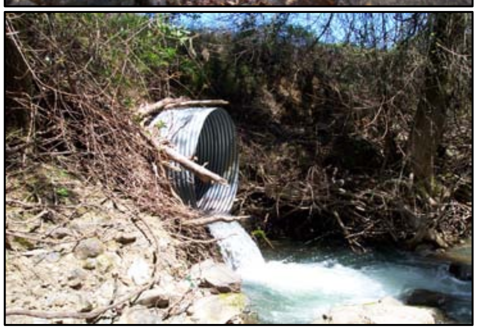
NAPA RIVER FISH BARRIER PLAN



August 2011

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INTRODUCTION

The Napa River watershed encompasses an area of approximately 426 square miles at the northern end of San Pablo Bay in the San Francisco Estuary (Figure 1). The Napa River and its tributaries support a diverse community of native fishes including two salmonid species: steelhead (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*). Steelhead spawning and rearing occurs primarily in the smaller, high-gradient tributary streams throughout the watershed, while Chinook spawning and rearing occurs primarily in the mainstem Napa River and low-gradient reaches of some large tributary streams. Both species are anadromous, meaning they need an uninterrupted corridor from their freshwater spawning and rearing habitat to the ocean.

Artificial migration barriers constructed during the past century have contributed to population declines of salmonids in the Napa River watershed by limiting access to potential habitat. These obstructions range from small temporal barriers, which can delay upstream migration depending on flow conditions, to large-scale municipal dams (e.g. Conn dam, Rector dam, etc.), which completely cut off access to otherwise suitable habitat. The effects of such large, complete barriers are obvious and well documented; however, until recently, little was known about the severity, specific location, and amount of potential habitat upstream of the many smaller barriers located throughout the watershed. This is mainly because barriers can be difficult to assess – they are spread across the landscape, often located in remote areas on private property, and their severity can change through time.

In an attempt to generate a truly useful barrier dataset, the Napa County Resource Conservation District (RCD) completed an inventory of all known and potential fish-passage barriers using extensive stream habitat survey data, recent and historical records, and reconnaissance surveys wherever possible (RCD 2008). With such high quality and extensive source data, the resulting list was the most comprehensive and accurate description of fish-passage barrier sites ever compiled for the Napa River watershed. This report addresses 21 of the highest priority fish passage sites identified during that 2008 study.

FOCUS SPECIES

Steelhead

Steelhead return to the Napa River to spawn in the winter, typically from January to March; although in years with abundant late-season rainfall, adult fish have been observed spawning as late as May (Figure 2). Steelhead spawning is difficult to document because adult fish migrate primarily at night and spawn during winter storm flows when water clarity is low. Therefore, not much is known about the specific movement patterns of adult steelhead in the Napa River watershed. In order to maximize access to high-gradient and often intermittent streams, adult fish typically migrate upstream on the receding limbs of winter storm flows. In years with below average runoff, access to small tributary streams, which this species prefers, can be limited. Steelhead spawning in the mainstem Napa River has been recently documented, although it appears to be most prevalent in dry years when access to prime tributary spawning habitat is limited by low streamflow (Koehler and Blank 2010).

Figure 1. The Napa River watershed

Figure 2. Steelhead spawning pair in Heath Canyon Creek, Sulphur Creek watershed. (May 2008)

Juvenile steelhead rear in freshwater for one or more years before smolting (outmigrating) to the ocean (Figure 3). Juvenile fish typically remain in cool, shady streams with perennial flow for up to three years before smolting at 125 to 200 mm (about five to eight inches) in length (Koehler and Blank, 2011). During their freshwater rearing and growth phase, juvenile steelhead feed mostly on aquatic and terrestrial invertebrates and may move around within a stream and between streams at higher flows. Therefore, unimpeded migration and dispersal routes are an important component of steelhead rearing habitat.

Figure 3. Juvenile steelhead collected in the mainstem Napa River. (May 2010)

Chinook salmon
Chinook salmon return to the Napa River to spawn in the fall, typically around late September and early October. Adult fish will hold in deep pools in the estuarine portion of the river near the city of Napa for a month or more waiting for the first rains of the season to generate runoff. Once a sufficient storm occurs, adult salmon swim immediately upstream to suitable spawning areas before flows recede. During this part of the year, winter baseflow is usually not well-established, and the Napa River is still very flashy (i.e. subject to rapid increases and decreases in flow). As a result, Chinook salmon migration can be limited both temporally and spatially by rapidly changing flow conditions. Fish that are able to swim upstream to suitable spawning areas typically construct spawning redds (nests) in the streambed gravels and cobbles within a day or two. After spawning, fish typically remain in the area for up to a month before dying (Figure 4). Peak spawning activity occurs from November through early January (Koehler 2008).

Figure 4. Female Chinook salmon guarding a Napa River redd post spawning. (December 2006)

Juvenile Chinook salmon spend several months rearing in the Napa River from January through June (Figure 5). Based on recent data, Chinook salmon appear to smolt (outmigrate) to the estuary throughout the spring with the highest peak occurring in May at sizes ranging from 80-100 mm (approximately three to four inches) in length (Koehler and Blank 2011).


Figure 5. Juvenile Chinook salmon in the mainstem Napa River. (May, 2008)

FISH PASSAGE BARRIERS

In 2008, RCD identified 118 fish passage obstructions on streams known to support salmonids (Figure 6). Many of these sites were natural features and generally not considered for modification or removal. The remaining artificial passage sites consisted mostly of dams and road crossings such as bridges and culverts. All sites were ranked by severity using California Department of Fish and Game (DFG) guidelines. The ranking system categorizes a site as green if it is mostly passable, gray if it is partially passable, and red if it represents a severe or complete obstacle. Approximately 75% of the artificial sites scored either gray or red, while the remaining sites were either scored green or lacked sufficient data to be ranked.

From this initial analysis, RCD identified 21 sites for further assessment (Table 1). These sites were selected based on qualitative ranking of severity, upstream habitat quality, and other factors. For this project, RCD then conducted hydraulic analyses and upstream habitat assessments for each site to determine their relative ranking within the Napa River watershed. Each site was ranked based on the amount of upstream habitat to be gained and the relative quality of that habitat. The total amount of upstream habitat was calculated using a combination of field survey data and GIS analysis. The quality of this habitat was based on habitat typing data and professional judgment of the RCD biologist.

High quality habitat contains perennially flowing reaches that are suitable for both spawning and rearing. Moderate quality habitat contains a mix of intermittent and perennially flowing reaches that are suitable for spawning, but may have limited rearing value. Low quality habitat contains intermittent or degraded reaches, such that spawning and rearing habitat is very limited.

Map Label	Stream	Site Description	Owner	Severity	Status
1	Bell	Silverado Trail Culvert	Public	Green	Removed from list – not significant
2	Browns Valley	Robinson Lane Culvert	Public	Gray	In place
3	Campbell	Dry Creek Road Culvert	Public	Red	In place
4	Carneros	Defunct Pumping Station	Private	Gray	In place
5	Carneros	Defunct Dam	Private	Gray	In place
6	Huichica	State Highway 12/121 Culvert	Public	Red	In place – planning underway
7	Huichica	Defunct Dam	Private	Red	In place
8	Mill	State Highway 29 Culvert	Public	Gray	In place
9	Milliken	Silverado Resort Reservoir	Private	Red	In place – planning underway
10	Murphy	Single Weir	Private	Red	In place
11	Murphy	Double Weir	Private	Red	In place
12	Napa River	Calistoga Footpath	Public	Gray	In place
13	Pickle	Ford Crossing	Private	Red	In place
14	Rector	State Lane Ford Crossing	Private	Red	In place
15	Ritchey	Hwy 29	Public	Gray	In place
16	Selby	Silverado Trail Culvert	Public	Red	In place
17	Spencer	Green Valley Road Culvert	Public	Red	In place
18	Sulphur	Sulphur Springs Rd culvert	Public	Green	Removed from list – not significant
19	Suscol	State Highway 29 Culvert	Private	Red	In place
20	Wing	Defunct Dam	Private	Gray	In place
21	Wing	Road crossing/ debris jam	Private	Gray	Repaired in 2009

Table1. Fish passage barrier sites assessed under this project. Locations are shown in Figure 6.
Note: Severity is based on the California Department of Fish and Game's criteria for salmonid passage at stream crossings using the following system: Green = unlikely to obstruct passage at most flows, Gray = temporal barrier likely to obstruct passage at certain flows, Red = Severe or complete barrier at most flows.

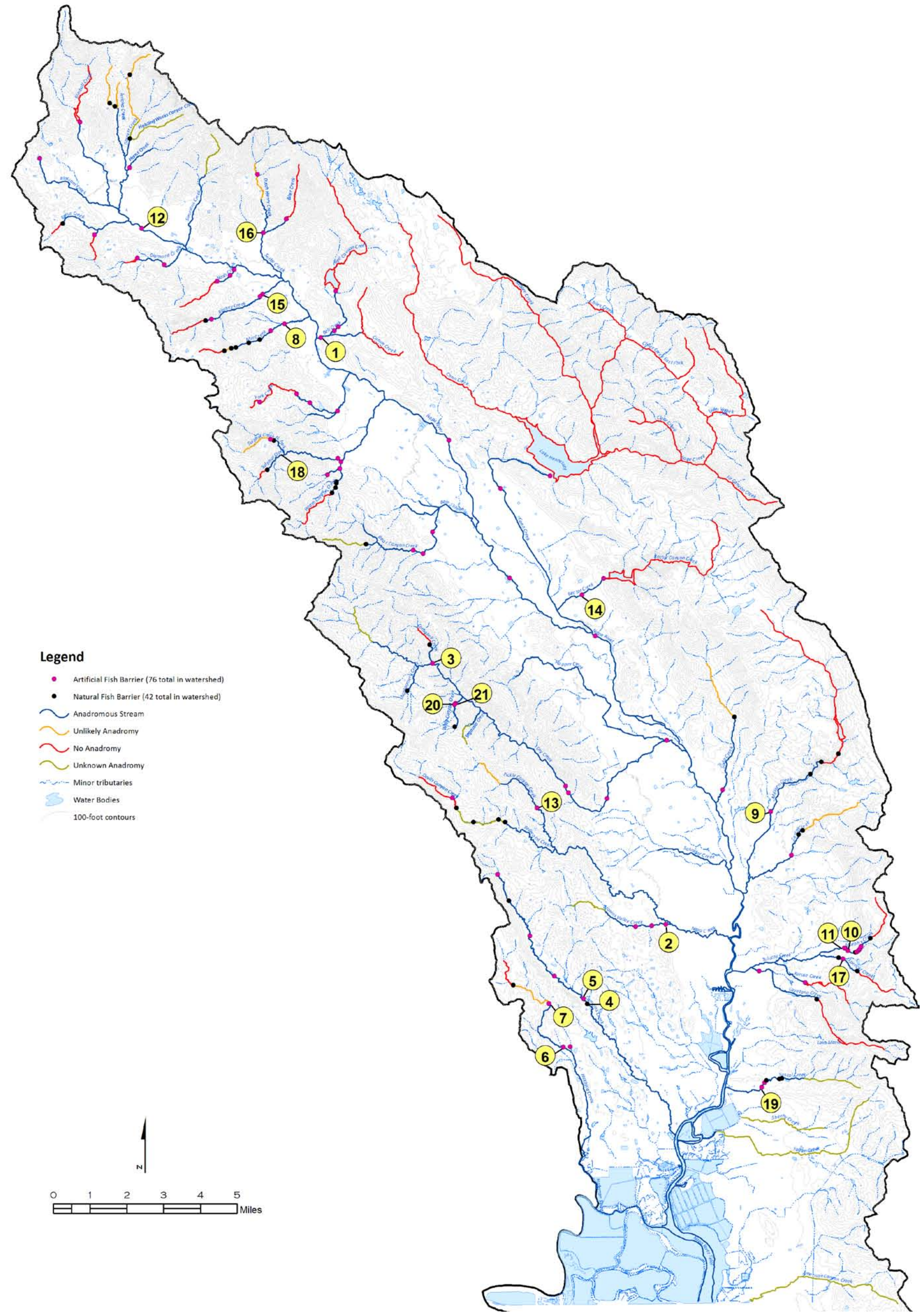

Figure 6. Napa River watershed map showing streams, known limits of anadromy, and barrier locations.
Note: Site labels refer to Table 1 and do not denote ranking.

From the original list of 21 sites, two sites were determined to be minor obstacles that did not warrant further action, and three sites were assessed by other entities during the course of this study. The current status of each of these sites is discussed below.

Bell Creek Culvert at Silverado Trail – This site consists of a 6" concrete weir at the downstream edge of a natural-bottomed box culvert over the Silverado Trail (Figure 7). RCD field crews originally identified the weir as a potential passage barrier in 2004 during a summertime habitat survey. However, as part of this project, RCD observed passage conditions at the site over a range of typical winter and spring flows, and it was determined to be only a minor low-flow obstacle. No further assessment was deemed necessary.

Figure 7. Bell Creek culvert at the Silverado Trail (facing upstream)

Huichica Creek Culvert at Highway 12/121 – This site consists of a triple-barrel culvert with an approximately 50-foot long concrete apron at the Highway 12/121 crossing (Figure 8). RCD contacted Caltrans at the beginning of this project to determine the status of the crossing and to discuss if there were any pending plans for replacement or retrofit of the site. Caltrans staff stated that the crossing is slated for replacement with a free-span bridge within the next five years (Blizard, pers. comm.). However, the specific design of this crossing repair has not yet been finalized, and implementation funding has not been secured. RCD determined that, given the existing momentum for this site along with Caltrans' commitment to replace the structure, an assessment under this project was not warranted.

In an effort to keep the passage improvement efforts planned for this site progressing, RCD participated in several meetings in late 2010 and early 2011 with representatives from the California Department of Fish and Game (DFG), NOAA National Marine Fisheries Service (NMFS), US Fish and Wildlife Service (USFWS), and the Natural Resources Conservation Service (NRCS) to discuss alternative approaches.

Figure 8. Huichica Creek culvert at Highway 12/121.

Milliken Creek at Silverado Resort – This site consists of a small seasonal reservoir created by an on-stream concrete-lined earthen dam on private property. The dam contains a corrugated steel culvert outlet with a gate valve, which carries streamflow at most low to moderate flows. The reservoir is seasonally filled during the summer and drained in fall when the valve is opened. During the course of this project, the Silverado Resort was acquired by new ownership that is actively cooperating with RCD, NRCS, and other stakeholders to acquire funds to remove the dam and replace it with a free-span bridge or other structure that does not impede fish passage. In 2010, the site was analyzed with Fish Xing software by a consulting hydraulic engineer. Given the increased interest in improving the site, RCD determined that further assessment under this project was not warranted.

Ritchey Creek Culvert at Highway 29 – This site consists of a concrete box culvert at the Highway 29 crossing near Bothe State Park (Figure 9). During the course of this project, another watershed group, the *California Land Stewardship Institute*, received funding to assess the culvert. The resulting report was completed by Phillip Williams and Associates in December 2008. RCD is continuing to collaborate with California State Parks, Caltrans, and other stakeholders to implement a fix for this site.

Figure 9. Ritchey Creek culvert at Highway 29

Sulphur Creek Culvert at Sulphur Springs Road - This site consists of concrete box culvert (Figure 10). It was originally identified in 2002 during a summertime habitat survey as a potential barrier. However, as part of this project, RCD observed passage conditions at the site over a range of typical winter and spring flows, and the site was determined to not be a significant obstacle. No further assessment was deemed necessary.

Figure 10. Sulphur Creek culvert at Sulphur Springs Road

Recommendations

Each barrier site is addressed its own separate attachment at the end of this report; summary results of these analyses are shown in Table 2.

Priority Ranking	Stream	Site Description	Upstream Habitat (miles)	Upstream Habitat Quality	Repair Cost Estimate
High	Napa River	Calistoga Footpath	14.8	High	Low
High	Mill Cr.	State Highway 29 Culvert	2.7	High	Moderate
High	Suscol Cr.	State Highway 29 Culvert	2.57	High	Moderate
High*	Milliken Cr.	Silverado Resort Reservoir	2.6	High	High
**	Bell Cr.	Silverado Trail Culvert	2.34	High	N/A
High*	Ritchey Cr.	Hwy 29	1.99	High	Moderate
High*	Huichica Cr.	State Highway 12/121 Culvert	1.45	High	High
**	Sulphur Cr.	Sulphur Springs Rd culvert	0.83	High	N/A
High	Wing Cr.	Defunct Dam	0.82	High	Low
High	Wing Cr.	Road crossing/ debris jam	0.77	High	N/A
High	Murphy Cr.	Single Weir	0.76	High	Low
High	Campbell Cr.	Dry Creek Road Culvert	0.67	High	Moderate - High
High	Murphy Cr.	Double Weir	0.64	High	Low
Medium	Carneros Cr.	Defunct Pumping Station	5.0	Moderate	Moderate
Medium	Carneros Cr.	Defunct Dam	4.7	Moderate	Moderate
Medium	Pickle Cr.	Low-Water Crossing (Ford)	2.45	Moderate	Moderate
Medium	Selby Cr.	Silverado Trail Culvert	2.12	Moderate	High
Medium	Spencer Cr.	Green Valley Road Culvert	0.60	Moderate	High
Low	Browns Valley Cr.	Robinson Lane Culvert	4.6	Low	Moderate
Low	Huichica Cr.	Defunct Dam	3.5	Low	Low - Moderate
Low	Rector Cr.	State Lane Low-Water Crossing (Ford)	0.85	Low	Moderate

Table 2. Barrier sites with ranking based on distance and quality of upstream habitat. Estimated construction cost is included as general guidance.

*Sites have already been assessed by others or are in the process of being assesed and repaired by others

**Sites were assessed and determined to be insignificant passage obstacles

In total, we determined that 11 of the 21 sites contained high-quality upstream habitat. These 11 sites represent the highest priority fish barriers in our study and, if repaired, would improve access to a total of approximately 32.9 miles of spawning and rearing habitat. Four of the highest priority sites would be relatively inexpensive and simple to repair. These include the footpath across the Napa River in Calistoga, the defunct dam on Wing Creek, and the three concrete weirs on Murphy Creek. All four sites involve demolition or minor modification of an existing structure. Details of the recommended approach are in the individual reports for each site.

Five sites contain moderate-quality upstream habitat and should be given medium priority. If funding or other circumstances allow for the repair of one of these sites, it may still provide a significant benefit by increasing access to suitable spawning areas. However, these streams only offer limited rearing habitat value, and would therefore not contribute as much to the overall Napa River steelhead and/or salmon population.

Three sites were found to contain low-quality upstream habitat and are therefore a lower priority for repair. RCD recommends that these sites only be repaired as part of another maintenance or improvement project, or if all higher-priority sites on the list have been addressed.

ACKNOWLEDGMENTS

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REFERENCES

Blizard, R. (Caltrans) March 30,2011. Personal communication with Jonathan Koehler (RCD) during a site visit to Huichica Creek at Highway 12/121.

Koehler, J. 2008. Napa River Salmon Monitoring Project Spawning Year 2007 Report. Napa County Resource Conservation District, Napa, California.

Koehler, J., P. Blank. 2010. Napa River Steelhead and Salmon Smolt Monitoring Program. Annual Report Year 2. Napa County Resource Conservation District, Napa, California.

Koehler, J., P. Blank. 2011. Napa River Steelhead and Salmon Smolt Monitoring Program. Annual Report Year 3. Napa County Resource Conservation District, Napa, California.

Napa county Resource Conservation District (RCD) 2008. Napa River Watershed Fish Passage Barrier Inventory.

ROBINSON LANE CULVERT AT BROWNS VALLEY CREEK

FISH PASSAGE ASSESSMENT

Prepared for

California State Coastal Conservancy
Agreement No. 08-069

Prepared by

NAPA COUNTY RCD Resource Conservation District

June 2011

STREAM DESCRIPTION

Browns Valley Creek is a tributary of Napa Creek, which is tributary to the Napa River and ultimately the San Francisco Estuary. Its 4.40 square mile watershed contains 8.98 miles of blue-line stream, 3.52 miles of which is second order stream, according to the USGS 7.5-minute quadrangle (Figure 1). Elevations range from 54 feet above mean sea level at the mouth of the creek to 1,060 feet at the ridgeline. The lower portion of the watershed is highly developed with residential neighborhoods and vineyards. Mixed hardwood forest and grassland dominate the uplands with minor areas of shrubland and vineyard. The watershed is almost entirely under private ownership.

Steelhead trout are present Browns Valley Creek, but in very low densities. Although stream slope is favorable for approximately 4.6 miles, the habitat is of poor to moderate quality. Streamflow is perennial in the lower urbanized reaches, but often dry in the summer months in the upper reaches.

Three barriers to upstream migration of steelhead have been identified on Browns Valley Creek (Koehler and Edwards, 2009). The barriers are listed in Table 1 and shown on Figures 1 and 2.

Fish-Passage Barrier	Distance Upstream from Mouth (mi)	Max Upstream Habitat (mi)	Barrier Type	Status
Robinson Lane Culvert	**0.15**	**4.6**	**Partial**	**Under assessment**
Browns Valley Road Culvert	0.62	4.0	Partial	More significant downstream barriers
McCormick Lane Culvert	1.15	3.5	Partial	More significant downstream barriers

Table 1. Browns Valley Creek fish-passage barriers.

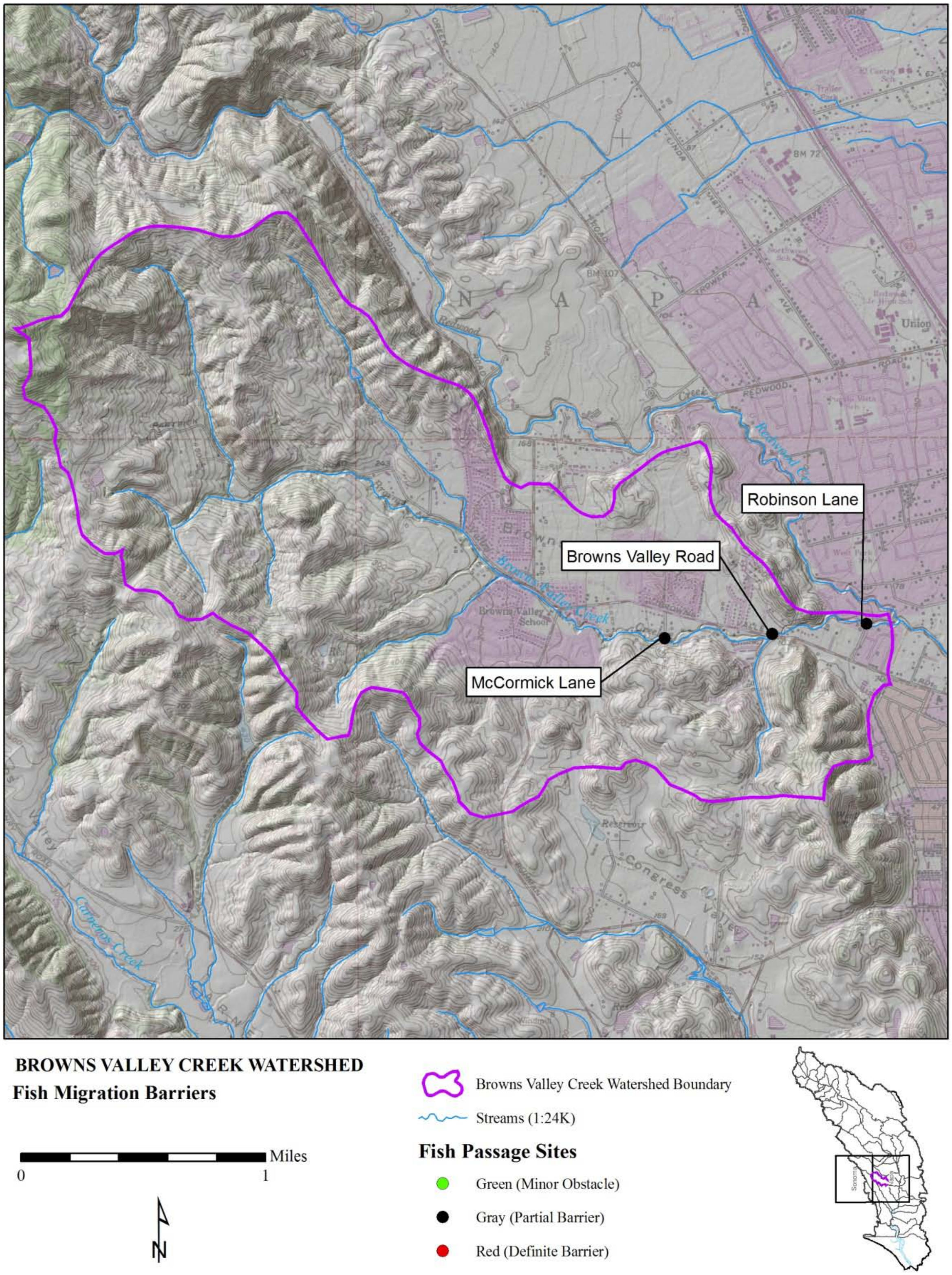


Figure 1. Browns Valley Creek watershed and barrier locations.

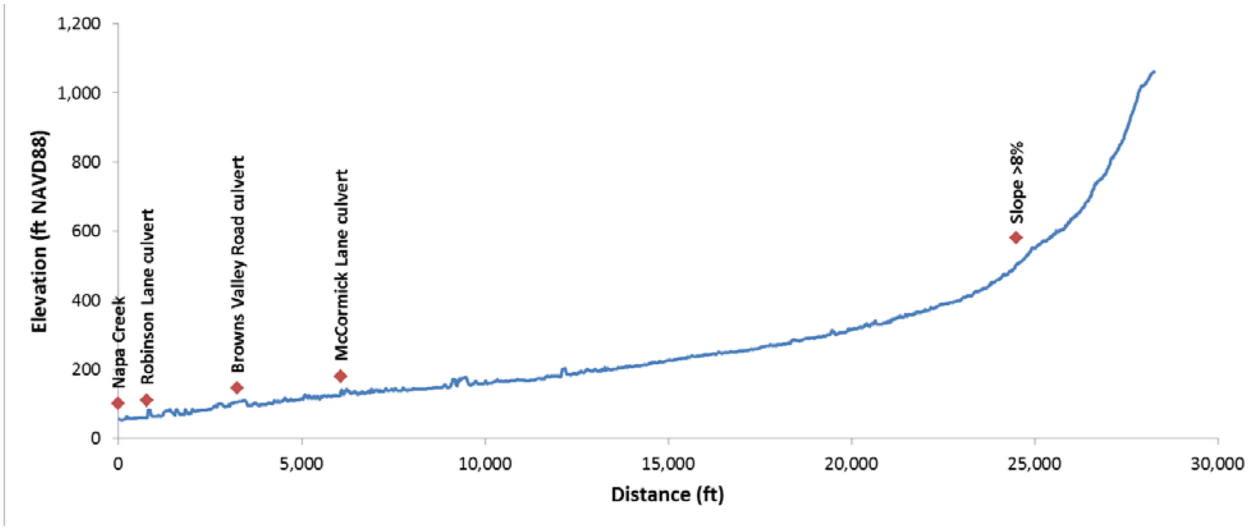


Figure 2. Browns Valley Creek LiDAR-derived longitudinal streambed profile with barrier locations

BARRIER DESCRIPTION

The Robinson Lane culvert at Browns Valley Creek is an 80-foot long concrete box culvert with a slightly concave bottom that concentrates low flows along the centerline. The upper corners of the culvert are rounded, but it is more of a box culvert than an arch culvert (Figures 3 and 4). There is a 143-foot long concrete apron protecting the streambed on the downstream end of the culvert (Figure 5) and another 17 feet of concrete apron on the upstream end, creating a total stream crossing length of 240 feet. The culvert is located very near the outlet of the watershed, only 780 feet upstream of the Napa Creek confluence, so the vast majority of the watershed and habitat areas are located above the barrier.

The culvert was identified as a potential barrier to fish passage in October 2006 as part of a Browns Valley Creek stream inventory conducted by the Napa County RCD (Koehler and Edwards 2009). It was categorized as “gray” in the DFG Green-Gray-Red system because it is expected to be a partial barrier, impassable to juvenile steelhead at all flows and impassable to adult steelhead at certain flows, due to lack of water depth in the culvert and over the concrete aprons and excessive velocity.

Figure 3. Looking downstream through the Robinson Lane culvert.

Figure 4. View of downstream face of culvert looking upstream.


Figure 5. View looking upstream toward culvert from downstream end of concrete apron.

BARRIER ASSESSMENT

The RCD evaluated fish-passage at the Robinson Lane stream crossing in general accordance with *Part IX Fish Passage Evaluation at Stream Crossings* of the California Department of Fish and Game (DFG) Salmonid Stream Habitat Restoration Manual (DFG 2010). The assessment included a fish-passage inventory, a peak flow estimate, a culvert capacity analysis, and a fish-passage analysis.

Fish-Passage Inventory

On July 15, 2010, Jonathan Koehler (RCD) and Paul Blank (RCD) conducted a fish-passage inventory of the stream crossing including:

- Measurement of culvert dimensions;
- Longitudinal profile survey;
- Channel cross section survey;
- Site sketch; and,
- Completion of the DFG fish passage inventory data sheet.

The longitudinal profile survey was completed with tape and level and was surveyed relative to an arbitrary datum. It began more than 500 feet upstream of the culvert and continued for approximately 1,100 feet to a point 300 feet downstream of the culvert. The survey captured the profile of the culvert and apron, the upstream resting pool, the tailwater control and the overall slope of the reach (Figure 6). The channel cross section was also surveyed with tape and level and was located at the tailwater control. The cross section was completed specifically for low-flow hydraulic analyses and does not include top of bank or overbank data.

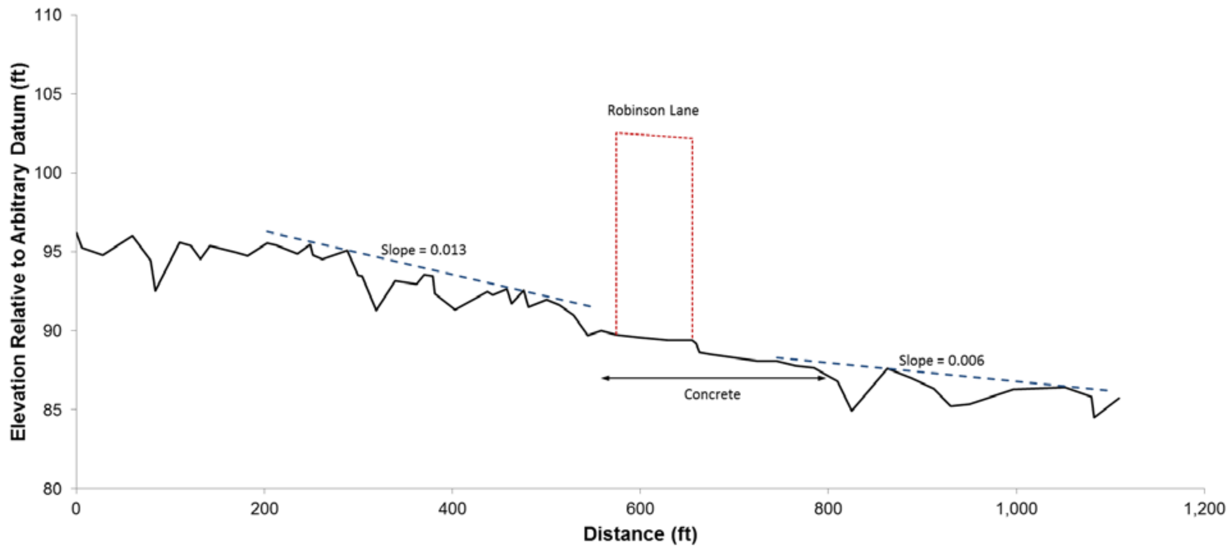


Figure 6. Surveyed longitudinal streambed profile.

Peak Flow Estimate

The Browns Valley Creek subwatershed is an ungaged basin. In order to evaluate culvert capacity it is necessary to estimate peak flows at the stream crossing. RCD calculated the 50% through the 1% annual exceedance probability flows (Q2, Q5, Q10, Q25, Q50, and Q100) in cubic feet per second (cfs) by adjusting the peak flow statistics for retired United States Geological Survey (USGS) Station 11458200 REDWOOD C NR NAPA CA located on Redwood Creek approximately 1.7 miles northwest of the barrier site, also in the Napa Creek subwatershed. Station 11458200 operated continuously for 15 years, from 1958 through 1973. The Q2 through Q100 calculated by USGS were obtained from water.usgs.gov/osw/streamstats. As suggested by USGS (Waananen and Crippen 1977), RCD adjusted the flow for the difference in drainage areas using the relation:

—

where Q_u and Q_g are the discharges at the ungaged and gaged sites, A_u and A_g are the drainage areas, and b is the exponent for the drainage area from the corresponding regional regression equation. Peak flow estimates are listed in Table 2.

Flow Event	Annual Exceedance Probability	Return Interval (yrs)	Peak Streamflow (cfs)	
			USGS 11458200	Browns Valley Creek at Robinson Lane Culvert
Q2	0.5	2	1,200	584
Q5	0.2	5	1,310	643
Q10	0.1	10	1,360	673
Q25	0.04	25	1,420	708
Q50	0.02	50	1,460	728
Q100	0.01	100	1,500	748

Table 2. Peak streamflow estimates for Browns Valley Creek at Robinson Lane culvert.

Culvert Flow Capacity

RCD performed an analysis of the culvert using the *HY-8 version 7.2* software developed by the Federal Highways Administration (FHWA). Culvert data, site data, tailwater data, and roadway data were collected in the field during the fish-passage inventory. RCD analyzed the culvert's performance under the Q10 and Q100 flows for Browns Valley Creek (Table 2). In addition, RCD calculated the flow capacity at the top of the culvert inlet (headwater-to-diameter ratio equal to one). The results are presented in Table 3.

Event	Streamflow (cfs)	Headwater Elevation Relative to Arbitrary Datum (ft)
Q10	673	95.44
Q100	748	95.84
Top of culvert inlet	2,171	102.57

Table 3. Culvert flow capacity analysis results.

Fish Passage Analysis

The first-phase evaluation indicated that the Robinson Lane culvert is a temporal barrier for adult steelhead, as well as a partial barrier, impassable to juvenile steelhead. To test this conclusion, RCD performed an analysis using *FishXing v3*, a program intended to assist engineers, hydrologists, and fish biologists in the evaluation and design of culverts for fish passage (http://www.stream.fs.fed.us/fishxing).

Upper and lower fish passage flows were estimated from surrogate data in accordance with DFG protocols. RCD selected the former USGS streamgaging station on Redwood Creek as a surrogate because it is the nearest to Browns Valley Creek with at least 5 years of daily average flow data (15 years) and with a drainage area less than 50 square miles (9.79 square miles). Calculated fish passage flows were adjusted for Browns Valley Creek by multiplying them by the ratio of the two drainage areas. The calculated fish passage flows are presented in Table 2.

Species/Lifestage	Upper Passage Flow (cfs)		Lower Passage Flow (cfs)	
Adult steelhead	89.9	1% Exceedance Flow	3	Alternate Minimum Flow
Juvenile steelhead	9.4	10% Exceedance Flow	1	Alternate Minimum Flow

Table 2. Calculated Fish Passage Flows.

The FishXing model was constructed using the surveyed dimensions of the culvert, the streambed slope, and the surveyed tailwater control cross section. Swimming capabilities and minimum depth requirements for adult and juvenile steelhead were based on Table IX-6 of the DFG Manual. The results of the *FishXing* analysis are presented in Table 3.

	Adult Steelhead	Juvenile Steelhead (>6”)	Juvenile Steelhead (<6”)
Percent of Flows Passable	0.0%	0.0%	0.0%
Passable Flow Range	None	None	None
Depth Barrier	All Flows* (3-72 cfs)**	All Flows*	All Flows*
Leap Barriers	None	None	None
Velocity Barrier – EB	32.8 cfs to 89.9 cfs	All Flows	All Flows
Pool Depth Barrier	None	None	None

Table 3. Results of *FishXing* analysis.
*Simplification of the culvert geometry in *FishXing* altered barrier conditions at the site. See Discussion.
**Results of analysis using HY-8

DISCUSSION

Comparison of the peak flow estimates to the culvert flow capacity analysis results indicates that the Robinson Lane culvert at Browns Valley Creek will convey 2,171 cfs at the top of the culvert inlet. California Department of Transportation guidelines indicate that culverts should convey the Q10 “…without causing headwater elevation to rise above the inlet top of culvert,” and the Q100 “…without damage to the facility or adjacent property” (Caltrans 2006). DFG states that “crossing structures should typically be designed to accommodate the 100-year flood event” (DFG 2010). Based on these guidelines, the culvert is oversized and will accommodate installation of internal or external energy dissipation structures or backwatering. This stream crossing is a candidate for a retrofit project.

The culvert has an irregular shape that cannot be accurately modeled using Fish Xing alone. Therefore, HY-8 was used to determine the flows at which minimum depth requirements were achieved for both adult and juvenile anadromous salmonids (0.8 ft and 0.5 ft respectively). Results of these analyses showed that a flow of 71 cfs is needed to provide sufficient adult passage depth. A minimum passage depth for juveniles was not achieved at any flow between the target range of 1 to 9.4 cfs.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this analysis, the Robinson Lane culvert at Browns Valley Creek is a partial barrier to upstream movement of steelhead trout. The culvert regularly blocks the upstream movement of adults and may completely block the upstream movement of juveniles. Although the barrier is relatively severe, the upstream habitat (up to 4.5 miles) is of relatively poor to moderate quality. Therefore, within the greater Napa River watershed, this site is a lower priority.

The capacity of the culvert far exceeds the 100-year flow estimate, indicating that there is likely space for installing baffles or other instream structures without increasing flooding risk. Additionally, the culvert appears to be in excellent structural condition, so complete replacement of the culvert is not warranted, and the site should be retrofitted to improve fish passage.

Options for mitigation include:

1) Install baffles in the culvert to reduce velocities and increase depth

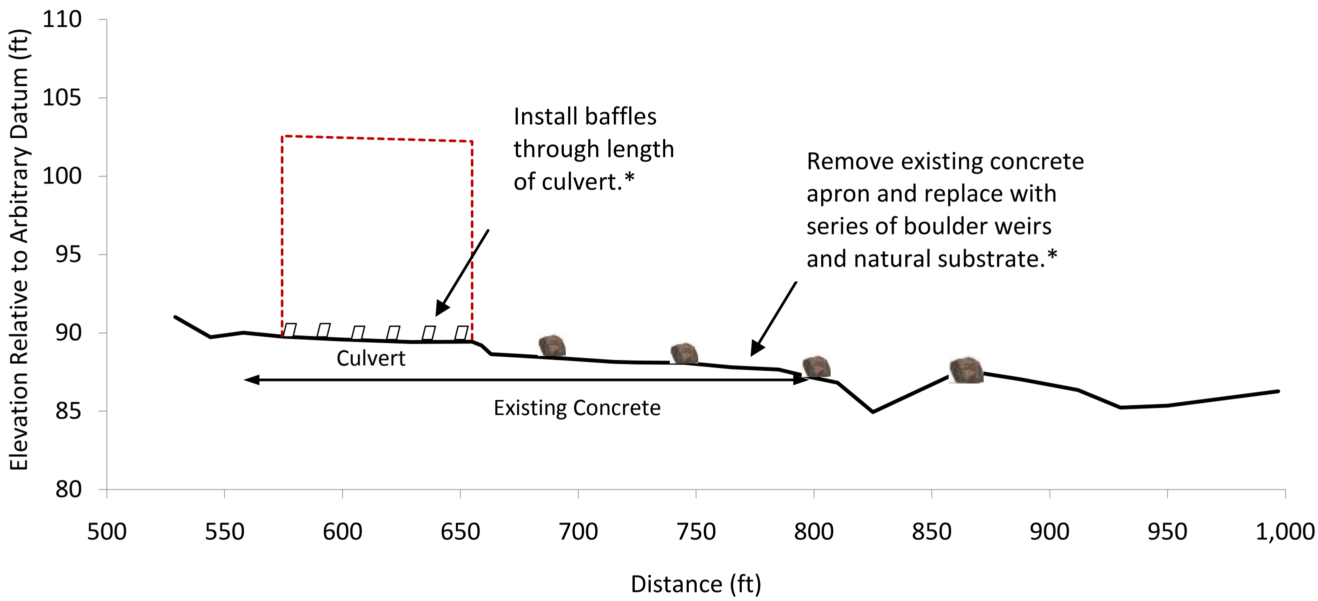
2) Remove the downstream concrete apron and install a series of downstream passable rock weirs to control grade and backwater the culvert

3) Install baffles, remove the downstream concrete apron, and install downstream rock weirs.

Implementing either Option 1 or 2 would improve passage conditions, but both would still leave a partial barrier at the site. Therefore, Option 3, which addresses both passage barriers is recommended.

As discussed above, the limited habitat quality offered by Browns Valley Creek make this a lower priority site within the Napa River watershed. If at some point in the future, funding is allocated to improve fish passage specifically in Browns Valley Creek, this barrier should be modified following the above recommendations. However, improving passage at other known fish barriers in higher quality streams would be a higher priority for the overall watershed.

CONCEPTUAL DESIGN



*Exact location, size, and number of features to be determined by a qualified engineer to achieve velocity and depth targets for salmonid passage.

REFERENCES

Koehler, J., Edwards, C. 2009. *Southern Napa River Watershed Restoration Plan.* Napa County Resource Conservation District. Funded by the California Department of Fish and Game, Fisheries Restoration Grant Program.

State of California Department of Fish and Game (DFG). 2010. *California Salmonid Stream Habitat Restoration Manual.* 4th Edition.

Waananen, A.O., and J.R. Crippen. June 1977. *Magnitude and Frequency of Floods in California*. United States Geological Survey Water-Resources Investigations 77-21.

State of California Department of Transportation (Caltrans). January 2006. *Local Assistance Procedures Manual Chapter 11 Design Standards*.

DRY CREEK ROAD CULVERT AT CAMPBELL CREEK

FISH PASSAGE ASSESSMENT

Prepared for

California State Coastal Conservancy
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Prepared by

NAPA COUNTY RCD Resource Conservation District

June 2011

STREAM DESCRIPTION

Campbell Creek is a tributary of Dry Creek, which is tributary to the Napa River and ultimately the San Francisco Estuary. Its 1.29 square mile watershed contains 3.91 miles of blue-line stream, 1.19 miles of which is second order stream, according to the USGS 7.5-minute quadrangle (Figure 1). Elevations range from 560 feet above mean sea level at the mouth of the creek to 2,100 feet at the ridgeline. Mixed hardwood forest and chaparral dominate the watershed, with minor areas of grassland and rural residential development. The watershed is entirely under private ownership.

Campbell Creek offers perennial flow and high-quality steelhead spawning and rearing habitat. Juvenile steelhead/rainbow trout (*Oncorhynchus mykiss*), are present in Campbell Creek, although the full degree of anadromous parentage is not known. The Dry Creek Road culvert, located at the mouth of the stream, is the only anthropogenic barrier to fish passage on Campbell Creek (Figure 1).

BARRIER DESCRIPTION

The Dry Creek Road culvert at Campbell Creek is a 6-foot diameter 100-foot long circular thin-wall corrugated steel pipe culvert with a projecting barrel inlet (Figure 2). The culvert is located at the outlet of the watershed, with the downstream end of the culvert emptying directly into Dry Creek. Under low-flow conditions, there is an approximate 3-foot drop from the outlet of the culvert to the tailwater surface (Figure 3).

The culvert was first identified as a potential barrier to fish passage in July 1998 during a stream inventory conducted by DFG and the Napa County Resource Conservation District (RCD). It was later categorized as “red” in the DFG Green-Gray-Red system because it was expected to be a total barrier (impassable to all fish at all flows) due to excessive jump height into the perched culvert outlet.

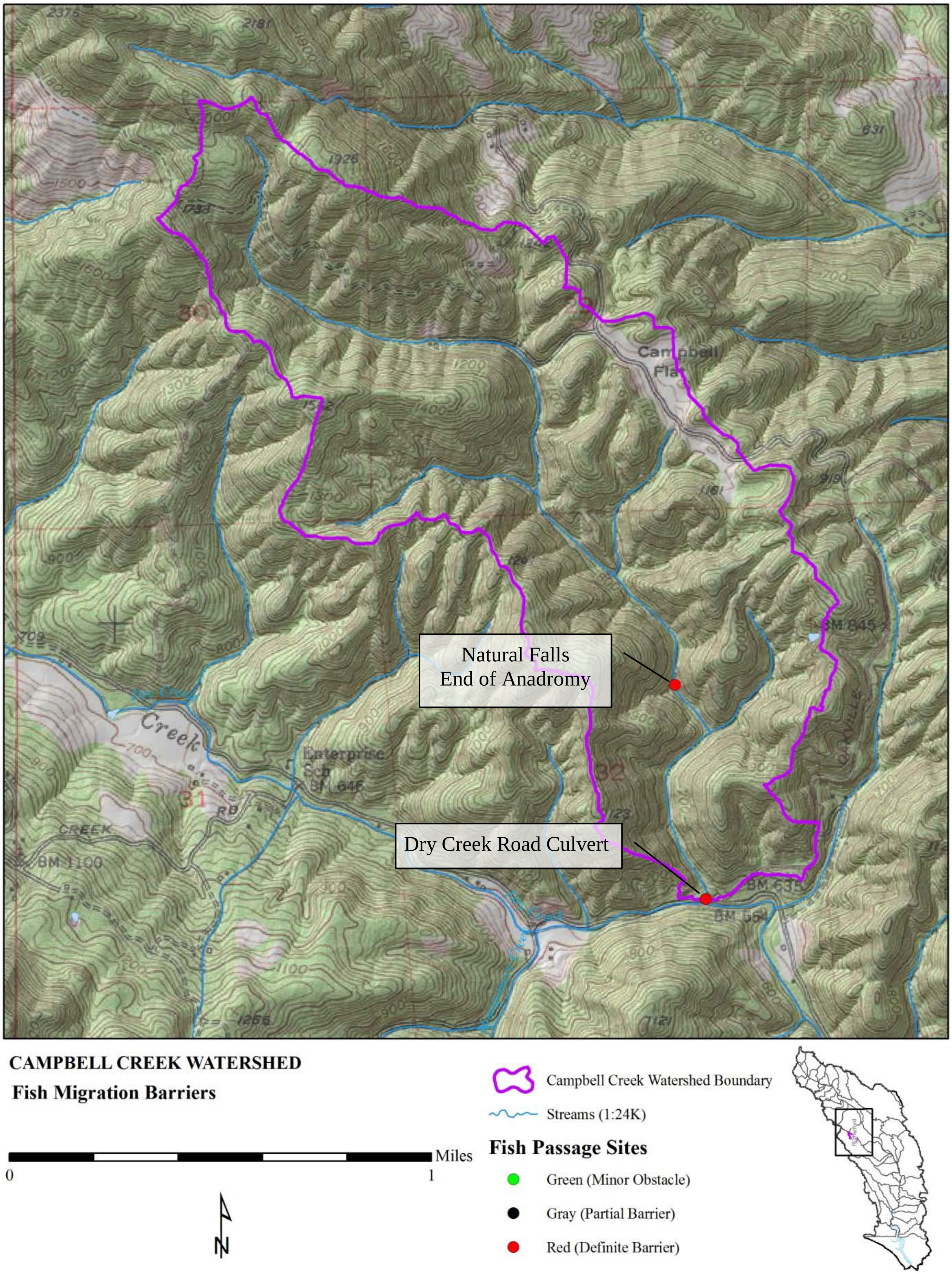


Figure 1. Campbell Creek watershed and barrier locations.


Figure 2. View of the inlet of the Dry Creek Road culvert.


Figure 3. View looking upstream through the Dry Creek Road culvert.

BARRIER ASSESSMENT

RCD evaluated fish-passage at the Dry Creek Road stream crossing in general accordance with *Part IX Fish Passage Evaluation at Stream Crossings* of the California Department of Fish and Game (DFG) Salmonid Stream Habitat Restoration Manual (DFG 2010). The assessment included a fish-passage inventory of the barrier site, an upstream habitat assessment, a peak flow estimate, a culvert flow capacity analysis, and a fish-passage analysis.

Fish-Passage Inventory

On August 4, 2010, Jonathan Koehler (RCD) and Paul Blank (RCD) conducted a fish-passage inventory of the stream crossing including:

- Measurement of culvert dimensions;
- Longitudinal profile survey;
- Channel cross section survey;
- Site sketch; and,
- Completion of the DFG fish passage inventory data sheet.

The longitudinal profile survey was completed with tape and level and was surveyed relative to an arbitrary datum. It began 300 feet upstream of the culvert and continued through the culvert and into Dry Creek to a point in Dry Creek 180 feet downstream of the culvert. The survey captured the profile of the culvert, the upstream resting pool, the height of the fill prism, the tailwater configuration, and the overall slope of the reach (Figure 4). Since the culvert empties into Dry Creek, RCD surveyed a cross section of the Dry Creek stream channel at the tailwater control to establish tailwater elevations at the design flows.

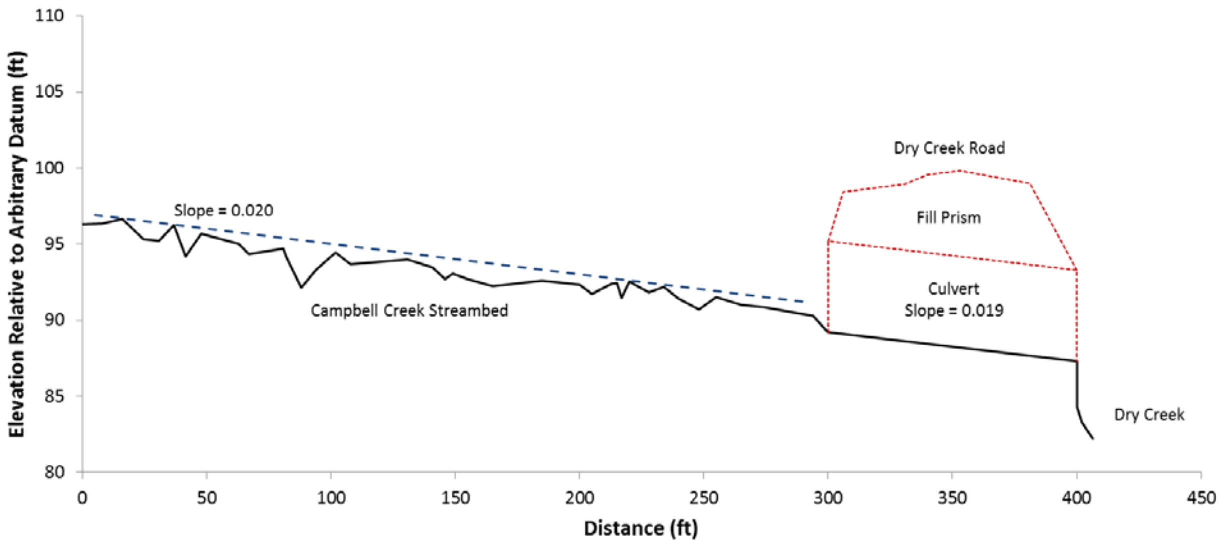


Figure 4. Surveyed longitudinal streambed profile.

Upstream Habitat Assessment

RCD evaluated the amount of salmonid habitat located upstream of the barrier. A topographic profile of the mainstem of Campbell Creek generated from the LiDAR digital elevation model (DEM) showed a sharp slope break, interpreted to be a falls or cascade, at 0.67 miles upstream of the mouth of the creek (Figure 5). RCD staff made a field visit on January 7, 2011, and confirmed that the falls at this location is indeed a natural complete barrier and the end of anadromy for the stream. RCD did not observe any anthropogenic or significant natural barriers to fish passage between the Dry Creek Road culvert and the end of anadromy. During the assessment, RCD observed young-of-year *O. mykiss* in this reach of the creek. It is unknown whether these fish were of anadromous or resident descent. There is one blue-line tributary that enters the creek between the mouth and the end of anadromy (Figure 1). RCD concluded in the field that this tributary was ephemeral and of little habitat value for steelhead. A review of the topography later confirmed that it is too steep to provide fish habitat.

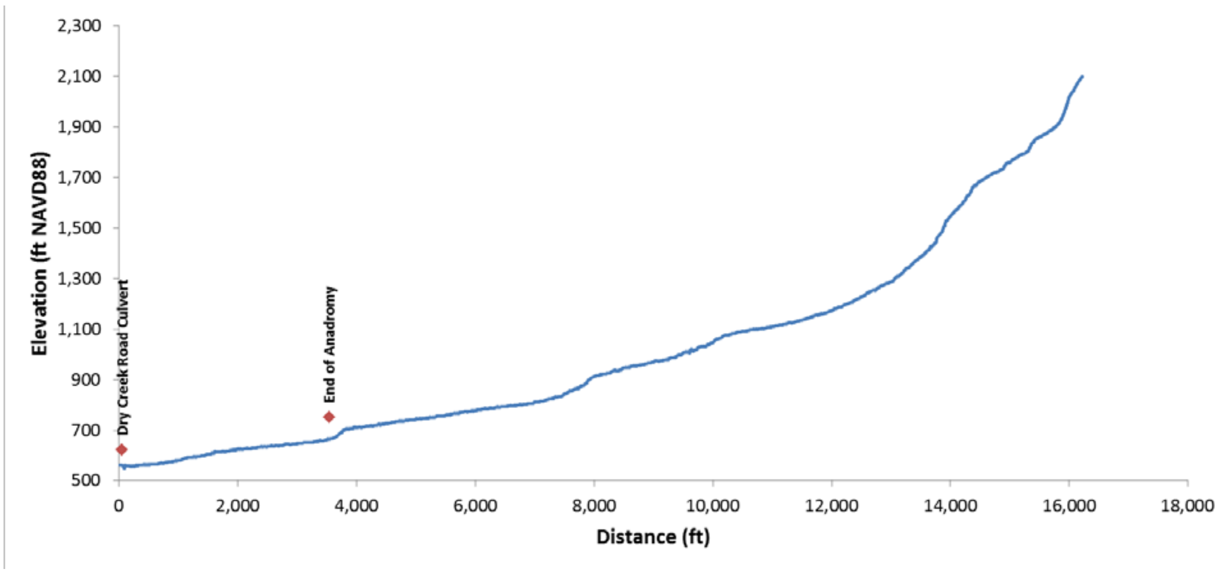


Figure 5. Campbell Creek LiDAR-derived longitudinal streambed profile with barrier location.

Peak Flow Estimate

The Campbell Creek subwatershed is an ungaged basin. In order to evaluate culvert capacity it is necessary to estimate Campbell Creek peak flows at the stream crossing. In this case, since the culvert empties directly into Dry Creek it is also necessary to estimate peak flows for Dry Creek in order to calculate tailwater elevations for culvert capacity and fish passage analyses. RCD calculated the 50% through the 1% annual exceedance probability flows (Q2, Q5, Q10, Q25, Q50, and Q100) in cubic feet per second (cfs) by adjusting the peak flow statistics for retired United States Geological Survey (USGS) Station 11457000 DRY C NR NAPA CA located on Dry Creek approximately 6 miles downstream. Station 11457000 operated continuously for 15 years, from 1951 to 1966. The Q2 through Q100 calculated by USGS were obtained from water.usgs.gov/osw/streamstats. As suggested by USGS (USGS, 1977), RCD adjusted the flow for the difference in drainage areas by using the relation:

—

where Q_u and Q_g are the discharges at the ungaged and gaged sites, A_u and A_g are the drainage areas, and b is the exponent for the drainage area from the corresponding regional regression equation (USGS 1977). Peak flow estimates are listed in Table 1.

Flow Event	**Annual Exceedance Probability**	**Return Interval (yrs)**	**Peak Streamflow (cfs)**		
			USGS 11457000	**Dry Creek at Campbell Creek Confluence**	**Campbell Creek at Dry Creek Road Culvert**
Q2	0.5	2	1,290	631	124
Q5	0.2	5	2,590	1,277	256
Q10	0.1	10	3,670	1,824	372
Q25	0.04	25	5,270	2,640	548
Q50	0.02	50	6,620	3,316	688
Q100	0.01	100	8,080	4,047	840

Table 1. Peak streamflow estimates derived from USGS flow frequency analysis of 15-year data record at former station 11457000, located approximately 6 miles downstream.

RCD considers this method of estimating peak streamflow to be the most accurate for this site, but it should be noted that the potential for significant error exists due to the short (15-year) data record from Station 11457000 and variations in watershed characteristics between the barrier site and the surrogate site.

Culvert Flow Capacity

RCD performed an analysis of the culvert using the HY-8 software developed by the Federal Highways Administration (FHWA). Culvert data, site data, tailwater data, and roadway data were collected in the field during the fish-passage inventory. RCD calculated the flow capacity at the top of the culvert inlet (headwater-to-diameter ratio equal to one) and the flow that overtops the roadway. In addition, RCD analyzed the culvert's performance under the Q10 and Q100 flows for Campbell Creek (Table 1). The results are presented in Table 2.

Tailwater data for the culvert flow capacity calculations were estimated by performing a channel analysis of Dry Creek using the cross section surveyed across tailwater control during the fish-passage inventory. RCD analyzed the cross section using the Hydraulic Toolbox 2.1 software developed by FHWA. Given cross section geometry, roughness estimates, channel slope, and streamflow, the software computes a flow-depth rating using Manning's Equation. RCD then related Dry Creek water surface elevations to Campbell Creek flows to produce tailwater elevation estimates.

Event	Total Flow (cfs)	Flow Control	Culvert Flow (cfs)	Roadway Flow (cfs)
Top of culvert inlet	178	Inlet	178	0
Top of Fill Prism	320	Inlet	320	0
Q10	372	Inlet	333	39
Q100	840	Outlet	382	458

Table 2. Culvert flow capacity analysis results.

Fish Passage Analysis

The first-phase evaluation indicated that the stream crossing is a complete barrier for juvenile and adult steelhead. To test this conclusion, RCD performed an analysis using *FishXing v3*, a program intended to assist engineers, hydrologists, and fish biologists in the evaluation and design of culverts for fish passage (http://www.stream.fs.fed.us/fishxing).

Upper and lower fish passage flows were estimated from surrogate data in accordance with DFG protocols. RCD selected the former USGS Station 11457000 as a surrogate because it is the nearest to Campbell Creek with at least 5 years of daily average flow data (15 years) and with a drainage area less than 50 square miles (17.4 square miles). Calculated fish passage flows were adjusted for Campbell Creek by multiplying them by the ratio of the two drainage areas. The calculated fish passage flows are presented in Table 3.

Species/Lifestage	Upper Passage Flow (cfs)		Lower Passage Flow (cfs)	
Adult steelhead	23.1	1% Exceedance Flow	3	Alternate Minimum Flow
Juvenile steelhead	3.0	10% Exceedance Flow	1	Alternate Minimum Flow

Table 3. Calculated fish passage flows.

The *FishXing* model was constructed using survey data collected during the fish passage inventory. Swimming capabilities and minimum depth requirements for adult and juvenile steelhead were based on Table IX-6 of the DFG Manual. The results of the *FishXing* analysis are presented in Table 2.

	Adult Steelhead	Juvenile Steelhead (>6”)	Juvenile Steelhead (<6”)
Percent of Flows Passable	0.0%	0.0%	0.0%
Passable Flow Range	None	None	None
Depth Barrier	3.0 to 12.1 cfs	All Flows	All Flows
Leap Barriers	11.9 to 23.1 cfs	All Flows	All Flows
Velocity Barrier	16.8 to 23.1 cfs	None	1.0 to 3.0 cfs
Pool Depth Barrier	3.0 to 23.1 cfs	All Flows	All Flows

Table 2. Results of *FishXing* analysis.

DISCUSSION

Comparison of the peak flow estimates to the culvert flow capacity analysis results indicates that the Dry Creek Road culvert at Campbell Creek will safely convey the Q2 flow event. During the Q5 event the inlet will be submerged and ponding will occur upstream, but the roadway should not be flooded if the culvert inlet and barrel remain clear of debris. The Q10 and larger events will likely overtop the roadway. The analysis indicates that the culvert will convey less than half of the flow during the Q100 event, with the rest flooding adjacent properties and spilling over the roadway. While some minor flooding risk may be acceptable in such a large and rare event, these results suggest that there is risk of erosion of the fill prism and catastrophic failure of the stream crossing during large flow events. California Department of Transportation (CalTrans, 2006) guidelines indicate that culverts should convey the Q10 "…without causing headwater elevation to rise above the inlet top of culvert," and the Q100 "…without damage to the facility or adjacent property." DFG states that "crossing structures should typically be designed to accommodate the 100-year flood event" (DFG, 2009). Based on these guidelines, the culvert is significantly undersized.

The results of the fish-passage analysis of the Dry Creek Road culvert indicate that it is a complete barrier for adult and juvenile steelhead due to excessive jump height, inadequate jump pool depth, and excessive outlet water velocities during the design flow range. Given the natural variability in swimming capabilities of individual steelhead, an occasional fish may be able to pass the culvert under ideal flow conditions. *O. mykiss* were observed upstream of the culvert during our January 2011 survey, but it is unknown whether these were anadromous or resident trout. The limit-of-anadromy survey revealed the presence of 0.67 miles of high-quality steelhead spawning and rearing habitat upstream of the culvert.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this assessment, the Dry Creek Road culvert at Campbell Creek is undersized and a complete barrier to the upstream movement of anadromous fishes. It is at risk of flooding and failure during large storm events and blocks or severely limits the ability of fish to access 0.67 miles of high-quality habitat; therefore, it is a high-priority candidate for an improvement project.

Mitigation options include:

1) Do nothing, and leave the current culvert in place;

2) Remove and replace the existing culvert and re-grade the streambed to match the elevation of the Dry Creek streambed.

Option 1 does not address fish passage or flooding issues, and is not recommended.

RCD recommends Option 2. Although 0.67 miles of additional habitat is a relatively small contribution to the overall watershed, it is habitat of the highest quality in the area. In addition, frequent flooding of the stream crossing due to the undersized culvert carries several risks including motorist safety, stream channel erosion, and costs associated with the potential failure and emergency stabilization and replacement of the culvert. If Option 2 is selected, the replacement culvert should be embedded or have rock baffles in the floor to reduce velocities and increase depth in the culvert.

CONCEPTUAL DESIGNS

Option 2:

Drawings by Carolyn M. Jones, PE, Natural Resource Conservation Service

REFERENCES

California Department of Fish and Game (CDFG). 2010. Edition. California Salmonid Stream Habitat Restoration Manual. 4th Edition.

Waananen, A.O., and J.R. Crippen. 1977. *Magnitude and Frequency of Floods in California*. United States Geological Survey Water-Resources Investigations 77-21.

CARNEROS CREEK DEFUNCT IN-STREAM FLASHBOARD DAM

FISH PASSAGE ASSESSMENT

Prepared for

California State Coastal Conservancy
Agreement No. 08-069

Prepared by

NAPA COUNTY RCD Resource Conservation District

June 2011

STREAM DESCRIPTION

Carneros Creek is a tributary of the Napa River which flows into San Pablo Bay in the San Francisco Estuary. Its 8.9 square mile watershed contains 26.8 miles of blue-line stream, 6.0 miles of which is third order stream and 4.7 miles of which is second order stream, according to the USGS 7.5-minute quadrangle (Figure 1). Elevations range from sea level at the mouth of the creek to 1,660 feet at the ridgeline. The watershed is a long, narrow valley with the low-lying areas largely planted in vineyards. Grassland and mixed hardwood forest dominate the uplands. There are areas of rural residential development in the southern portion of the watershed. The entire watershed is under private ownership.

Steelhead trout are present in Carneros Creek and the slope and substrate of the streambed are favorable for approximately 11 miles, at which point the slope exceeds 8% (Figure 2). The creek is flow-limited, however, and extensive reaches are completely dry in the summer months. Juvenile steelhead are observed in high densities in the limited areas where rearing habitat is available.

Five barriers to upstream migration of steelhead have been identified on Carneros Creek (Koehler, 2003). The barriers are listed in Table 1 and shown on Figures 1 and 2.

Fish-Passage Barrier	Distance Upstream from Mouth (mi)	Max Upstream Habitat (mi)	Barrier Type	Status
Pumping Station	6.0	5.0	Temporal/Partial	Under assessment
Defunct Flashboard Dam	**6.3**	**4.7**	**Temporal/Partial**	**Under assessment**
Operating Flashboard Dam	7.6	3.4	Temporal/Partial	More significant downstream barriers
Concrete Ford	9.5	1.5	Temporal/Partial	Flow-limited reach
Slope Exceeds 8%	11.0	0.0	Probable end-of-anadromy	Natural feature
Earthen Dam	12.0	0.0	Complete	Above slope end-of-anadromy

Table 1. Carneros Creek fish-passage barriers.

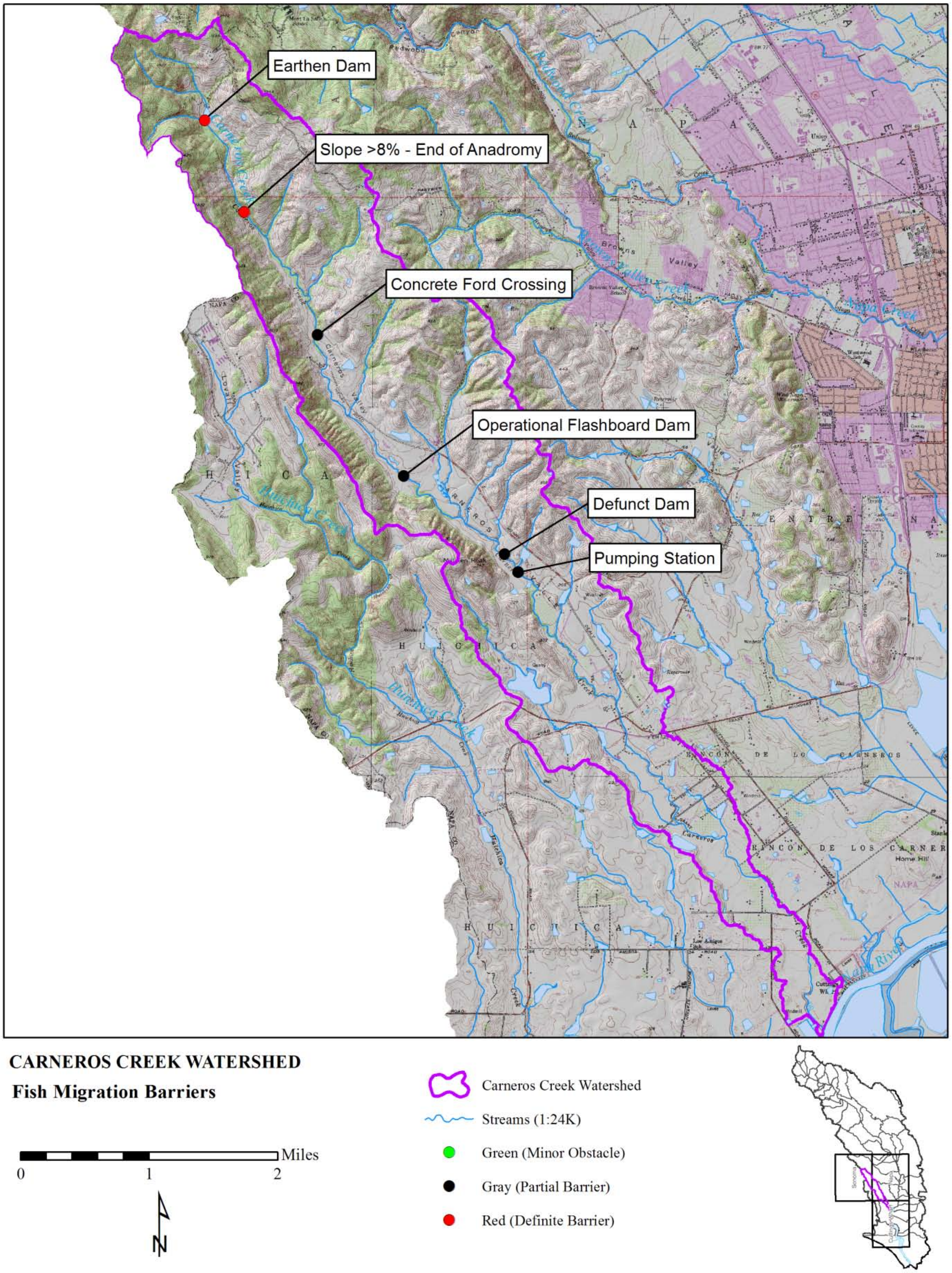


Figure 1. Carneros Creek watershed and barrier locations.

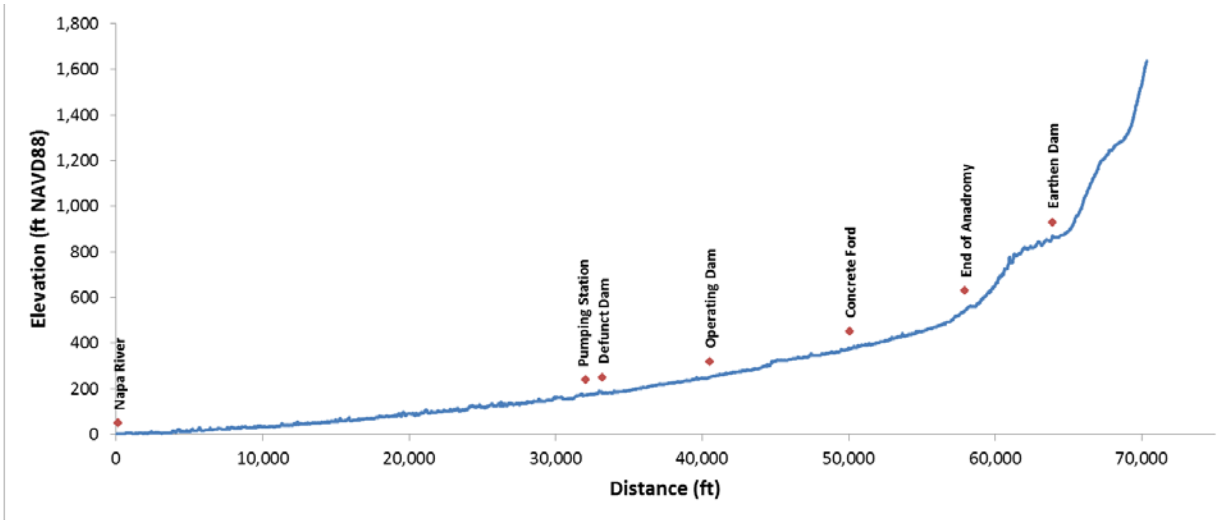


Figure 2. Carneros Creek LiDAR-derived longitudinal streambed profile with barrier locations

BARRIER ASSESSMENT

The RCD evaluated fish-passage at the defunct flashboard dam in general accordance with *Part IX Fish Passage Evaluation at Stream Crossings* of the California Department of Fish and Game (DFG) Salmonid Stream Habitat Restoration Manual (CDFG 2010).

Barrier Description

The defunct in-stream flashboard dam is a concrete dam with an 8-foot wide lower water channel up to a height of 5.2 feet above the streambed elevation (Figures 3 and 4). Above 5.2 feet, the water channel widens to 23.8 feet and this width extends to the crest of the dam at 12.2 feet above the streambed (Figure 5). It appears that flashboards could be installed in both of these openings to impound water up to the crest of the dam. When the stream is flowing, the sill of the lower water channel is backwatered by the downstream pool. Since it no longer operates, the dam itself is not a low-flow barrier; however, the dam constricts the flow which can create a velocity barrier under high-flow conditions, and the constriction can easily become jammed with large wood, as it is currently (Figure 4), creating a significant low-flow barrier.


Figure 3. Looking upstream at the defunct flashboard dam under summer zero-flow conditions.


Figure 4. Looking upstream at the lower water channel and jammed log under summer zero-flow conditions.

Figure 5. Looking obliquely downstream at upstream side of dam on left bank. Upper water channel and dam crest are shown.

First-Phase Evaluation

The dam was identified as a potential barrier to fish passage in September 2002 as part of a Carneros Creek stream inventory conducted by Napa County RCD (Koehler, 2003). It was categorized as "gray" in the DFG Green-Gray-Red system because it is expected to be a temporal barrier (impassable to adult steelhead at certain flows) as well as a partial barrier (impassable to juvenile steelhead at all flows) due to excessive velocity and/or jump height.

Field Work

On September 7, 8, and 24, 2010, Jonathan Koehler (RCD) and Paul Blank (RCD) conducted a fish-passage inventory of the stream crossing including:

- Measurement of dam dimensions;
- Longitudinal profile survey;
- Channel cross section survey;
- Site sketch; and,
- Completion of the DFG fish passage inventory data sheet.

The longitudinal profile survey was completed with tape and level and was surveyed relative to an arbitrary datum. It began more than 500 feet upstream of the dam and continued for more than 1,600 feet in the downstream direction, beyond the site of the "Pumping Station" fish-passage barrier (Figure 6). The survey captured the slope of the reach, the upstream resting pool, the profile of the jammed log and sill of the dam, the jump pool, and the tailwater control. Channel cross sections were also surveyed with tape and level and were located at the riffle crest upstream of the upstream resting pool, along the upstream edge of the dam, 3 feet downstream of the dam, at the tailwater control, and 190 feet downstream of the dam. Cross-sections were completed specifically for low-flow hydraulic analyses, and do not include the top of bank or overbank data.

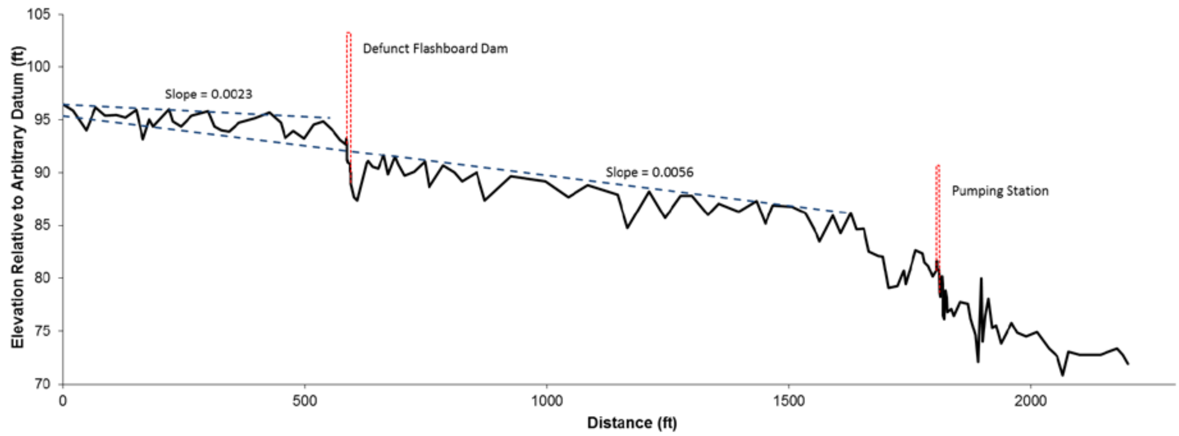


Figure 6. Surveyed longitudinal streambed profile.

Fish Passage Analysis

The first-phase evaluation indicated that the defunct dam is a temporal barrier for adult steelhead, as well as a partial barrier, impassable to juvenile steelhead. To test this assumption, RCD performed an analysis using *HEC-RAS* version 4.1, a software package developed by the US Army Corps of Engineers Hydrologic Engineering Center (HEC) for one-dimensional steady and unsteady flow hydraulics calculations (http://www.hec.usace.army.mil/software/hec-ras).

Upper and lower fish passage flows were estimated from surrogate data in accordance with DFG protocols. RCD selected the former USGS streamgaging station on Redwood Creek as a surrogate because it is the nearest to Carneros Creek with at least 5 years of daily average flow data (15 years) and with a drainage area less than 50 square miles (9.79 square miles). Calculated fish passage flows were adjusted for Carneros Creek by multiplying them by the ratio of the two drainage areas. The calculated fish passage flows are presented in Table 2.

Species/Lifestage	Upper Passage Flow (cfs)		Lower Passage Flow (cfs)	
Adult steelhead	118	1% Exceedance Flow	3	Alternate Minimum Flow
Juvenile steelhead	12.3	10% Exceedance Flow	1	Alternate Minimum Flow

Table 2. Calculated Fish Passage Flows.

The HEC-RAS model was constructed using the five surveyed channel cross sections and the surveyed dimensions of the defunct dam. Steady flow analyses were then run for each fish passage flow and jump height, jump pool depth, flow depth over the barrier, and average water velocity over the barrier were calculated. RCD analyzed existing conditions (with jammed log), as well as with the log removed. The results of the fish passage analysis are presented in Table 3.

Flow Description	Flow (cfs)	Jump Height (ft)	Jump Pool Depth (ft)	Depth (ft)	Avg Velocity (ft/s)
Existing Conditions					
Juvenile lower passage flow	1	1.5	3.3	0.4	0.8
Adult lower passage flow	3	1.1	3.7	0.6	1.2
Flow that produces 0.8 ft depth over log	6	0.9	3.9	0.8	1.7
Juvenile upper passage flow	12.3	0.6	4.2	1.1	2.3
Adult upper passage flow	118	0.0	5.9	2.8	8.4
With Jammed Log Removed					
Juvenile lower passage flow	1	0.0	NA	0.7	0.2
Flow that produces 0.8 ft depth over sill	1.5	0.0	NA	0.8	0.2
Adult lower passage flow	3	0.0	NA	1.1	0.4
Juvenile upper passage flow	12.3	0.0	NA	1.6	1.0
Adult upper passage flow	118	0.0	NA	3.1	4.7

Table 3. Fish Passage Analysis Results

RCD compared the fish passage analysis results to the swimming capabilities and minimum depth requirements for adult and juvenile steelhead from Table IX-6 of the DFG Manual. Maximum jump heights were obtained from NMFS Guidelines for Salmonid Passage at Stream Crossings (NMFS 2001). Based on comparison to these criteria, the defunct dam with the jammed log is a temporal barrier to upstream passage of adult steelhead, due to insufficient depth at the low end of the adult passage flow range. The dam is a complete barrier to movement of juvenile steelhead due to excessive jump height across the passage flow range, and excessive water velocity at the upper end of the range. The finding of the first-phase evaluation and the classification of the barrier as “gray” in the DFG Green-Gray-Red system were confirmed by this analysis.

The analysis also included a simulation of fish passage conditions at the defunct dam if the jammed log were removed. This simulation indicated that no impediments to movement of juvenile or adult steelhead would be presented by the defunct dam if the lower water channel was clear of obstruction.

DISCUSSION

The results of hydraulic analyses of the defunct flashboard dam indicate that it is a temporal barrier for adult steelhead; however, this is only because the flow depth over the jammed log decreases to 0.6 feet (below the criterion of 0.8 feet) at the low end of the adult passage flow range. The barrier is passable for most of the adult passage flow range and it is likely that most adult steelhead are able to get upstream. In addition, since the result is so close in value to the criterion, it is possible that further hydraulic analysis using more detailed topographic data could reveal that adult steelhead are not impeded. Based on this analysis, the defunct dam should be considered a partial barrier for adult steelhead, but should be considered a low priority.

The analysis indicates that the defunct dam with the jammed log present a complete barrier to juvenile steelhead due to jump height in excess of 0.5 feet across the juvenile passage flow range. At the upper end of the juvenile passage flow range, the jump height was calculated to be 0.6 feet, which is close in value to the criterion indicating the possibility that further hydraulic analysis may be able to demonstrate some minor level of passage; however, the dam with the jammed log will still present a significant obstacle to upstream movement of juvenile steelhead even if it is not a complete barrier.

The analysis indicates that all impediments to fish passage would be eliminated if the jammed log were removed. The dam itself creates an artificial constriction in the channel, however, and will easily become jammed with other large woody debris in future flood events. Removal of the jammed log would only temporarily improve fish passage.

RECOMMENDATIONS

Based on the results of this analysis, the defunct flashboard dam on Carneros Creek is a partial barrier to upstream movement of steelhead trout which likely completely blocks the upstream movement of juveniles and infrequently blocks the upstream movement of adults. Upstream of the dam are 4.7 miles of habitat that is suitable for spawning but very limited in its summer rearing value.

Options for mitigation include:

1) Do nothing, and leave the structure in place

2) Remove the jammed log with a field crew and hand tools

3) Widen the lower water channel with heavy equipment to allow unobstructed downstream passage of debris

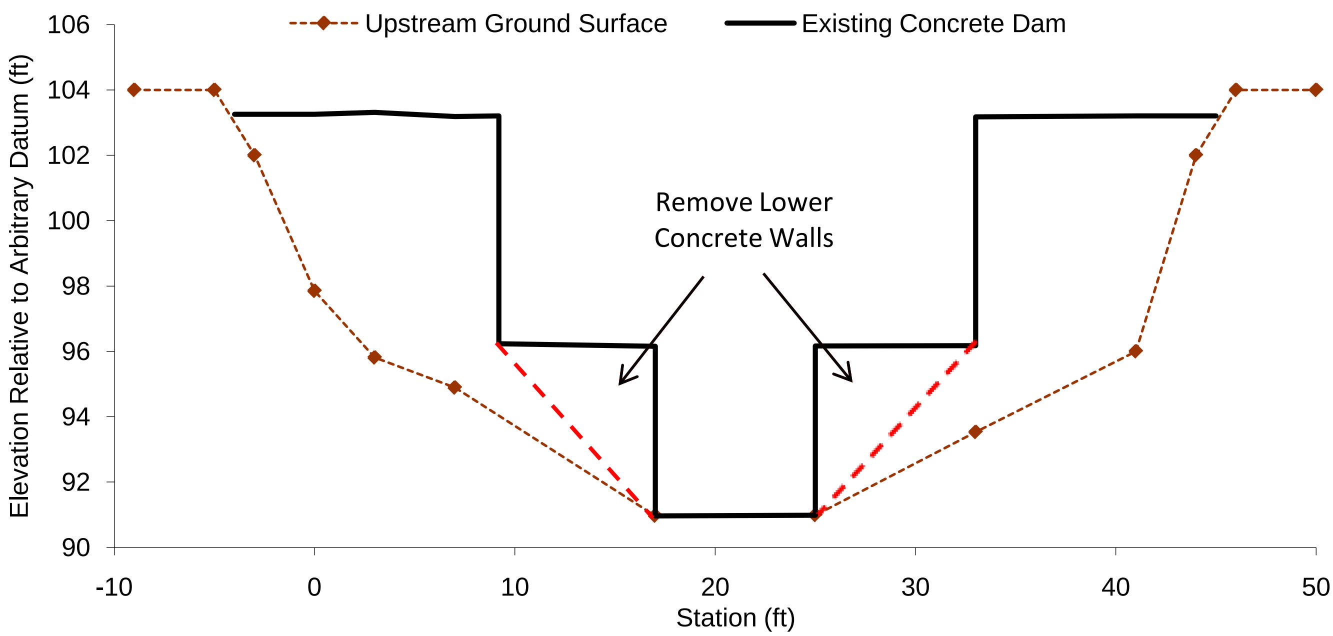
4) Remove the dam entirely, and re-grade and re-vegetate both stream banks.

It should be evaluated whether the upstream movement of juveniles is essential at this location. Resource agency staff (NMFS and DFG) will need to make this determination based on management and recovery strategies for steelhead in the region. If juvenile passage is not deemed essential, Option 1 may be warranted, since the defunct dam is having limited impact on passage of adults. Option 2 is only a temporary solution and is not recommended.

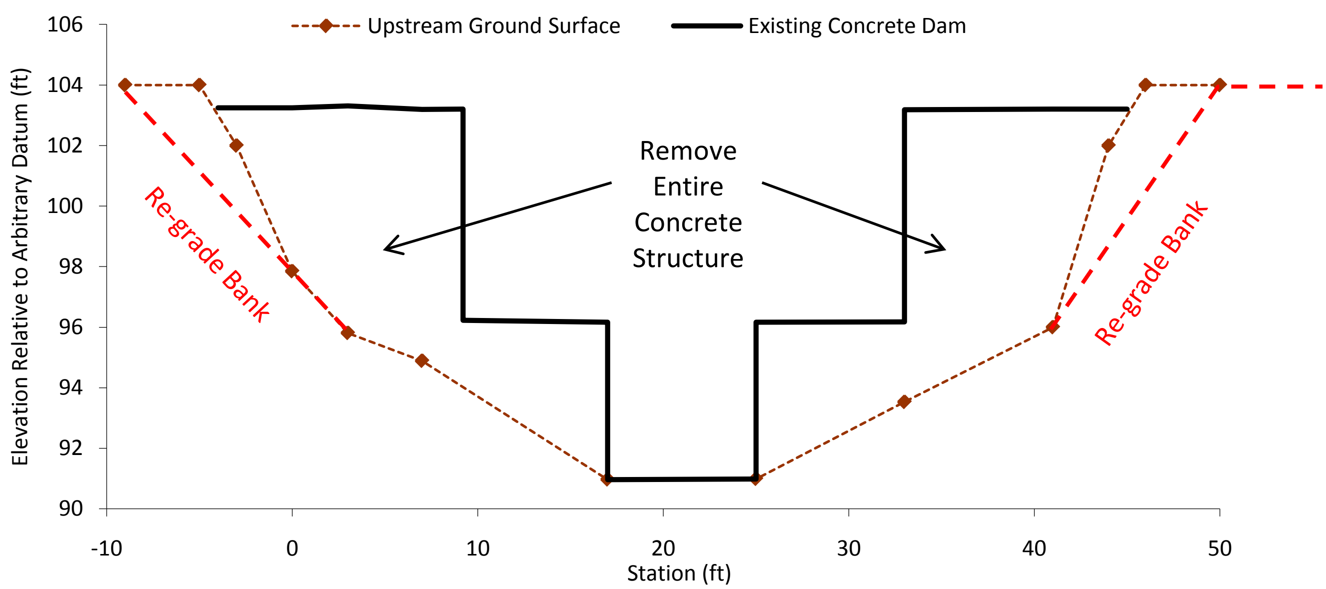
Since the dam is relatively small, Options 3 and 4 are likely similar in cost. They would both require the same permits, the same heavy equipment, and disposal of rubble. Therefore if the structure is to be modified, RCD recommends complete removal of the dam combined with re-grading and re-vegetating of both banks.

CONCEPTUAL DESIGNS

Option 3: Widen lower water channel (*Not recommended*)



Option 4: Complete dam removal (*Recommended*)



REFERENCES

California Department of Fish and Game (CDFG). 2010. Edition. California Salmonid Stream Habitat Restoration Manual. 4th Edition.

Koehler, J. 2003. Fish Habitat Assessment: A Component of the Watershed Management Plan for the Carneros Creek Watershed, Napa County, California (Napa County Resource Conservation District). Prepared For Stewardship Support and Watershed Assessment in the Napa River Watershed: A CALFED project, CALFED contract no. 4600001703

NMFS 2001. Guidelines for Salmonid Passage at Stream Crossings. National Marine Fisheries Service Southwest Region. Santa Rosa, California.

CARNEROS CREEK PUMPING STATION

FISH PASSAGE ASSESSMENT

Prepared for

California State Coastal Conservancy
Agreement No. 08-069

Prepared by

NAPA COUNTY RCD
Resource Conservation District

June 2011

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Table 1. Carneros Creek fish-passage barriers.

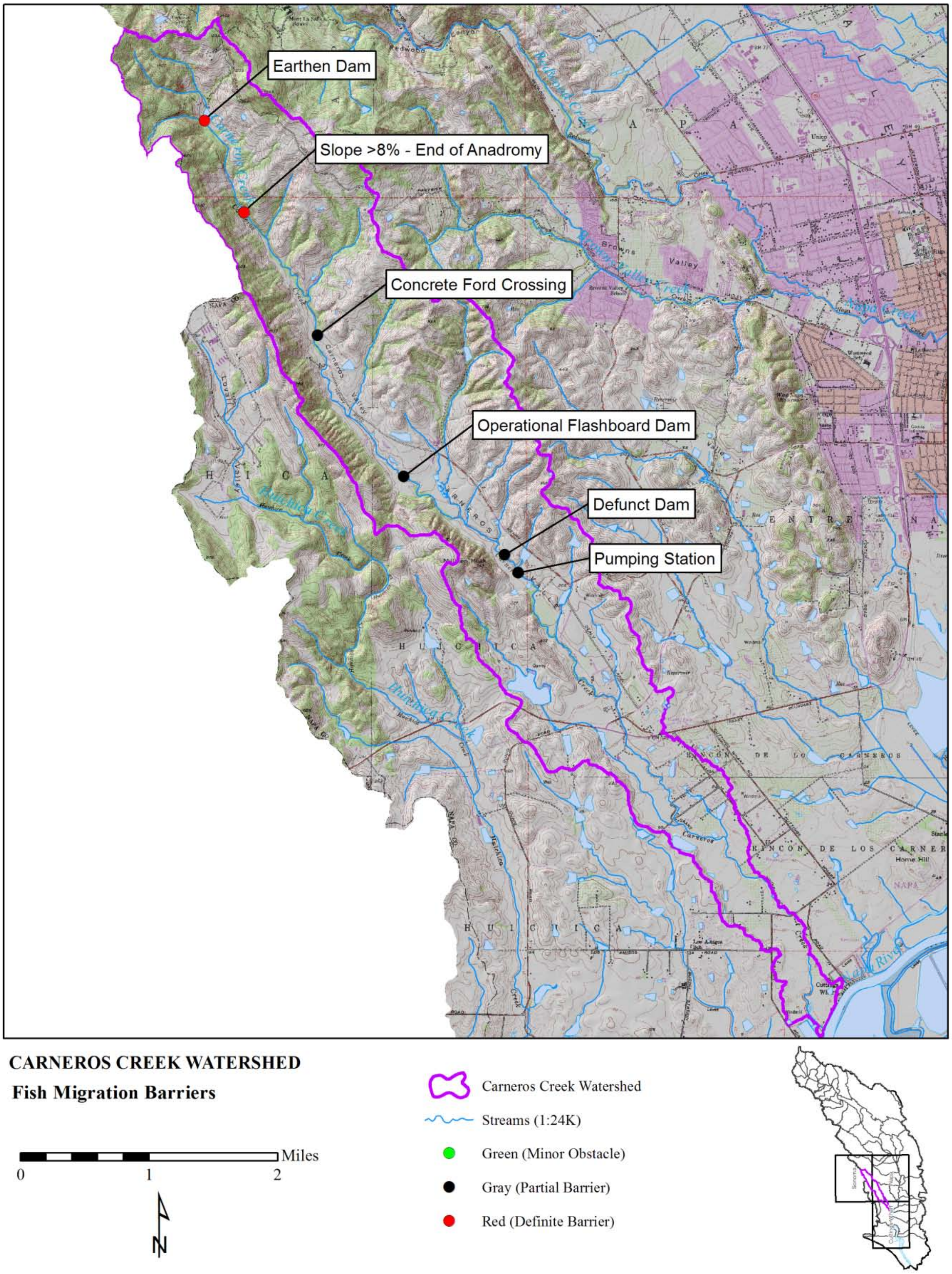


Figure 1. Carneros Creek watershed and barrier locations.

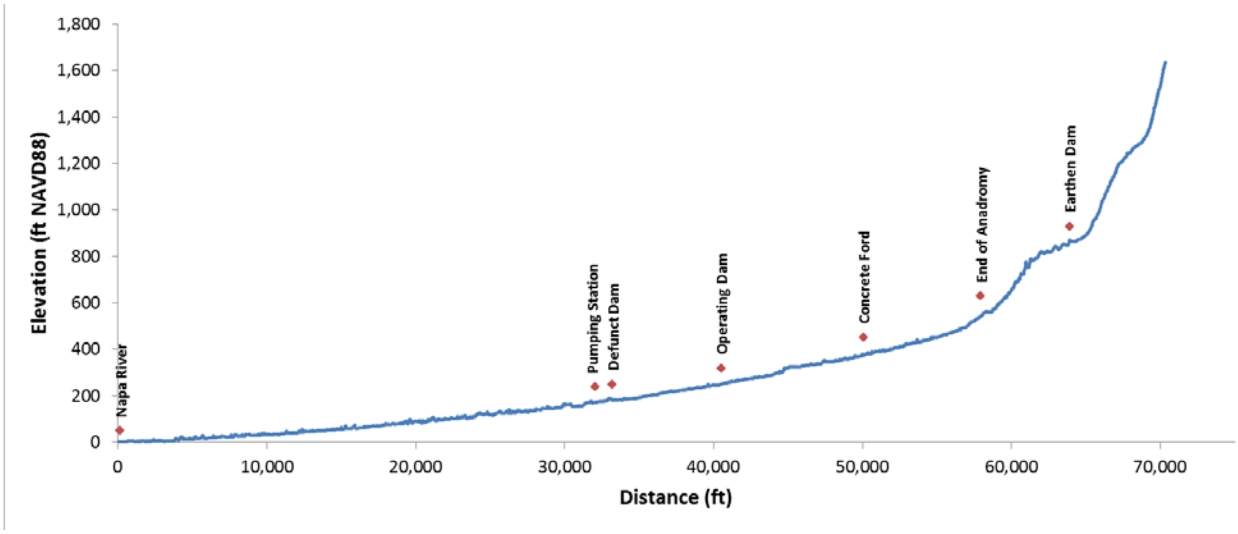


Figure 2. Carneros Creek LiDAR-derived longitudinal streambed profile with barrier locations

BARRIER ASSESSMENT

The RCD evaluated fish-passage at the pumping station in general accordance with *Part IX Fish Passage Evaluation at Stream Crossings* of the California Department of Fish and Game (DFG) Salmonid Stream Habitat Restoration Manual (CDFG 2010).

Barrier Description

The pumping station is a structure built atop a natural bedrock outcropping in the stream channel. It includes a concrete weir and apron, a cinder-block pump house, and a steel bridge with concrete abutments (Figures 3, 4, and 5). The station functions by using the weir to create a small pool that inundates the pump house, allowing water to be withdrawn. Although the bridge no longer appears to be in use as a stream crossing, the pumping capabilities of the station are operational and in use by the landowner. This site is located completely on private property.

This reach has a greater slope than the neighboring reaches of the stream (Figure 6), and was likely a natural obstacle to fish passage prior to construction of the pumping station. The concrete apron on the streambed below the bridge appears to have partially fallen away exposing the underlying bedrock cascade, which likely allows migrating fish to advance upstream as far as the weir. Though less than a foot high, the weir likely impedes the upstream passage of many fish due to its position at the top of a natural obstacle and insufficient jump pool depth.

Figure 3. Looking upstream at the pumping station under summer low-flow conditions. Weir, apron, and bridge are shown.

Figure 4. Looking upstream at the weir under summer low flow conditions.


Figure 5. Looking downstream at the pump house and left bank bridge abutment.

First-Phase Evaluation

The pumping station was identified as a potential barrier to fish passage in September 2002 as part of a Carneros Creek stream inventory conducted by Napa County RCD (Koehler, 2003). It was categorized as “gray” in the DFG Green-Gray-Red system because it is expected to be a temporal barrier (impassable to adult steelhead at certain flows) as well as a partial barrier (impassable to juvenile steelhead at all flows) due to excessive jump height and insufficient jump pool depth.

Fish Passage Inventory

On September 8, 2010, Jonathan Koehler (RCD) and Paul Blank (RCD) conducted a fish-passage inventory of the stream crossing including:

- Measurement of structure dimensions;
- Longitudinal profile survey;
- Site sketch; and,
- Completion of the DFG fish passage inventory data sheet.

The longitudinal profile survey was completed with tape and level and was surveyed relative to an arbitrary datum. It began approximately 1,800 feet upstream, beyond the site of the “Defunct Flashboard Dam” fish-passage barrier (Figure 6), and continued for 2,200 feet in the downstream direction to approximately 400 feet downstream of the pumping station (Figure 6). The survey captured the slope of the reach, the upstream resting pool, the profile of the weir, and the bedrock cascade. Channel cross sections were not surveyed.

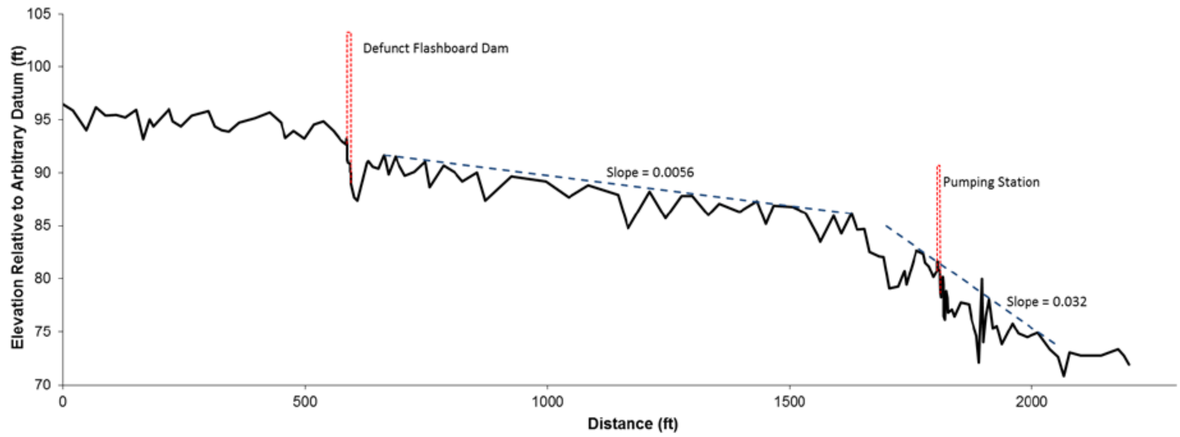


Figure 6a. Surveyed longitudinal streambed profile.

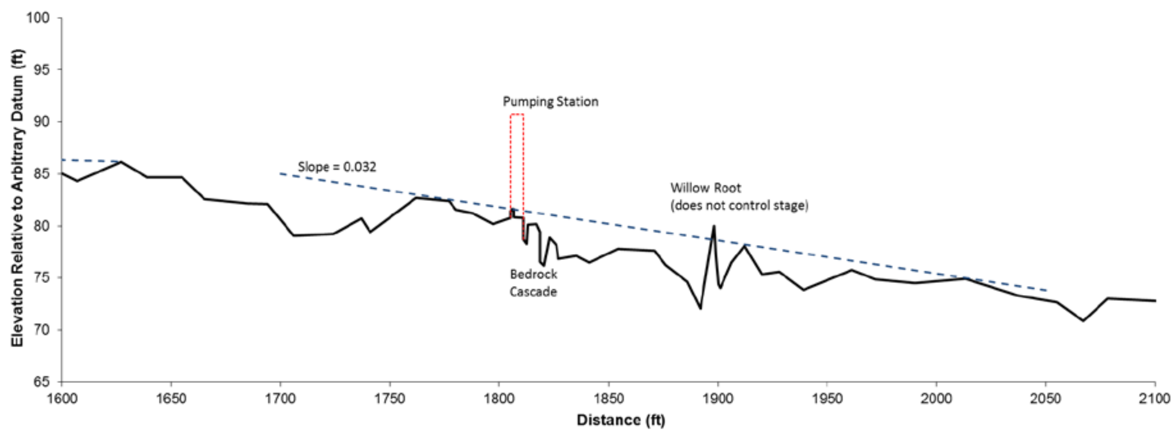


Figure 6b. Closer look at pumping station reach from Figure 6a.

Fish Passage Analysis

The first-phase evaluation indicated that the pumping station is a temporal barrier for adult steelhead, as well as a partial barrier, impassable to juvenile steelhead. As part of a fish passage assessment, RCD usually confirms the first-phase evaluation with a fish passage analysis using a modeling tool such as FishXing or HEC-RAS. In this case, however, the relevant streambed features are so small as to require a much more detailed surveying effort and analysis than possible within the scope of this project. Even if we had the capacity, that level of effort would not likely be warranted. As a result, this assessment relies on the judgment of RCD's fisheries biologist.

DISCUSSION

Due to its irregular shape and configuration, this site was not able to be hydraulically assessed with simple modeling software. However, based on field observations and measurements, the existing structure is clearly an impediment to migrating steelhead under a range of flows. RCD staff visited this site with John Klochak, a USFWS biologist with extensive experience in fish passage assessment, who agreed that the structure represents a significant impediment to fish passage. Additional hydraulic modeling efforts would provide more specific information on the severity of the impediment; however given the high cost of setting up and running such a model and the relatively small size and simplicity of the structure, such efforts seem unwarranted.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this analysis, the weir associated with the pumping station on Carneros Creek is a partial barrier to movement of steelhead trout which partially blocks the upstream movement of adults and likely completely blocks the upstream movement of juveniles. Upstream of the pumping station are 5.0 miles of habitat that are suitable for spawning but very limited in summer rearing value.

Mitigation options include:

1) Remove or notch the concrete weir

2) Remove all elements of the pumping station and install a new pump intake structure at or near the site with a modern design that will not affect fish passage.

3) Install a series of boulder weirs downstream of the station to gradually step up the streambed elevation to the elevation of the existing structure, thereby backwatering the weir.

Since the weir is required for operation of the station, it cannot be notched or removed, and therefore Option 1 is not viable. If the station is no longer needed or used, then Option 1 may be the simplest and least expensive option.

RCD recommends Option 2, working with the landowner to find funds to demolish the current structure and design and install a new pump intake if needed. Developing conceptual designs for such a structure are beyond the scope of this project and will need to be completed by a qualified engineer.

RCD recommends further investigation into whether Option 3 would be possible at this particular site, given the relatively steep channel slope (approximately 3.2%) and bedrock substrate. If further analysis determines that a series of weirs could successfully be installed in this reach, Option 3 would provide both juvenile and adult passage at the site, where it currently is limited by the natural bedrock outcrop.

REFERENCES

California Department of Fish and Game (CDFG). 2010. Edition. California Salmonid Stream Habitat Restoration Manual. 4th Edition.

Koehler, J. 2003. Fish Habitat Assessment: A Component of the Watershed Management Plan for the Carneros Creek Watershed, Napa County, California (Napa County Resource Conservation District). Prepared For Stewardship Support and Watershed Assessment in the Napa River Watershed: A CALFED project, CALFED contract no. 4600001703

HUICHICA CREEK DEFUNCT DAM

FISH PASSAGE ASSESSMENT

Prepared for

California State Coastal Conservancy
Agreement No. 08-069

Prepared by

NAPA COUNTY RCD Resource Conservation District

June 2011

STREAM DESCRIPTION

Huichica Creek is a tributary to Napa Slough, which is in the estuarine portion of the lower Napa River as it flows into the San Francisco Estuary. Huichica Creek is a third order stream and has approximately 16.5 miles of blue line stream according to the USGS Sonoma and Cutting Wharf 7.5 minute quadrangles (Figure 1). Huichica Creek drains a watershed of 6.36 square miles. Elevations range from sea level at the mouth of the creek to approximately 1,130 feet in the headwater areas. Mixed hardwood forest, grasslands, and vineyards are the primary land cover types in the watershed. With the exception of the lower tidal reaches, which are owned by the State of California, the rest of watershed is privately owned.

Steelhead (*Oncorhynchus mykiss*) are present in Huichica Creek and the slope and substrate of the streambed are favorable for approximately 7.1 miles, at which point a natural waterfall occurs. The creek is flow-limited, however, and extensive sections are completely dry in the summer months. The reach from the estuary up to around Highway 12/121 goes dry by July in most years. The reach between the Highway and the defunct dam site being assessed in this report contains perennial flow in most years. This is approximately 2.0 miles of suitable steelhead rearing habitat. Juvenile steelhead have been observed in high densities in this reach of creek (Koehler and Edwards 2009). Above the defunct dam, the stream goes dry up to the natural limit of anadromy.

Three barriers to upstream migration of steelhead have been identified on the main fork of Huichica Creek (Koehler and Edwards 2009). The barriers are listed in Table 1 and shown on Figures 1 and 5.

Fish-Passage Barrier	Distance Upstream from Mouth (mi)	Max Upstream Habitat (mi)	Barrier Description	Status
Highway 12/121 Culvert	3.68	3.45	Severe – may be complete barrier to adult steelhead. Definite complete barrier to juveniles	Caltrans currently working to replace culvert with bridge by 2015
Defunct dam	5.68	1.45	Severe – likely complete barrier to adult steelhead. Definite complete barrier to juveniles	Under assessment
Natural falls	7.13	0.0	Natural end of anadromy	Natural feature

Table 1. Huichica Creek fish-passage barriers.

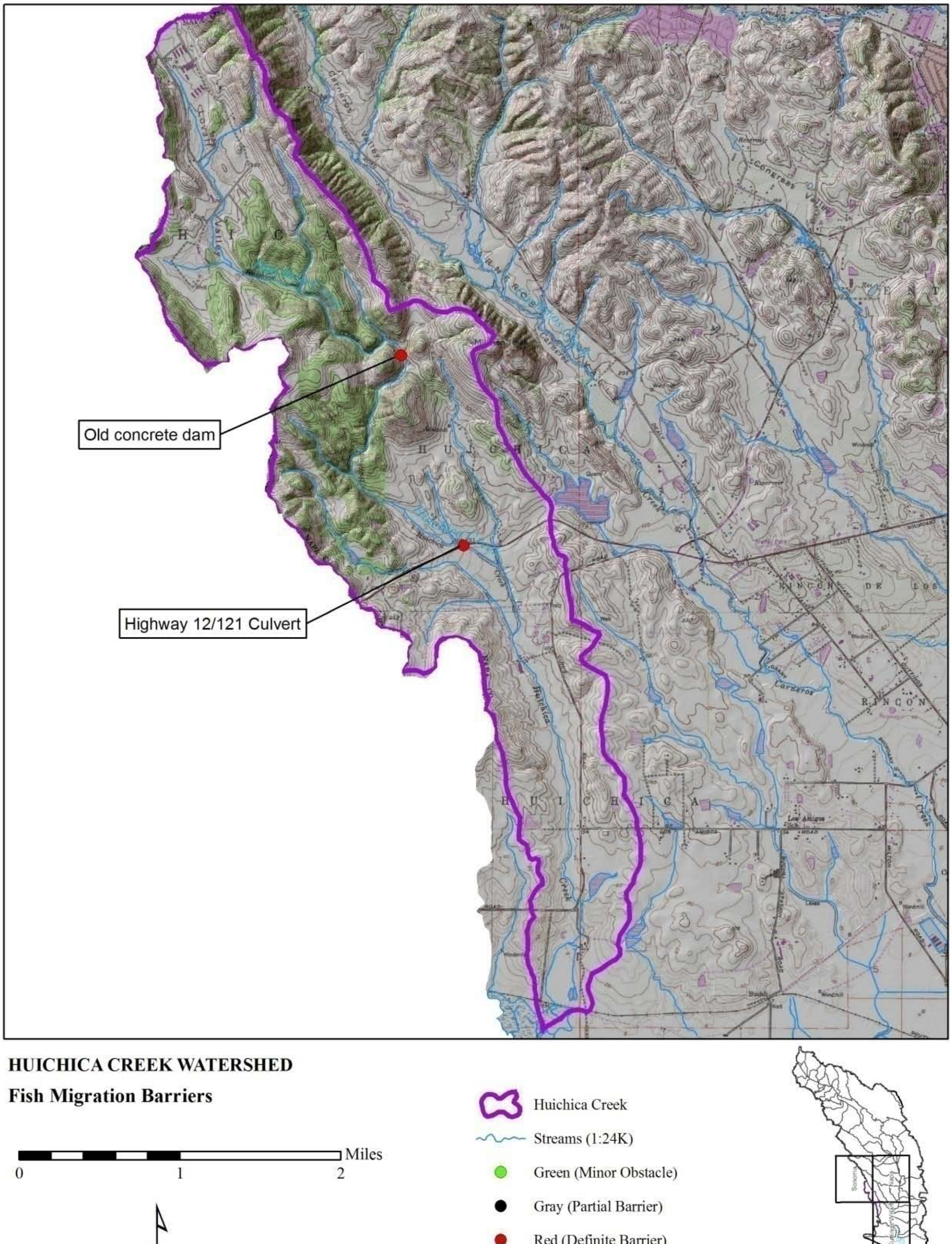


Figure 1. Huichica Creek watershed and barrier locations.

BARRIER DESCRIPTION

The defunct dam is built in a bedrock-dominated section of Huichica Creek. The dam is 6.6 feet high in the center of the channel and approximately 46 feet across (Figures 2, 3, and 4). The structure appears to consist of a single poured concrete wall 2.0 feet thick with a small notch in the center where low flows are concentrated. The channel upstream of the dam is filled in with sediment for up to 170 feet and the channel returns to its undisturbed grade upstream of that point. According to the current landowner, the original use of the dam was to impound water for domestic and agricultural water supply. The dam no longer functions in this capacity, as the reservoir is completely filled in and no diversion infrastructure remains in place.

The defunct dam was identified as a barrier to fish passage in October 2007 as part of a Huichica Creek stream inventory conducted by Napa County RCD (Koehler and Edwards 2009). It was categorized as “red” in the DFG Green-Gray-Red system because it is expected to be a severe (possibly complete) barrier to both adult and juvenile steelhead due to excessive jump height and insufficient jump pool depth. The current landowner observed a single adult steelhead above the structure several years ago, but this appears to be a very rare occurrence.

Figure 2. View of the dam from the left bank under low flow conditions.

Figure 3. Looking upstream at the dam face under zero-flow conditions.

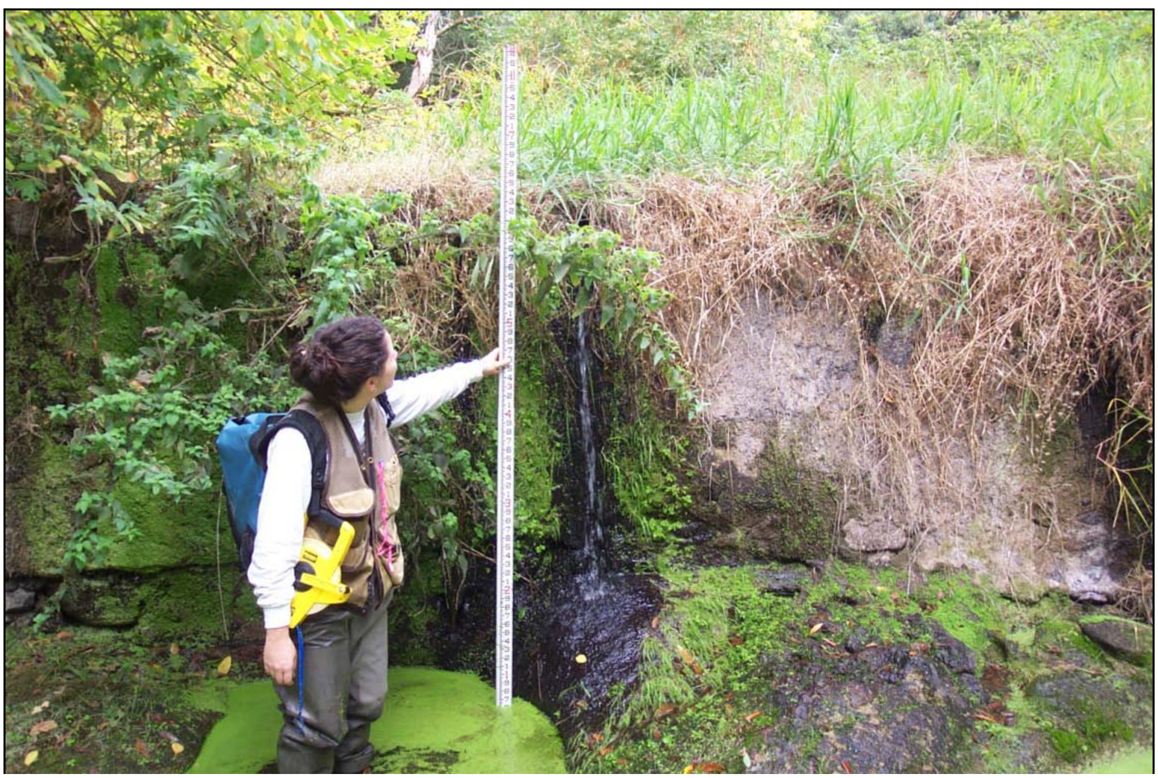


Figure 4. Closer view of the dam face built atop a bedrock outcropping.

BARRIER ASSESSMENT

RCD evaluated fish-passage at the defunct dam in general accordance with *Part IX Fish Passage Evaluation at Stream Crossings* of the California Department of Fish and Game (DFG) Salmonid Stream Habitat Restoration Manual (DFG 2010). The assessment included a limit-of-anadromy survey, a fish-passage inventory of the barrier site, and a fish-passage analysis.

Limit-of-Anadromy Survey

RCD evaluated the amount of *O.mykiss* habitat located upstream of the barrier. A topographic profile of the mainstem of Huichica Creek generated from the LiDAR digital elevation model (DEM) showed a sharp slope break, interpreted to be a falls, at 7.13 miles upstream of the mouth of the creek, 1.45 miles upstream of the barrier site (Figure 5). RCD staff made a field visit on January 5, 2010, and confirmed that the falls at this location is indeed a natural complete barrier and the end of anadromy for the stream. RCD did not observe any anthropogenic or significant natural barriers to fish passage between the defunct dam and the end of anadromy. There are two blue-line tributaries that enter the creek between the defunct dam and the end of anadromy (Figure 1). RCD concluded in the field that these tributaries were intermittent and too small to provide fish habitat.

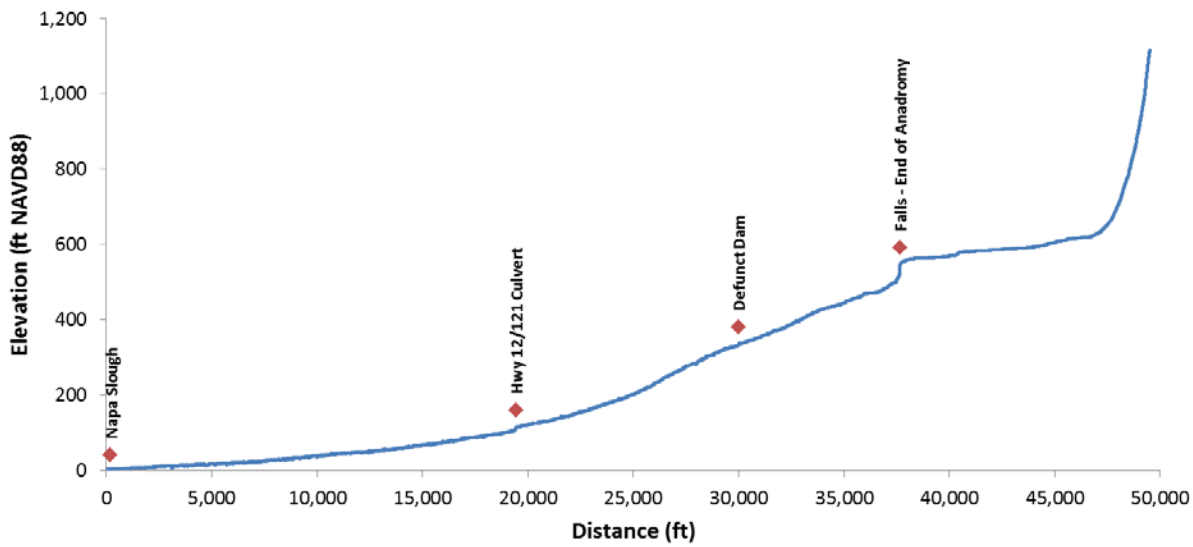


Figure 5. Huichica Creek LiDAR-derived longitudinal streambed profile with barrier locations.

Fish-Passage Inventory

On August 18 and September 28, 2010, Jonathan Koehler (RCD) and Paul Blank (RCD) conducted a fish-passage inventory of the stream crossing including:

- Measurement of structure dimensions;
- Longitudinal profile survey;

- Channel cross section survey;
- Site sketch; and,
- Completion of the DFG fish passage inventory data sheet.

The longitudinal profile survey was completed with tape and level and was surveyed relative to an arbitrary datum. It began 300 feet upstream of the defunct dam and continued for 600 feet in the downstream direction to approximately 300 feet downstream of the dam. The survey captured the profile of the dam, the upstream resting pool, the downstream channel, and the overall slope of the reach (Figure 6). A total of four cross sections were surveyed: one in the upstream channel above the influence of the dam, one immediately upstream of the dam, one immediately downstream of the dam, and one in the downstream channel. Cross sections were completed specifically for low-flow hydraulic analyses and do not include top of bank or overbank data.

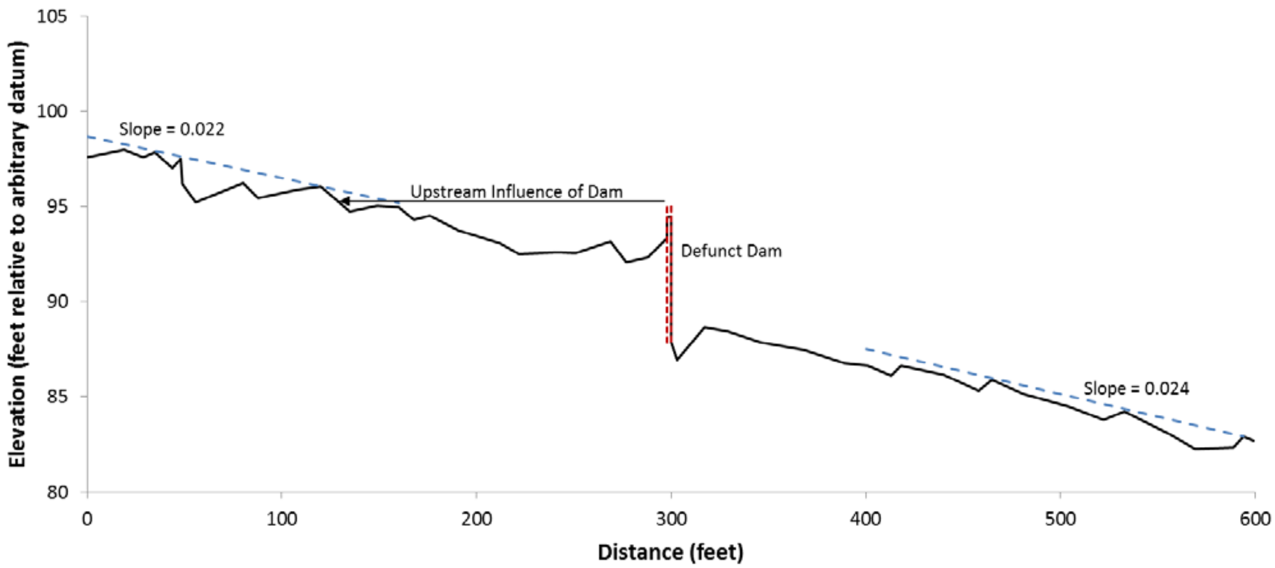


Figure 6. Surveyed longitudinal streambed profile.

Fish Passage Analysis

The first-phase evaluation indicated that the defunct dam is a severe barrier for adult steelhead and impassable to juvenile steelhead. To test this assumption, RCD performed an analysis using the *HEC-RAS version 4.1* software developed by the US Army Corps of Engineers Hydrologic Engineering Center (HEC) for one-dimensional steady and unsteady flow hydraulics calculations (http://www.hec.usace.army.mil/software/hec-ras).

Upper and lower fish passage flows were estimated from surrogate data in accordance with DFG protocols. RCD selected the former USGS streamgaging station on Redwood Creek as a surrogate because it is the nearest to Huichica Creek with at least 5 years of daily average flow data (15 years) and with a drainage area less than 50 square miles (9.79 square miles). Calculated fish passage flows were adjusted for Carneros Creek by multiplying them by the ratio of the two drainage areas. The calculated fish passage flows are presented in Table 2.

Species/Lifestage	Upper Passage Flow (cfs)		Lower Passage Flow (cfs)	
Adult steelhead	47.0	1% Exceedance Flow	3	Alternate Minimum Flow
Juvenile steelhead	4.9	10% Exceedance Flow	1	Alternate Minimum Flow

Table 2. Calculated Fish Passage Flows.

The HEC-RAS model was constructed using the four surveyed channel cross sections and the surveyed dimensions of the defunct dam. In addition, a copy of the cross section measured immediately downstream of the dam was modified and used 13 feet downstream at the tailwater control. Steady flow analyses were then run for each fish passage flow and jump height, jump pool depth, flow depth over the barrier, and average water velocity over the barrier were calculated. The results of the fish passage analysis are presented in Table 3.

Flow Description	Flow (cfs)	Jump Height (ft)	Jump Pool Depth (ft)	Depth (ft)	Avg Velocity (ft/s)
Juvenile lower passage flow	1	5.71	3.06	0.14	0.04
Adult lower passage flow	3	5.65	3.12	0.21	0.10
Juvenile upper passage flow	4.9	5.60	3.17	0.27	0.15
Adult upper passage flow	47	5.07	3.70	0.79	0.90
Flow that produces 0.8 ft depth at top of dam	49	5.05	3.72	0.80	0.93

Table 3. Fish Passage Analysis Results

RCD compared the fish passage analysis results to the swimming capabilities and minimum depth requirements for adult and juvenile steelhead from Table IX-6 of the DFG Manual. Maximum jump heights were obtained from NMFS Guidelines for Salmonid Passage at Stream Crossings (NMFS 2001). Based on comparison to these criteria, the defunct dam is a complete barrier to upstream passage of adult and juvenile steelhead due to excessive jump height and insufficient depth across the range of passage flows. The finding of the first-phase evaluation and the classification of the barrier as "red" in the DFG Green-Gray-Red system were confirmed by this analysis.

DISCUSSION

The results of hydraulic analyses of the defunct dam indicate that it is a complete barrier for adult and juvenile steelhead due to excessive jump height and insufficient depth. Given the natural variability in swimming capabilities of individual steelhead, an occasional adult fish may be able to pass the dam under ideal flow conditions; however, this appears to be very rare. No juvenile steelhead were observed upstream of the dam during either our 2007 habitat survey or 2010 field surveys.

The slope and substrate of the main fork of Huichica Creek are favorable for 1.45 miles above the defunct dam, but this reach of the stream is thought to go dry during the summer months in most years. Given the limited flow conditions upstream of the site, removal of the dam to increase access for spawning adults would likely not result in a significant increase in juvenile steelhead production. Any fish born in this upstream reach would need to migrate downstream to the perennial reach in order to survive the summer. Based on previous surveys, the perennial section of Huichica Creek appears to be well-seeded with juvenile steelhead, so additional fish may lead to excessive competition for limited space and food resources. Therefore, with the limited amount of upstream habitat, modifying this barrier is a low priority within the greater Napa River watershed.

The dam is no longer in use to impound water for domestic and agricultural use because accumulated sediment has reduced the reservoir capacity. The full extent of the sedimentation is not obvious on the surveyed longitudinal profile (Figure 6) because a narrow channel is present through the fill; however, if the dam were to be modified or removed trapped sediment could be expected to become mobile if left unaddressed. It was beyond the scope of this assessment to estimate the nature and quantity of the trapped sediment.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this analysis, the defunct dam on Huichica Creek is a complete barrier to movement of adult and juvenile steelhead trout. Upstream of the dam are 1.45 miles of habitat that are suitable for spawning but very limited in summer rearing value due to deficient flows.

Mitigation options include:

1) Do nothing and leave the dam in place

2) Notch the dam

3) Notch the dam and install a short series of one or two boulder weirs downstream to gradually step up the streambed elevation and backwater the dam's jump pool.

4) Remove the dam and trapped sediment entirely, and re-grade and re-vegetate both stream banks.

Although our analysis found this dam to be a complete barrier to steelhead, there is limited upstream habitat to be gained from its removal or modification. It should be evaluated whether the upstream habitat is of sufficient quality to justify the cost and effort of pursuing funds to implement an improvement project. Resource agency staff (NMFS and DFG) will need to make this determination based on management and recovery strategies for steelhead in the region. If it is not deemed to be a high enough priority by these agencies, then Option 1 is warranted.

The dam is an old structure with limited information about specific construction details. Given this lack of structural detail, it is impossible to know whether the dam could withstand modification via notching. Option 2 and 3 would require additional structural analysis that does not seem warranted for a low priority site such as this. Therefore, RCD does not recommend pursuing Options 2 or 3.

Since the dam is relatively small, modifying the structure to allow for fish passage would likely be similar in cost to removing it completely (Option 4). However, depending on the amount of sediment stored behind the dam, the cost of full removal may be significantly higher than notching the dam face. If the structure is fully removed, the trapped sediment behind the dam would also need to be removed and disposed of so as not to degrade downstream habitat quality. Therefore if the structure is to be modified, RCD recommends Option 4.

REFERENCES

California Department of Fish and Game (CDFG). 2010. Edition. California Salmonid Stream Habitat Restoration Manual. 4th Edition.

Koehler, J. C. Edwards. 2009. Southern Napa River Watershed Restoration Plan. Napa County Resource Conservation District. Prepared for California Department of Fish and Game, Fisheries Restoration Grant Program.

NMFS 2001. Guidelines for Salmonid Passage at Stream Crossings. National Marine Fisheries Service Southwest Region. Santa Rosa, California.

HIGHWAY 29 CULVERT AT MILL CREEK

FISH PASSAGE ASSESSMENT

Prepared for

California State Coastal Conservancy
Agreement No. 08-069

Prepared by

NAPA COUNTY
RCD
Resource
Conservation
District

June 2011

STREAM DESCRIPTION

Mill Creek is a tributary of the Napa River, which flows to the San Francisco Estuary. Its 2.21 square mile watershed contains 5.30 miles of blue-line stream, 1.06 miles of which is second order stream, according to the USGS Calistoga and St. Helena 7.5-minute quadrangle maps (Figure 1). Elevations range from 245 feet at the mouth of the creek to 2,125 feet at the ridgeline. Mixed hardwood forest dominates the watershed with significant areas of shrubland and vineyard. Approximately 41% of the watershed, including most of the stream channel, is publicly-owned California State Park (Bothe Napa Valley State Park). The remainder is under private ownership.

Mill Creek is an important Napa Valley steelhead (*Oncorhynchus mykiss*) stream, with perennial flow and abundant and high-quality steelhead spawning and rearing habitat. Eight barriers to upstream migration of steelhead have been identified, but only two of these are anthropogenic features. The barriers are listed in Table 1 and shown on Figures 1 and 5. There is one blue-line tributary that enters the mainstem just upstream of the Highway 29 culvert. It has not been surveyed, but it has a 0.45 square-mile watershed and is estimated to include up to 0.5 miles of additional habitat.

Fish-Passage Barrier	**Distance Upstream from Mouth (mi)**	**Max Upstream Habitat (mi)**	**Barrier Type**	**Status**
Hwy 29 culvert	**0.84**	**2.67**	**Temporal/Partial**	**Under assessment**
Concrete weir	1.33	1.68	Temporal	Minor structure - more significant downstream barrier
Boulder cascade	1.81	1.20	Partial	Natural feature
Boulder cascade	2.18	0.83	Partial (Severe)	Natural feature – may be end of anadromy in dry years
Slope >8%	2.37	0.64	Partial (Severe)	Natural feature
Boulder cascade	2.62	0.39	Partial	Natural feature
Boulder cascade	2.77	0.24	Partial	Natural feature
Falls	3.01	0	Complete	Natural feature - definite end of anadromy

Table 1. Mill Creek fish-passage barriers.

BARRIER DESCRIPTION

The Highway 29 culvert at Mill Creek is an old stone arch bridge, approximately 27 feet wide as measured along the stream centerline. The bridge has been extended approximately 7 feet in both the upstream and downstream directions with concrete box culverts creating a total stream crossing length of 41 feet (Figures 2 and 3). A concrete apron has been constructed along the streambed beneath the bridge that connects the bridge and extensions together and causes the stream crossing to look and function like a concrete arch culvert. The apron is not level, but slightly concave so low flows are concentrated along the centerline. The culvert is located 0.84

miles upstream of the Napa River. There are 2.16 square miles of watershed area above the culvert, including up to 2.7 miles of steelhead habitat.

The culvert was identified as a potential barrier to fish passage in 2006 during a site visit by the RCD. It was categorized as “gray” in the DFG Green-Gray-Red system because it is expected to be a temporal barrier (impassable at certain flows) for adult steelhead due to excessive leap at the outlet, and excessive velocity, as well as a partial barrier (impassable to juvenile steelhead at all flows).

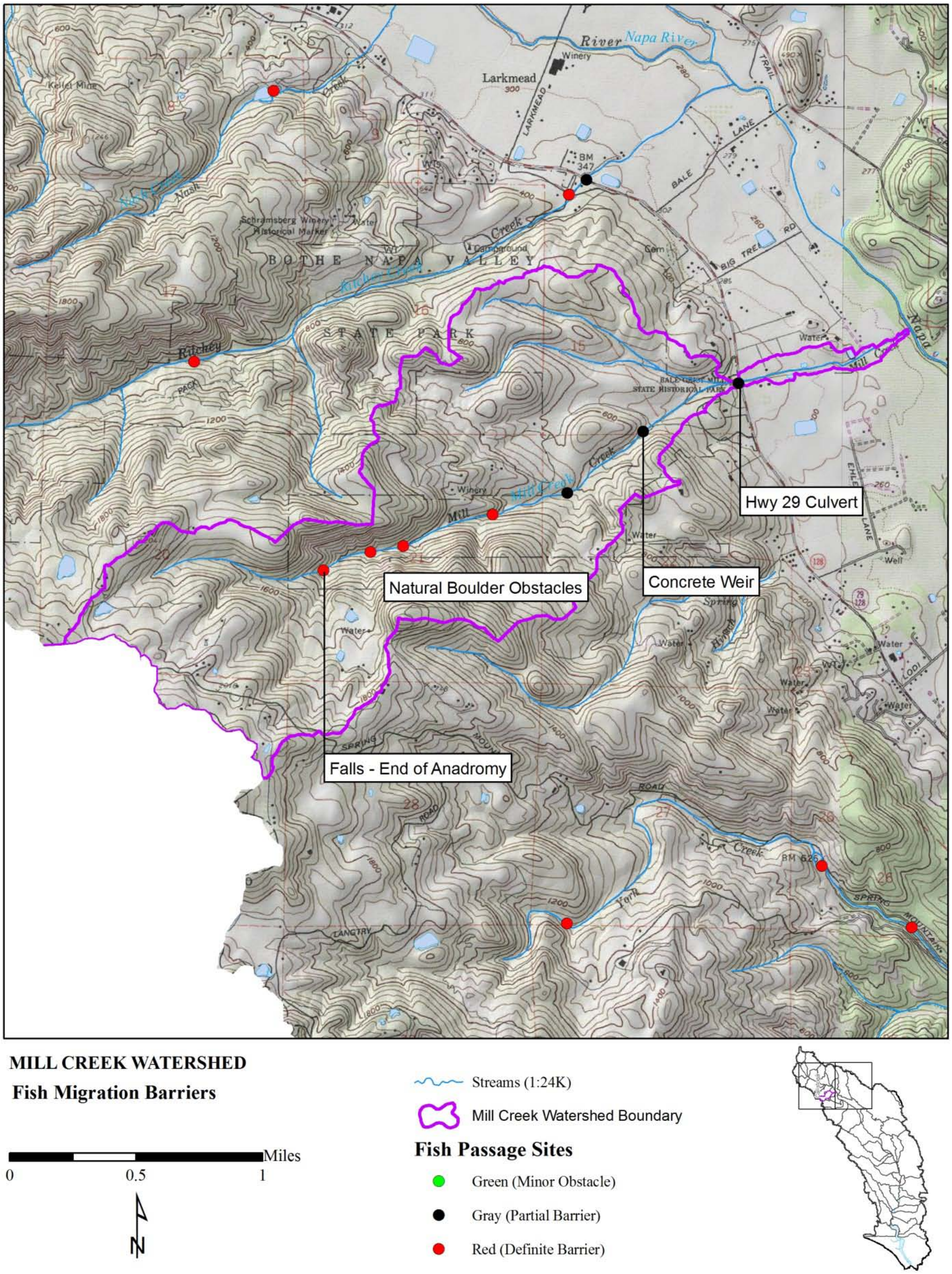


Figure 1. Mill Creek watershed and barrier locations.

Figure 2. View of upstream culvert face looking downstream.

Figure 3. View of downstream end of culvert looking upstream.

BARRIER ASSESSMENT

RCD evaluated fish-passage at the Highway 29 stream crossing in general accordance with *Part IX Fish Passage Evaluation at Stream Crossings* of the California Department of Fish and Game (DFG) Salmonid Stream Habitat Restoration Manual (DFG 2010). The assessment included a fish-passage inventory of the barrier site, an upstream habitat assessment, a peak flow estimate, a culvert capacity analysis, and a fish-passage analysis.

Fish-Passage Inventory

On September 22, 2009, Jonathan Koehler (RCD) and Paul Blank (RCD) conducted a fish-passage inventory of the stream crossing including:

- Measurement of culvert dimensions;
- Longitudinal profile survey;
- Channel cross section survey;
- Site sketch; and,
- Completion of the DFG fish passage inventory data sheet.

The longitudinal profile survey was completed with tape and level and was surveyed relative to an arbitrary datum. It began 77 feet upstream of the culvert and continued through the culvert for 152 feet until it ended at the downstream tailwater control. The survey captured the profile of the culvert, the upstream resting pool, the height of the fill prism, the tailwater configuration, and the overall slope of the reach (Figure 4). The channel cross section was also performed with tape and level and was located at the tailwater control.

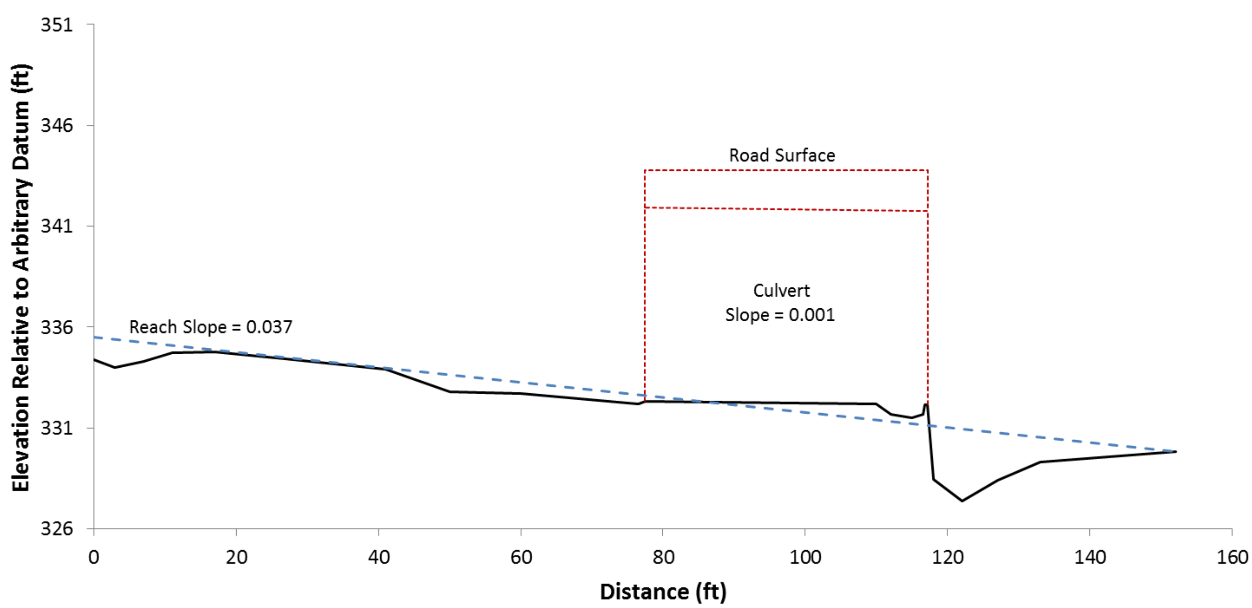


Figure 4. Surveyed longitudinal streambed profile.

Upstream Habitat Assessment

RCD estimated the amount of *O. mykiss* habitat located upstream of the barrier based on slope and existing survey reports. A topographic profile of the mainstem of Mill Creek generated from the LiDAR digital elevation model (DEM) showed a steady rise in slope that increases to over 8% at approximately 2.4 miles upstream of the Napa River, and up to 15% prior to reaching a sharp slope break, interpreted to be a falls or cascade, at 3.0 miles. There is one blue-line tributary to the mainstem of Mill Creek (Figure 1). It has a 0.45 square-mile watershed and has not been surveyed, but is estimated to provide up to 0.5 miles of additional habitat. RCD staff made a field visit on January 8, 2010, and observed one small weir and several natural obstructions to fish passage upstream of the barrier site that are likely only passable at certain flows. RCD also observed young-of-year *O. mykiss* as far as 1.9 miles upstream of the barrier site. Figure 4 depicts the longitudinal profile of the Mill Creek mainstem from the Napa River to the ridgeline, and notes the locations of the Highway 29 stream crossing and other obstacles to fish passage.

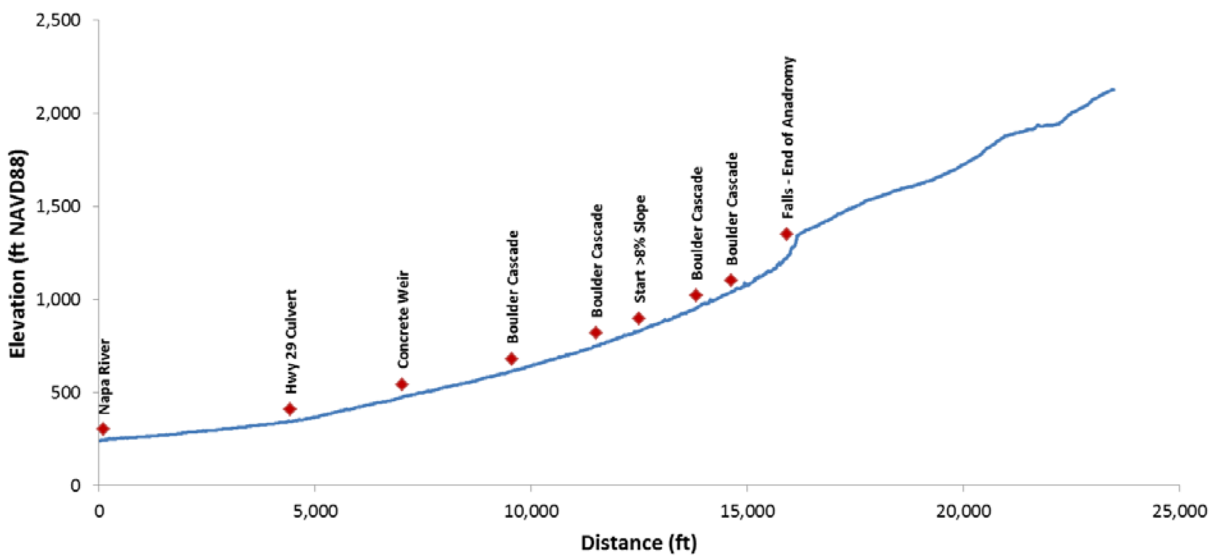


Figure 5. Mill Creek LiDAR-derived longitudinal streambed profile with barrier locations.

Peak Flow Estimate

The Mill Creek subwatershed is an ungaged basin. In order to evaluate culvert capacity it is necessary to estimate peak flows at the stream crossing. RCD calculated the 50% through the 1% annual exceedance probability flows (Q2, Q5, Q10, Q25, Q50, and Q100) in cubic feet per second (cfs) by adjusting the peak flow statistics for retired United States Geological Survey (USGS) Station 11455950 SULPHUR C NR ST HELENA CA located on Sulphur Creek approximately 4.0 miles south of the barrier site. Station 11455950 operated as a peak streamflow measurement station continuously for 18 years, from 1955 through 1973. The Q2 through Q100 calculated by USGS were obtained from water.usgs.gov/osw/streamstats. As suggested by USGS (USGS 1977), RCD adjusted the flow for the difference in drainage areas using the relation:

—

where Q_u and Q_g are the discharges at the ungaged and gaged sites, A_u and A_g are the drainage areas, and b is the exponent for the drainage area from the corresponding regional regression equation (USGS 1977). Peak flow estimates are listed in Table 2.

Flow Event	Annual Exceedance Probability	Return Interval (yrs)	Peak Streamflow (cfs)	
			USGS 11455950	Mill Creek at Hwy 29 Culvert
Q2	0.5	2	532	275
Q5	0.2	5	738	384
Q10	0.1	10	870	456
Q25	0.04	25	1,030	544
Q50	0.02	50	1,150	607
Q100	0.01	100	1,260	665

Table 2. Peak streamflow estimates derived from USGS flow frequency analysis at former station 11455950, located approximately 4 miles south.

Culvert Flow Capacity

RCD performed an analysis of the culvert using the HY-8 software developed by the Federal Highways Administration (FHWA). Culvert data, site data, tailwater data, and roadway data were collected in the field during the fish-passage inventory. Tailwater channel slope and roadway elevation were measured in GIS from the LiDAR DEM. RCD analyzed the culvert's performance under the Q10 and Q100 flows for Mill Creek (Table 1). In addition, RCD calculated the flow capacity at the top of the culvert inlet (headwater-to-diameter ratio equal to one) and the flow that overtops the roadway. The results are presented in Table 3.

Since the shape of the stream crossing varies along its length, RCD modeled the culvert as if the arch section, the most-constricted section, extended the full length of the barrier.

Event	Streamflow (cfs)	Headwater Elevation Relative to Arbitrary Datum (ft)
Q10	456	337.55
Q100	665	339.15
Top of culvert inlet	1,070	341.92
Top of roadway	1,286	343.77

Table 3. Culvert flow capacity analysis results.

Fish Passage Analysis

The first-phase evaluation indicated that the stream crossing is a temporal barrier for adult steelhead, as well as a partial barrier, impassable to juvenile steelhead. To test this conclusion, RCD performed an analysis using *FishXing v3,* a program intended to assist engineers, hydrologists, and fish biologists in the evaluation and design of culverts for fish passage (http://www.stream.fs.fed.us/fishxing).

Upper and lower fish passage flows were estimated from surrogate data in accordance with DFG protocols. Since there is no nearby gaged subbasin that is similar in size to Mill Creek, RCD calculated upper and lower fish passage flows for 3 sites around the Valley and compared the results. RCD selected Redwood Creek (9.8 square miles), Dry Creek (17.4 square miles), and the Napa River at Calistoga (21.9 square miles). Each of these is a former USGS streamgaging station with at least 5 years of daily average flow data. Calculated fish passage flows were adjusted for Mill Creek by multiplying them by the ratio of the two drainage areas. The results were comparable with the 1% exceedance flow ranging from 39 to 59 cubic feet per second (cfs), and the 10% exceedance flow ranging from 4.6 to 6.2 cfs. RCD selected the lowest flows for the analysis as presented in Table 4.

Species/Lifestage	**Upper Passage Flow (cfs)**		**Lower Passage Flow (cfs)**	
Adult steelhead	39	1% Exceedance Flow	3	Alternate Minimum Flow
Juvenile steelhead	4.6	10% Exceedance Flow	1	Alternate Minimum Flow

Table 4. Calculated fish passage flows.

The *FishXing* model was constructed using data collected during the fish-passage inventory. Swimming capabilities and minimum depth requirements for adult and juvenile steelhead were based on Table IX-6 of the DFG Manual. The results of the *FishXing* analysis are presented in Table 5.

	Adult Steelhead	**Juvenile Steelhead (>6")**	**Juvenile Steelhead (<6")**
Percent of Flows Passable	0.0%	0.0%	0.0%
Passable Flow Range	None	None	None
Depth Barrier	All Flows	All Flows	All Flows
Leap Barriers	All Flows	All Flows	All Flows
Velocity Barrier	19.80 cfs and above	None	3.13 cfs to 4.60 cfs
Pool Depth Barrier	None	None	None

Table 5. Results of *FishXing* analysis.

DISCUSSION

Of the available methods for estimating peak streamflows at an ungaged site, RCD chose to use retired USGS Station 11455950 as a surrogate for the Highway 29 culvert at Mill Creek. RCD considers this method to be the most accurate for this site since the two watersheds are similar in size and land cover and in proximity to each other. It should be noted that the potential for significant error in the results exists due to the short (18-year) data record from Station 11455950 and variations in watershed characteristics between the barrier site and the surrogate site.

Due to the complex shape of this particular stream crossing, RCD modeled the culvert in HY-8 as if the arch section extended the full length of the barrier. This may cause the results to vary from actual conditions because inlet geometry is an important element of culvert capacity, and our analysis revealed this culvert to be inlet-controlled at all flows. However, since the actual geometry roughly serves to reduce the flow contraction compared to the model, the complexity can be expected to improve culvert performance. The model, therefore, likely underestimates capacity and provides a conservative result.

Comparison of the peak flow estimates to the culvert flow capacity analysis results indicates that the Highway 29 culvert at Mill Creek will safely convey the Q100 flow event with room to spare. California Department of Transportation guidelines indicate that culverts should convey the Q10 "…without causing headwater elevation to rise above the inlet top of culvert," and the Q100 "…without damage to the facility or adjacent property" (Caltrans 2006). DFG states that "crossing structures should typically be designed to accommodate the 100-year flood event" (DFG 2009). Based on these guidelines, the culvert is oversized and may be able to accommodate installation of internal or external energy dissipation structures or backwatering, and is a candidate for a retrofit project.

As with the HY-8 analysis, RCD simplified the geometry of the stream crossing for the fish passage analysis. The shape of the culvert varies along its length, a configuration that cannot be reproduced in *FishXing*. Therefore, the barrier was modeled as if the arch culvert section extended the full length of the barrier. Since the fish passage analysis examines low flows, this simplification should not have a significant effect on the results. The apron that forms the bottom of the culvert is slightly concave, which also cannot be modeled in *FishXing*, which assumed a flat bottom. The curvature has the effect of increasing water depths in the culvert, so the model likely underestimates this depth. RCD does not believe this effect is large enough to meaningfully affect the results of the analysis.

The results of fish-passage analysis indicate that the culvert does not meet current fish passage requirements, and is not passable by steelhead at any life stage under any flow conditions. The analysis was based on conservative swimming capabilities and minimum depth requirements from the DFG guidelines. The analysis uses average velocities to determine passage, which may not account for hydraulic variation that may facilitate passage under specific flows. Given these assumptions, the barrier is likely passable by some unknown fraction of the steelhead population with stronger swimming capabilities at certain flows. However, DFG and NOAA Fisheries guidelines are designed to allow passage of all fish in the population, not just the strongest swimmers. Based on the results of this analysis, RCD re-categorized the stream crossing as a complete barrier, "red" in the DFG Green-Gray-Red system.

The main obstacle for fish passage is the excessive leap height at the culvert outlet. In addition, insufficient water depth in the culvert during low flows, and excessive velocity at higher flows are also barriers to fish passage.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this analysis, the Highway 29 stream crossing at Mill Creek is a candidate for a retrofit project that will improve passage conditions for upstream migration of steelhead, and open up to 2.7 miles of high quality steelhead habitat.

Mitigation options include:

1) Cut a fishway channel into the existing concrete apron that extends upstream through the culvert

2) Install concrete berm-type baffles on the existing apron to increase water depth and reduce velocities

3) Replace the concrete floor of the culvert with a series of rock weirs

4) Install a series of rock weirs in the downstream channel to backwater the culvert

Options 1and 3 would involve modifying the existing concrete apron in order to lower the grade and reduce or eliminate the outlet jump height. A structural/geotechnical analysis of the culvert would be required to assess whether removal of the concrete floor is viable. The exact configuration and dimensions of such modifications would need to be developed in collaboration with Caltrans to ensure highway safety standards are maintained.

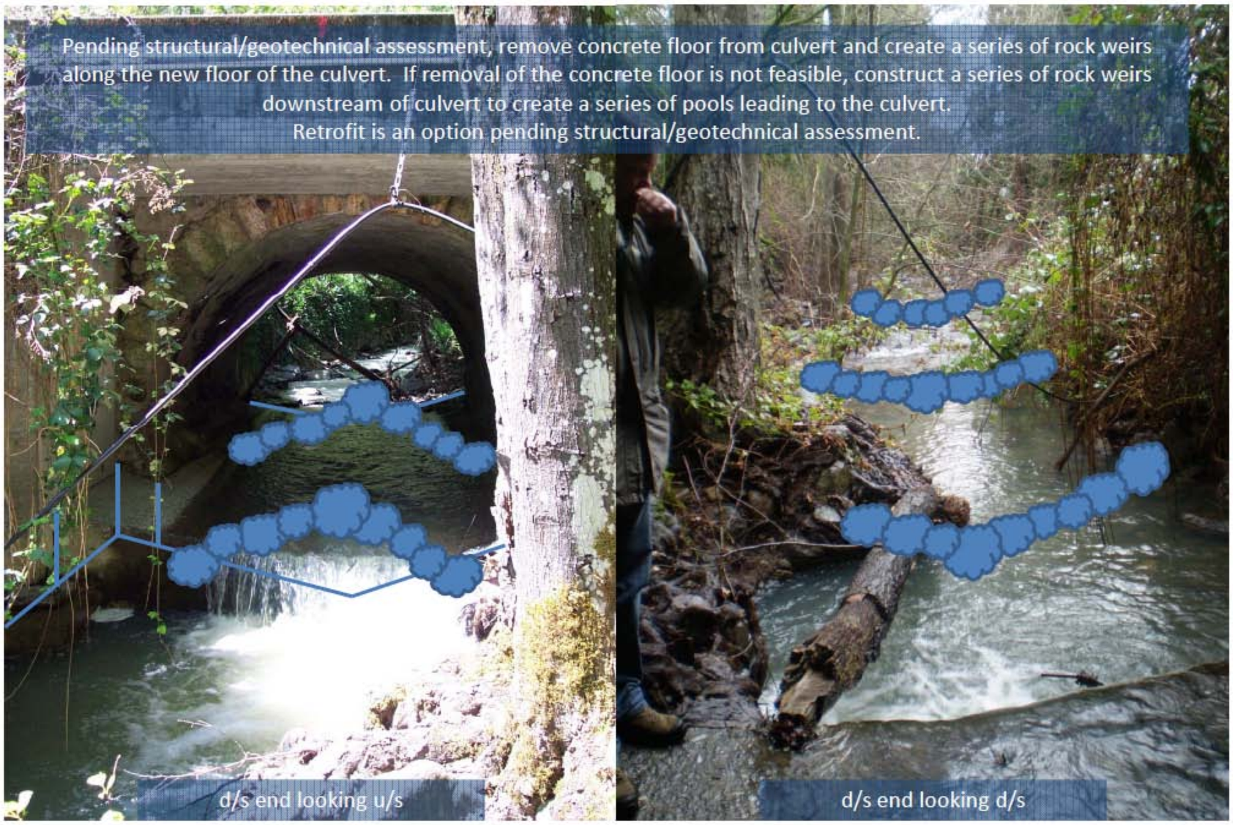
Option 2 would likely be the least expensive approach to reducing velocities and increasing depths through the culvert. However, it would need to be done in conjunction with Option 4 to address the jump height and velocity barrier leading into the culvert.

Options 3 and 4 reduce the outlet jump by restoring the channel's natural slope beneath the roadway. In conjunction, these two options would decrease water velocities and increases water depths by increasing roughness and complexity of the streambed. The rock weirs may be able to provide scour protection for the structure as well.

Implementing Option 4 alone may enable fish passage by converting the one large jump into several smaller jumps downstream, while backwatering the culvert to reduce velocities and increase depths. Since the site is located on a State highway, Caltrans will need to make the final determination on which of the above options meet their structural engineering and safety criteria.

CONCEPTUAL DESIGN

Options 3 and 4:



Drawings by Carolyn M. Jones, PE, Natural Resource Conservation Service

REFERENCES

State of California Department of Fish and Game. April 2003. *Salmonid Stream Habitat Restoration Manual Part IX – Fish Passage Evaluation at Stream Crossings*.

Waananen, A.O., and J.R. Crippen. June 1977. *Magnitude and Frequency of Floods in California*. United States Geological Survey Water-Resources Investigations 77-21.

State of California Department of Transportation. January 2006. *Local Assistance Procedures Manual Chapter 11 Design Standards*.

State of California Department of Fish and Game. April 2009. *Salmonid Stream Habitat Restoration Manual Part XII – Fish Passage Design and Implementation*.

MURPHY CREEK CONCRETE WEIRS

FISH PASSAGE ASSESSMENT

Prepared for

California State Coastal Conservancy
Agreement No. 08-069

Prepared by

NAPA COUNTY RCD Resource Conservation District

June 2011

STREAM DESCRIPTION

Murphy Creek is a tributary to Tulucay Creek, which is a tributary of the Napa River, and ultimately the San Francisco Estuary. Murphy Creek is a second order stream and has approximately 4.3 miles of blue line stream according to the USGS Mt. George 7.5 minute quadrangle. The creek drains a watershed area of approximately 1.18 square miles, with elevations ranging from about 100 feet above sea level at the mouth of the creek to 1,800 feet in the headwater areas. Mixed hardwood forest dominates the Murphy Creek watershed with areas of vineyard development occurring primarily in the lower reaches. Rural residential properties line the creek for most of its course, and the watershed is entirely privately owned. Vehicle access exists via Coombsville Road and Shady Brook Lane.

Steelhead (*Oncorhynchus mykiss*) are present in Murphy Creek and the slope and substrate of the streambed are favorable for approximately 1.7 miles, at which point the slope of the streambed significantly increases. Murphy creek maintains perennial flow, and as a result, supports favorable steelhead rearing areas throughout much of its length.

A total of ten barriers to upstream migration of steelhead have been identified on Murphy Creek (Koehler and Edwards 2009). The barriers are listed in Table 1 and shown on Figures 1 and 5.

Fish-Passage Barrier	Distance Upstream from Mouth (mi)	Max Upstream Habitat (mi)	Barrier Description	Barrier Type	Status
MUR-1	0.92	0.78	Bedrock outcrop	Partial (Minor)	Natural
MUR-2	**0.94**	**0.76**	**Two concrete weirs**	**Partial (Severe)**	**Under assessment**
MUR-3	**1.06**	**0.64**	**Single concrete weir**	**Partial (Severe)**	**Under assessment**
MUR-4	1.3	0.40	Boulder cascade	Partial (Minor)	Natural feature
MUR-5	1.35	0.35	Box culvert	Partial (Minor)	Low flow obstacle
MUR-6	1.41	0.29	Driveway crossing culvert	Partial (Moderate)	Low flow obstacle
MUR-7	1.46	0.24	Concrete channel	Partial (Minor)	Low flow obstacle
MUR-8	1.50	0.20	Concrete weir	Partial (Severe)	Built atop natural bedrock outcrop – may be end of anadromy in dry years
MUR-9	1.58	0.12	Concrete weir	Partial (Minor)	Low flow obstacle
MUR-10	1.70	0	Falls	Complete	Natural feature – end of anadromy

Table 1. Murphy Creek fish-passage barriers.

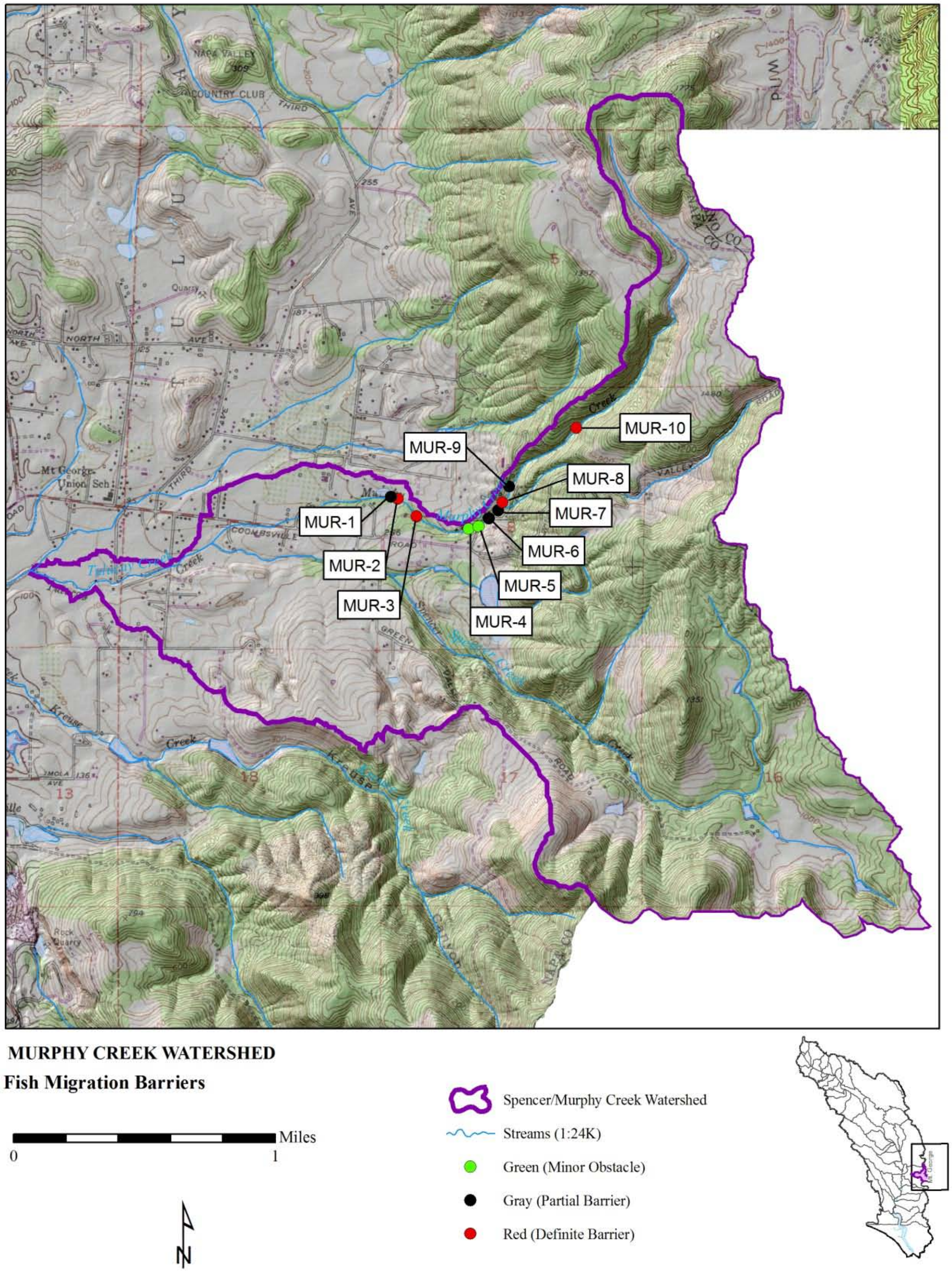


Figure 1. Murphy Creek watershed and barrier locations.

BARRIER DESCRIPTION

Short concrete weirs have historically been built in Murphy Creek to impound water and create pools for water diversion and recreation. While no longer in use for their original purpose, these structures remain in place and present major obstacles to fish passage. Three such structures have been identified within 585 feet of each other, including two weirs at site MUR-2 and a single weir at site MUR-3 (Figures 2 and 3).

At site MUR-2, the downstream weir is 1.0 foot tall and 0.7 foot thick. The upper weir, located 12.3 feet upstream, is 2.2 feet tall and 0.7 feet thick. Both weirs are constructed of poured concrete and both are approximately horizontally level. There are shallow, wide notches in the center of each structure that direct lower flows into the center of the channel. The channel upstream of the weirs is filled in with sediment for up to 50 feet and the channel returns to its undisturbed grade upstream of that point. According to one adjacent landowner, the weirs are not currently being used for any known purpose.

At site MUR-3, a single concrete weir approximately 2.4 feet tall and 3.0 feet thick spans the low-flow channel. The structure is made from poured concrete and contains old non-functional metal piping embedded within it (Figure 4). The channel upstream is filled in with sediment for approximately 35 feet before returning to its natural grade.

All three weirs were identified as barriers to fish passage in September 2007 as part of a Murphy Creek stream inventory conducted by Napa County RCD (Koehler and Edwards 2009). They were categorized as “red” in the DFG Green-Gray-Red system because they are expected to be severe (possibly complete) barriers to both adult and juvenile steelhead due to excessive jump height and insufficient jump pool depth.

Figure 2. View of the two weirs at site MUR-2 during typical late winter flow conditions (March 10, 2010).

Figure 3. Looking upstream at the weir at site MUR-3 under typical winter low flow conditions.

Figure 4. Closer view of the concrete weir at site MUR-3.

BARRIER ASSESSMENT

RCD evaluated fish-passage at the concrete weirs in general accordance with *Part IX Fish Passage Evaluation at Stream Crossings* of the California Department of Fish and Game (DFG) Salmonid Stream Habitat Restoration Manual (DFG 2010). The assessment included a fish-passage inventory of the barrier site and a fish-passage analysis.

Limit-of-Anadromy Analysis

RCD evaluated the amount of *O.mykiss* habitat located upstream of the barrier based on slope and existing survey reports. A topographic profile of Murphy Creek was generated from the LiDAR digital elevation model (DEM) to graphically depict known barriers along the length of the stream (Figure 5).

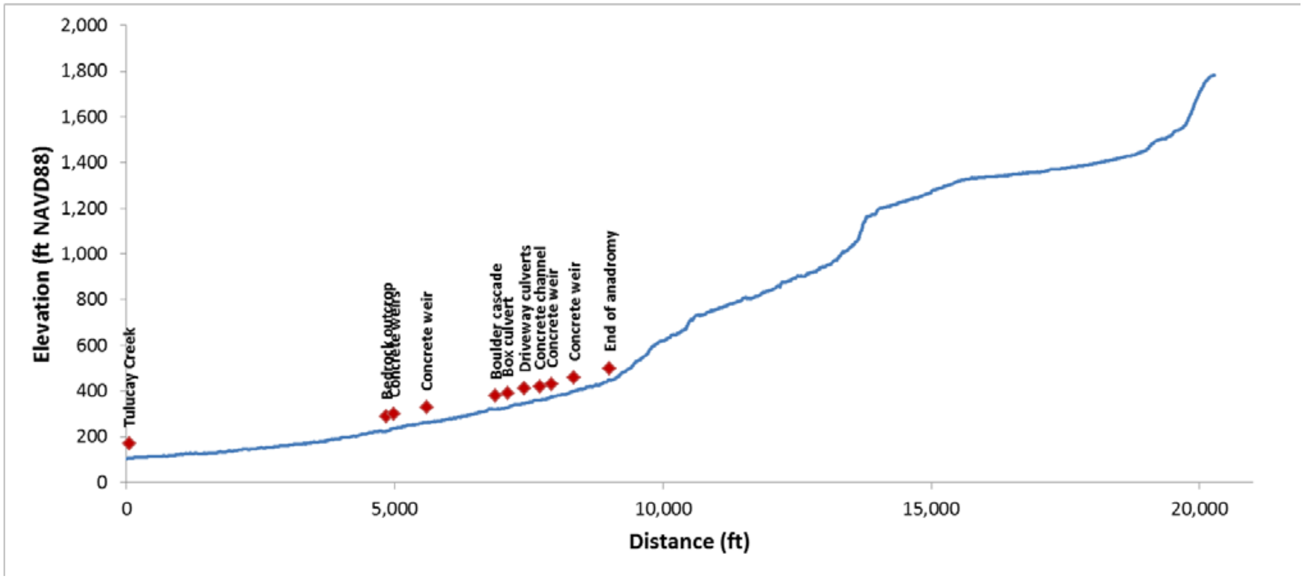


Figure 5. Murphy Creek LiDAR-derived longitudinal streambed profile with barrier locations.

Fish-Passage Inventory

On August 27, 2010, January 28, 2011, and March 10, 2011, Jonathan Koehler (RCD) and Paul Blank (RCD) conducted a fish-passage inventory of the concrete weirs including:

- Measurement of structure dimensions;
- Longitudinal profile survey; and
- Completion of the DFG fish passage inventory data sheet.

The longitudinal profile survey was completed with tape and level and was surveyed relative to an arbitrary datum. It began 300 feet upstream of MUR-3 and continued for 1,064 feet in the downstream direction to approximately 176 feet downstream MUR-2. The survey captured the profiles of the weirs, the upstream resting pools, the downstream channel, and the overall slope of the reach (Figure 6). Channel cross sections were not surveyed.

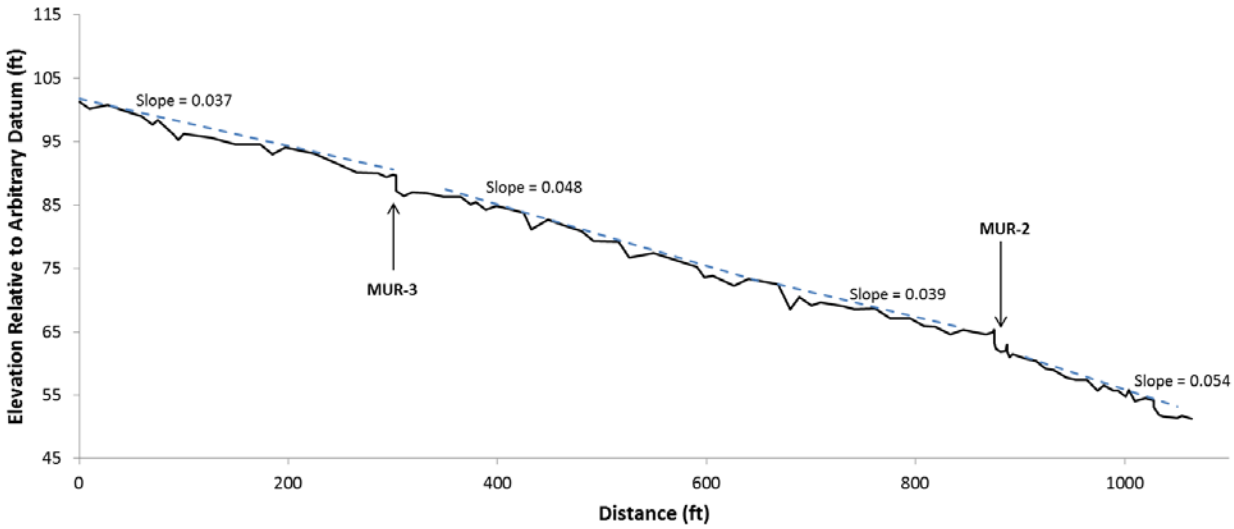


Figure 6. Surveyed longitudinal streambed profile.

Fish Passage Analysis

The first-phase evaluation indicated that the concrete weirs are severe barriers for adult steelhead and impassable to juvenile steelhead. To test this assumption, RCD considered developing a hydraulic model (i.e. HEC-RAS) for each site. However, given the relatively small size of Murphy Creek and the simple construction details of the weirs, we determined such an approach was not justified. Additionally, we do not believe such a modeling effort would provide significantly more detail about the severity of fish passage than we could ascertain through professional judgment.

DISCUSSION

Due to their small size and configuration, these weirs were not hydraulically assessed with modeling software (FishXing or HEC-RAS). However, based on field observations and measurements, the existing structures are clearly impediments to migrating steelhead under a wide range of flows. RCD staff visited this site with John Klochak, a USFWS biologist with extensive experience in fish passage assessment, who agreed that the structures represent a significant impediment to fish passage. Additional hydraulic modeling might provide more specific information on the severity of the impediments; however given the high cost of developing such models and the relatively small size and simplicity of these structures, such efforts are unwarranted.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this assessment, the concrete weirs on Murphy Creek are severe barriers to movement of adult and juvenile steelhead trout. Upstream of the weirs are 0.76 miles of habitat that are suitable for steelhead spawning and rearing.

Mitigation options include:

1) Notch the center of each weir to the elevation of the streambed in order to create a passage lane through each structure

2) Notch the weirs partially and install a series of boulder weirs downstream of each concrete weir to gradually step up the streambed elevation to the elevation of the existing structure

3) Remove the weirs and trapped sediment entirely, and re-grade and re-vegetate adjacent stream banks

The weirs are old structures with limited information about specific construction details. Given this lack of structural detail, it is impossible to know whether they could withstand modification via notching. Therefore, Options 1 and 2 would require additional structural analysis that does not seem warranted for such simple features. Additionally, since the weirs are relatively small, modifying the structures to allow for fish passage would likely be similar in cost to removing them completely (Option 3).

If the structures are fully removed, the trapped sediment behind them will also need to be removed and disposed of so as not to degrade downstream habitat quality. Removal of this sediment would add some additional cost, but we do not believe it would be prohibitively expensive. Therefore, RCD recommends Option 3.

REFERENCES

California Department of Fish and Game (CDFG). 2010. Edition. California Salmonid Stream Habitat Restoration Manual. 4th Edition.

Koehler, J. C. Edwards. 2009. Southern Napa River Watershed Restoration Plan. Napa County Resource Conservation District. Prepared for California Department of Fish and Game, Fisheries Restoration Grant Program.

NMFS 2001. Guidelines for Salmonid Passage at Stream Crossings. National Marine Fisheries Service Southwest Region. Santa Rosa, California.

CALISTOGA FOOT PATH ON NAPA RIVER

FISH PASSAGE ASSESSMENT

Prepared for

California State Coastal Conservancy
Agreement No. 08-069

Prepared by

NAPA COUNTY
RCD
Resource
Conservation
District

June 2011

STREAM DESCRIPTION

The Napa River is a direct tributary to the San Francisco Estuary. It drains 48 major tributaries and numerous smaller un-named streams on its 55-mile path from the headwaters of Mt. St. Helena near Calistoga to the San Pablo Bay. Along this route the river winds through vineyards, urban areas, grasslands and ultimately brackish marshes. There are seven named tributary streams above Calistoga including Cyrus, Blossom, Kimball, Jericho, Garnett, Hoisting Works, and Horns Creek (Figure 1).

The upper reaches of the Napa River near Calistoga offer abundant and relatively high-quality spawning and rearing habitat for steelhead (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*). The seven named tributaries also support steelhead spawning to differing degrees; however Chinook are not believed to utilize these smaller streams regularly. In addition to steelhead and Chinook, the Napa River also supports an assemblage of 13 other native fish species including two that are migratory: Pacific lamprey (*Lampetra tridentata*) and River lamprey (*Lampetra ayresi*). There are approximately 14.8 stream miles of habitat located upstream of the concrete foot path (Figures 1 and 2).

BARRIER DESCRIPTION

The concrete foot path is a public pedestrian crossing located in the Napa River at the Calistoga Community Center. The crossing is open to foot traffic during most of the year, and is accessible via staircases on either bank. There is a removable handrail on the downstream side, which is installed by City of Calistoga staff during the low flow season and removed during the winter (Figure 3). The foot path is 18.5 feet wide and 2.8 feet high. The footpath in the channel contains fifteen (15) bores through the concrete, each 1.1 feet in diameter, to convey low flows (Figure 4).

The concrete crossing was identified as a potential barrier to fish passage in 2006 during a site visit by Jonathan Koehler (RCD). It was categorized as “gray” in the DFG Green-Gray-Red system because it is expected to be a partial barrier for adult and juvenile steelhead and salmon due to excessive leap at the downstream side and excessive velocities through the series of culverts at moderate flows.

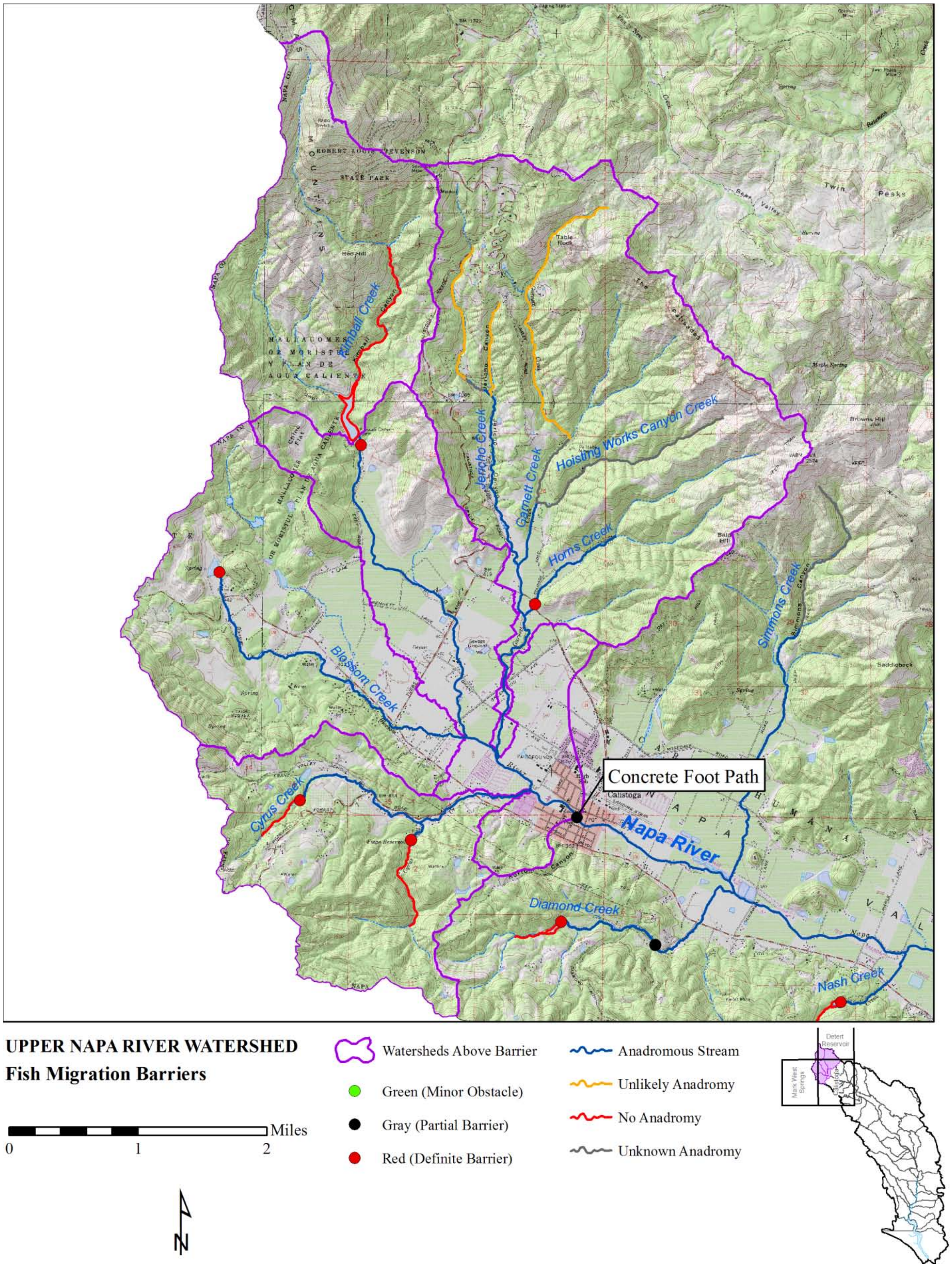


Figure 1. Upper Napa River watershed and barrier location.

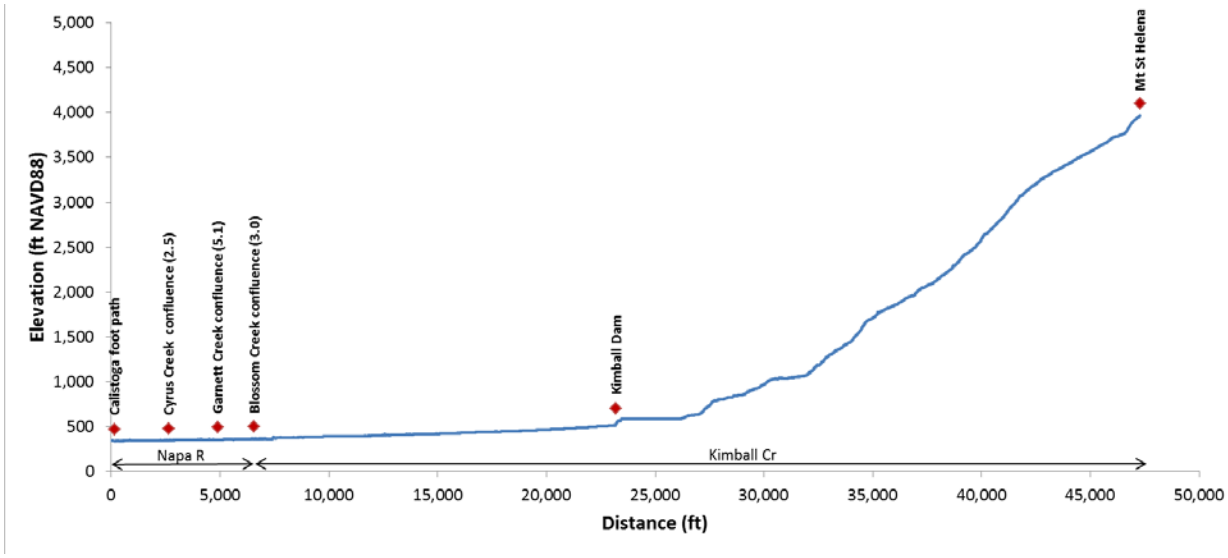


Figure 2. Napa River/Kimball Creek LiDAR-derived longitudinal streambed profile with tributary confluences and end of Kimball Creek anadromy. Estimated habitat amounts for tributaries, in stream miles, are shown in parentheses.

Figure 3. View of foot path from the west bank looking east. Note: seasonal railing is installed on downstream side.

Figure 4. Closer look at upstream side of foot path under near zero-flow conditions.

BARRIER ASSESSMENT

RCD evaluated fish-passage at the concrete ford in general accordance with *Part IX Fish Passage Evaluation at Stream Crossings* of the California Department of Fish and Game (DFG) Salmonid Stream Habitat Restoration Manual (DFG 2010). The assessment included a fish-passage inventory of the barrier site, a culvert capacity analysis, and a fish-passage analysis.

Fish-Passage Inventory

On September 22, 2009, Jonathan Koehler (RCD) and Paul Blank (RCD) conducted a fish-passage inventory of the stream crossing including:

- Measurement of structure dimensions;
- Longitudinal profile survey; and,
- Channel cross section survey.

The longitudinal profile survey was completed with tape and level and was surveyed relative to an arbitrary datum. It began 133 feet upstream of the foot path and continued for 300 feet in the downstream direction to approximately 147 feet downstream of the crossing. The survey captured the profile of the crossing, the upstream resting pool, and the tailwater configuration (Figure 5). Two full-channel cross sections were surveyed: one immediately upstream of the crossing and one immediately downstream of the crossing.

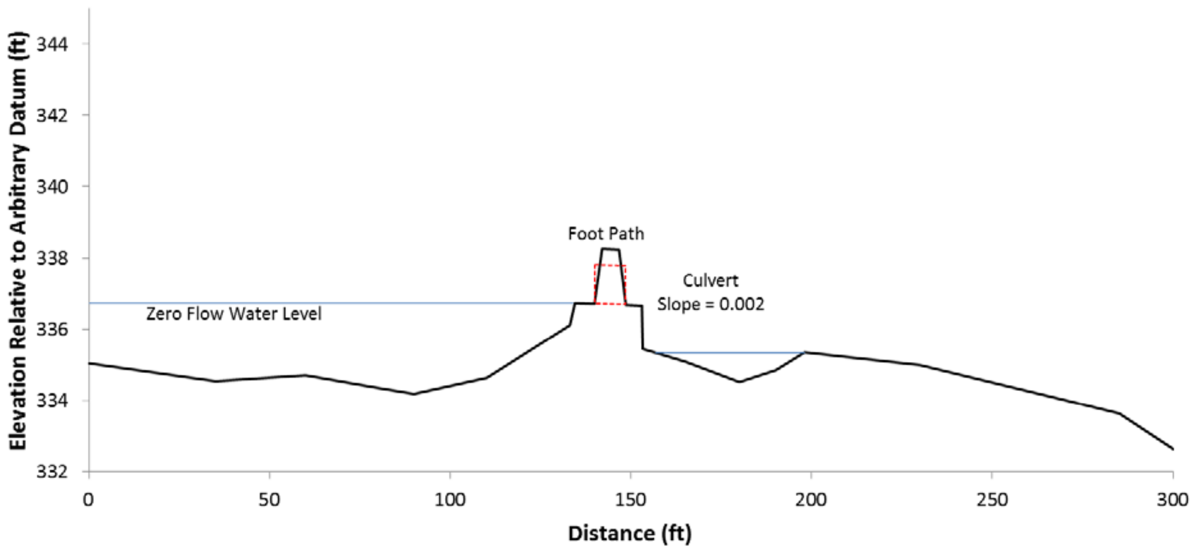


Figure 5. Surveyed longitudinal streambed profile.

Culvert Capacity Analysis

RCD performed an analysis of the concrete foot path using the *HY-8 version 7.2* software developed by the Federal Highways Administration (FHWA). Culvert data, site data, tailwater data, and roadway data were collected in the field during the fish-passage inventory. Tailwater channel slope was measured in GIS from the LiDAR DEM. RCD calculated the flow that overwhelms the culverts and overtops the foot path to be 64 cubic feet per second (cfs).

Fish Passage Analysis

The first-phase evaluation indicated that the concrete foot path is a partial barrier for all life stages of salmonids. To test this assumption, RCD performed an analysis using the HY-8 model developed for the culvert capacity analysis.

Upper and lower fish passage flows were calculated from the data record for retired USGS Station 11455900 NAPA R AT CALISTOGA CA, which is located 1,150 feet downstream of the barrier site. Since there is only a 2% difference between the drainage areas of these two locations, the data for Station 11455900 were used without adjustment. Station 11455900 was operated continuously from 1975 to 1983. The calculated fish passage flows are presented in Table 1.

Species/Lifestage	Upper Passage Flow (cfs)		Lower Passage Flow (cfs)	
Adult salmonids	599	1% Exceedance Flow	3	Alternate Minimum Flow
Juvenile salmonids	63	10% Exceedance Flow	1	Alternate Minimum Flow

Table 1. Calculated Fish Passage Flows.

RCD used the HY-8 model to compute jump height, jump pool depth, water depth in the culvert outlet, and outlet water velocity. The results of the fish passage analysis are presented in Table 2.

Flow Description	Flow (cfs)	Jump Height (ft)	Jump Pool Depth (ft)	Outlet Depth (ft)	Outlet Velocity (ft/s)
Juvenile lower passage flow	1	1.25	0.92	0.10	1.51
Adult lower passage flow	3	1.16	1.01	0.18	2.00
Juvenile upper passage flow	63	0.40	1.77	0.86	5.30
Adult upper passage flow	599	NA	NA	NA	NA

Table 2. Fish Passage Analysis Results

RCD compared the fish passage analysis results to the swimming capabilities and minimum depth requirements for adult and juvenile salmonids from Table IX-6 of the DFG Manual. Maximum jump heights were obtained from NMFS Guidelines for Salmonid Passage at Stream Crossings (NMFS 2001). Based on comparison to these criteria, the concrete foot path is a partial barrier to upstream passage of adult salmonids due to excessive leap and insufficient culvert depth at lower flows. The foot path is also a partial barrier for juvenile salmonids due to excessive leap and insufficient culvert depth at lower flows and excessive velocity at the upper end of the passage flow range. The finding of the first-phase evaluation and the classification of the barrier as “gray” in the DFG Green-Gray-Red system were confirmed by this analysis.

DISCUSSION

The fish-passage analysis indicates that jump heights, jump pool depths, and culvert outlet depths do not meet requirements for any species or life stage of salmonids during low flows. At the upper end of the juvenile passage flow range, jump heights, jump pool depths, and culvert depths become more favorable, but outlet water velocities increase to above passable levels for some juveniles.

The culvert capacity analysis indicates that the foot path will be overtopped at approximately 64 cfs. As flow increases, a hydraulic jump will form over the foot path that may impact fish passage. At some point, the foot path will be drowned out and fish may able to swim over the barrier, but it is unknown whether this happens before the adult upper passage flow of 599 cfs. It was beyond the scope of this assessment to evaluate hydraulics above the top of the foot path.

RCD expects that there are passable ranges of flows on both the rising and recession limbs of the hydrograph that allow passage of adult and juvenile salmonids, but the concrete foot path limits fish access to upstream spawning and rearing habitat. The foot path may also limit downstream movement of juveniles during summer and fall low flows.

CONCLUSIONS AND RECOMMENDATIONS

The results of this fish passage assessment indicate that the Calistoga foot path in the Napa River is a partial barrier for all life stages of salmonids that is limiting fish access to approximately 14.8 stream miles of relatively high quality habitat. Due to the amount and quality of upstream habitat, RCD recommends mitigation of the barrier.

Mitigation options include:

1) Complete removal of the concrete foot path.

2) Complete removal of the concrete foot path and installation of a pedestrian bridge that spans the full channel.

3) Removal of the center section of the concrete foot path to create a passable lane for fish. Bridge this gap with steel plate or grate for pedestrians.

While Option 1 addresses fish-passage issues, it does not provide a pedestrian crossing. The foot path is well used and appreciated by the community. Its absence would require a 1,000-foot walk to the Lincoln Avenue bridge downstream. RCD does not expect Option 1 to be acceptable by the City of Calistoga, and therefore, it is not recommended.

Option 2 addresses both fish-passage and pedestrian issues, but may be prohibitively expensive. The costs associated with Option 2 should be evaluated in comparison to the ongoing costs to fish and wildlife and maintenance costs associated with the concrete foot path. It should be noted that Option 2 would eliminate the stairs and make the crossing more accessible for the disabled.

Option 3 also addresses both fish-passage and pedestrian issues for what RCD expects to be a much lower cost; however, it is unknown whether this change to the design of the concrete foot path will affect its structural integrity. This option would require a structural assessment to be performed.

RCD recommends pursuit of Option 2 if a cost benefit analysis proves favorable. If not, Option 3 should be pursued.

CONCEPTUAL DESIGNS

Options 2 and 3:

Drawings by Carolyn M. Jones, PE, Natural Resource Conservation Service

REFERENCES

Koehler, J. C. Edwards. 2009. Southern Napa River Watershed Restoration Plan. Napa County Resource Conservation District. Prepared for California Department of Fish and Game, Fisheries Restoration Grant Program.

NMFS 2001. Guidelines for Salmonid Passage at Stream Crossings. National Marine Fisheries Service Southwest Region. Santa Rosa, California.

State of California Department of Fish and Game. April 2003. *Salmonid Stream Habitat Restoration Manual Part IX – Fish Passage Evaluation at Stream Crossings*.

PICKLE CANYON CREEK CONCRETE FORD

FISH PASSAGE ASSESSMENT

Prepared for

California State Coastal Conservancy
Agreement No. 08-069

Prepared by

NAPA COUNTY RCD Resource Conservation District

June 2011

STREAM DESCRIPTION

Pickle Canyon Creek is a tributary of Redwood Creek, which flows into Napa Creek, then into the Napa River, and ultimately into the San Francisco Estuary. Its 2.81 square mile watershed contains 7.29 miles of blue-line stream, 3.84 miles of which is second order stream, according to the USGS Sonoma and Napa 7.5-minute quadrangle maps (Figure 1). Elevations range from 355 feet at the mouth of the creek to 1,900 feet at the ridgeline (Figure 2). Mixed hardwood forest dominates the watershed with significant areas of vineyard and minor areas of shrubland and grassland. The watershed is entirely under private ownership.

Pickle Canyon Creek offers abundant and high-quality spawning and rearing habitat for steelhead (*Oncorhynchus mykiss*). Though some reaches are intermittent during the summer months, many reaches have perennial flow in most years. There are five blue-line tributaries to the mainstem of Pickle Canyon Creek, none of which are believed to offer additional habitat for salmonids.

BARRIER DESCRIPTION

The Pickle Canyon Creek concrete ford is a private small-vehicle stream crossing located on a rural residential parcel. The ford has a small-diameter (1.64 feet) corrugated steel pipe culvert running through it to convey low flows, but it is designed for storm flows to go over the surface (Figure 3). The concrete ford, located 1.71 miles upstream of the mouth, is the only known anthropogenic barrier to fish passage on Pickle Canyon Creek (Figure 2). There are 1.98 square miles of watershed area above the culvert, including an estimated 2.45 miles of steelhead habitat.

The concrete crossing was identified as a potential barrier to fish passage in April 2007 during fish habitat survey by the RCD (Koehler and Edwards 2009). It was categorized as “red” in the DFG Green-Gray-Red system because it is expected to be a total barrier for adult and juvenile steelhead due to excessive leap at the downstream side. Additionally, the channel downstream of the crossing is comprised of exposed bedrock, which does not afford suitable jump pool conditions for fish attempting to pass the structure. The concrete crossing is located entirely on private property.

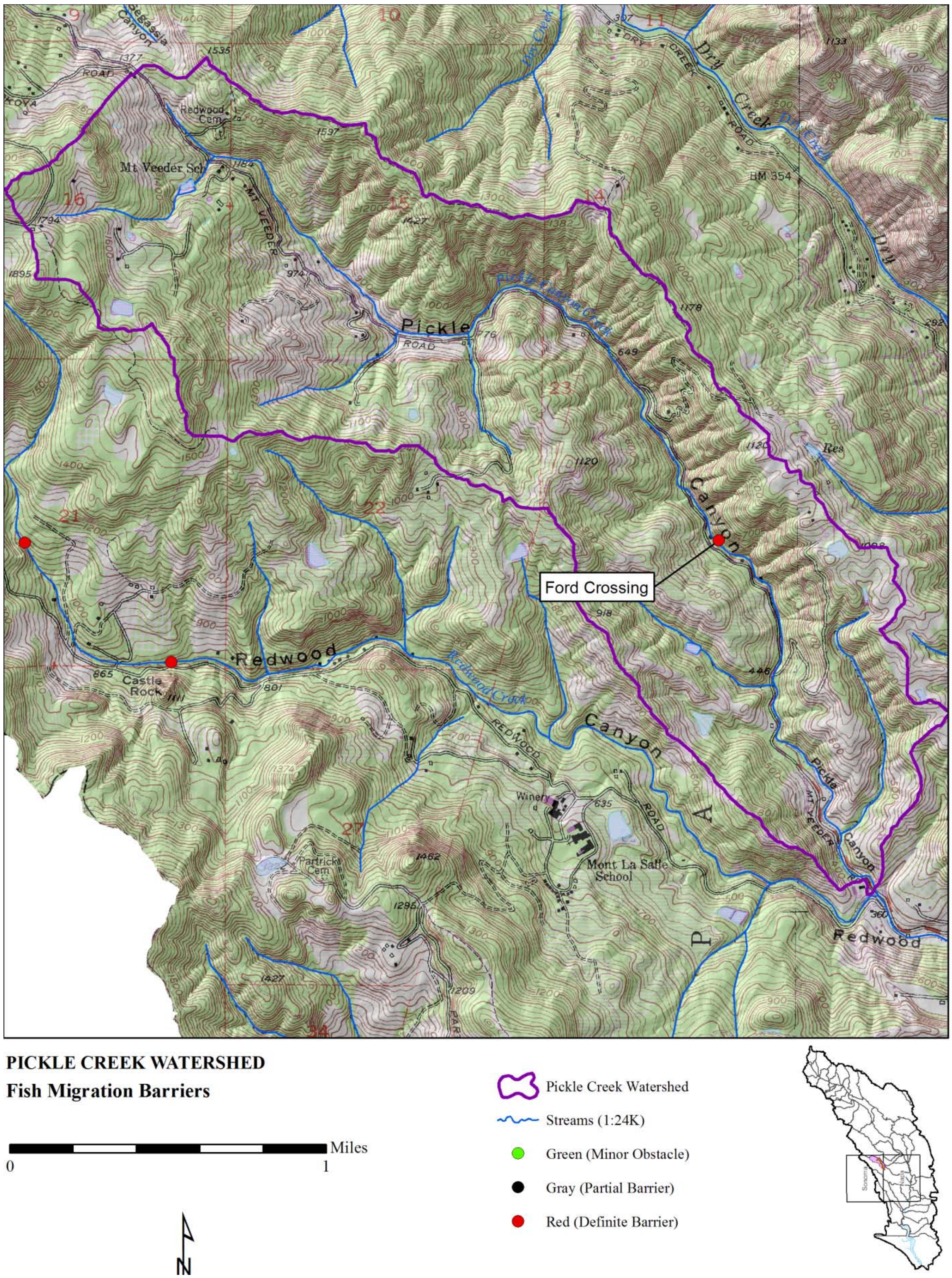


Figure 1. Pickle Canyon Creek watershed and barrier location.

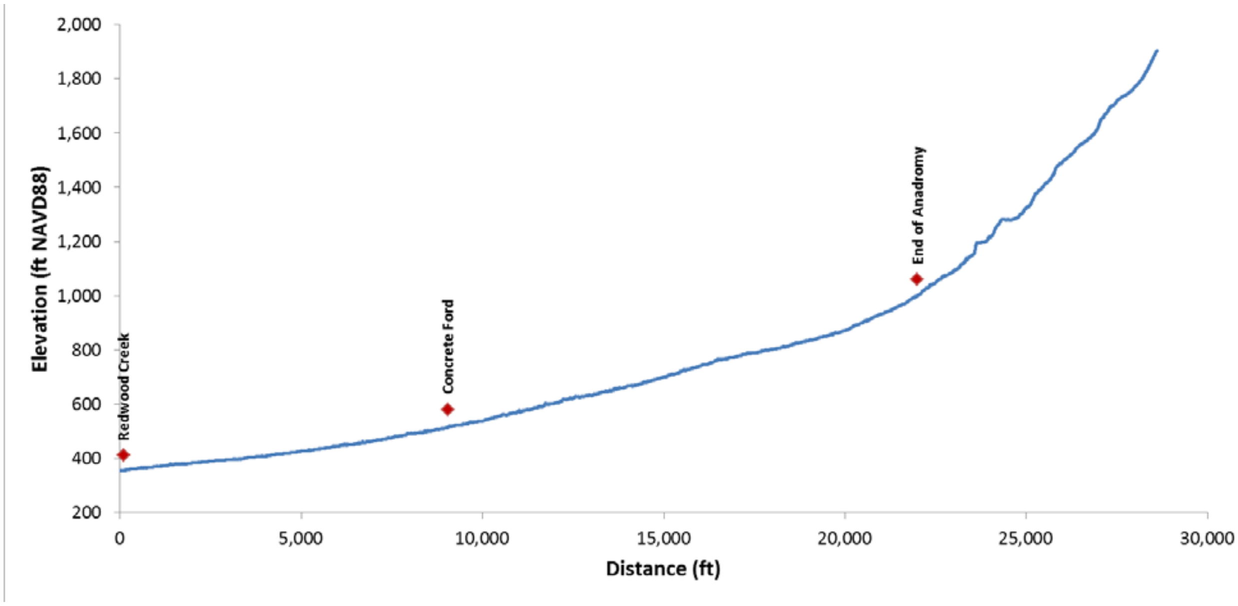


Figure 2. Pickle Canyon Creek LiDAR-derived longitudinal streambed profile with barrier location.

Figure 3. View of downstream face of Pickle Canyon Creek concrete ford under low flow.

BARRIER ASSESSMENT

RCD evaluated fish-passage at the Pickle Creek stream crossing in general accordance with *Part IX Fish Passage Evaluation at Stream Crossings* of the California Department of Fish and Game (DFG) Salmonid Stream Habitat Restoration Manual (DFG 2010). The assessment included a fish-passage inventory of the barrier site, an upstream habitat assessment, a peak flow estimate, and a fish-passage analysis.

Fish-Passage Inventory

On October 5, 2010, Jonathan Koehler (RCD) and Paul Blank (RCD) conducted a fish-passage inventory of the stream crossing including:

- Measurement of structure dimensions;
- Longitudinal profile survey;
- Channel cross section survey;
- Site sketch; and,
- Completion of the DFG fish passage inventory data sheet.

The longitudinal profile survey was completed with tape and level and was surveyed relative to an arbitrary datum. It began 172 feet upstream of the ford and continued for 392 feet in the downstream direction to approximately 220 feet downstream of the ford. The survey captured the profile of the ford, the upstream resting pool, the downstream channel, and the overall slope of the reach (Figure 4). A total of five cross sections were surveyed: one in the upstream channel above the influence of the ford, one immediately upstream of the ford, one immediately downstream of the ford, one at the tailwater control, and one in the downstream channel. Cross sections were completed specifically for low-flow hydraulic analyses and do not include top of bank or overbank data.

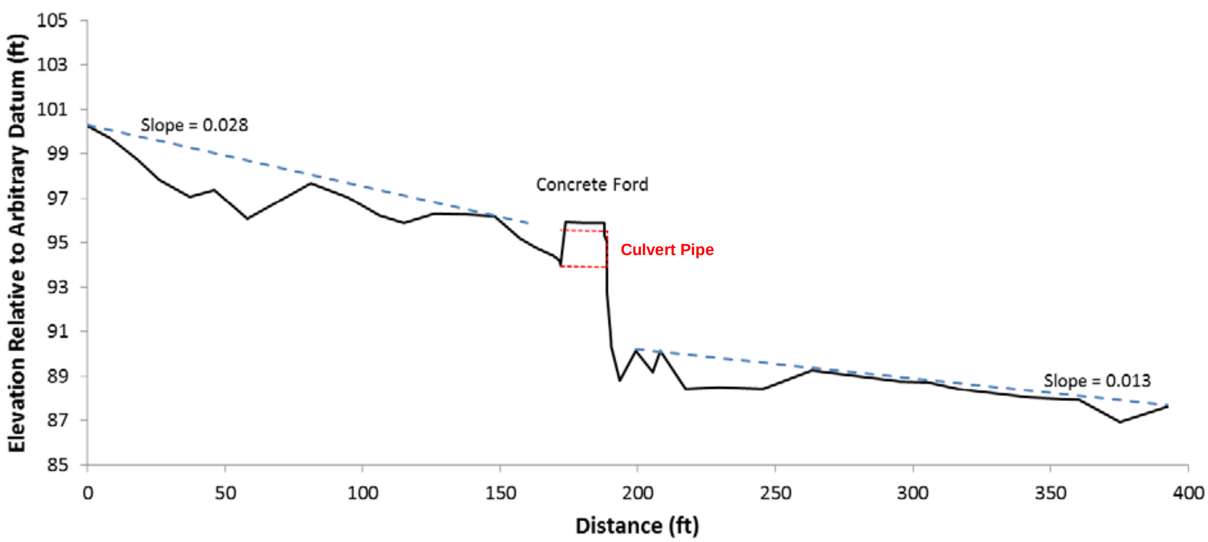


Figure 4. Surveyed longitudinal streambed profile.

Fish Passage Analysis

The first-phase evaluation indicated that the concrete ford is a total barrier for all life stages of steelhead. To test this assumption, RCD performed an analysis using the *HEC-RAS version 4.1* software developed by the US Army Corps of Engineers Hydrologic Engineering Center (HEC) for one-dimensional steady and unsteady flow hydraulics calculations (http://www.hec.usace.army.mil/software/hec-ras).

Upper and lower fish passage flows were estimated from surrogate data in accordance with DFG protocols. RCD selected the former USGS streamgaging station on Redwood Creek as a surrogate because it is the nearest to Pickle Canyon Creek with at least 5 years of daily average flow data (15 years) and with a drainage area less than 50 square miles (9.79 square miles). Calculated fish passage flows were adjusted for Pickle Canyon Creek by multiplying them by the ratio of the two drainage areas. The calculated fish passage flows are presented in Table 1.

Species/Lifestage	Upper Passage Flow (cfs)		Lower Passage Flow (cfs)	
Adult steelhead	40.4	1% Exceedance Flow	3	Alternate Minimum Flow
Juvenile steelhead	4.2	10% Exceedance Flow	1	Alternate Minimum Flow

Table 1. Calculated Fish Passage Flows.

The HEC-RAS model was constructed using the five surveyed channel cross sections and the surveyed dimensions of the concrete ford. In addition, a copy of the cross section measured immediately downstream of the ford was modified and used 3.3 feet downstream to represent the maximum pool depth. Steady flow analyses were then run for each fish passage flow and jump height, jump pool depth, culvert outlet velocity, and average water velocity over the barrier were calculated. The results of the fish passage analysis are presented in Table 2.

Flow Description	Flow (cfs)	Jump Height (ft)	Jump Pool Depth (ft)	Culvert Outlet Velocity (ft/s)	Avg Velocity at Top of Ford (ft/s)
Juvenile lower passage flow	1	3.36 (culvert)	1.71	2.87	NA
Adult lower passage flow	3	3.15 (culvert)	1.92	3.92	NA
Juvenile upper passage flow	4.2	3.06 (culvert)	2.01	4.36	NA
Top of culvert inlet	8.0	2.86 (culvert)	2.21	5.48	NA
Adult upper passage flow	40.4	4.07	3.00	7.05	4.62
Flow that produces 0.8 ft depth at downstream end of top of ford	60	3.77	3.30	7.52	5.06

Table 2. Fish Passage Analysis Results

RCD compared the fish passage analysis results to the swimming capabilities and minimum depth requirements for adult and juvenile steelhead from Table IX-6 of the DFG Manual. Maximum jump heights were obtained from NMFS Guidelines for Salmonid Passage at Stream Crossings (NMFS 2001). Based on comparison to these criteria, the concrete ford is a total barrier to upstream passage of adult and juvenile steelhead due to excessive jump height across the range of passage flows. The finding of the first-phase evaluation and the classification of the barrier as "red" in the DFG Green-Gray-Red system were confirmed by this analysis.

DISCUSSION

The results of hydraulic analyses of the concrete ford indicate that it is a complete barrier for adult and juvenile steelhead due to excessive leap height. Given the natural variability in swimming capabilities of individual steelhead, an occasional adult fish may be able to pass the dam under ideal flow conditions.

The slope and substrate of the main fork of Pickle Canyon Creek are favorable for 2.45 miles above the concrete ford. Portions of this reach of the stream dry out during the summer months in some years, but other portions are known to flow perennially (Koehler and Edwards 2009). Given the amount of high quality upstream habitat and close proximity to Redwood Creek, which is also known to be an important steelhead stream, this site would be a high priority for improvement within the greater Napa River watershed.

Although the crossing is used infrequently, the site does provide access across the stream channel for the landowner. There is currently a small railcar bridge upstream of the crossing that may provide suitable access if the ford crossing is removed; however the landowner will need to be consulted prior to any construction details can be developed.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this analysis, the concrete ford crossing on Pickle Creek is a complete barrier to movement of adult and juvenile steelhead trout. Upstream of the dam are 2.45 miles of habitat that are suitable for spawning but may be somewhat limited in summer rearing value due to deficient flows.

Mitigation options include:

1) Replace the existing culvert with a larger pipe placed at streambed elevation and grade

2) Remove the ford crossing entirely, and re-grade and re-vegetate both stream banks.

3) Install a short series of two to three boulder weirs downstream of the ford to gradually step up the streambed elevation to match the upstream grade.

Given the infrequent use of the crossing, replacing the culvert within the existing concrete structure is not warranted. This effort would require significant cost and design that we believe would be more efficiently spent on a non-intrusive stream crossing design or complete removal. Therefore, Option 1 is not recommended.

RCD recommends Option 2 in conjunction with Option 3 if determined necessary to achieve fish passage. A qualified hydraulic engineer will need to determine what the anticipated water depths and velocities will be for the site at a range of flows once designs are developed. However, based on the results of our longitudinal profile, it appears that some form of downstream grade control structure will be needed in order to make up for the large drop in elevation between the current crossing and the natural streambed.

CONCEPTUAL DESIGNS

Options 2 and 3:

Drawings by Carolyn M. Jones, PE, Natural Resource Conservation Service

REFERENCES

California Department of Fish and Game (CDFG). 2010. Edition. California Salmonid Stream Habitat Restoration Manual. 4th Edition.

Koehler, J. C. Edwards. 2009. Southern Napa River Watershed Restoration Plan. Napa County Resource Conservation District. Prepared for California Department of Fish and Game, Fisheries Restoration Grant Program.

NMFS 2001. Guidelines for Salmonid Passage at Stream Crossings. National Marine Fisheries Service Southwest Region. Santa Rosa, California.

State Lane Crossing at Rector Creek

Fish Passage Assessment

Prepared for

California State Coastal Conservancy
Agreement No. 08-069

Prepared by

NAPA COUNTY RCD
Resource Conservation District

June 2011

STREAM DESCRIPTION

Rector Creek is a tributary of Conn Creek, which is tributary to the Napa River and ultimately the San Francisco Estuary. Its 11.38 square mile watershed contains approximately 5.84 miles of third order blue-line stream (1.65 miles below Rector Dam) and approximately 30.25 total miles of blue-line stream (first, second, and third order) according to the USGS 7.5-minute quadrangle (Figure 1). Elevations range from 106 feet above mean sea level at the mouth of the creek to 2,650 feet at the ridgeline. Chaparral and mixed hardwood riparian forest dominate the land cover, with large expanses of vineyard, and minor rural residential areas. The majority of the land (9.34 square miles) is under private ownership. Approximately 2 square miles in the vicinity of Rector Reservoir are owned by the State of California.

Rector Dam is located 1.80 miles upstream of the Conn Creek confluence and was constructed in 1946. It forms the 4,500 acre-foot Rector Reservoir which provides water supply to the Town of Yountville, the State of California Yountville Veteran's Home, Napa State Hospital, and the California Department of Fish and Game Yountville facility. Historically, it is likely that there was greater than 3 miles of steelhead habitat upstream of the reservoir, however, the site of the dam is now the limit of anadromy for migratory fish and has been since installation (Figures 1 and 2).

The portion of Rector Creek located below the dam only flows during late winter and early spring when the reservoir is spilling. Due to this flow limitation, habitat conditions are generally poor and steelhead have only been observed in low densities.

BARRIER DESCRIPTION

The State Lane crossing at Rector Creek is an asphalt paved ford across the streambed. There is no culvert beneath the roadway and all streamflow runs over the pavement surface (Figure 3). A 5-foot drop in elevation on the downstream side of the crossing indicates headcutting from downstream channel incision may be occurring, and the crossing may be providing grade control. Localized erosion of the streambanks is also occurring on the downstream side of the crossing, which is armored with large riprap boulders partially grouted with concrete (Figure 4).

The ford, located 0.95 miles upstream of the mouth, is the only barrier to fish passage between the confluence with Conn Creek and the base of Rector Dam (Figure 2). There are 11.16 square miles of watershed area above the ford, including an estimated 0.85 miles of relatively low quality steelhead habitat.

The crossing was identified as a potential barrier to fish passage in May 2003 as part of a Rector Creek stream inventory conducted by RCD (Koehler 2005). It was categorized as "red" in the DFG Green-Gray-Red system because it is expected to fail to meet fish passage criteria (impassable to steelhead of all life stages at all flows) due to excessive jump height, lack of depth, and excessive velocity.

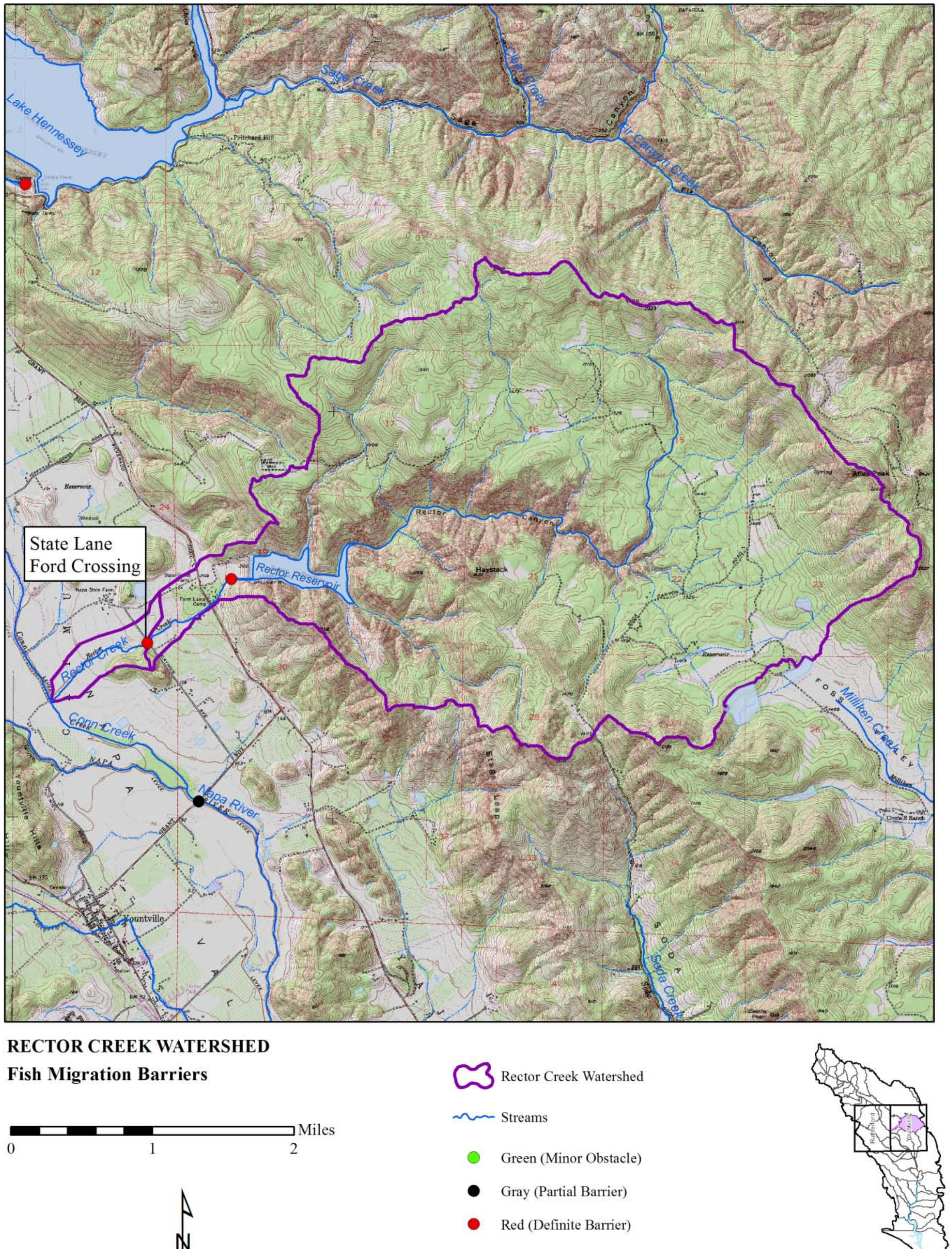


Figure 1. Rector Creek watershed and barrier locations.

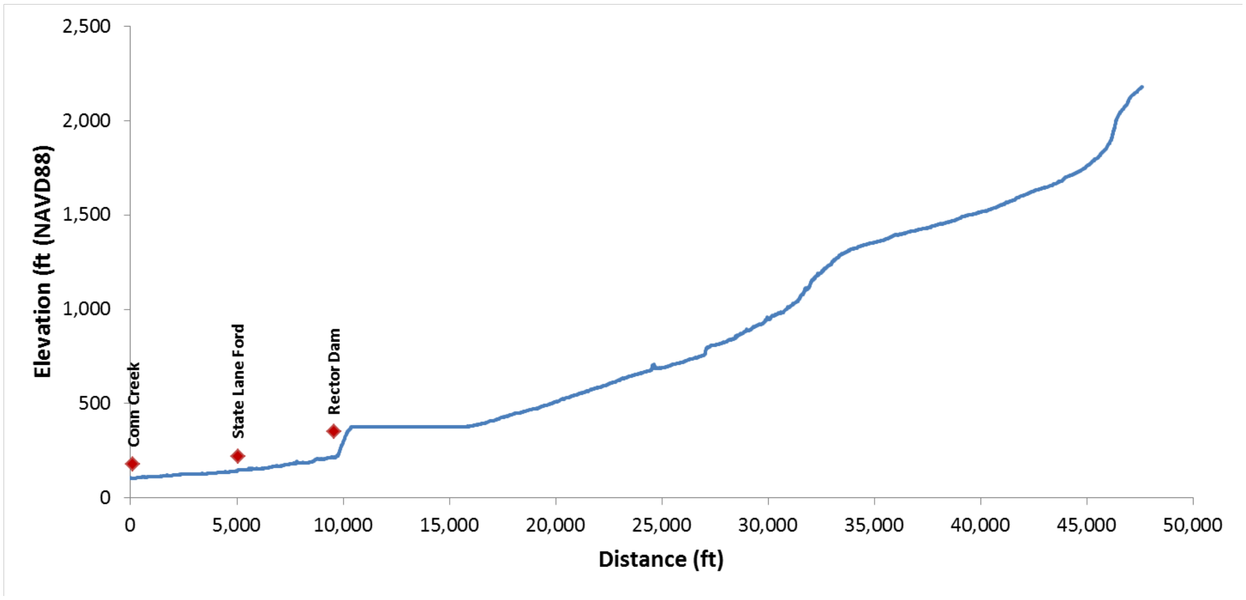


Figure 2. Rector Creek LiDAR DEM-derived longitudinal streambed profile with barrier location.

Figure 3. Looking south down State Lane, across Rector Creek under spring flow (April 2006).

Figure 4. View of downstream side of crossing looking north along State Lane (August 2010).

BARRIER ASSESSMENT

RCD evaluated fish-passage at the Rector Creek stream crossing in general accordance with *Part IX Fish Passage Evaluation at Stream Crossings* of the California Department of Fish and Game (DFG) Salmonid Stream Habitat Restoration Manual (DFG 2010). The assessment included a fish-passage inventory of the barrier site and a fish-passage analysis.

Fish Passage Inventory

On August 17, 2010, Jonathan Koehler (RCD) and Paul Blank (RCD) conducted a fish-passage inventory of the Rector Creek stream crossing including:

- Longitudinal profile survey;
- Site sketch; and,
- Completion of the DFG fish passage inventory data sheet.

The longitudinal profile survey was completed with tape and level and was surveyed relative to an arbitrary datum. It began 300 feet upstream of the crossing and continued in a downstream direction to a point 300 feet downstream of the crossing. The survey captured the profile of the road crossing, the upstream resting pool, the tailwater configuration, and the overall slope of the reach (Figure 5).

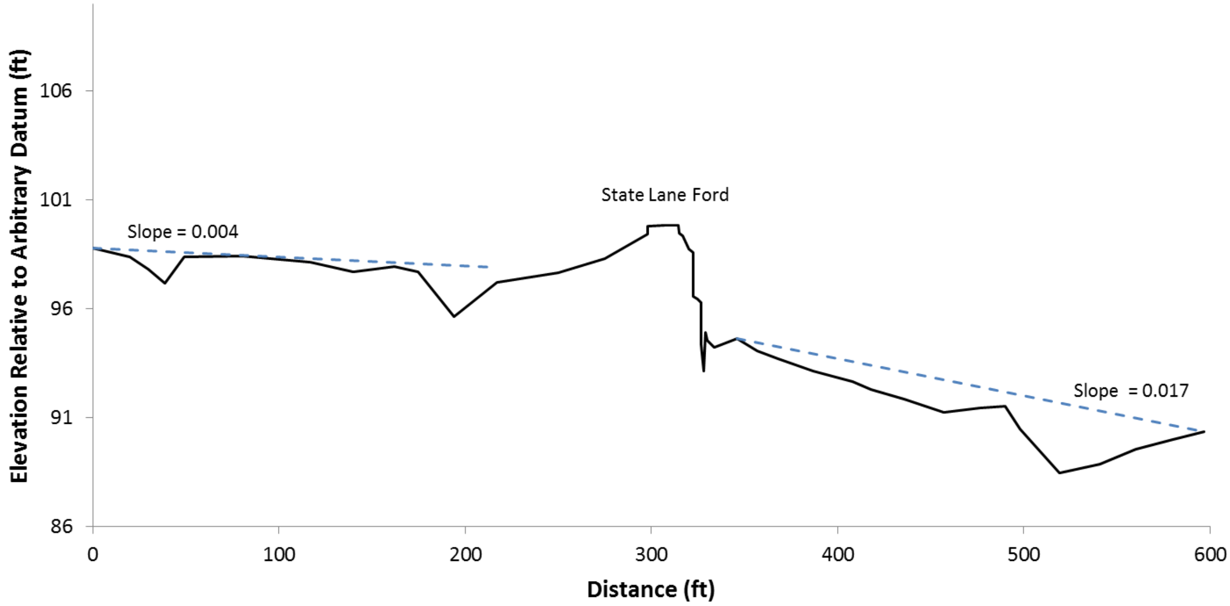


Figure 5. Surveyed longitudinal streambed profile.

Fish Passage Analysis

The first-phase evaluation indicated that the State Lane ford is a total barrier for all life stages of steelhead at all flows. To test this conclusion, RCD performed an analysis using the *HEC-RAS version 4.1* software developed by the US Army Corps of Engineers Hydrologic Engineering Center (HEC) for one-dimensional steady and unsteady flow hydraulics calculations (http://www.hec.usace.army.mil/software/hec-ras).

Upper and lower fish passage flows were estimated from surrogate data in accordance with DFG protocols. RCD selected the former USGS streamgaging station on Tulucay Creek as a surrogate because it is the most comparable to Rector Creek in drainage area, land cover, and rainfall patterns with at least 5 years of daily average flow data (12 years) and with a drainage area less than 50 square miles (12.54 square miles). Calculated fish passage flows were adjusted for Rector Creek by multiplying them by the ratio of the two drainage areas. The calculated fish passage flows are presented in Table 1. These flows do not take into account flow regulation by Rector Reservoir. Since Rector Creek only flows when the reservoir is spilling, it would have more zero daily average flow days per year than Tulucay which would cause these values to be lower.

Species/Lifestage	Upper Passage Flow (cfs)		Lower Passage Flow (cfs)	
Adult steelhead	198	1% Exceedance Flow	3	Alternate Minimum Flow
Juvenile steelhead	22.2	10% Exceedance Flow	1	Alternate Minimum Flow

Table 1. Calculated fish-passage flows.

The HEC-RAS model was constructed using the surveyed dimensions of the ford and four channel cross sections that were cut from the high-resolution light detection and ranging (LiDAR) digital elevation model (DEM). Although highly useful for many purposes, DEM data tend to be significantly less accurate than surveyed data in stream channels, presumably due to interference from dense riparian forests, and are often not adequate for certain types of stream channel computations. This reach of Rector Creek, however, has little riparian vegetative cover and therefore RCD considers this site to be a good candidate for modeling with channel geometry derived from the DEM. RCD downloaded the data from the National Science Foundation's National Center for Airborne Laser Mapping (NSF NCALM) at http://calm.geo.berkeley.edu/ncalm, and processed the LiDAR DEM to generate the cross sections.

Steady flow analyses were run for each fish passage flow and jump height, water depth at the top of the ford, and water velocity at the top of the ford were calculated. The flow that produces a depth of 0.8 feet at the top of the ford was also calculated. The results of the fish passage analysis are presented in Table 2.

Flow Description	Flow (cfs)	Jump Height (ft)	Depth at Top of Ford (ft)	Avg Velocity at Top of Ford (ft/s)
Juvenile lower passage flow	1	5.0	0.06	1.1
Adult lower passage flow	3	4.9	0.09	1.4
Juvenile upper passage flow	22	4.6	0.26	2.2
Adult upper passage flow	198	3.8	0.70	3.8
Flow that produces 0.8 ft depth at top of ford	260	3.6	0.80	4.1

Table 2. Fish passage analysis results.

RCD compared the fish passage analysis results to the swimming capabilities and minimum depth requirements for adult and juvenile steelhead from Table IX-6 of the DFG Manual. Maximum jump heights were obtained from NMFS Guidelines for Salmonid Passage at Stream Crossings (NMFS 2001). Based on comparison to these criteria, the ford is a total barrier to upstream passage of adult and juvenile steelhead due to excessive leap and insufficient depth across the ford across the range of passage flows. The finding of the first-phase evaluation and the classification of the barrier as "red" in the DFG Green-Gray-Red system were confirmed by this analysis.

DISCUSSION

The construction of Rector Dam in 1946 reduced the amount of fish habitat in Rector Creek from an estimated 4.8 stream miles to 1.8 stream miles. The creek, below Rector Dam, only flows when the reservoir is spilling and this flow limitation has decreased habitat quality significantly. Rector Creek empties into Conn Creek, which due to the upstream presence of Lake Hennessy, is in the same degraded and flow-limited condition, and thus limits fish access to Rector Creek.

Based on these factors, RCD considers Rector Creek to be a low priority for fish passage improvement projects.

The fish-passage analysis indicates that jump heights and water depths do not recommended criteria for any life stage of steelhead under any flow conditions. Jump pool depths could not be calculated because there is no jump pool at the site. Large rip rap has been installed on the downstream side of the ford to protect against scour and as a result no pool has formed. This further decreases a fish's ability to pass the ford, if not making it altogether impossible.

CONCLUSIONS AND RECOMMENDATIONS

The results of this fish passage assessment indicate that the State Lane ford at Rector Creek is a total barrier for all life stages of steelhead that is blocking fish access to approximately 0.85 stream miles of relatively low quality habitat. RCD concludes that this site is a low priority for improvement.

Options for next steps include:

1) Doing nothing.

2) Removing the ford and installing a culvert stream crossing that will convey the 1% probability flow (100-year flood) and allow for fish passage.

3) Delaying action until such time as the crossing might be improved for other reasons (such as flood damage or the land owner wanting a dry winter crossing) and pursuing Option 2 at that time.

Option 1 does not address fish-passage issues at the site, but this may be warranted given the small amount of low quality upstream habitat. Option 2 provides for fish-passage but may be a prohibitively expensive project solely for the purpose of providing fish passage due to the low priority status of the site.

Option 3 allows the costs of improving fish passage at the crossing to be lessened and does not significantly impact the overall health of the Napa Valley steelhead fishery due to the low-priority status of the site. RCD recommends Option 3.

REFERENCES

California Department of Fish and Game (CDFG). 2010. Edition. California Salmonid Stream Habitat Restoration Manual. 4th Edition.

Koehler, J. 2005. Central Napa River Watershed Project: *Salmonid Habitat Form and Function.* Napa County Resource Conservation District (NCRCD). Funded by the California Department of Fish and Game, Fisheries Restoration Grant Program.

GREEN VALLEY ROAD CULVERT AT SPENCER CREEK

FISH PASSAGE ASSESSMENT

Prepared for

California State Coastal Conservancy
Agreement No. 08-069

Prepared by

NAPA COUNTY RCD
Resource Conservation District

June 2011

STREAM DESCRIPTION

Spencer Creek is a tributary of Tulucay Creek, which flows to the Napa River and ultimately into the San Francisco Estuary. Its 2.26 square mile watershed contains 6.56 miles of blue-line stream, 2.53 miles of which is second order stream, according to the USGS Napa and Mt. George 7.5-minute quadrangle maps (Figure 1). Elevations range from 100 feet at the mouth of the creek to 1,300 feet at the ridgeline. Mixed hardwood forest, shrubland, and grassland dominate the watershed with minor areas of vineyard and rural residential development. The watershed is entirely under private ownership except for two City of Vallejo parcels at the ridgeline.

Steelhead (*Oncorhynchus mykiss*) are present in Spencer Creek and the slope and substrate of the streambed are favorable for approximately 1.4 miles, at which point a natural waterfall occurs. Some portions of this reach are intermittent and dry in the summer months, but at least one section is perennial in most years and several *O. mykiss* were observed in this area during a 2007 habitat survey (Koehler and Edwards 2009).

Three barriers to upstream migration of steelhead have been identified on the main fork of Spencer Creek (Koehler and Edwards 2009). The barriers are listed in Table 1 and shown on Figures 1 and 6.

Fish-Passage Barrier	Distance Upstream from Mouth (mi)	Max Upstream Habitat (mi)	Barrier Type	Status
Boulder cascade	0.66	0.74	Temporal	Natural feature
Green Valley Road culvert	**0.80**	**0.60**	**Total**	**Under assessment**
Falls	1.40	0	Total	Natural end of anadromy

Table 1. Spencer Creek fish-passage barriers.

BARRIER DESCRIPTION

The Green Valley Road culvert at Spencer Creek is a 90.5-foot long single-barrel concrete box culvert with a 6.1-foot rise and 6.1-foot span (Figures 2, 3, and 4). Due to the depth of the canyon at this location there is a 27-foot high fill prism above the culvert. The culvert was built atop a bedrock outcrop in the stream channel and part of the floor of the culvert is bedrock. Bedrock is also present at the outlet which causes water to cascade into the tailwater pool. The culvert has a steep slope, a maximum of 14% near the inlet, and the slope varies along its length.

The culvert was identified as a potential barrier to fish passage in 2007 during a stream inventory by the RCD. It was categorized as “red” in the DFG Green-Gray-Red system because it is expected to be a total barrier, impassable for adult and juvenile steelhead at all flows, due to excessive leap at the outlet, insufficient depth in the culvert, and excessive outlet velocity during higher flows.

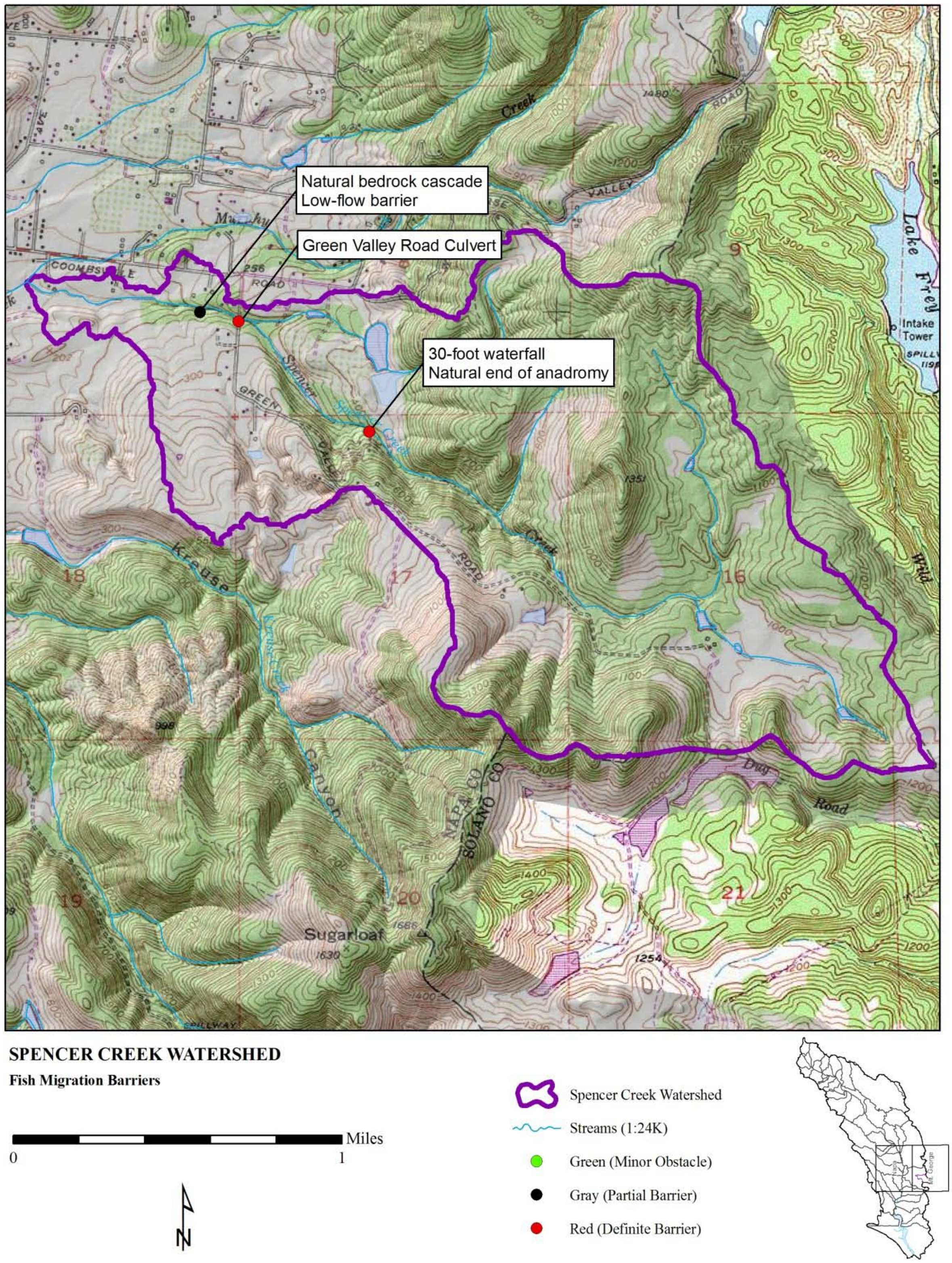


Figure 1. Spencer Creek watershed and barrier locations.

Figure 2. View of culvert inlet looking downstream.

Figure 3. Looking downstream through the culvert.

Figure 4. View of culvert outlet looking upstream.

BARRIER ASSESSMENT

RCD evaluated fish-passage at the Green Valley Road stream crossing in general accordance with *Part IX Fish Passage Evaluation at Stream Crossings* of the California Department of Fish and Game (DFG) Salmonid Stream Habitat Restoration Manual (DFG 2010). The assessment included a fish-passage inventory of the barrier site, a limit-of-anadromy analysis, a peak flow estimate, a culvert capacity analysis, and a fish-passage analysis.

Fish-Passage Inventory

On August 10, 2010, Jonathan Koehler (RCD) and Paul Blank (RCD) conducted a fish-passage inventory of the stream crossing including:

- Measurement of culvert dimensions;
- Longitudinal profile survey;
- Channel cross section survey;
- Site sketch; and,
- Completion of the DFG fish passage inventory data sheet.

The longitudinal profile survey was completed with tape and level and was surveyed relative to an arbitrary datum. It began 80 feet upstream of the culvert and continued for 364 feet in the downstream direction to a point 194 feet downstream of the culvert. The survey captured the profile of the culvert, the upstream resting pool, the height of the fill prism, the tailwater configuration, and the overall slope of the reach (Figure 5). The channel cross section was also performed with tape and level and was located at the tailwater control.

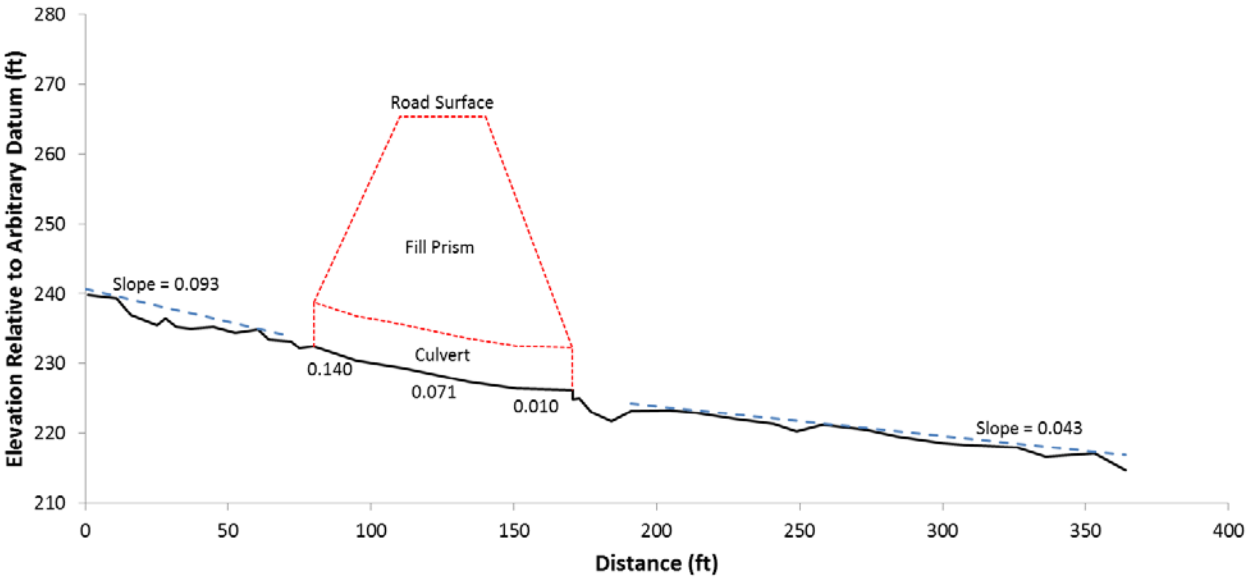


Figure 5. Surveyed longitudinal streambed profile.

Limit-of-Anadromy Analysis

RCD evaluated the amount of *O.mykiss* habitat located upstream of the barrier based on slope and existing survey reports. A topographic profile of Spencer Creek was generated from the LiDAR digital elevation model (DEM) to graphically depict known barriers along the length of the stream (Figure 6).

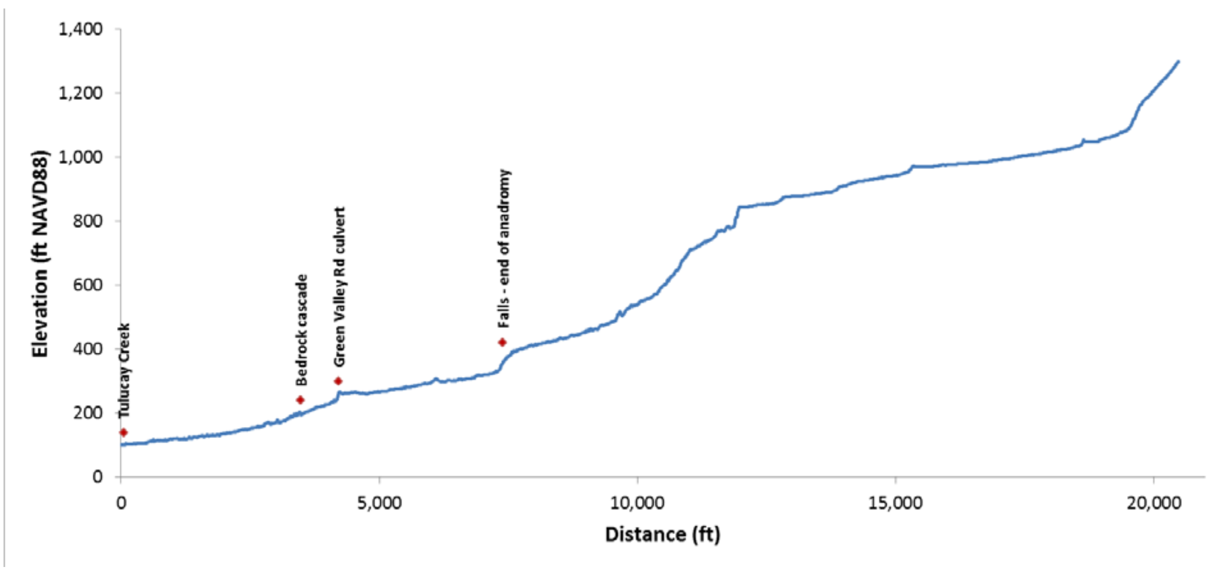


Figure 6. Spencer Creek LiDAR-derived longitudinal streambed profile with barrier locations.

Peak Flow Estimate

The Spencer Creek subwatershed is an ungaged basin. In order to evaluate culvert capacity it is necessary to estimate peak flows at the stream crossing. One way to estimate peak flows is to adjust the peak flow statistics for a nearby gaging station. The United States Geological Survey (USGS) operated retired Station 11458350 TULUCAY C A NAPA CA approximately 3.0 miles downstream on Tulucay Creek for 12 years from 1971 through 1983; however, they have not provided peak flow statistics. RCD assumes this is because the data are insufficient for such calculations. The nearest gaging station with a reasonably similar watershed area for which peak flow statistics are available is retired USGS Station 11458200 REDWOOD C NR NAPA CA, located approximately 6.7 miles northwest of the barrier site. Station 11458200 operated continuously for 15 years, from 1958 through 1973. RCD calculated the 50% through the 1% annual exceedance probability flows (Q2, Q5, Q10, Q25, Q50, and Q100) in cubic feet per second (cfs) by adjusting the peak flow statistics for Station 11458200. The Q2 through Q100 calculated by USGS were obtained from water.usgs.gov/osw/streamstats. As suggested by USGS (USGS 1977), RCD adjusted the flow for the difference in drainage areas using the relation:

—

where Q_u and Q_g are the discharges at the ungaged and gaged sites, A_u and A_g are the drainage areas, and b is the exponent for the drainage area from the corresponding regional regression equation (USGS 1977). For comparison, RCD also estimated peak flows for the site using the regional method. To perform this analysis, RCD used the National Streamflow Statistics (NSS) software developed by USGS (water.usgs.gov/software/NSS). The regional regression equations for the California North Coast Region use drainage area, mean annual precipitation, and an altitude index to estimate peak flows. Peak flow estimates are listed in Table 2.

Flow Event	Annual Exceedance Probability	Return Interval (yrs)	Peak Streamflow (cfs)		
			USGS 11458200	Spencer Creek at Green Valley Road Culvert (Surrogate Method)	Spencer Creek at Green Valley Road Culvert (Regional Equations)
Q2	0.5	2	1,200	274	106
Q5	0.2	5	1,310	304	161
Q10	0.1	10	1,360	321	210
Q25	0.04	25	1,420	341	265
Q50	0.02	50	1,460	351	317
Q100	0.01	100	1,500	360	352

Table 2. Peak streamflow estimates for Spencer Creek at Green Valley Road culvert.

Culvert Flow Capacity

Due to the changes in slope along the length of the culvert, RCD performed the culvert capacity analysis using the *Broken-back Culvert Analysis Program (BCAP) version 4.11c* software developed by the Nebraska Department of Roads. Culvert data, culvert profile data, and tailwater data were collected in the field during the fish-passage inventory. RCD analyzed the culvert's performance under the Q10 and Q100 flows for Spencer Creek (Table 2). In addition, RCD calculated the flow capacity at the top of the culvert inlet (headwater-to-diameter ratio equal to one). The results are presented in Table 3.

Event	**Streamflow (cfs)**	**Headwater Elevation Relative to Arbitrary Datum (ft)**
Q10	321	239.04
Q100	360	239.77
Top of culvert inlet	309	238.83

Table 3. Culvert flow capacity analysis results.

Fish Passage Analysis

The first-phase evaluation indicated that the stream crossing is a total barrier, impassable for adult and juvenile steelhead. To test this conclusion, RCD performed an analysis using the BCAP model constructed for the culvert flow capacity analysis. RCD normally uses the *FishXing v3* software for this kind of analysis, however, the *FishXing* software is unable to manage the breaks in slope along the profile of the culvert.

Upper and lower fish passage flows were estimated from surrogate data in accordance with DFG protocols. RCD selected retired USGS Station 11458350 on Tulucay Creek as a surrogate because it is the nearest to Spencer Creek with at least 5 years of daily average flow data (12 years) and with a drainage area of less than 50 square miles (12.54 square miles). Calculated fish passage flows were adjusted for Spencer Creek by multiplying them by the ratio of the two drainage areas. The calculated fish passage flows are presented in Table 4.

Species/Lifestage	**Upper Passage Flow (cfs)**		**Lower Passage Flow (cfs)**	
Adult steelhead	33.8	1% Exceedance Flow	3	Alternate Minimum Flow
Juvenile steelhead	3.8	10% Exceedance Flow	1	Alternate Minimum Flow

Table 4. Calculated fish passage flows.

Swimming capabilities and minimum depth requirements for adult and juvenile steelhead were based on Table IX-6 of the DFG Manual. The results of the fish passage analysis are presented in Table 5.

Flow Description	**Flow (cfs)**	**Jump Height (ft)**	**Jump Pool Depth (ft)**	**Outlet Depth (ft)**	**Outlet Velocity (ft/s)**
Juvenile lower passage flow	1	2.72	1.75	0.09	1.82

Adult lower passage flow	3	2.61	1.86	0.17	2.89
Juvenile upper passage flow	3.8	2.57	1.90	0.21	2.97
Adult upper passage flow	33.8	1.80	2.67	0.54	10.18

Table 5. Fish passage analysis results.

DISCUSSION

RCD estimated peak streamflows for the Green Valley Road culvert at Spencer Creek using two methods. The first method adjusted the peak flow statistics for retired USGS Station 11458200 for the difference in drainage area. Although this is the preferred method in many cases where there is an appropriate surrogate gaging station nearby, it was not ideal in this case because Station 11458200, while less than seven miles away, is located on the opposite side of the valley in an area with different land cover and rainfall patterns. Therefore, RCD also computed peak flows using the regional flood-frequency equations for comparison. While widely used and accepted, it is the RCD's experience that the regional equations often seem to underestimate peak flows in our area, when compared to other methods. In this case, the two methods produce widely varying results for the Q2 through Q25 flows, but are in agreement on the Q50 and Q100 flows. RCD believes this is due to the unusually small difference between the Q2 and Q100 for Station 11458200, which may be an effect of the short data record (15 years) or other site-specific issue. The agreement between the two methods in the Q100 gives us confidence in this result, and we selected the larger value (360 cfs). We have less confidence in the values estimated for the smaller peak flows, but we do think that the results of the surrogate method represent the high end of the possible range. Therefore, to be conservative, we selected 321 cfs as the Q10.

Comparison of the peak flow estimates to the culvert flow capacity analysis results indicates that the Green Valley Road culvert at Spencer Creek will convey 309 cfs at the top of the culvert inlet. California Department of Transportation guidelines indicate that culverts should convey the Q10 "…without causing headwater elevation to rise above the inlet top of culvert," and the Q100 "…without damage to the facility or adjacent property" (Caltrans 2006). DFG states that "crossing structures should typically be designed to accommodate the 100-year flood event" (DFG 2009). Based on these guidelines, the culvert is slightly undersized; however, RCD believes the Q10 estimate of 321 cfs is an overestimation and although upstream ponding can be expected during the Q100 it will not be significant enough to threaten the structure, streambanks, or adjacent properties. Therefore, we think this culvert is appropriately sized from a flow conveyance standpoint. However, it will not accommodate installation of internal or external energy dissipation structures or backwatering, and is not a candidate for a retrofit project.

RCD's usual culvert fish-passage analysis tool, *FishXing*, could not be used for this site because of breaks-in-slope along the length of the culvert. We were, however, able to use our BCAP model to calculate jump heights, jump pool depths, culvert outlet depths, and outlet velocities.

The results of fish-passage analysis indicate that the culvert does not meet current fish passage requirements, and is not passable by steelhead at any life stage under any flow conditions. The analysis was based on conservative swimming capabilities and minimum depth requirements from the DFG guidelines. The analysis uses average velocities to determine passage, which may not account for hydraulic variation that may facilitate passage under specific flows. Given these assumptions, the barrier may be passable by some small fraction of the steelhead population with stronger swimming capabilities at certain flows. However, DFG and NOAA Fisheries guidelines are designed to allow passage of all fish in the population, not just the strongest swimmers. Based on the results of this analysis, RCD confirmed the stream crossing as a complete barrier, "red" in the DFG Green-Gray-Red system. The obstacles for fish passage are excessive leap height at the culvert outlet, insufficient depths in the culvert, and excessive velocities at higher flows.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this analysis, the Green Valley Road culvert at Spencer Creek is a total barrier to fish passage and is not a candidate for retrofit. There are 0.60 miles of moderate-quality habitat upstream of the barrier.

Mitigation options include:

1) Do nothing and leave the current culvert configuration in place

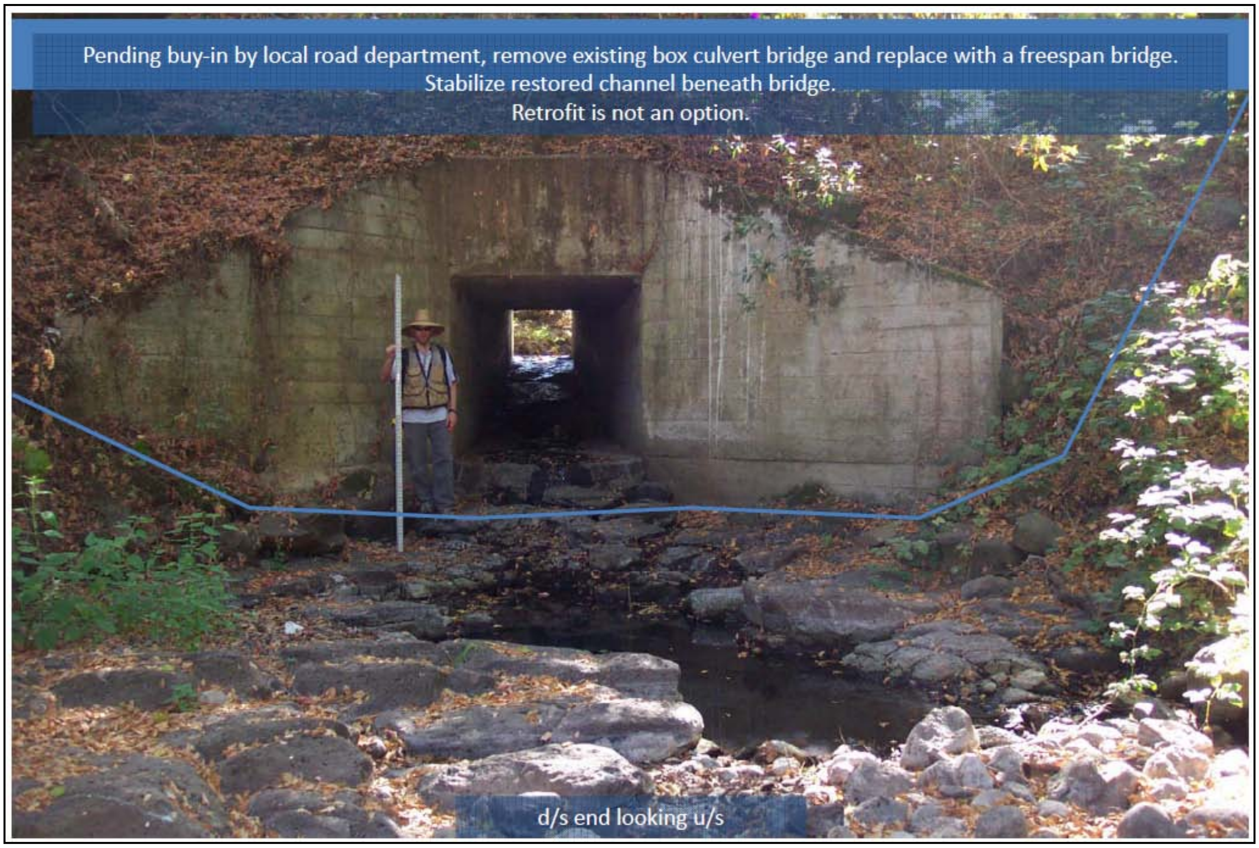
2) Replace the existing culvert with a bridge or bottomless culvert that spans the bankfull channel and restores the natural streambed profile

Although our analysis found this dam to be a complete barrier to steelhead, there is limited upstream habitat to be gained from its removal or modification. It should be evaluated whether the upstream habitat is of sufficient quality to justify the cost and effort of pursuing funds to implement an improvement project. Resource agency staff (NMFS and DFG) will need to make this determination based on management and recovery strategies for steelhead in the region. If it is not deemed to be a high enough priority by these agencies, then Option 1 is warranted.

Option 2 would likely be very expensive due to the elevation of the roadway and the amount of fill currently in place above the culvert. Additionally, since this site is constructed on a natural bedrock high point, simply replacing the culvert may not achieve unobstructed fish passage. The stream slope in this section may be prohibitively steep for fish passage under natural conditions. If the structure is replaced with a bridge or bottomless culvert, it may be necessary to construct a series of rock weirs throughout the reach to gradually step up the stream bed elevation to allow for fish passage.

CONCEPTUAL DESIGN

Option 2:



Drawings by Carolyn M. Jones, PE, Natural Resource Conservation Service

REFERENCES

State of California Department of Fish and Game. April 2003. *Salmonid Stream Habitat Restoration Manual Part IX – Fish Passage Evaluation at Stream Crossings*.

Waananen, A.O., and J.R. Crippen. June 1977. *Magnitude and Frequency of Floods in California*. United States Geological Survey Water-Resources Investigations 77-21.

State of California Department of Transportation. January 2006. *Local Assistance Procedures Manual Chapter 11 Design Standards*.

State of California Department of Fish and Game. April 2009. *Salmonid Stream Habitat Restoration Manual Part XII – Fish Passage Design and Implementation*.

HIGHWAY 29 CULVERT AT SUSCOL CREEK

FISH PASSAGE ASSESSMENT

Prepared for

California State Coastal Conservancy
Agreement No. 08-069

Prepared by

NAPA COUNTY
RCD
Resource
Conservation
District

June 2011

STREAM DESCRIPTION

Suscol Creek is a tributary of the Napa River, which flows to the Pacific Ocean via San Pablo Bay. It is a third order stream with approximately 9.35 miles of blue-line stream according to the USGS Mt. George, Cordelia, and Cuttings Wharf 7.5-minute quadrangle maps (Figure 1). Suscol Creek drains a watershed of approximately 3.24 square miles. Elevations range from sea level at the mouth of the creek to 1,500 feet at the ridgeline. Grassland dominates the watershed with significant areas of oak woodland and vineyard. The watershed is mostly privately owned.

Suscol Creek is an important Napa Valley steelhead stream, with relatively abundant and high-quality *Oncorhynchus mykiss* spawning and rearing habitat. The upper extent of anadromy has not been verified due to lack of access to private lands, but a notable increase in slope is apparent on the stream profile beginning at 3.9 miles upstream of the Napa River. This point appears to represent the natural limit of anadromy in Suscol Creek.

A total of six barriers to steelhead migration have been identified on Suscol Creek between the Napa River and the natural end of anadromy (Koehler and Edwards 2009). The barriers are listed in Table 1.

Fish-Passage Barrier	Distance Upstream from Mouth (mi)	Max Upstream Habitat (mi)	Barrier Type	Status
Hwy. 29 Culvert	**1.33**	**2.57**	**Partial (Severe)**	**Under Assessment**
Old Defunct Concrete Dam	1.49	2.41	Partial (Moderate)	Low-flow obstacle for adults and juveniles. Built on natural bedrock outcrop
Bedrock Cascade (approx. 5-foot drop)	1.59	2.31	Partial (Severe)	Natural Feature
Bedrock Cascade	2.12	1.78	Partial (Minor)	Natural Feature
Bedrock Cascade (approx. 2-foot drop)	2.20	1.70	Partial (Minor)	Natural Feature
Slope exceeds 8%	3.90	0	Complete	Natural Feature

Table 1. Suscol Creek fish-passage barriers.

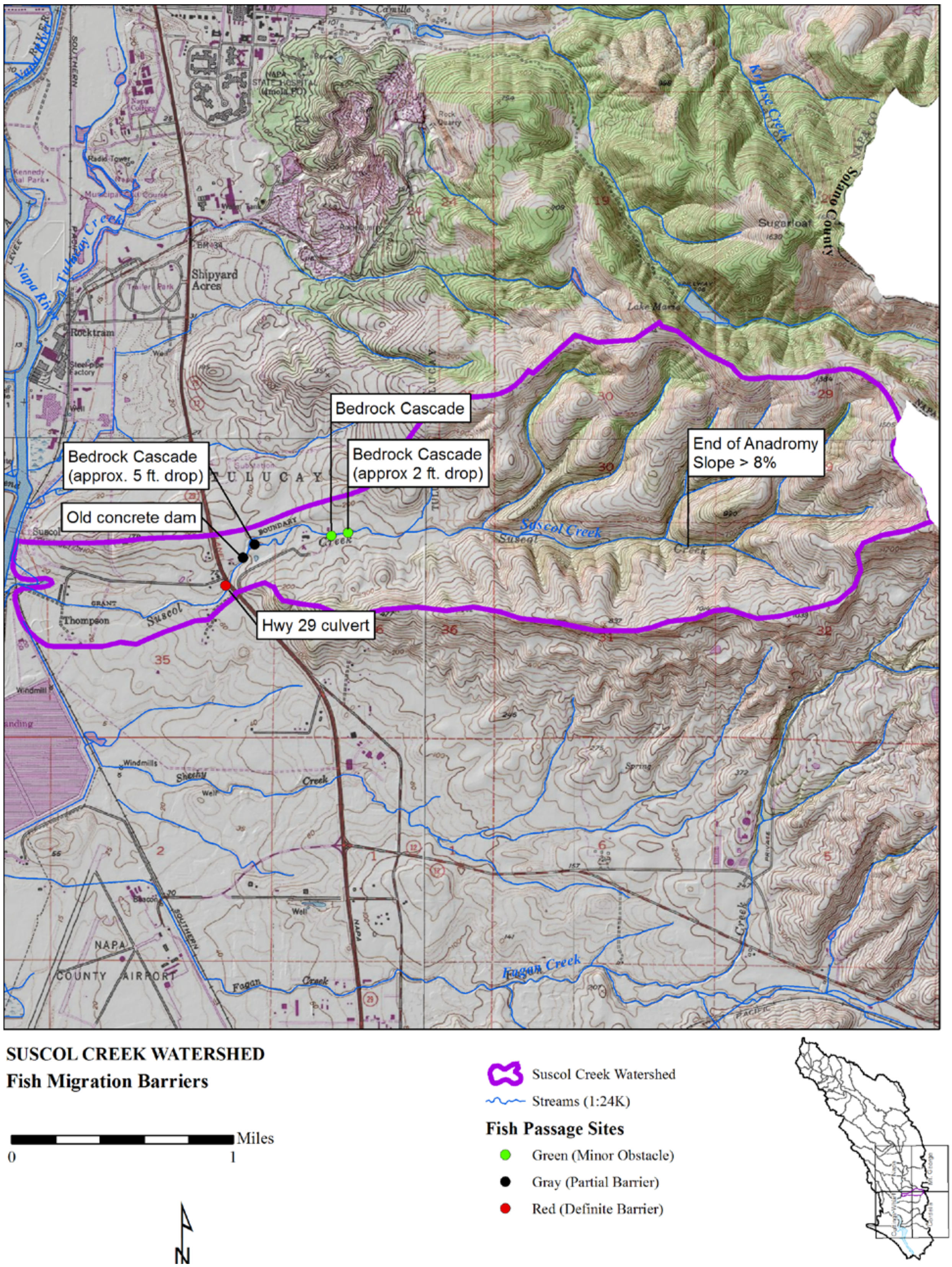


Figure 1. Suscol Creek watershed and barrier location.

BARRIER DESCRIPTION

The Highway 29 culvert at Suscol Creek is a 102-foot long concrete arch culvert with an 18-foot box culvert extension (Figures 4, and 5). The overlying roadway was further widened with a bridge span and there is an additional 82 feet of concrete trapezoidal channel and concrete apron protecting the streambed beneath the bridge on the downstream end of the culvert, creating a total stream crossing length of 202 feet (Figure 3).

At the barrier site, Suscol Creek is crossed by the intersection of California State Highways 29 and 121, maintained by the California Department of Transportation (Caltrans). A highway project has been conceived for the site, but it is a very low priority, and there is no schedule for implementation (Hanson pers. comm.). The project, a flyover of Highway 121 onto Highway 29, originally included a full fish-passage barrier assessment; however, due to the lack of in-stream work, this element was not required by National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS), and was removed from the plan.

The culvert was identified as a potential barrier to fish passage in October 2007 as part of a Suscol Creek stream inventory conducted by the Napa County Resource Conservation District (Koehler and Edwards 2009). It was categorized as "gray" in the DFG Green-Gray-Red system because it is expected to be a partial barrier (impassable to juvenile steelhead and impassable to adult steelhead at low flows) due to lack of water depth in the culvert and excessive velocity.

Figure 2. View of upstream culvert inlet and wing-walls looking downstream.

Figure 3. View of box culvert extension and trapezoidal channel looking upstream.

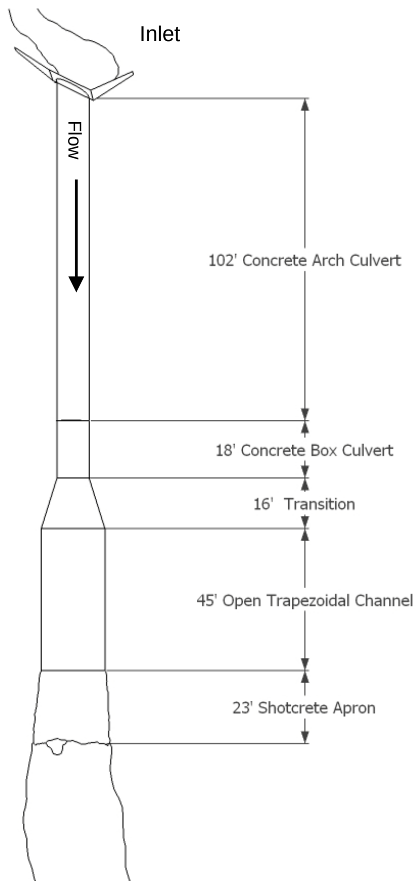


Figure 4. Suscol Creek site sketch (plan view) with measured dimensions in feet.

BARRIER ASSESSMENT

RCD evaluated fish-passage at the Highway 29 crossing in general accordance with *Part IX Fish Passage Evaluation at Stream Crossings* of the California Department of Fish and Game (DFG) Salmonid Stream Habitat Restoration Manual (DFG 2010). The assessment included a limit-of-anadromy analysis, a fish-passage inventory of the barrier site, a peak flow estimate, a culvert capacity analysis, and a fish-passage analysis.

Limit of Anadromy Analysis

RCD determined the amount of *O.mykiss* habitat located upstream of the barrier based on channel slope and existing survey data. A topographic profile of the mainstem of Suscol Creek generated from the LiDAR digital elevation model (DEM) showed a steady rise in slope that increases to over 8% at approximately 3.90 miles upstream of the Napa River (Figure 5).

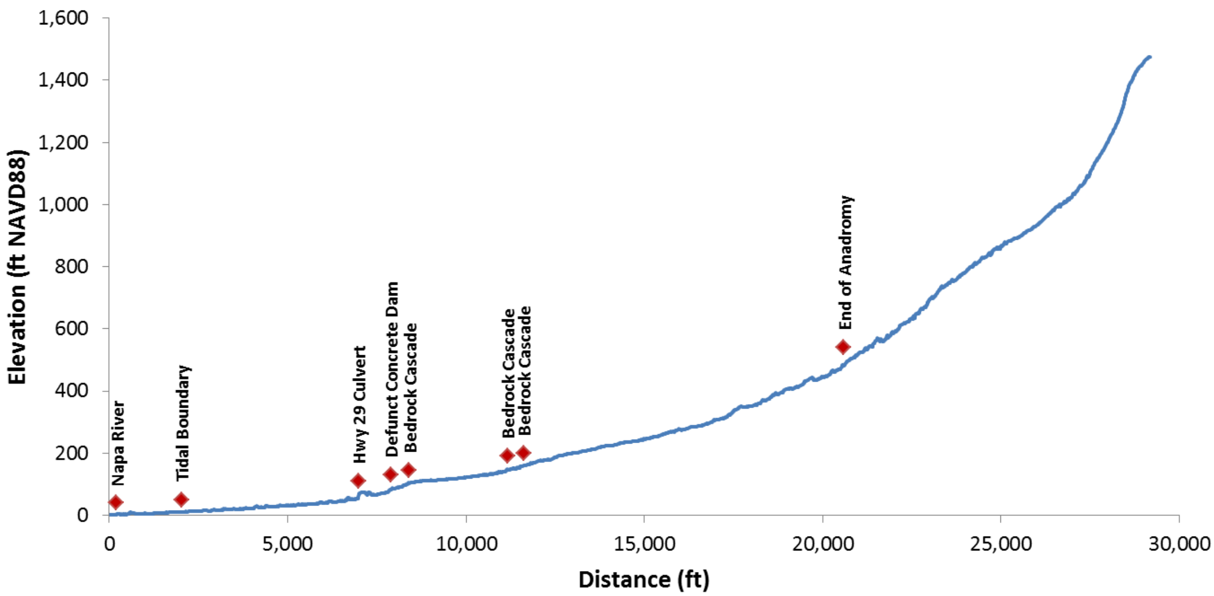


Figure 5. Suscol Creek LiDAR-derived longitudinal streambed profile with barrier locations.

Fish Passage Inventory

On September 3, 2009, RCD staff conducted a fish-passage inventory of the stream crossing including:

- Measurement of culvert dimensions;
- Longitudinal profile survey;
- Channel cross section survey;
- Site sketch; and,
- Completion of the DFG fish passage inventory data sheet.

The longitudinal profile survey was completed with tape and level and was surveyed relative to an arbitrary datum. It began 53 feet upstream of the culvert and continued through the culvert for 311 feet in the downstream direction and ended at the tailwater control. The survey captured the profile of the stream crossing, the upstream resting pool, and the tailwater pool (Figure 6). A cross section survey was completed at the tailwater control. The cross section was completed specifically for hydraulic analyses and did not include top of bank or overbank data.

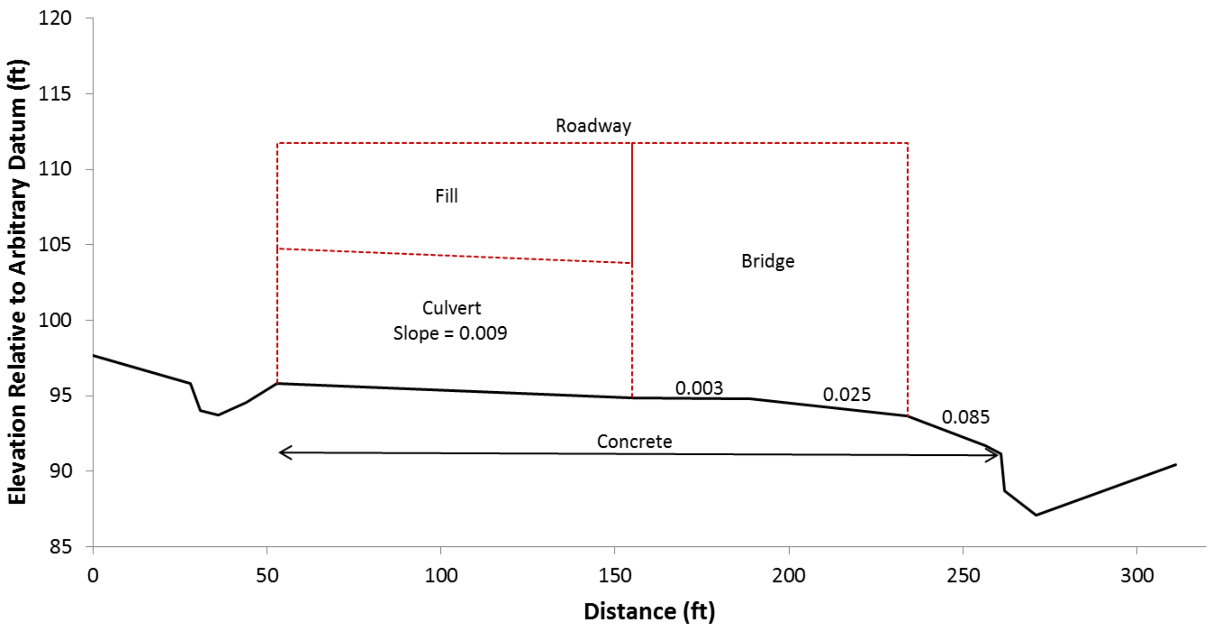


Figure 6. Surveyed longitudinal streambed profile.

Peak Flow Estimate

The Suscol Creek subwatershed is an ungaged basin. In order to evaluate culvert capacity it is necessary to estimate peak flows at the stream crossing. One way to estimate peak flows is to adjust the peak flow statistics for a nearby gaging station. The United States Geological Survey (USGS) operated retired Station 11458350 TULUCAY C A NAPA CA approximately 3.2 miles north of the barrier site on Tulucay Creek for 12 years from 1971 through 1983; however, they have not provided peak flow statistics. RCD assumes this is because the data are insufficient for such calculations. The nearest gaging station with a reasonably similar watershed area for which peak flow statistics are available is retired USGS Station 11458200 REDWOOD C NR NAPA CA, located approximately 6.7 miles northwest of the barrier site. Station 11458200 operated continuously for 15 years, from 1958 through 1973.

RCD calculated the 50% through the 1% annual exceedance probability flows (Q2, Q5, Q10, Q25, Q50, and Q100) in cubic feet per second (cfs) by adjusting the peak flow statistics for Station 11458200. The Q2 through Q100 calculated by USGS were obtained from water.usgs.gov/osw/streamstats. As suggested by USGS (USGS 1977), RCD adjusted the flow for the difference in drainage areas using the relation:

—

where Q_u and Q_g are the discharges at the ungaged and gaged sites, A_u and A_g are the drainage areas, and b is the exponent for the drainage area from the corresponding regional regression equation (USGS 1977).

For comparison, RCD also estimated peak flows for the site using the regional method. To perform this analysis, RCD used the National Streamflow Statistics (NSS) software developed by USGS (water.usgs.gov/software/NSS). The regional regression equations for the California North Coast Region use drainage area, mean annual precipitation, and an altitude index to estimate peak flows. Peak flow estimates are listed in Table 2.

Flow Event	Annual Exceedance Probability	Return Interval (yrs)	Peak Streamflow (cfs)		
			USGS 11458200	Suscol Creek at Highway 29 Culvert (Surrogate Method)	Suscol Creek at Highway 29 Culvert (Regional Equations)
Q2	0.5	2	1,200	391	146
Q5	0.2	5	1,310	433	220
Q10	0.1	10	1,360	455	286
Q25	0.04	25	1,420	481	359
Q50	0.02	50	1,460	494	429
Q100	0.01	100	1,500	508	476

Table 2. Peak streamflow estimates for Suscol Creek at Highway 29 culvert.

Culvert Flow Capacity

RCD performed an analysis of the culvert using the *HY-8 version 7.2* software developed by the Federal Highways Administration (FHWA). Culvert data, site data, tailwater data, and roadway data were collected in the field during the fish-passage inventory. Tailwater channel slope was measured in GIS from the LiDAR DEM. RCD analyzed the culvert's performance under the Q10 and Q100 flows for Suscol Creek (Table 2). In addition, RCD calculated the flow capacity at the top of the culvert inlet (headwater-to-diameter ratio equal to one). The results are presented in Table 3.

Event	Streamflow (cfs)	Headwater Elevation Relative to Arbitrary Datum (ft)
Q10	455	102.22
Q100	508	102.69
Top of culvert inlet	722	104.72

Table 3. Culvert flow capacity analysis results.

Fish Passage Analysis

The first-phase evaluation indicated that the stream crossing is a partial barrier, impassable to juvenile steelhead at all flows and impassable for adults at certain flows. To test this conclusion, RCD performed an analysis using *FishXing v3*, a program intended to assist engineers, hydrologists, and fish biologists in the evaluation and design of culverts for fish passage (http://www.stream.fs.fed.us/fishxing).

Upper and lower fish passage flows were estimated from surrogate data in accordance with DFG protocols. RCD selected the former USGS streamgaging station on Tulucay Creek as a surrogate because it is the nearest to Suscol Creek with at least 5 years of daily average flow data (12 years) and with a drainage area less than 50 square miles (12.5 square miles). Calculated fish passage flows were adjusted for Suscol Creek by multiplying them by the ratio of the two drainage areas. The calculated fish passage flows are presented in Table 1. The calculated fish passage flows are presented in Table 2.

Species/Lifestage	Upper Passage Flow (cfs)		Lower Passage Flow (cfs)	
Adult steelhead	50	1% Exceedance Flow	3	Alternate Minimum Flow
Juvenile steelhead	5.6	10% Exceedance Flow	1	Alternate Minimum Flow

Table 4. Calculated Fish Passage Flows

Swimming capabilities and minimum depth requirements for adult and juvenile steelhead were based on Table IX-6 of the DFG Manual. The results of the *FishXing* analysis are presented in Table 3

	Adult Steelhead	Juvenile Steelhead (>6”)	Juvenile Steelhead (<6”)
Percent of Flows Passable	0.0%	0.0 %	0.0 %
Passable Flow Range	None	None	None
Depth Barrier	All Flows	All Flows	All Flows
Leap Barriers*	None	2.83 cfs to 5.60 cfs	All Flows
Velocity Barrier – EB	12.38 cfs and above	4.28 cfs and above	1.0 cfs and above
Pool Depth Barrier	None	None	None

Table 5. Fish Passage Summary

*Simplification of the culvert geometry in *FishXing* altered leap barrier conditions at the site. See Discussion.

DISCUSSION

RCD estimated peak streamflows for the Highway 29 culvert at Suscol Creek using two methods. The first method adjusted the peak flow statistics for retired USGS Station 11458200 for the difference in drainage area. Although this is the preferred method in many cases where there is an appropriate surrogate gaging station nearby, it was not ideal in this case because Station 11458200, while less than seven miles away, is located on the opposite side of the valley in an area with different land cover and rainfall patterns. Therefore, RCD also computed peak flows using the regional flood-frequency equations for comparison. While widely used and accepted, it is the RCD’s experience that the regional equations often seem to underestimate peak flows in our area, when compared to other methods. In this case, the two methods produce widely varying results for the Q2 through Q25 flows, but are in agreement on the Q50 and Q100 flows. RCD believes this is due to the unusually small difference between the Q2 and Q100 for Station 11458200, which may be an effect of the short data record (15 years) or other site-specific issue. The agreement between the two methods in the Q100 gives us confidence in this result, and we selected the larger value (508 cfs). We have less confidence in the values estimated for the smaller peak flows, but we do think that the results of the surrogate method represent the high end of the possible range. Therefore, to be conservative, we selected 455 cfs as the Q10.

Comparison of the peak flow estimates to the culvert flow capacity analysis results indicates that the Highway 29 culvert at Suscol Creek will convey 722 cfs at the top of the culvert inlet. California Department of Transportation guidelines indicate that culverts should convey the Q10 "…without causing headwater elevation to rise above the inlet top of culvert," and the Q100 "…without damage to the facility or adjacent property" (Caltrans 2006). DFG states that "crossing structures should typically be designed to accommodate the 100-year flood event" (DFG 2009). Based on these guidelines, the culvert is oversized and may accommodate installation of internal or external energy dissipation structures or backwatering. This stream crossing is a candidate for a retrofit project.

The Highway 29 stream crossing at Suscol Creek is not a simple pipe, but an arch culvert, extended with a box culvert, and further extended with a long trapezoidal concrete channel and concrete apron on the downstream end. It varies in shape and slope along its length and is not easily modeled with the preliminary methods that were within the scope of this assessment. RCD simplified the geometry of the stream crossing for the fish passage assessment. The barrier was modeled as if the arch culvert section extended the full length of the barrier and was oriented at the average slope of the overall barrier. These simplifications should have the effect of making the culvert easier for fish to pass by increasing the water depth and decreasing the slope and velocity near the outlet.

The results of our analysis of the Highway 29 stream crossing at Suscol Creek indicate that it does not meet current fish passage requirements, and is not passable by steelhead at any life stage under any flow conditions. The analysis was based on conservative swimming capabilities and minimum depth requirements from the DFG guidelines. The analysis uses average velocities to determine passage, which may not account for hydraulic variation that may facilitate passage under specific flows. Given these assumptions, the barrier is likely passable by some unknown fraction of the steelhead population with stronger swimming capabilities at certain flows. However, DFG and NOAA Fisheries guidelines are designed to allow passage of all fish in the population, not just the strongest swimmers. Based on the results of this analysis, RCD re-categorized the stream crossing as a total barrier, "red" in the DFG Green-Gray-Red system.

The main obstacles for fish passage are lack of water depth in the culvert and high velocities at higher flows. The culvert is flat-bottomed and relatively wide, which promotes sheet flow (shallow, fast-moving water) during most low to moderate flows. In addition, the simplifications that were necessary to run the analysis eliminated the steep-slopes at the downstream end of the barrier which likely constitute a leap barrier for juveniles. This analysis did not adequately assess potential leap barriers at this site.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this analysis, the Highway 29 stream crossing at Suscol Creek is a candidate for a retrofit project that will improve passage conditions for upstream migration of steelhead, and open up an estimated 2.57 miles of moderate and high-quality steelhead habitat.

Mitigation options include:

1) Replace the existing culvert with an arch culvert or free-span bridge

2) Install concrete berm-type baffles on the existing apron to increase water depth and reduce velocities through the culvert

3) Replace the concrete floor of the culvert with a series of rock weirs

4) Install a series of rock weirs in the downstream channel to backwater the culvert

Implementing Option 1would provide full fish passage, but such an effort would likely be prohibitively expensive on its own. As future highway improvement projects are developed for this site by Caltrans, improving fish passage at this crossing should be an important consideration.

Option 2 would likely be the least expensive approach to reducing velocities and increasing depths through the culvert. However, it would need to be done in conjunction with Option 4 to address the jump height and velocity barrier leading into the culvert.

Option 3 would involve modifying the existing concrete apron in order to lower the grade and reduce or eliminate the outlet jump height. A structural/geotechnical analysis of the culvert would be required to assess whether removal of the concrete floor is viable. The exact configuration and dimensions of such modifications would need to be developed in collaboration with Caltrans to ensure highway safety standards are maintained.

Options 3 and 4 reduce the outlet jump by restoring the channel's natural slope beneath the roadway. In conjunction, these two options would decrease water velocities and increases water depths by increasing roughness and complexity of the streambed. The rock weirs may be able to provide scour protection for the structure as well.

Implementing Option 4 alone may enable fish passage by converting the one large jump into several smaller jumps downstream, while backwatering the culvert to reduce velocities and increase depths. Since the site is located on a State highway, Caltrans will need to make the final determination on which of the above options meet their structural engineering and safety criteria. Prior to design and construction, detailed channel surveying and hydraulic modeling should be performed to confirm the estimated culvert capacity, depths, and velocities, under current conditions. The model should also be used to test the retrofit design and assess post-project fish passage conditions.

CONCEPTUAL DESIGNS

Options 3 and 4:

Drawings by Carolyn M. Jones, PE, Natural Resource Conservation Service

REFERENCES

Napa County Resource Conservation District (NCRCD). 2009. Southern Napa River Watershed Restoration Plan. Funded by the California Department of Fish and Game, Fisheries Restoration Grant Program.

Hanson, Chuck. Caltrans. Telephone conversation with J. Koehler, NCRCD, December 2009, regarding migration barriers in Napa County.

WING CANYON CREEK DEFUNCT FLASHBOARD DAM

FISH-PASSAGE ASSESSMENT

Prepared for

California State Coastal Conservancy
Agreement No. 08-069

Prepared by

NAPA COUNTY RCD
Resource Conservation District

June 2011

STREAM DESCRIPTION

Wing Canyon Creek is a tributary of Dry Creek, which is a tributary of the Napa River, and ultimately the San Francisco Estuary. Wing Canyon Creek has approximately 4.8 miles of blue line stream, 1.0 mile of which is second order stream, according to the USGS Rutherford and Sonoma 7.5-minute quadrangle maps. The creek drains a watershed area of 1.50 square miles, with elevations ranging from approximately 450 feet above sea level at the mouth of the creek to 2,675 feet in the headwater areas. Mixed evergreen forest dominates the Wing Canyon Creek watershed with minor areas of deciduous forest, shrubland, vineyard, and rural residential development. The watershed is entirely privately owned and limited vehicle access exists via Mt. Veeder Road.

Oncorhynchus mykiss are present in the mainstem of Wing Canyon Creek, which offers high-quality spawning and rearing habitat for steelhead with perennial flow and frequent cool shaded pools (Koehler 2005). The extent of anadromy is located 1.14 miles upstream of the mouth at a natural falls (Figures 1 and 2).

Three barriers to upstream migration of steelhead have been identified on Wing Canyon Creek (Koehler 2005). The barriers are listed in Table 1 and shown on Figures 1 and 5.

Fish-Passage Barrier	Distance Upstream from Mouth (mi)	Max Upstream Habitat (mi)	Barrier Type	Status
Former Earthen Ford	0.32	0.82	Partial	Debris jam cleared in 2009, winter flows continue to restore natural bed slope
Defunct Flashboard Dam	**0.37**	**0.77**	**Partial**	**Under assessment**
Falls	1.14	0	Total	Natural feature

Table 1. Wing Canyon Creek fish-passage barriers.

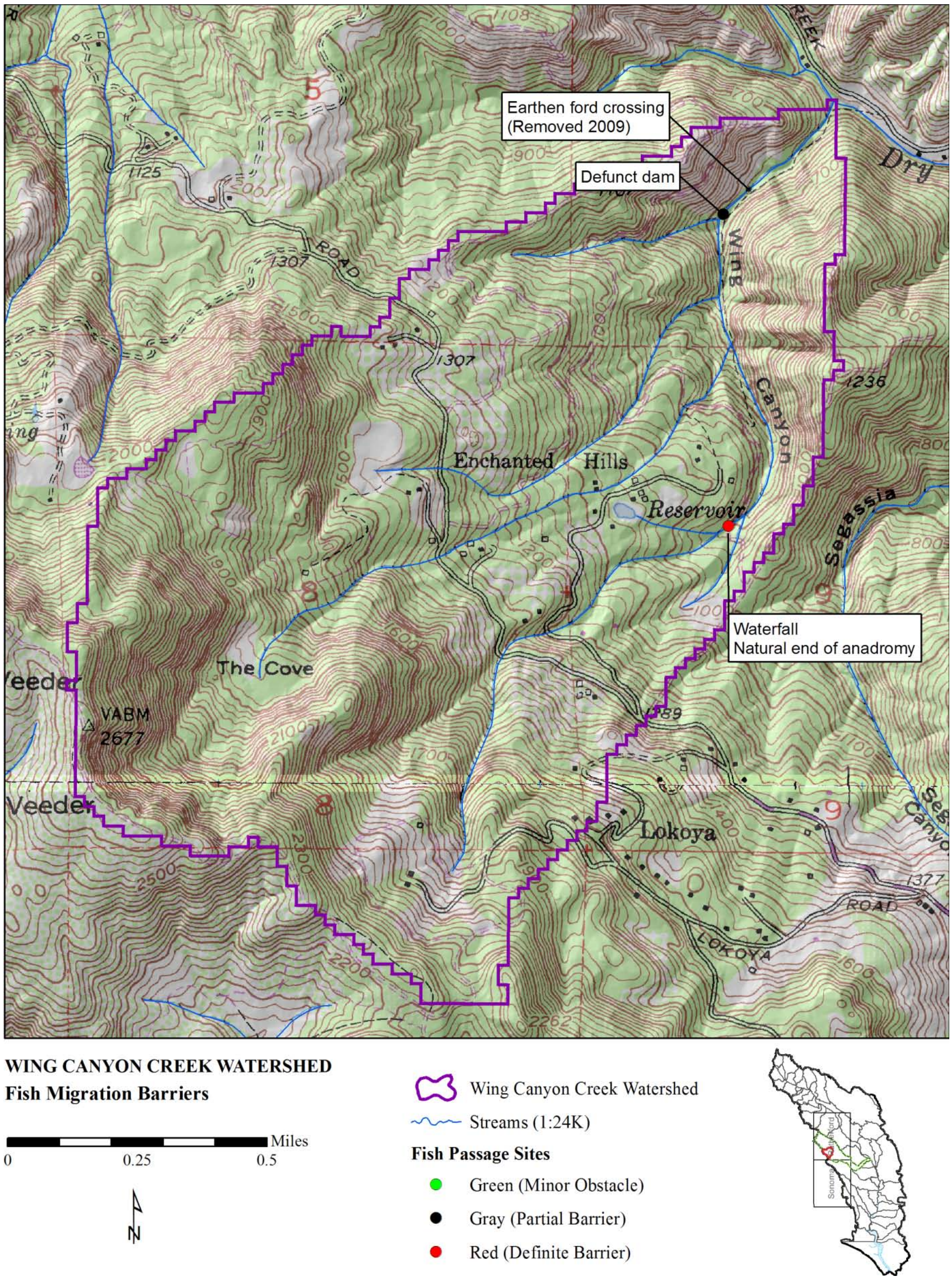


Figure 1. Wing Canyon Creek watershed and barrier locations.

BARRIER DESCRIPTION

The defunct flashboard dam on Wing Canyon Creek is a 6.2-foot tall dilapidated concrete dam with a 4.9-foot wide water channel in the center and was built atop a bedrock cascade (Figure 2). The dam is no longer in use, but flashboards could be installed in the water channel to impound water up to the crest of the dam. There is a low concrete sill across the bottom of the water channel that creates a low flow obstacle, and at higher flows the dam constricts the flow to increase velocity and perhaps downstream scour (Figure 3).

The defunct dam was identified as a potential barrier to fish passage in 2004 during a stream inventory completed by RCD (Koehler 2005). It was categorized as “gray” in the DFG Green-Gray-Red system because it is expected to be a partial barrier (impassable to adult and juvenile steelhead at certain flows) due to excessive velocity and insufficient jump pool depth.

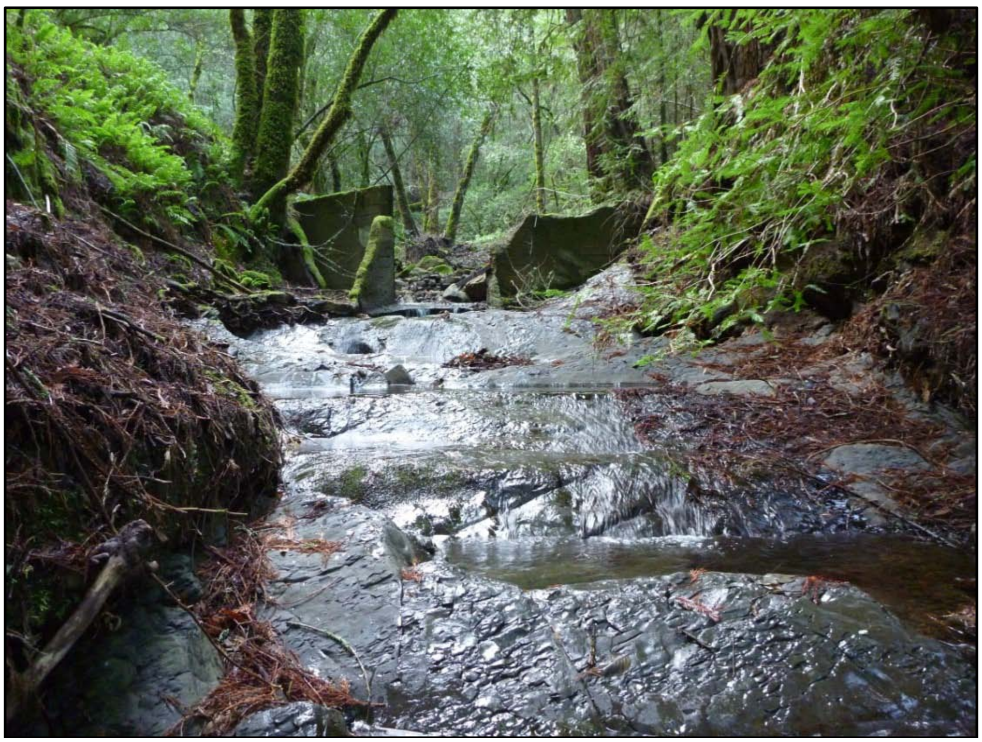


Figure 2. Looking upstream at the defunct flashboard dam and bedrock cascade under winter low flow conditions.

Figure 3. Defunct flashboard dam during a winter storm.

BARRIER ASSESSMENT

RCD evaluated fish-passage at the defunct dam in general accordance with *Part IX Fish Passage Evaluation at Stream Crossings* of the California Department of Fish and Game (DFG) Salmonid Stream Habitat Restoration Manual (DFG 2010). The assessment included a limit-of-anadromy analysis and a fish-passage inventory.

Limit-of-Anadromy Analysis

RCD evaluated the amount of *O.mykiss* habitat located upstream of the barrier based on slope and existing survey reports. A topographic profile of Wing Canyon Creek was generated from the LiDAR digital elevation model (DEM) to graphically depict known barriers along the length of the stream (Figure 5).

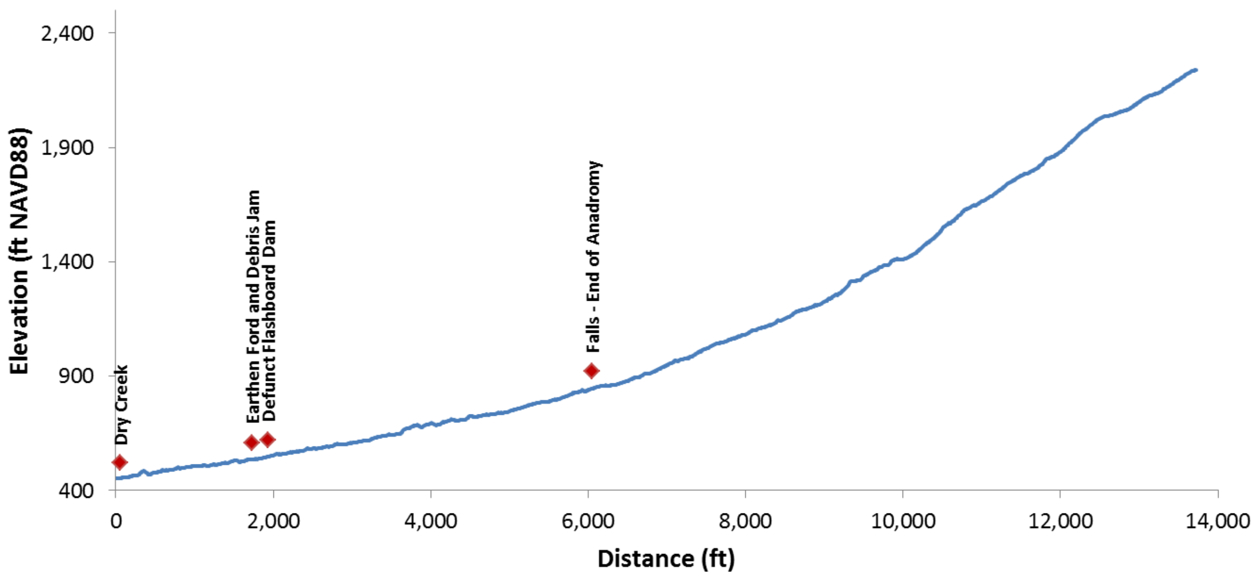


Figure 5. Wing Canyon Creek LiDAR-derived longitudinal streambed profile with barrier locations.

Fish-Passage Inventory

On January 7, 2010, Jonathan Koehler (RCD) and Paul Blank (RCD) conducted a fish-passage inventory of the defunct dam including:

- Measurement of structure dimensions; and,
- Longitudinal profile survey.

The longitudinal profile survey was completed with tape and level and was surveyed relative to an arbitrary datum. It began 300 feet upstream of the defunct flashboard dam and continued for 881 feet in the downstream direction to approximately 180 feet downstream of the earthen ford and debris jam. The survey captured the profiles of the barriers, the upstream resting pools, the downstream channel, and the overall slope of the reach (Figure 6). Channel cross sections were not surveyed.

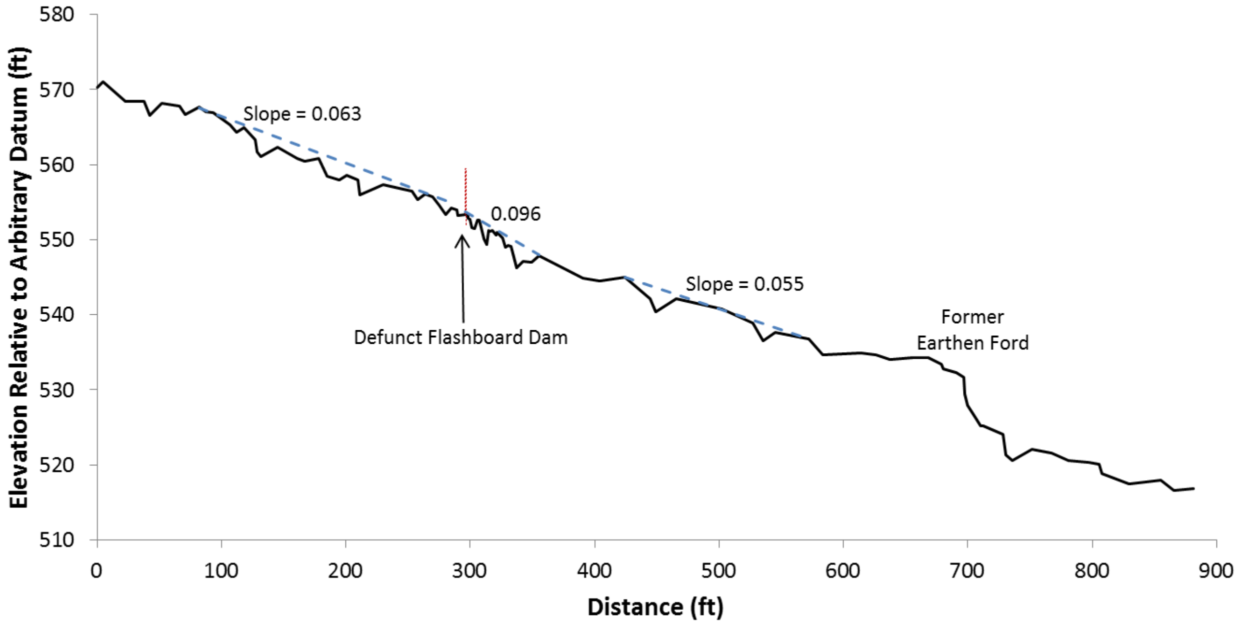


Figure 6. Surveyed longitudinal streambed profile.

DISCUSSION

Due to its irregular shape and configuration, this site was not able to be hydraulically assessed with simple modeling software. However, based on field observations and measurements the existing structure is clearly an impediment to migrating steelhead under some flow conditions. Additional hydraulic modeling might provide more specific information on the severity of the impediment; however, RCD does not think the cost of such an analysis is warranted given the relatively low expected cost of addressing anthropogenic fish-passage issues at this site.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this assessment, the defunct flashboard dam on Wing Canyon Creek is a partial barrier to upstream passage of adult and juvenile steelhead.

Mitigation options include:

1) Allowing natural stream processes to continue erosion of the structure

2) Demolition of all components of the dam and removal (and/or transportation and landfill disposal) of concrete rubble from the stream channel

The defunct dam has sustained damage from past high flows and impacts from large floating debris. Over time these same processes can be expected to continue, which can be expected to increase the width of the water channel and decrease water velocities. Eventually, the low concrete sill can be expected to fail which will reduce the required leap. Since the dam is not expected to be a total barrier or a high-priority in the overall watershed, Option 1 may be warranted.

Implementation of Option 2 can be expected to improve fish passage and increase steelhead access to, and use of, the 0.77 miles of habitat upstream of the barrier site. Due to the small size of the structure, the costs associated with implementing Option 2 are expected to be relatively low. Therefore, RCD recommends implementation of Option 2. Vehicle access should be explored during planning, but given the remoteness of the site, this project may be a candidate for use of volunteer labor with hand tools.

REFERENCES

California Department of Fish and Game (DFG). 2010. Edition. California Salmonid Stream Habitat Restoration Manual. 4th Edition.

Koehler, J. 2005. Central Napa River Watershed Project: *Salmonid Habitat Form and Function.* Napa County Resource Conservation District (NCRCD). Funded by the California Department of Fish and Game, Fisheries Restoration Grant Program.

NMFS 2001. Guidelines for Salmonid Passage at Stream Crossings. National Marine Fisheries Service Southwest Region. Santa Rosa, California.

WING CANYON EARTHEN FORD AND DEBRIS JAM

FISH-PASSAGE BARRIER REMOVAL

Prepared for

California State Coastal Conservancy
Agreement No. 08-069

Prepared by

NAPA COUNTY RCD Resource Conservation District

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STREAM DESCRIPTION

Wing Canyon Creek is a tributary of Dry Creek, which is a tributary of the Napa River, and ultimately the San Francisco Estuary. Wing Canyon Creek has approximately 4.8 miles of blue line stream, 1.0 mile of which is second order stream, according to the USGS Rutherford and Sonoma 7.5-minute quadrangle maps. The creek drains a watershed area of 1.50 square miles, with elevations ranging from approximately 450 feet above sea level at the mouth of the creek to 2,675 feet in the headwater areas. Mixed evergreen forest dominates the Wing Canyon Creek watershed with minor areas of deciduous forest, shrubland, vineyard, and rural residential development. The watershed is entirely privately owned and limited vehicle access exists via Mt. Veeder Road.

Oncorhynchus mykiss are present in the mainstem of Wing Canyon Creek, which offers high-quality spawning and rearing habitat for steelhead with perennial flow and frequent cool shaded pools (Koehler 2005). The extent of anadromy is located 1.14 miles upstream of the mouth at a natural falls (Figures 1 and 2).

Three barriers to upstream migration of steelhead have been identified on Wing Canyon Creek (Koehler 2005). The barriers are listed in Table 1 and shown on Figures 1 and 2.

Fish-Passage Barrier	Distance Upstream from Mouth (mi)	Max Upstream Habitat (mi)	Barrier Type	Status
Former Earthen Ford	**0.32**	**0.82**	**Partial**	**Debris jam cleared in 2009, winter flows continue to restore natural bed slope**
Defunct Flashboard Dam	0.37	0.77	Partial	Under assessment
Falls	1.14	0	Total	Natural feature

Table 1. Wing Canyon Creek fish-passage barriers.

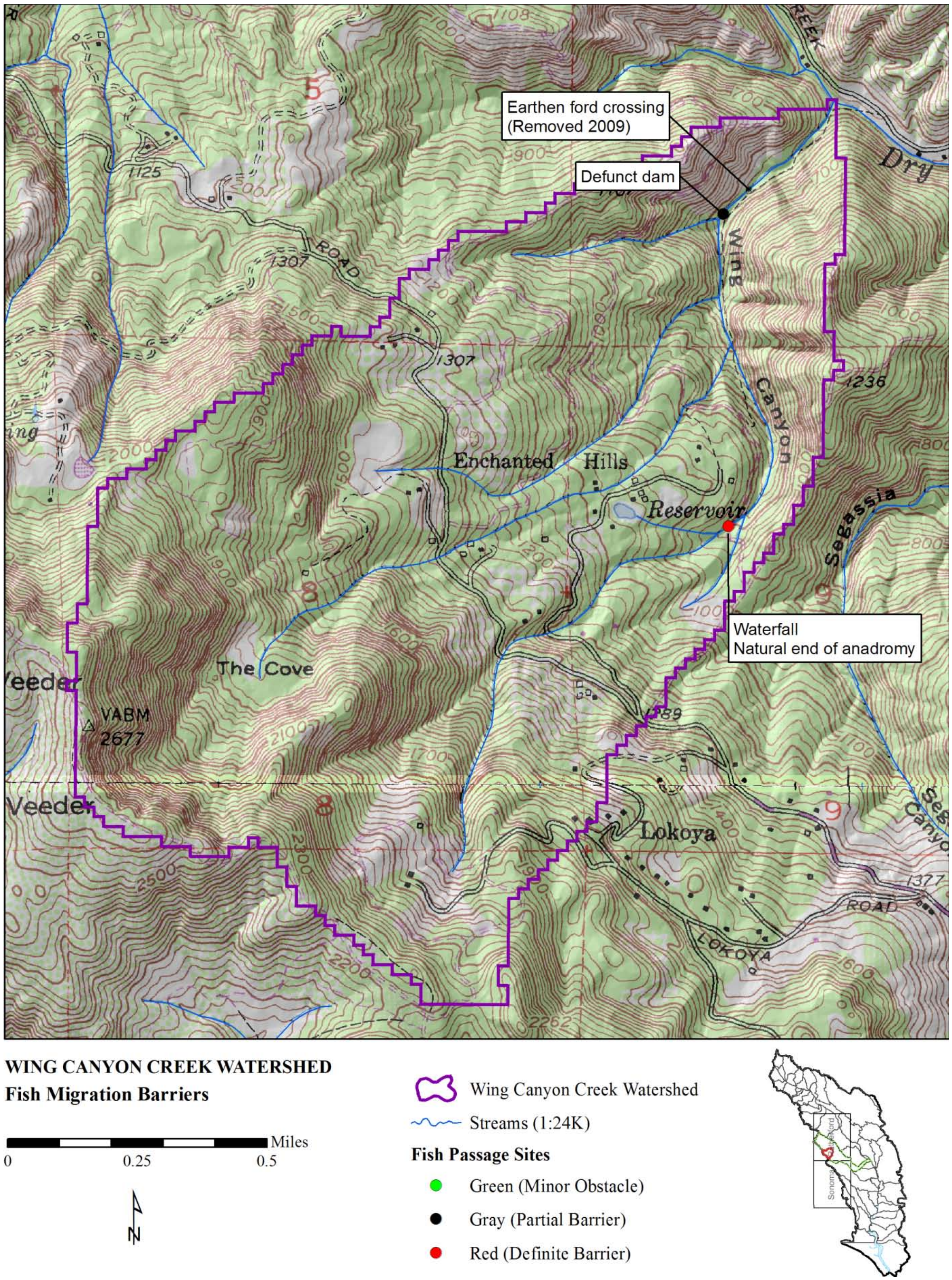

Figure 1. Wing Canyon Creek watershed and barrier locations.

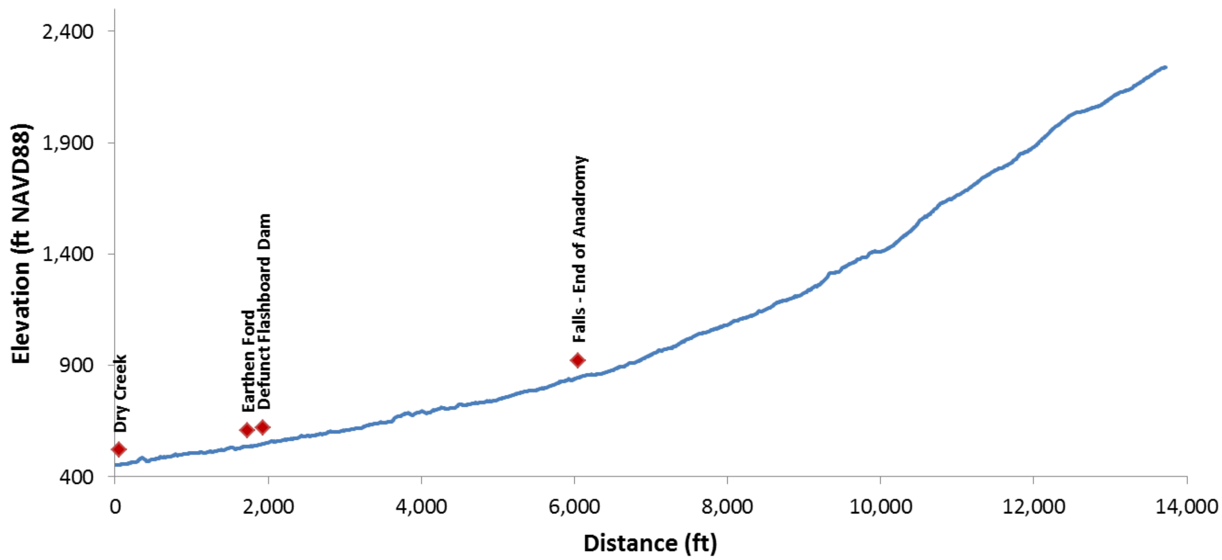

Figure 2. Wing Canyon Creek DEM-derived longitudinal streambed profile with barrier locations.

BARRIER DESCRIPTION

The former earthen ford on Wing Canyon Creek was the crossing of a currently unused and unmaintained dirt road. The ford appears to have been built across a natural accumulation of sediment behind a debris jam and was held in place by a fallen redwood tree and a few boulders that created an approximate 6-foot falls.

Figure 3. Looking downstream from the earthen ford under summer flow conditions prior to clearing of the debris jam.

BARRIER IMPROVEMENT

On September 23, 2009, RCD, with assistance from the Napa County Flood Control and Water Conservation District (Flood District) and volunteers from Napa River Steelhead (a local non-profit club), cleared the debris jam at the earthen ford barrier site. The work was performed under the Flood District's California Department of Fish and Game (DFG) stream maintenance permit for Napa County and with permission from the landowner. The purpose of the work was to improve fish passage by selectively repositioning accumulated woody debris and allowing stream processes to re-mobilize trapped gravel and restore the original bed slope.

Small woody debris associated with the jam was moved downstream to the margins of the channel. The major element of the jam was a fallen 24-inch (approx.) diameter redwood tree trunk that was cut and moved downstream and parallel to the channel at the toe of the right bank. Photographs of the barrier during the work are shown in Figures 4 through 6. No material was removed from the active channel.

Figure 4. View of the barrier site looking across Wing Canyon Creek toward the left bank, prior to clearing of redwood trunk. September 23, 2009.

Figure 5. Cutting and re-positioning of the redwood trunk. September 23, 2009.

Figure 6. Debris jam cleared. September 23, 2009.

STREAMBED MONITORING

On January 7, 2010, after the first winter storm flows, Jonathan Koehler (RCD) and Paul Blank (RCD) returned to the site and completed a longitudinal profile survey of Wing Canyon Creek beginning approximately 300 feet upstream of the defunct flashboard dam barrier site and continuing in the downstream direction for 881 feet to approximately 180 feet downstream of the former earthen ford barrier. The survey was completed with tape and level and was surveyed relative to an arbitrary datum. The survey captured barrier profiles and streambed slopes and is presented as Figure 7. A photograph taken of the former earthen ford site at this time is included as Figure 8.

On April 9, 2010, after the winter storm flow season, RCD returned to the site and re-surveyed the longitudinal profile in the vicinity of the earthen ford barrier relative to the same datum as the January survey. The profile is included on Figure 9. Photographs of the former earthen ford site at this time are included as Figures 10 and 11.

On March 2, 2011, RCD returned to the site to observe the former earthen ford barrier site under winter storm flow conditions (Figure 12).

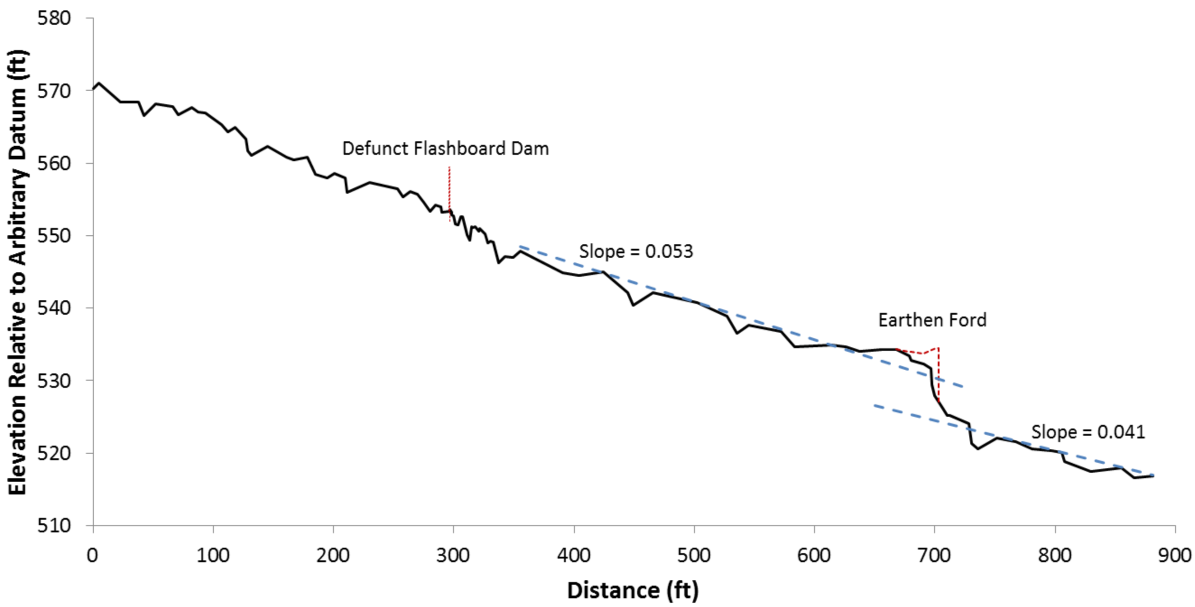

Figure 7. Surveyed longitudinal streambed profile. January 7, 2010. Estimated profile of earthen ford prior to debris jam removal is shown in red.

Figure 8. Looking upstream at earthen ford barrier after the first winter storm. A channel is beginning to form through the ford. January 7, 2010.

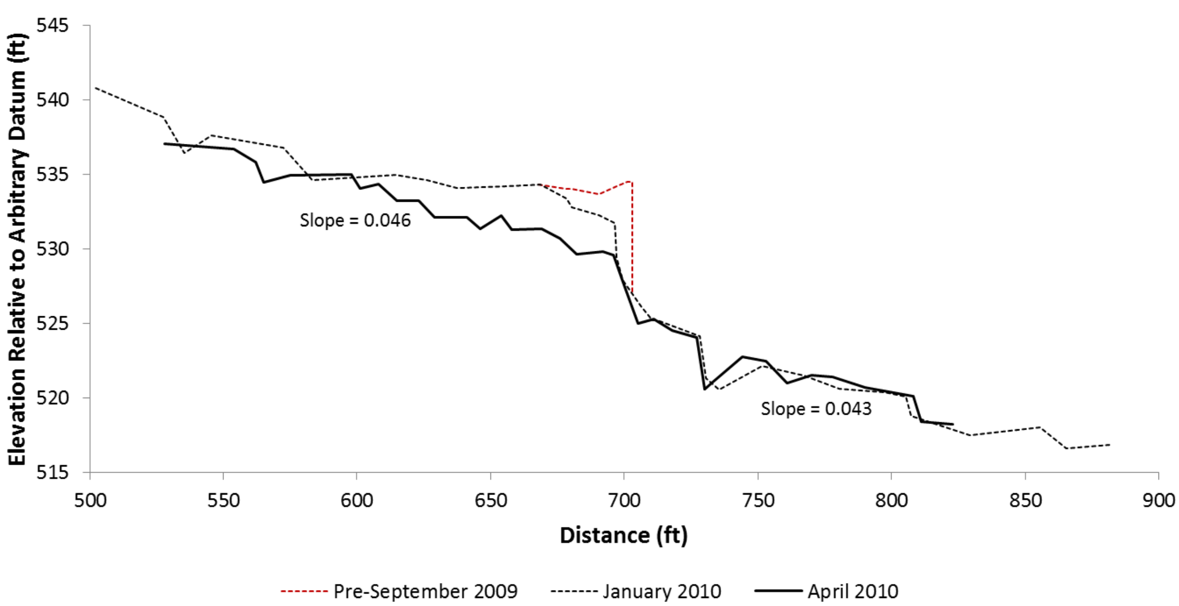

Figure 9. Surveyed longitudinal profiles in the vicinity of the earthen ford. January 7, 2010, and April 9, 2010.

Figure 10. Looking upstream at earthen ford barrier after first winter season. Channel has formed through the ford. April 9, 2010.

Figure 11. Looking across the earthen ford toward the right bank. Downcutting of channel through trapped gravels.

Figure 12. Former earthen ford barrier site under typical winter high flow. March 2, 2011.

DISCUSSION

Based on comparison of the January 7, 2010 and April 9, 2010 survey data, the channel has downcut approximately 3 feet through the accumulated gravel that was trapped behind the debris flow. This decrease along with removal of the large redwood trunk has reduced the height of the barrier by over 4 feet. In addition, rearrangement of boulders underlying the debris jam by storm water has caused water to cascade down the barrier as opposed to falling over the redwood trunk. These changes make the obstacle much easier for steelhead to negotiate.

CONCLUSIONS AND RECOMMENDATIONS

Though the former earthen ford remains an obstacle for fish passage, removal of the debris jam has allowed natural stream processes to reduce the height of the barrier and greatly improve passage conditions. Future high flows will continue to mobilize accumulated sediment that was trapped behind the debris jam and rearrange the boulder cascade to decrease slope and leap height for steelhead. RCD does not recommend further action.

REFERENCES

Koehler, J. October 2005. *Central Napa River Watershed Project*. Napa County Resource Conservation District. Prepared for the State of California Department of Fish and Game, SB271 Salmonid Restoration Grant Program.