Milliken Creek
Steelhead Habitat Modeling and Instream Flow Study

Prepared by:

NAPA COUNTY RESOURCE CONSERVATION DISTRICT

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1. Introduction

The Napa County Resource Conservation District (RCD) received funding to conduct an instream flow study of Milliken Creek. This study was intended to focus on periods of low flow (less than 20 cubic feet per second [cfs]), which is representative of conditions in spring, summer, and early fall. The goal of this project was to provide greater scientific understanding about the relationships between water use, stream flow, and fish habitat by utilizing a physical habitat model approach.

The Napa River watershed historically supported three salmonid species: steelhead (*Oncorhynchus mykiss*), Chinook salmon (*Oncorhynchus tshawytscha*), and coho salmon (*Oncorhynchus kisutch*). There has been a significant decline in the distribution and abundance of steelhead in the Napa River and its tributaries since the late 1940s (USFWS 1968; Anderson 1969; Leidy et al. 2005). The U.S. Fish and Wildlife Service (1968) estimates that the Napa River watershed once supported runs of 6,000–8,000 steelhead, and 2,000–4,000 coho salmon, and that by the late 1960s, coho salmon were extinct in the watershed, and the steelhead run had reduced to about 1,000 adults. Napa River steelhead belong to the Central California Coast Steelhead Distinct Population Segment (DPS), which was listed as a threatened species under the Federal Endangered Species Act in August 1997.

Human uses of water have been identified as a potential cause of reduction in springtime baseflow, leading to more rapid drying of the lower reaches of tributaries, and causing poor flow persistence over riffles. It has been hypothesized that these changes in stream conditions are exerting a significant influence on steelhead run size in the Napa River watershed (Stillwater Sciences, 2002; Stillwater Sciences, 2007). Reduced stream flow may impact steelhead habitat in two ways: it may reduce food availability for juveniles, thus limiting size at outmigration (which subsequently reduces survival during early ocean occupancy) and/or it may reduce the window of opportunity for steelhead to outmigrate in the spring, thus leaving steelhead either stranded in isolated pools or subject to mortality due to unsuitable dry season conditions.

Milliken Creek is known to support steelhead spawning and rearing (RCD 2009, Leidy et al. 2005). Occasionally, Chinook salmon are also sighted spawning in Milliken Creek (Koehler, pers. obs. 2006); however it is not known how common this is. Based on stream morphology, Chinook would be expected to be limited to the lower gradient reaches of Milliken Creek below Westgate Drive with occasional strays occurring higher in the watershed in favorable hydrologic years. Due to the inconsistent presence of Chinook in Milliken Creek, this study focused solely on the life history requirements of juvenile steelhead.

Prior to this study, the Napa RCD conducted a habitat survey of the entire length of Milliken Creek in the summer of 2007 as part of a larger assessment effort funded by the California Department of Fish and Game (RCD 2009). The 2007 survey identified a total of 5.01 miles of potential steelhead habitat between the Napa River and the upper limit of anadromy, which is located at a natural bedrock falls approximately 1.7 miles upstream of our study reach.

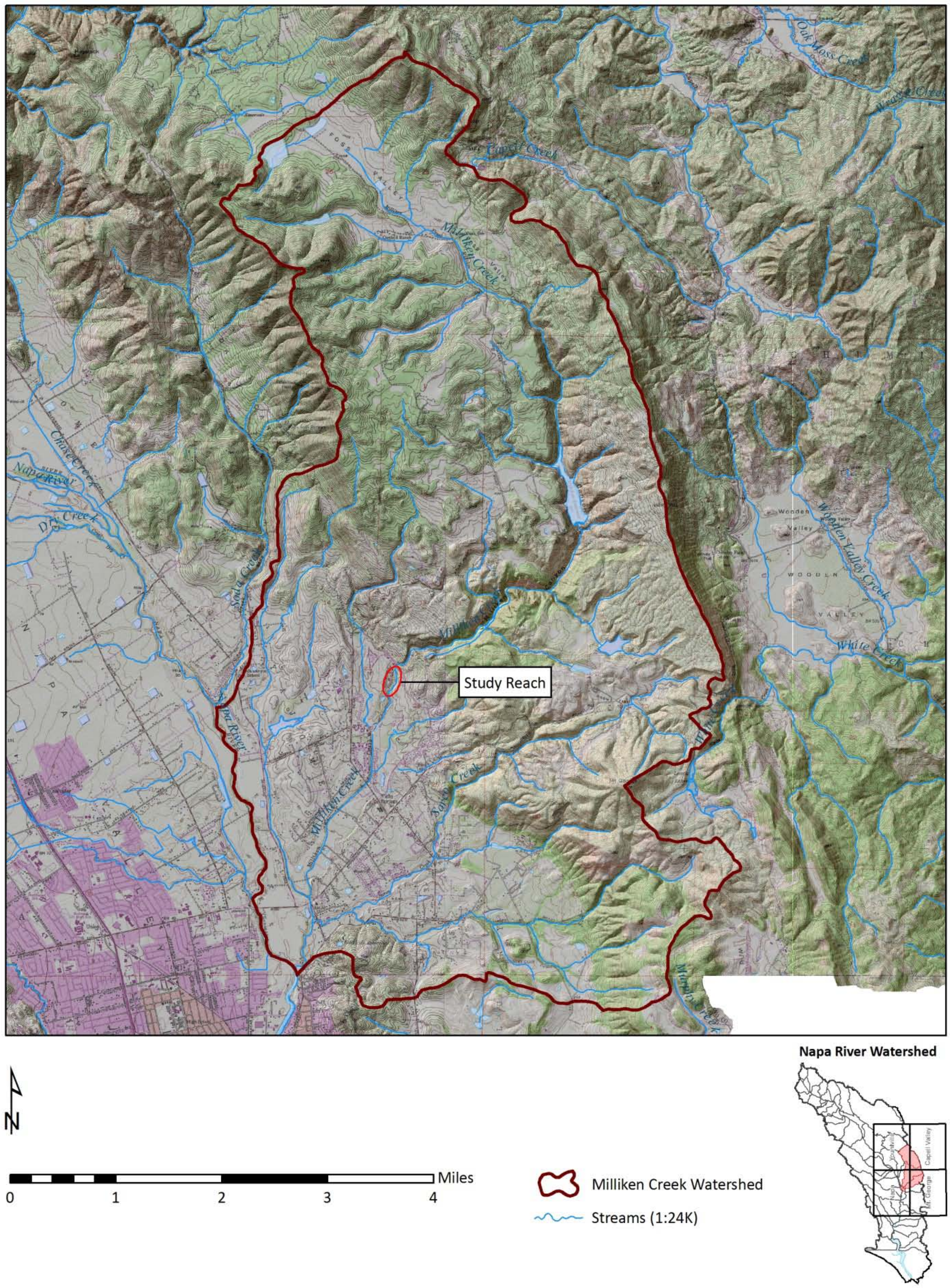

Figure 1. Milliken Creek watershed map

2. Physical Habitat Model

The Physical Habitat Simulation System (PHABSIM) model was developed by the US Fish and Wildlife Service, US Geological Survey, and other agencies to examine stream flow management issues as part of the Instream Flow Incremental Methodology (IFIM). PHABSIM predicts physical microhabitat changes associated with flow alterations such as a reduction in stream flow. It also provides a variety of simulation tools, which characterize the physical microhabitat structure of a stream and describe the flow-dependent characteristics of physical habitat relative to selected target species and life stages. When interpreting PHABSIM results, an assumption is normally made that flow-dependent habitats are useful in determining carrying capacity and therefore are related to the instream flow needs for fish or other aquatic organisms in streams (USGS, 2001).

For this project, we used PHABSIM to simulate habitat conditions for juvenile steelhead during low flow conditions that are typical of tributary streams throughout the Napa River watershed in spring and early summer. Based on historical flow records, we determined that flows between zero and 20 cfs were an appropriate range to characterize this period. The spring season (approximately March through July) has been identified as an important period for juvenile steelhead growth as well as smolt outmigration (Stillwater Sciences, 2007; Koehler, 2009). The results of the PHABSIM model were intended to identify important flow thresholds for juvenile steelhead during this critical period and ultimately help inform water management strategies within the Milliken Creek watershed.

3. Study Reach

A total of twelve transects were established in the Milliken Creek study reach, which began at Westgate Drive and extended approximately 1,258 feet downstream (Figure 2). The watershed area above the study reach is approximately 13.8 square miles.

Transect locations were determined by using existing habitat data to stratify the study reach into three major habitat types: pools, riffles, and runs. Four transects were placed in run habitat types, four were placed in riffle habitat types, and four were placed in pool habitat types. Beginning at the upstream end of the reach (Westgate Drive), we proceeded downstream until we encountered each habitat type. To minimize placement bias, we measured the full length of each potential unit and used a random number generator to locate a potential transect location within the unit. Exact transect locations were placed as close to these randomly selected points as possible while still allowing for collection of high quality flow measurements. Each transect was surveyed using a theodolite and stadia rod according to the methodology outlined in the PHABSIM User's Manual (USGS, 2001).

The study reach was selected for several reasons: 1. it was identified as flow-limited during previous habitat typing surveys, 2. it is located at the point where the channel transitions from canyon to alluvial fan, and 3. it is a representative stretch of Milliken Creek on the valley floor where water diversions are likely to take place in spring and summer. Habitat conditions upstream of the study reach are significantly different in regards to channel slope, substrate, width-to-depth ratio, and channel-type (RCD 2009). Therefore, the results of this model can be reasonably applied to the channel for some distance downstream of our study reach, perhaps past Atlas Peak Road, but we would caution against the use of these modeling results to characterize the upstream canyon reaches.

4. Model Input

We measured water surface levels (WSL) with a theodolite and stadia rod at all transects at the three target flows listed in Table 1. Water velocities were measured during the medium flow using the six-tenths depth method and USGS-style Price pygmy current meters and wading equipment. In addition, a stream discharge measurement was collected during each of the three field visits at a location deemed most suitable by the project hydrologist. This measurement was not necessarily taken on one of the transects.

Date	Discharge (cfs)	WSL Measured	Velocities Measured
May 19, 2010	2.32	Yes	No
May 4, 2010	4.91	Yes	Yes
April 21, 2010	14.90	Yes	No

Table 1. Summary of PHABSIM field measurements on Milliken Creek

There are several published juvenile steelhead Habitat Suitability Criteria (HSC) curves for water velocity and depth. We selected the Bovee 1978 HSC curves for juvenile steelhead based on extensive literature review, consultation with Stillwater Sciences, and experience with previous modeling efforts. Overall, we felt the two curves developed by the Bovee 1978 study were most appropriate for our analysis because of similarities in watershed areas, stream size, and target species. Both curves are shown in Appendix B.

In addition to the three calibration flows listed in Table 1, the PHABSIM model was setup to run simulations for 0.5, 1.0, 10.0, and 20.0 cfs to completely bracket the target flow range. Based on a recommendation by DFG, simulations of 30 and 40 cfs were also run to give insight into habitat conditions at higher flows. These simulations, however, extrapolate the model beyond the tops of several transects.

Figure 2. Milliken Creek PHABSIM study reach (P = pool, R = riffle, N = run)

5. Model Calibration

The STGQ option was selected to model WSLs because we did not intend to extrapolate the model very far from the calibration data. The STGQ model predicted WSLs in close agreement with observed data as shown in Table 2, and did not require calibration. The velocity model was calibrated by comparing simulated and observed results for the 4.91 cfs flow. Plots of simulated velocity were visually analyzed for consistency. Manning's N values for particular stations along transects with poor agreement between simulated and observed values were adjusted manually to minimize differences, as described in the PHABSIM users manual.

X-sec ID	2.32 (obs)	2.32 (sim)	diff (ft)	4.90 (obs)	4.90(sim)	diff (ft)	14.90 (obs)	14.90 (sim)	diff (ft)
0	67.070	67.071	0.001	67.190	67.188	-0.002	67.440	67.441	0.001
193	69.210	69.205	-0.005	69.400	69.410	0.010	69.870	69.864	-0.006
524	70.110	70.100	-0.010	70.230	70.250	0.020	70.610	70.598	-0.012
618	71.950	71.950	0.000	72.170	72.171	0.001	72.610	72.610	0.000
675	72.580	72.581	0.001	72.860	72.857	-0.003	73.480	73.482	0.002
781	75.250	75.240	-0.010	75.410	75.432	0.022	75.900	75.887	-0.013
872	77.500	77.508	0.008	77.660	77.639	-0.021	77.880	77.893	0.013
1010	78.720	78.717	-0.003	78.870	78.877	0.007	79.250	79.245	-0.005
1094	79.080	79.084	0.004	79.220	79.210	-0.010	79.440	79.446	0.006
1204	79.930	79.933	0.003	80.100	80.094	-0.006	80.420	80.423	0.003
1229	80.370	80.364	-0.006	80.480	80.491	0.011	80.750	80.744	-0.006
1258	80.420	80.412	-0.008	80.550	80.565	0.015	80.880	80.872	-0.008

Table 2. Milliken Creek PHABSIM model calibration results showing observed (obs) and simulated (sim) water surface levels and the difference between the two values (diff) at all nine transects. All values are in feet.

6. Results and Discussion

The Milliken Creek PHABSIM model results are shown in the form of a Weighted Usable Area (WUA) curve. The model produces quantitative estimates of total habitat area over the full range of flows, however it is generally considered more accurate to assess the shape of the WUA curve rather than the specific numeric results. In light of this, we analyzed the WUA curve for breaks in slope, which are believed to represent flow thresholds for juvenile steelhead.

PHABSIM model results suggest there is at least one distinct low-flow threshold for juvenile steelhead rearing habitat. This is apparent at approximately five cfs, where the WUA curve is steepest (Figure 3). The model predicts that the amount of juvenile steelhead rearing habitat continues to increase sharply until approximately 10 cfs, where there is a more subtle break in slope. Above 10 cfs, the amount of additional juvenile steelhead habitat gained gradually flattens out as flows increase, eventually leveling off at flows above approximately 40 cfs. Although the amount of juvenile steelhead habitat does not appear to increase as sharply at higher flows, it should be noted that higher flows are important for maintaining and creating habitat complexity as well as supporting adult fish passage and spawning.

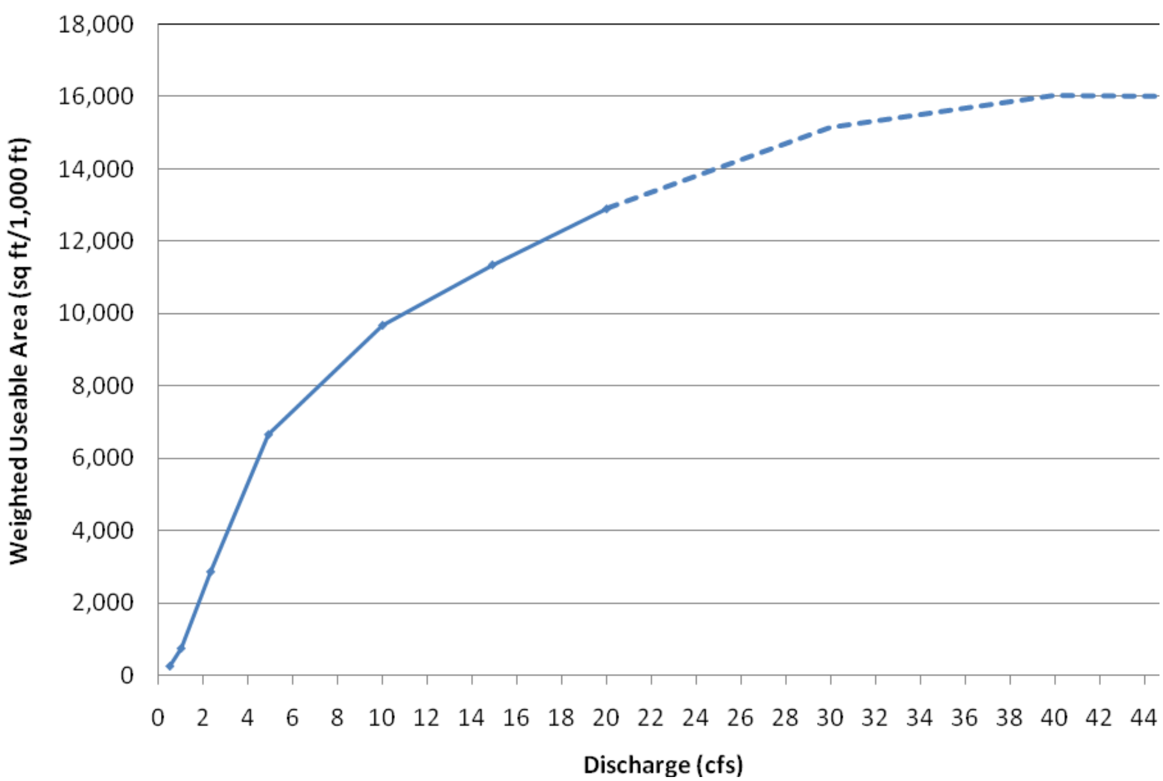

Figure 3. Weighted usable area (WUA) results from the Milliken Creek PHABSIM model for juvenile steelhead. Note: the dashed portion of the line depicts results that extend well beyond the model's calibration dataset and should be interpreted with this limitation in mind.

Based on our PHABSIM results, a critical threshold appears to exist at approximately five cfs, where the rate of habitat value gain/loss is steepest. We would expect that any reductions in streamflow under such low-flow conditions would have a disproportionately large negative effect on steelhead habitat.

7. Conclusions

1. In our study reach of Milliken Creek, we found five cfs to be a distinct flow threshold for juvenile steelhead habitat. Any water diversions occurring while the stream is flowing at or below five cfs are likely to substantially reduce the amount of habitat available to juvenile steelhead.

2. Juvenile steelhead habitat was gained up to a maximum flow of approximately 40 cfs. Flows above this magnitude would not be expected to improve conditions for juvenile steelhead. However, higher flows are beneficial for a variety of other reasons not directly investigated in this study, including maintaining adequate depth for adult passage and spawning, as well as helping to maintain habitat complexity.

Acknowledgments

NCRCD is grateful to the private landowners that granted us access to their properties for the duration of this study. We would also like to thank Kirk Candland (Silverado Resort) and Tyler York for their cooperation with this study. The California Department of Fish and Game, specifically Bob Hughes and Corinne Gray provided valuable technical review for this project.

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Appendices

A. Site Photos

Milliken Creek, 2.32 cfs, 5/19/2010

Milliken Creek, 4.91 cfs, 5/4/2010


Milliken Creek, 14.90 cfs, 4/21/2010

B. Habitat Suitability Criteria Curves

Both curves are based on data from Bovee, 1978