potato Creek.

	LWD (%)	RIP (%)	O VEG (%)	A VEG (%)	UB (%)	BD (%)	BO (%)	CO (%)	FI (%)
Avg	0.97	12.50	9.00	5.17	1.30	10.00	1.97	75.37	12.67
SD	1.00	10.11	6.56	4.25	0.61	17.32	1.05	11.28	7.09
Max	2.00	20.00	15.00	9.50	2.00	30.00	3.00	85.10	19.00
Min	0.00	1.00	2.00	1.00	0.90	0.00	0.90	63.00	5.00

Mainstem sites in tributaries had higher average percent cover of refugia elements (riparian vegetation (RIP), overhead vegetation (O VEG), and undercut banks (UB) than did mainstem SFTR sites. Mainstem tributary sites had slightly less average large wood percent cover (LWD) and less aquatic vegetation (A VEG) as well as larger average substrate size than did mainstem sites in the South Fork of the Trinity River.

Biotic Conditions

Tributary sites were quantitatively surveyed for aquatic community composition, species richness and size classes, and the density of assemblages in the stream whenever possible. All aquatic vertebrates as well as crayfish (*Pacifasticus* spp) were recorded. Cold water associated species, coho salmon (*Oncorhynchus kisutch*), chinook salmon (*Oncorhynchus tshawytscha*), rainbow trout/steelhead (*Oncorhynchus mykiss*) complexes, as well as more warm water associated species, speckled dace (*Rhinichthys osculus*), suckerfish (*Catostomus* spp), and sunfish (*Lepomis* spp), were found in tributaries.

Other species observed included Pacific Giant Salamanders (*Dicamptodon* spp), Foothill Yellow legged frogs (*Rana boylii*), garter snakes (*Thamnophis* spp), and crayfish.

Mainstem SFTR sites were qualitatively surveyed for aquatic community composition. Quantitative surveys were not possible because large areas or columnar algae reduced observer accuracy. Species observed in the SFTR mainstem sites were chinook salmon, steelhead/rainbow trout complexes, speckled dace, sucker fish, sun fish, blue gill, beaver, Foothill Yellow legged frogs, garter snakes, crayfish, bullfrog tadpoles, and turtles. Species observed in tributary "mainstem" sites were chinook salmon, steelhead/rainbow trout complexes, speckled dace, Foothill Yellow legged frogs, crayfish, and turtles. The East Fork of Hayfork Creek was the only "mainstem" site which could be accurately snorkeled for density counts due to low visibility from high algal abundance. For this reason, it is included in the representation of tributary results both as a tributary site at its confluence with Hayfork Creek as well as a mainstem site at the confluence with Potato Creek. Tributary sites had the highest species richness of salmonids,containing coho salmon, steelhead/rainbow trout complexes, and chinook salmon.

Table 4. Species composition and richness in tributary sites.

Tributary	Fish Species	Species Richness
Madden Cr	Coho, Steelhead/rainbow, Chinook, speckled dace, sucker fish	5
Plummer Cr	Steelhead/rainbow, chinook, speckled dace, sucker fish	4
Kerlin Cr	Steelhead/rainbow, chinook, speckled dace, sucker fish	4
Pelletreau Cr	Steelhead/rainbow, speckled dace, sun fish	3
Rattlesnake Cr	Steelhead/rainbow, speckled dace	2
Eltapom Cr	Steelhead/rainbow, sucker fish	2
Potato Cr	Steelhead/rainbow, chinook	2
EF Hayfork Cr	Steelhead/rainbow, chinook	2
Corral Cr	Steelhead/rainbow	1

Steelhead/rainbow trout

Size class distribution of Steelhead/rainbow trout complexes was skewed toward smaller size classes in tributaries. This is consistent with these areas being used as rearing habitats for rainbow trout/steelhead complexes. There were some larger size classes present, particularly in Corral Creek, which is likely indicative of a resident rainbow population. However, it is possible this tributary still contributes to the maintenance of the steelhead life history type as resident rainbow trout can have anadromous offspring (Pavlov et al, 2008).

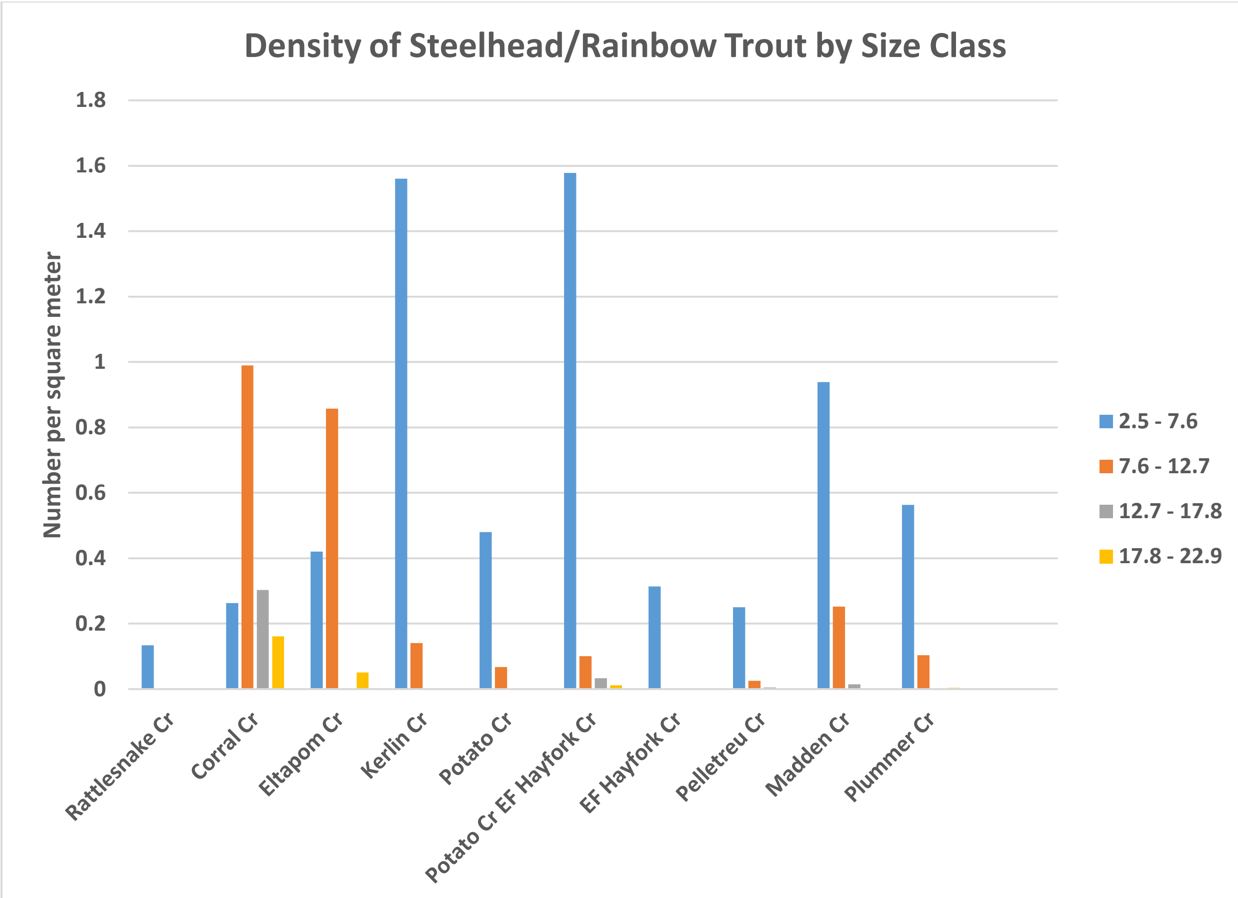


Figure 3. Steelhead/rainbow trout density by size class in each stream survey. Density in number of fish per square meter. Size classes by centimeter.

Chinook salmon

Chinook salmon were the next most common tributary species, occurring at five sites. Chinook salmon were found in Kerlin Creek, the East Fork of Hayfork Creek (as mainstem and tributary surveys), Madden Creek, and Plummer Creek. The size class distribution is skewed towards the smallest size classes because individuals were rearing prior to outmigration. Plummer Creek had the highest density of juvenile Chinook salmon.

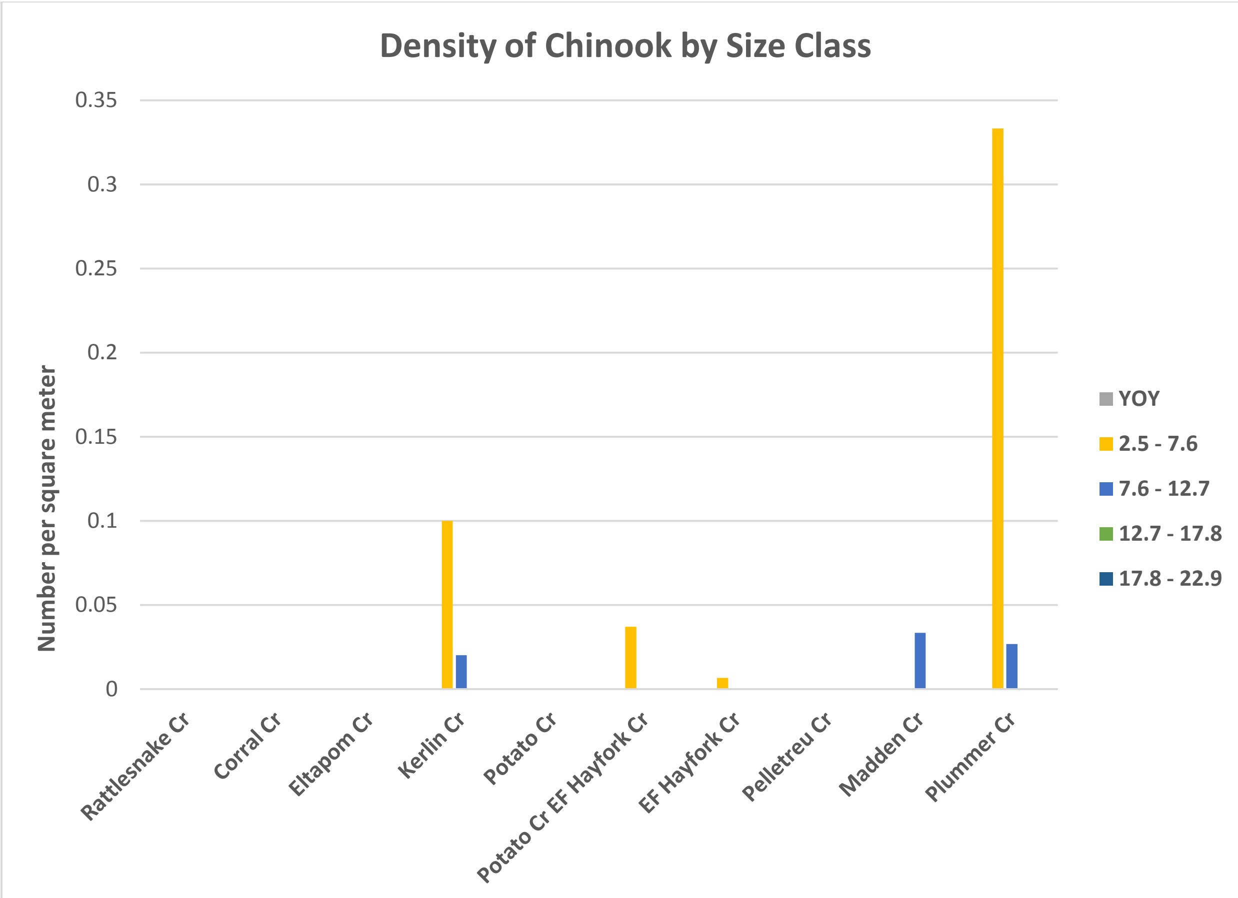


Figure 4. Chinook salmon density by size class in each stream survey. Density in number of fish per square meter. Size classes by centimeter.

Speckled dace

Speckled dace were found at four tributary survey sites. Speckled dace were found in Rattlesnake Creek, Kerlin Creek, Pelletreau Creek, and Madden Creek. The highest density of speckled dace was found at Kerlin Creek. However, Rattlesnake Creek was the only site that contained two size classes.

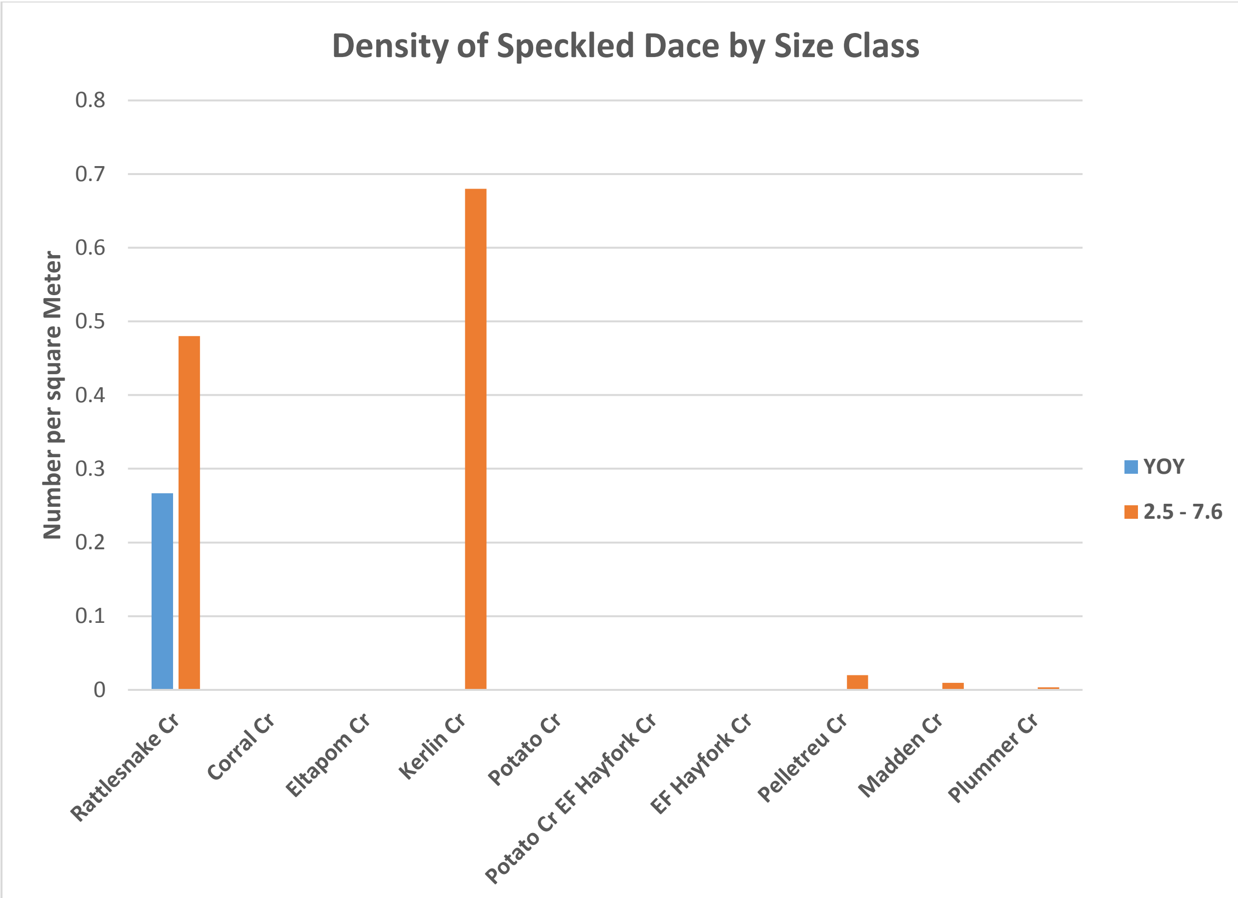


Figure 5. Speckled Dace density by size class per each stream surveyed. Density in number of fish per square meter. Size classes by centimeter.

Sucker fish

Sucker fish were also found at four tributary sites. They were found at Eltapom Creek, Kerlin Creek, Madden Creek, and Plummer Creek. Similar to speckled dace, the highest density of sucker fish was found at Kerlin Creek.

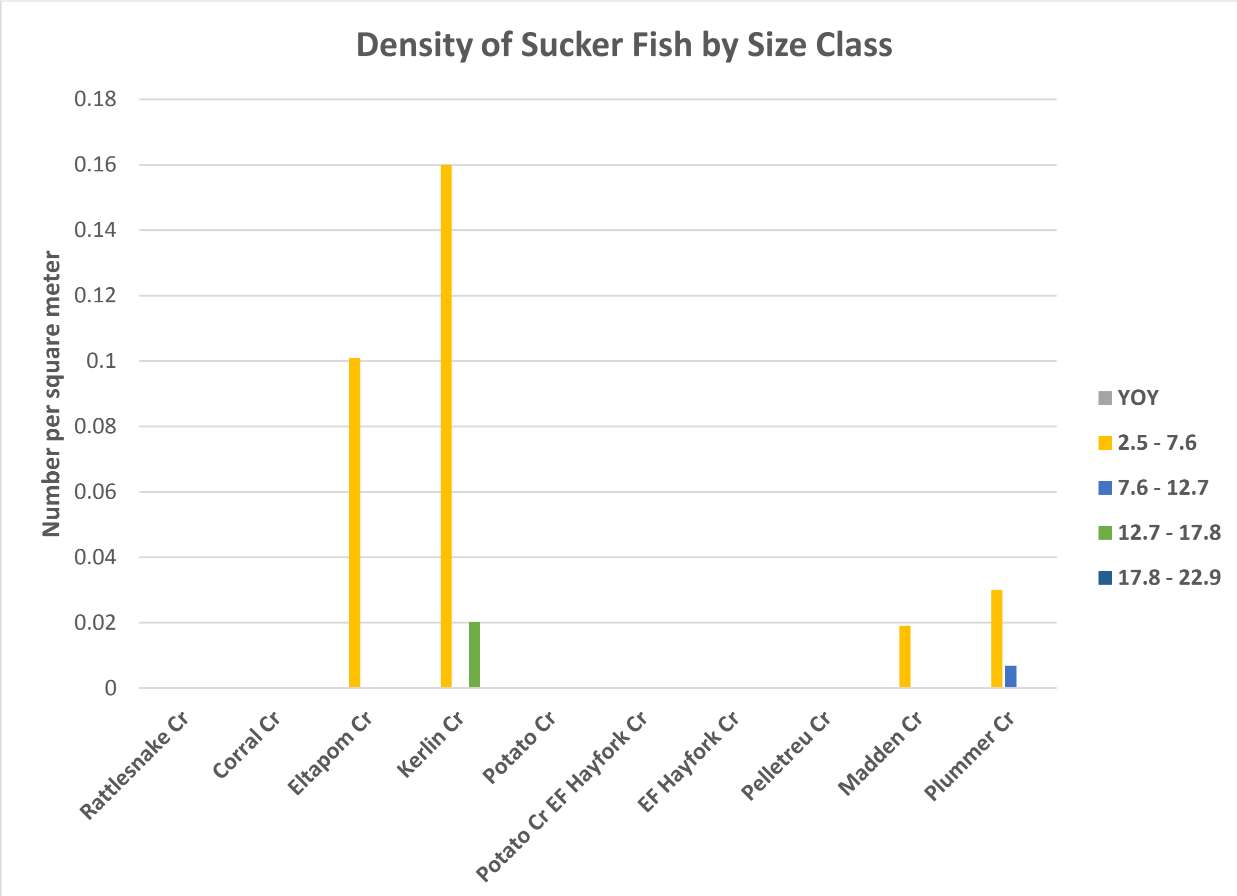


Figure 6. Sucker fish density by size class per each stream surveyed. Density in number of fish per square meter. Size classes by centimeter.

Other fish species

The only species found in the mainstem of the SFTR and not in tributary sites was blue gill. Coho salmon were only found in Madden Creek. Three 7.6-12.7 cm individuals were observed in the survey reach for a density of 0.014 individuals per square meter. Additionally, in the tributary surveys, sunfish were only found in Pelletreau Creek. Two 2.5-7.6 cm individuals were found for a density of 0.010 individuals per square meter.

RESTORATION RECOMMENDATIONS

Eleven streams were visually assessed (Table 5). Eight streams were found to be hydrologically connected to the SFTR and conditions at the mouth would allow passage of juvenile salmonids at the assessment flow. One site did not have sufficient fish passage at the mouth under observed flows, and visual observation indicates that handwork would not be sufficient to restore fish passage. Three sites were found to be a restoration priority at the observed flow for handwork to restore fish passage at the mouth. Grouse Creek (Figure 7), Rough Gulch (Figure 8), and Little Bear Wallow (Figure 9) were the only sites determined to have restoration potential from the visual assessments at the observed flows.

Table 5. Restoration recommendations for each visually assessed stream relative to the streamflow at the Hyampom gauge on the SFTR. Restoration recommendations were Not Necessary (NN), or Restoration Priority (RP)

Stream	**Flow during survey (cfs)**	**Restoration Recommendation**
Duncan Gulch	535	NN
Miner’s Creek	93	NN
Red Mountain Creek	17	NN
Rough Gulch	17	RP
Bear Creek (Hayfork Creek)	105	NN
Big Creek	866	NN
Carr Creek	830	NN
Grouse Creek	17	RP
Little Bear Wallow	600	RP
Olsen Creek	14	NN
Smokey Creek	830	NN

Figure 7. Mouth of Grouse Creek.

Figure 8. Rough Gulch at low flows.

Figure 9. Little Bear Wallow mouth at low flow conditions.

Thirteen streams were quantitatively surveyed in the summer of 2014 and 2015 (Table 6). Two streams, Rattlesnake and Corral Creeks, were found to be hydrologically connected to the SFTR and conditions at the mouth would allow passage of juvenile salmonids at or below historic base flow. One site, Crystal Creek, was reported by local landowners to be a high value coldwater refugia, however, investigations of aerial imagery showed this to be an orthfluvial oxbow on the SFTR floodplain. Restoration of fish passage from handwork at these sites is either not necessary or not applicable. Five sites (Big Creek and Mill Creek (Hyampom), Kerlin Creek, Olsen Creek, and Pelletreau Creek) were found to be disconnected at the mouth but handwork would not be sufficient to restore fish passage. Five sites were found to be restoration priorities for handwork to restore fish passage at the mouth; Eltapom, East Fork of Hayfork, Madden, Potato,and Plummer Creeks.

Table 6. Restoration recommendations for each surveyed stream relative to the streamflow at the Hyampom gauge on the SFTR. Restoration recommendations were Not Necessary (NN), Not Applicable (NA), Not Sufficient (NS), or Restoration Priority (RP).

Stream	Flow during survey (cfs)	Restoration Recommendation
Big Creek (Hyampom)	14	NS
Corral Creek	18	NN
Crystal Creek	74	NA
Eltapom Creek	18	RP
EF Hayfork Creek	74	RP
Kerlin Creek	74	NS
Madden Creek	55	RP
Mill Creek (Hyampom)	14	NS
Olsen Creek	14	NS
Pelletreau Creek	14	NS
Potato Creek	70	RP
Plummer Creek	66	RP
Rattlesnake Creek	17	NN

Coho salmon are currently found in the SFTR up to Butter Creek and in Hayfork Creek up to Corral Creek. There is occupied habitat in Eltapom Creek, Olsen Creek, and Madden which are characterized as important cool water refugia in the SONCC Recovery Plan (NOAA, 2014). Madden Creek was the only survey site in which coho salmon were observed and it had the highest species richness, 5, of any tributary surveyed. Eltapom Creek should be the second priority for restoration because it contains occupied coho habitat. These areas should be top priorities for restoration. Additionally, the SONCC Recovery Plan found moderate to high Intrinsic Potential habitat in Pelletreau Creek, and Rattlesnake Creek. Therefore, these streams should also be considered a high priority for recovery (NOAA, 2014). However, Rattlesnake Creek had sufficient hydrologic connectivity at the mouth to allow fish passage without restoration work. Fish passage at the mouth is not a limiting factor in coho recovery in this tributary. Pelletreau Creek was found to need more than handwork to restore fish passage into this tributary from the SFTR during base flows. Therefore, restoration priorities based on literature and field surveys to restore fish passage at the mouth using handwork should be:

1. Madden Creek
2. Eltapom Creek

3. Plummer Creek
4. East Fork of Hayfork Creek
5. Potato Creek
6. Rough Gulch
7. Grouse Creek
8. Little Bear Wallow

Madden Creek

Mouth restoration by handwork would be sufficient to restore passage from SFTR to Madden Creek (Figure 10). Although the creek is hydrologically connected by surface flows, the gradient at the mouth is fairly steep due to aggradation at the mouth.

Figure 10. The mouth of Madden Creek.

Handwork is recommended for enhancing fish passage at the mouth of Madden Creek. This area has a high gradient and would be enhanced by concentrating flows from the five channels into a single thread, reducing the gradient, and providing slower velocity resting areas for juvenile passage. Handwork should reduce the gradient from the confluence with the SFTR for 24.5 meters upstream. The vertical drop over this length is approximately 1.2 meters resulting in a stream gradient of 4.9%, with much of the vertical drop concentrated in the lower portion of the creek. Because coho salmon prefer gradients below 3% (Reeves et al, 1989), we recommend reducing the gradient with handwork at the mouth to below 3% by utilizing small step pools.

Figure 9. Conceptual drawing of Madden Creek a. before handwork and b. after handwork.

a. Before Handwork

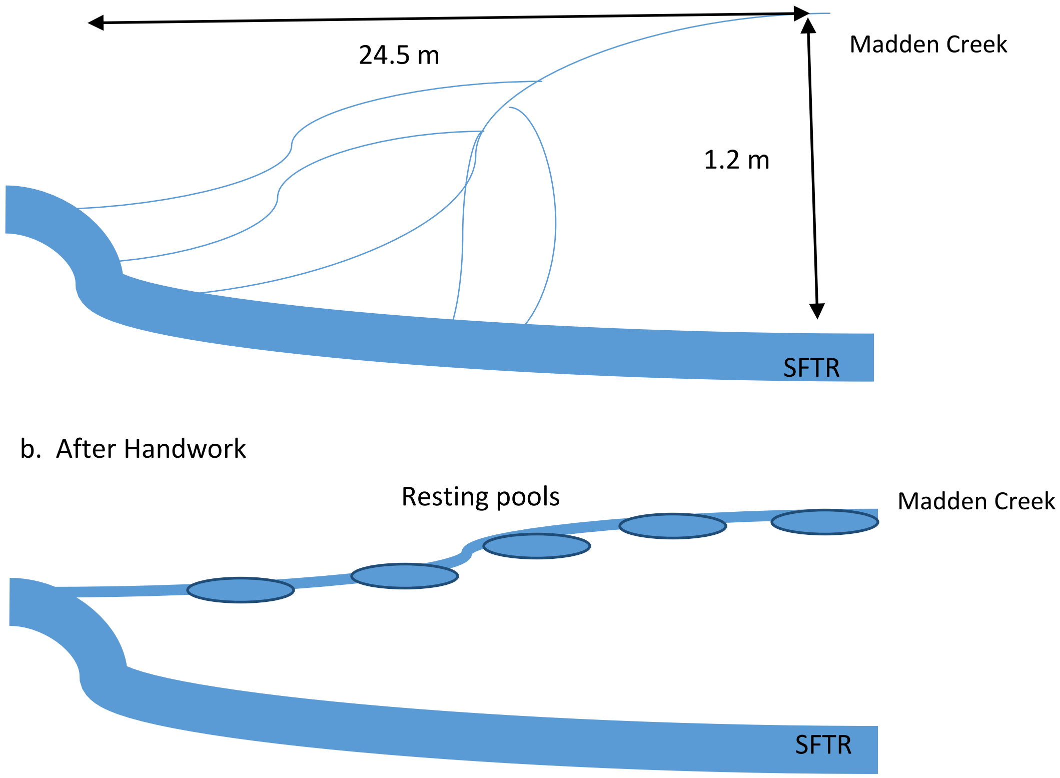


Figure 11. Conceptual drawing of Madden Creek handwork. Stream channel before handwork (a) and after handwork (b).

These step pools should not have any vertical drops over 2.3 cm (Whitman, 2011). Resting pools before and after any drops in this range should have sufficient depth (jump height to landing pool depth 1:1.25 or better (Taylor, 2011)) and area for takeoff and landing as well as slow enough velocities for fish resting and recovery (0.0035 m/s for juvenile coho (United States Department of Interior, 1996)). Pools have been identified as important restoration attributes because they were found to have the highest density of all fish species in this survey as well as a 1989 survey (Large Tributaries to the Lower South Fork Trinity River, 2015). Handwork could be used to improve juvenile fish passage, especially for coho salmon, to approximately a mile of anadromous fish habitat (Large Tributaries to the Lower South Fork Trinity River, 2015) and enhance habitat quality.

Eltapom Creek

Handwork would be sufficient to restore fish passage to Eltapom Creek. Eltapom Creek was perched at the mouth with sediment accumulation causing the stream to go subsurface 12.3 m from the confluence with the SFTR.

Figure 12. Eltapom Creek where the stream goes subsurface, looking downstream at the confluence with the SFTR.

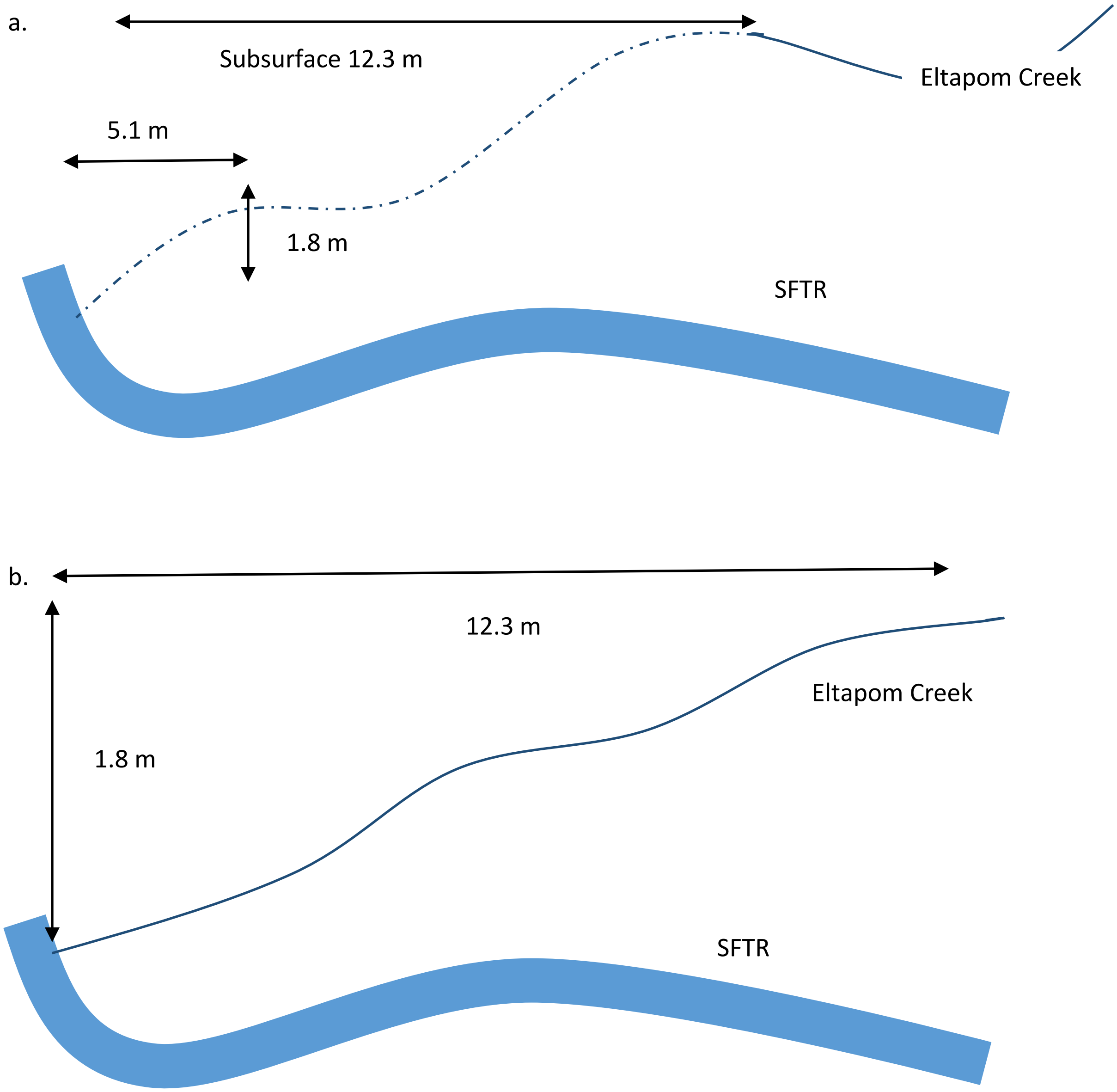
This eliminates fish passage for all species and life history stages at base flow. The subsurface flow reemerges just above the confluence with the SFTR.

Figure 13. Subsurface flow from Eltapom Creek at the confluence with the SFTR.

This is a good indication that handwork would be sufficient to restore surface hydrologic connectivity. There is also a steep slope from the elevation of Eltapom Creek's bed to the SFTR as can be seen in Figure 11. The slope is approximately 35.3%.

Currently, fish passage into Eltapom Creek during summer baseflow is limited by surface hydrology and the gradient at the mouth. Handwork to remove sediment from the subsurface portion of Eltapom Creek would also serve to reduce the gradient at the mouth. A single channel should be cleared along the 12.3 m subsurface section, establishing surface hydrologic connectivity. This will also reduce the gradient by dispersing the 1.8 m difference in elevation between the stream bed and the mainstem over 12.3 m as opposed to the current distance of 5.1 m. The remaining reduction in stream gradient can be achieved by using handwork to construct step pools.

Figure 12. The confluence of Eltapom Creek with the SFTR a. before handwork and b. after handwork.



The recommended step pools on Eltapom Creek would have the same restrictions as Madden Creek; no vertical drops over 2.3 cm (Whitman, 2011), jump height to landing pool depth 1:1.25 or better (Taylor, 2011), and construction of areas with velocities less than 0.0035 m/s (United States Department of the Interior, 1996).

Coho salmon have historically occupied Eltapom Creek but were absent in the current survey, as well as a 1989 survey (Large Tributaries to the Lower South Fork Trinity River, 2015). Enhanced fish passage might help coho to reoccupy this important cold water refugia. This would enhance juvenile fish passage to approximately a mile of anadromous fish habitat (Large Tributaries to the Lower South Fork Trinity River, 2015).

Plummer Creek

Plummer Creek had a high species richness and was connected by surface water to the SFTR at historic base flows. However, there was a high gradient at the mouth. Therefore, fish passage would be enhanced by hand work which could decrease the gradient at the mouth and provide resting areas for fish as they navigate through it.

Figure 14. Mouth of Plummer Creek.

The current survey found anadromous rainbow/steelhead complexes and chinook salmon. However, a United States Forest Service Watershed Analysis reported that the area was potentially used by coho salmon as well (USDA, 2001).

Currently, the gradient at the mouth of Plummer Creek is 37.5% and there are few pools for resting areas for juvenile fish as they pass. Hand work would be useful to reduce the gradient and create pool habitats for resting areas for juvenile fish as they navigate drops.

a.

b.

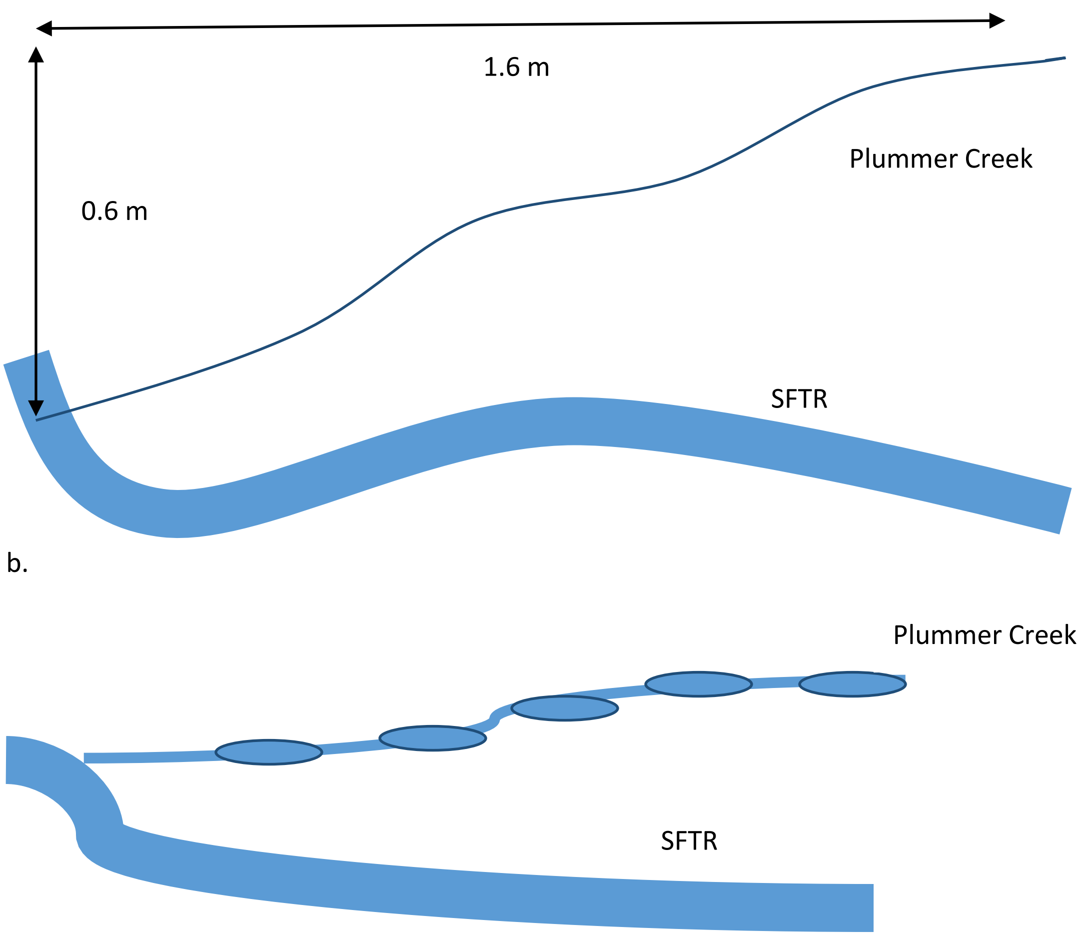


Figure 15. Proposed handwork on Plummer Creek.

The step pools on Plummer Creek would have the same restrictions as Madden and Eltapom Creeks, no vertical drops over 2.3 cm (Whitman, 2011), jump height to landing pool depth 1:1.25 or better (Taylor, 2011), areas with velocities less than 0.0035 m/s (United States Department of the Interior, 1996).

East Fork of Hayfork Creek

The East Fork of Hayfork Creek has a low gradient but it goes subsurface right before the confluence with Hayfork Creek. This creek is not known to be historically occupied by coho, but it does contain high intrinsic potential habitat (NOAA, 2014). Furthermore, it is occupied by anadromous rainbow/steelhead complexes and chinook salmon.

The East Fork of Hayfork Creek goes subsurface for approximately 60 meters before the confluence with Hayfork Creek. The survey was conducted at historic baseflow based on previous gauging data by the USGS so the low flow was not an artifact of the current drought in California. Handwork clearing fine sediment from the channel would be effective to restore surface hydrologic connectivity in this low gradient reach.

It is important to note that the EF of Hayfork Creek showed signs of impaired water quality, mostly in the form of filamentous algae. This is likely due to cows in the creek. However, there is high quality habitat with good water quality upstream of this area. Therefore, excluding cows from the riparian area would improve habitat quality and restoring surface hydrologic connectivity would restore fish passage to more suitable habitat upstream.

a.

b.

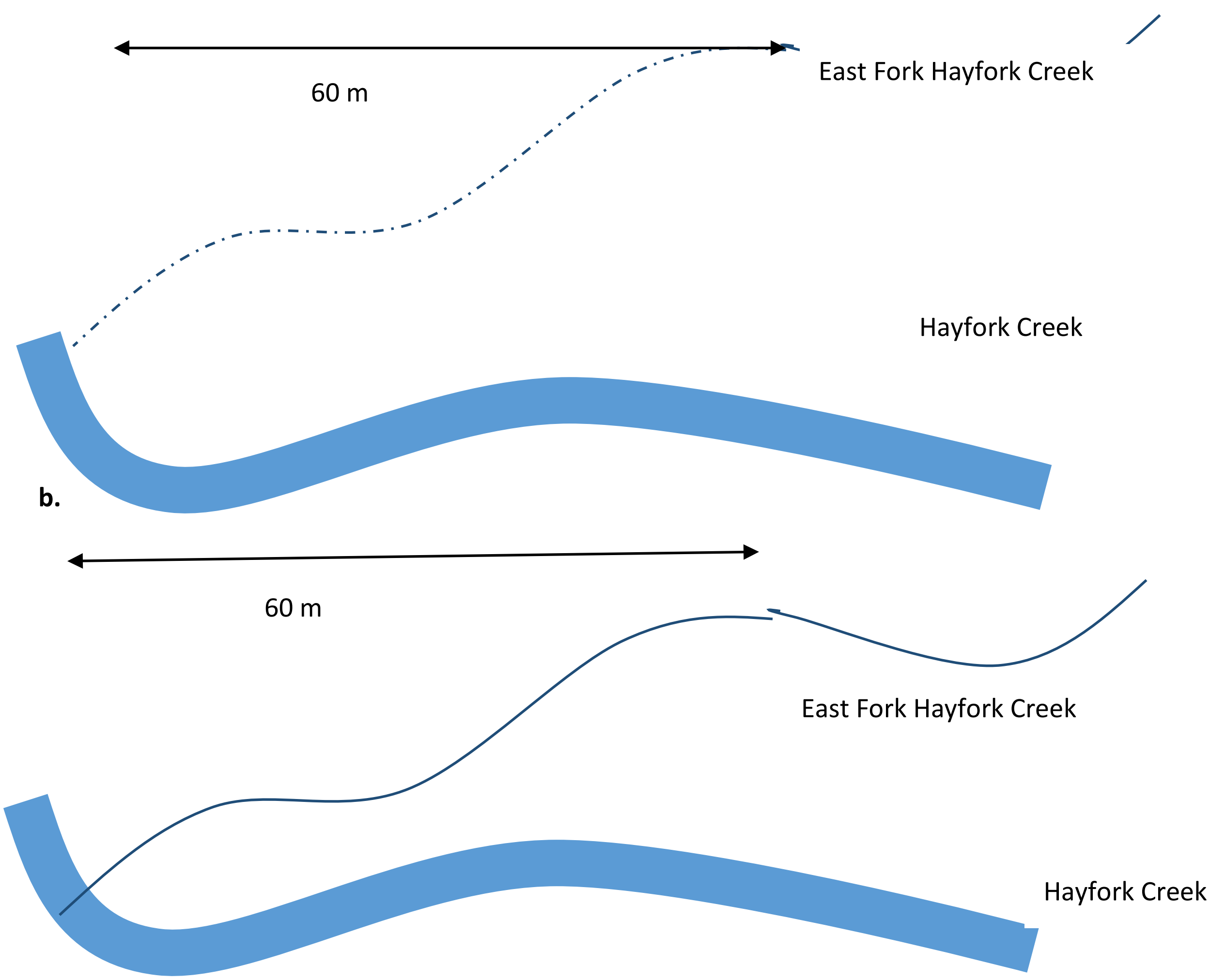


Figure 16. Proposed handwork of East Fork of Hayfork Creek.

Figure 17. Cows observed near the mouth of East Fork of Hayfork Creek.

Potato Creek

As with Eltapom Creek, Potato Creek would benefit from handwork at its mouth by reducing the gradient, and restoring surface hydrologic connectivity. Potato Creek goes subsurface for 24.5 m approximately 20 meters upstream of the confluence. The mouth of Potato Creek is above the mouth of the East Fork of Hayfork Creek. Therefore, connectivity must be restored in the downstream confluence to achieve restoration results upstream in Potato Creek. These areas are outside of historic occupied coho habitat but contain areas of high intrinsic potential habitat. Therefore, Potato and East Fork of Hayfork Creek offer potential restoration opportunities for coho salmon but also can offer restoration benefits to other species, such as chinook salmon and steelhead/rainbow trout complexes.

Figure 18. The beginning of the subsurface portion of Potato Creek.

Potato creek was surveyed at historic baseflow levels on the same day as the East Fork of Hayfork Creek, so the loss of surface flow is likely not a result of the current drought.

Handwork would be useful for removing sediment in the subsurface portion to restore surface connectivity while at the same time reducing the gradient at the mouth. There is an 18.75% gradient in the lower 2.4 meters of the stream. Digging out the subsurface section and extending the 0.45 m rise over a longer distance would improve juvenile fish passage into Potato Creek.

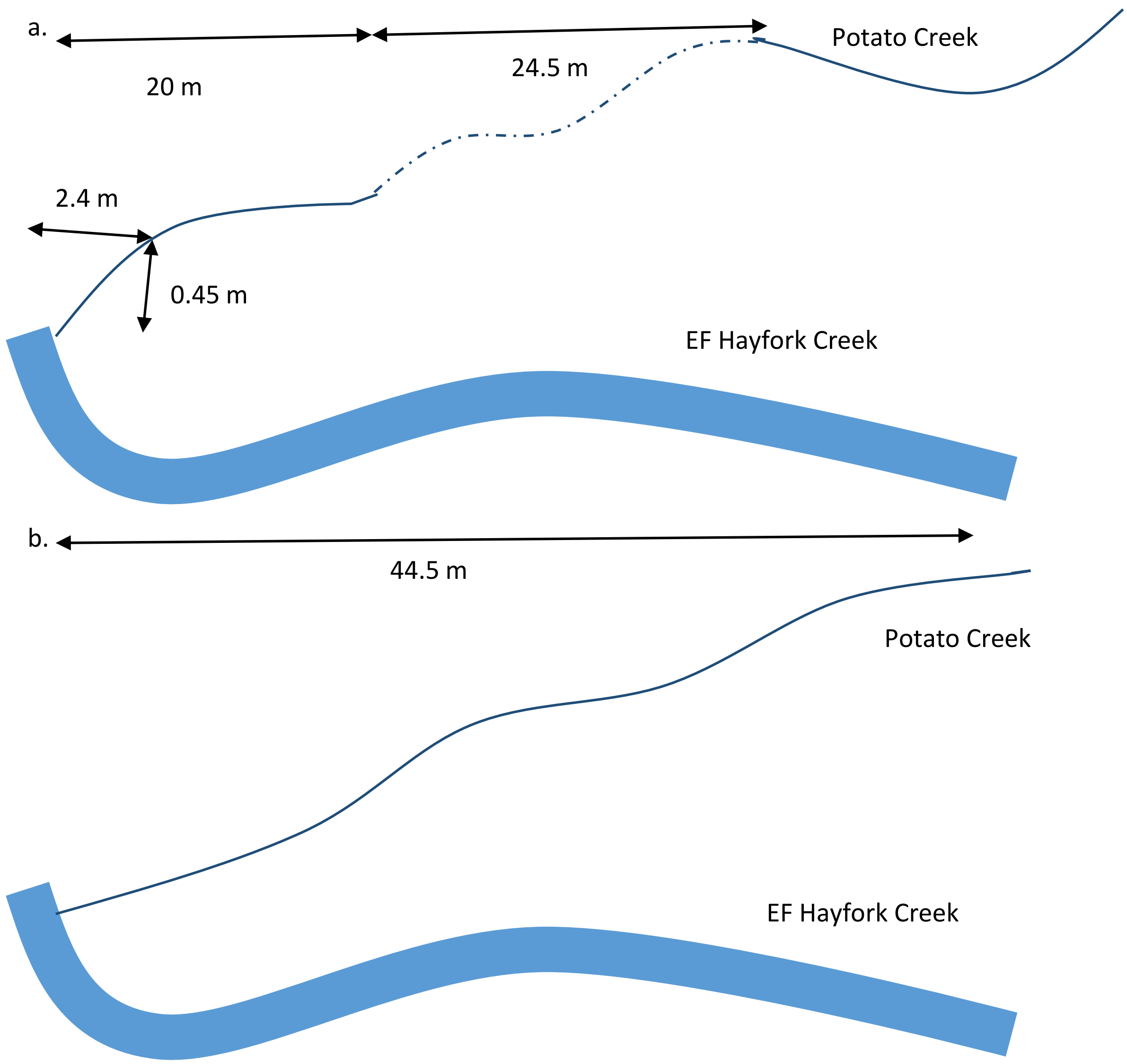


Figure 19. Proposed handwork for Potato Creek. Before handwork (a) and After handwork (b).

Step pools could also be used to lower the gradient. The step pools on Potato Creek would have the same restrictions as for Madden and Eltapom Creeks, no vertical drops over 2.3 cm (Whitman, 2011), jump height to landing pool depth 1:1.25 or better (Taylor, 2011), areas with velocities less than 0.0035 m/s (United States Department of the Interior, 1996).

The rest of the stream is relatively low gradient so dispersing the steepest rise at the mouth over a longer stream length would benefit fish passage while restoring hydrologic connectivity.

Grouse Creek, Little Bear Wallow and Rough Gulch

Grouse Creek, Little Bear Wallow and Rough Gulch were not qualitatively assessed. These sites are very remote and time consuming to access and assess. As such, they were only visually assessed and do not have detailed design descriptions. Cursory visual assessments indicate that each of these sites would benefit from handwork to support increased fish passage. More in-depth assessments of these areas is recommended.

CONCLUSIONS

Survey assessments indicate there are several opportunities for restoration of fish passage at tributary mouths in the SFTR watershed. Madden Creek, Eltapom Creek, EF of Hayfork Creek, Plummer Creek, and Potato Creek are good candidates for handwork activities to restore fish passage at tributary mouths. Rough Gulch, Little Bear Wallow, and Grouse Creek were the only sites determined to have handwork potential to restore fish passage at the tributary mouth based on the visual assessments. There are likely additional opportunities for handwork activities to restore fish passage at tributary mouths at other sites within the SFTR watershed. Priority sites for future quantitative assessments are Happy Camp Creek, Grouse Creek, Rough Gulch, Sulfur Glade Creek, Glen Creek, and Bierce Creek. The annual assessment of high value tributaries, particularly those in the Hyampom Valley such as Kerlin Creek, Mill Creek, Big Creek, Pelletreau Creek, and Eltapom Creek, is also recommended.

The restoration of fish passage at tributary mouths maximizes fishery benefits while minimizing planning and implementation costs. The availability of tributary habitat is particularly important in the SFTR watershed because tributaries offer high quality cold water refugia. Therefore, these areas are particularly important during summer months when the mainstem of the SFTR warms substantially and becomes more suitable to warm water fish assemblages. Attractant flows to tributary habitat would be enhanced by restoring hydrologic connectivity as well as other potential future restoration activities such as large wood projects to promote river scour. Access to and maintenance of tributary habitat represents a vital management action to sustaining salmonid assemblages in the SFTR watershed.

DATA GAPS

More data can be collected for the following stream mouths in order to create better designs for the following streams: Rough Gulch, Little Bear Wallow, and Grouse creeks. Several tributaries upstream of Forest Glen not been surveyed in this project including Collins, Farley, Marie, Silver, Charlton, Cable, Happy Camp, Bierce, and several un-named creeks.

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