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Carmel River Reroute and Dam Removal Fish Passage Assessment (Spring 2023)

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Executive Summary

San Clemente Dam was removed in 2015 to improve opportunities for *Oncorhynchus mykiss* spawning in the Carmel River. A new river channel was constructed to bypass the dam site in 2015. The constructed river included a low-gradient riffle-pool channel upstream from the confluence of San Clemente Creek and a more complex channel downstream from the confluence. The downstream reach included step-pool sequences separated by longer pools and boulder-rich plane bed reaches. The upstream reach has remained relatively stable, while the downstream reach experienced significant reorganization in high flows of 2017.

A five-year monitoring project was initiated to evaluate the constructed river for barriers to *O. mykiss* migration. The identification of potential barriers was based upon the occurrence of shallow flow and/or difficult jumps. Previous reports documented conditions in 2018, 2019 and 2020. This report is for the fifth year of the project.

The fifth year of monitoring occurred on May 30 and May 31, 2023 in approximately 70 cfs flow. All barriers described in previous reports were passable at this flow, except for two sites where riffle crests were below the one-foot depth criteria. The two site descriptions include the location, photos and geometry of the potential barrier and total station surveys. The shallow conditions at the riffle crest extend for 35 and 48 feet parallel to flow. Despite these two shallow riffles, we believe a healthy adult steelhead would be able to transit the entire constructed river at 70 cfs.

The river site continued to evolve during the high flows of 2023. The number of potential migration barriers has diminished from five to two since the 2020 survey. While this result may be in part due to an additional 10 cfs during the 2023 survey, we note that the improvement is also clearly the result of local geomorphic change and riparian forest growth. For example, a reach that had been very wide and shallow has narrowed and deepened in response to the growth of a cobble-rich side-attached bar.

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1 Introduction

San Clemente Dam was removed from the Carmel River in 2015 (Fig. 1) to improve conditions for all life stages of both resident (rainbow trout) and anadromous (steelhead) forms of *Oncorhynchus mykiss* (NMFS 2013; Boughton et al. 2016). The project was called "Carmel River Reroute and Dam Removal."

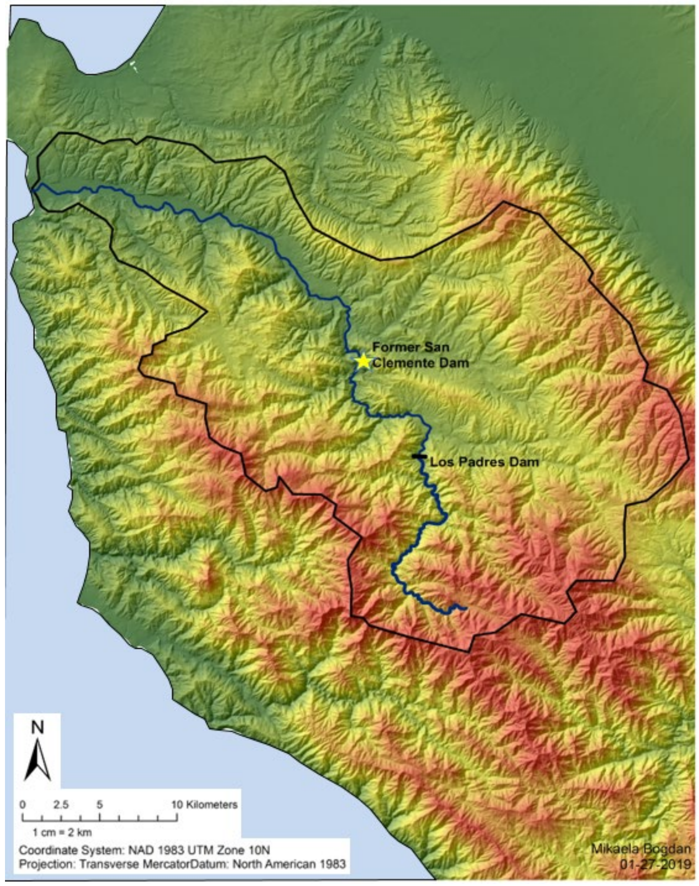

Figure 1. Location of the Carmel River Dam Removal and Reroute Project.

A new channel was constructed to foster migration past the former dam site, including a reach cut through bedrock to circumvent sediment sequestered in the old reservoir. The channel was designed to accommodate adult steelhead passage in flows as low as 15 cfs. A relatively steep reach of the new channel spanning from San Clemente Creek to the dam site was impacted by a high-magnitude flow event in 2017 (Fig. 2). Given the mobility of boulders in the channel, there was a concern that significant migration barriers might form. The large boulders have been mobilized in flows as low as 6000 cfs, leading to uncertainty in future channel configurations and barriers (Smith et al. 2020). Geomorphic surveys were conducted annually in 2018, 2019, and 2020 to assess fish passage in the constructed 0.7 mile long constructed river. This report provides data for the fifth year, following a two-year gap without surveys.

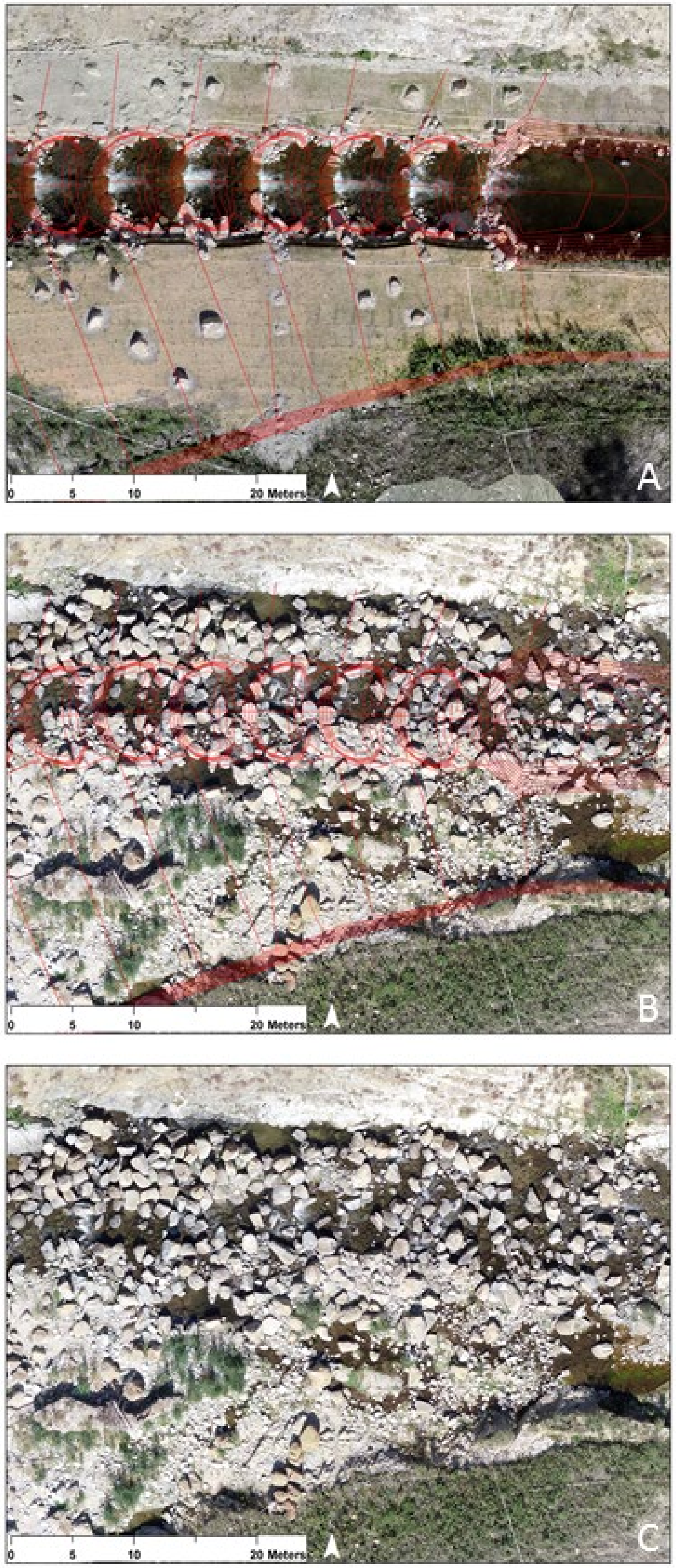

Figure 2. Example of step-pool sequences “auto-naturalized” by high flows of 2017. A) Design blueprint on step pool sequence in 2016. B) Same view as A in 2017. C) Same image as B with design removed.

The initial geomorphic fish-passage survey along the constructed channel occurred in summer 2018 (17 cfs). The assessment documented problematic fish passage conditions at summer base flow conditions (Smith et al. 2018). The next annual survey was completed in 2019 at 60 cfs, which is more typical of winter base flow conditions. That survey found no significant barriers, but eight sites were described or surveyed in detail because they were close to the 1-foot minimum depth condition (Smith et al 2019). The 2020 survey repeated the survey at 60 cfs, and described 5 sites of concern where the depth along the most conducive corridor approached the 1-foot minimum depth threshold. The current report presents the fifth year geomorphic fish-passage survey, conducted on May 30 and May 31 at a flow of approximately 70 cfs. A flow 10 cfs higher than the previous surveys was selected to determine how sensitive the depth-related impediments are to a slightly higher discharge.

2 Methods

2.1 River Discharge During Assessment

The spring 2023 survey included a visual inventory of potential barriers of the entire constructed river on May 30, 2023. Two sites of interest were surveyed on May 31, 2023. The flow was approximately 70 cfs during those days as indicated by the Sleepy Hollow gage, located one mile downstream of the site.

2.2 Visual Assessment

Potential barriers to fish passage (impediments) were identified along the 4100 ft length of the project site. A leveling rod was used to measure minimum water depths and maximum jump heights along the most conductive corridor in the river (Fig. 3). We based our assessment on criteria presented in the CRRDR post-construction monitoring plan (AECOM, 2018). As was done in 2019 and 2020, we did not consider narrow “width” to indicate a potential barrier, and we used the maximum depth (instead of average depth) when assessing the one-foot minimum depth value (Pers. Comm. Steven McNeely, AECOM). The two criteria for identifying impediments were:

- **At a given channel cross section, the dimensions of the single passage corridor—or passage corridor that is most conducive to passage where multiple corridors exist—indicate that the maximum flow depth is less than 1 foot.**

- **Where a hydraulic drop spans the wetted channel width and jump behavior is required to pass the feature due to absence of an identifiable subsurface corridor, the required jump height is greater than 1 foot, the downstream jump takeoff pool depth is less than 2 feet, or such jumps occur in a sequence of four or more.**

The impediment site identification numbers presented in Smith et al. (2020) were used in the current study. The UTM (NAD 83) coordinates for each surveyed site were recorded (Appendix A) and plotted on an orthophoto base map. Site photographs were taken to document the problem areas.

Figure 3. Estimating jump heights and water depths at 70 cfs (May 30, 2023).

2.3 Total Station Surveys

Each site identified as a potential impediment was surveyed with Nikon 3" total station. We surveyed the thalweg longitudinal profile and a critical cross section along the riffle crest where the depth problem was present. The cross section transect was not necessarily perpendicular to the banks. Instead, it followed the critical riffle crest geometry. Total station shot elevations were used to determine channel bottom elevations, while co-located depths were read from a leveling rod. Each survey closed with ≤ 0.05 ft horizontal error and ≤ 0.005 ft vertical error. All cross sections were plotted as a downstream view.

3 Results

The typical impediments in the project area include shallow riffle crests in the low-gradient reach upstream of the confluence of San Clemente Creek and hydraulic jumps or cascades formed by boulders located between the confluence and the downstream end of the project.

The downstream reach had no impediments, and channel morphology had locally improved since the 2020 survey. Several hydraulic drops greater than 1 foot were present in the downstream reach, but each was navigable because it was either a single jump with adequate launching and landing pools or because of the presence of submerged passages between rocks that were at least 1-foot wide. The tallest jump was 3 ft tall, had a launching pool of approximately 5 ft depth, and could be passed with one jump. Only one of the 53 constructed arcuate boulder weirs (step-pool unit) is still easily identifiable (Fig. 4). The center block has been displaced, leaving a gap where fish transit does not require a jump. The weir faces a 2.5 foot deep launching pool, facilitating the 1. 5 ft jump over the tall section of the weir. High flow conditions of winter 2023 built a tall, gravel and cobble, side-attached bar in the very wide, 150 ft long reach located north of 2020 "Site 1" (Fig. 4). The resulting channel is much narrower and deeper, providing better passage conditions in 2023 than in all previous surveys.

Figure 4. An original constructed arched rock weir (step-pool unit) with 70 cfs of flow. Fish can pass this feature with a modest jump from a 2.5 foot deep launching pool or by burst swimming up the center chute, which has >1 ft depth in a gap between rocks.

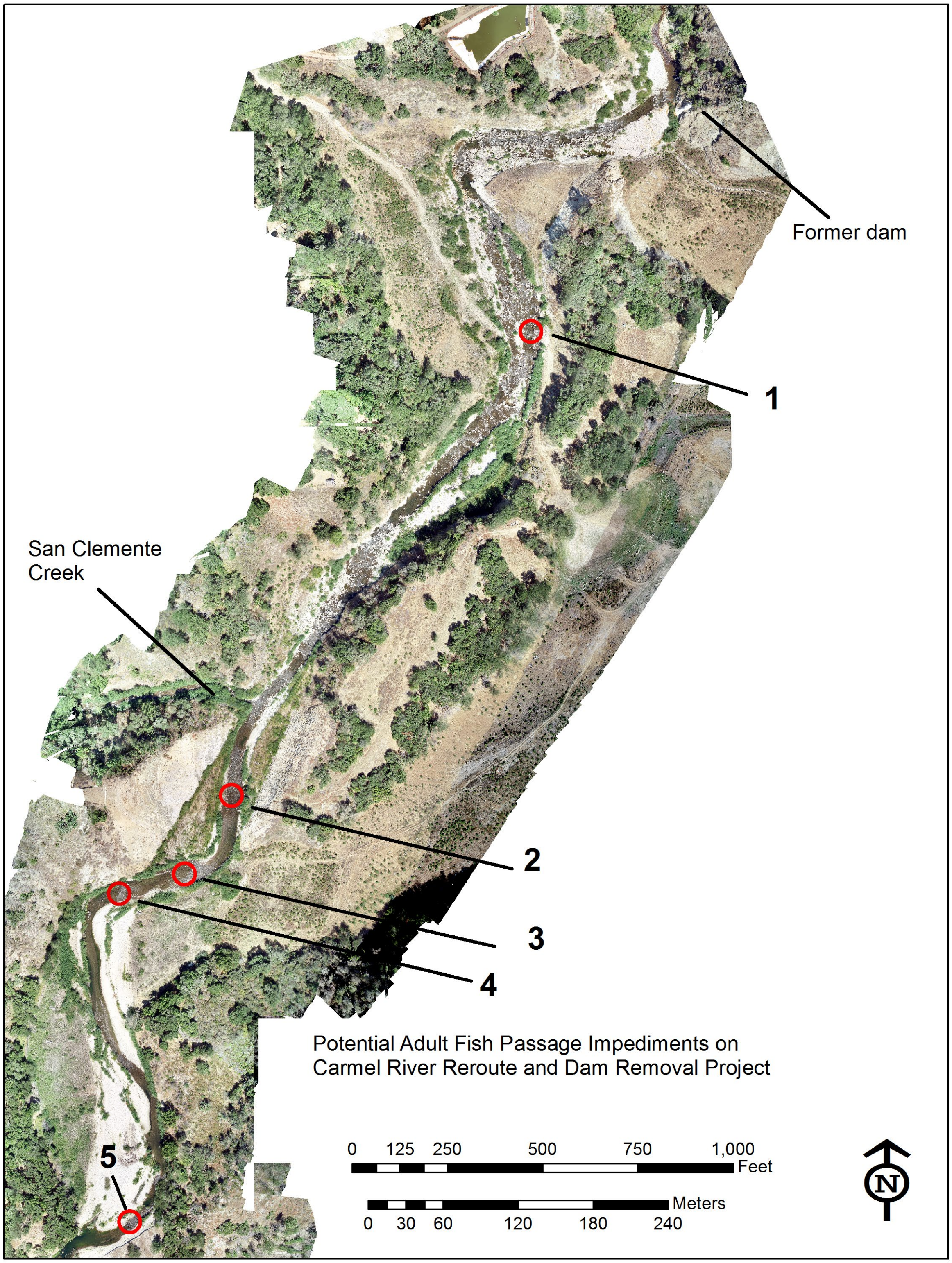

Figure 5. Five sites identified as potential impediments to fish passage in 2020. Only sites 3 and 5 were potential impediments in 2023. Orthophoto obtained on 8/31/19.

The low-gradient reach located upstream from the confluence of San Clemente Creek has developed and maintained relatively stable riffle and pool locations, inherited from the original constructed channel geometry. The features have remained stable despite transporting a very high volume of sediment during high flows of 2017 and 2023. The potential for migration barriers in this reach is the shallow water that marks each riffle crest (Smith et al. 2018, 2019; Smith & Bogdan 2020). At base flow, every riffle crest is difficult to traverse (Smith et al. 2018). In 2020, four crests were shallow (Sites 2 through 5 in Fig. 5). In 2023, two of those sites (Sites 3 and 5) were shallow at 70 cfs. These sites are described below.

Site 3 is the head of a low-gradient riffle within the reroute reach (Fig. 5). It has a complex crest that crossed the channel at a low angle to the banks. The riffle was deeper than one foot except near the riffle crest where the maximum depth of the most conductive passage was approximately 0.9 feet (Figs. 14, 15, 16). This location is site 45 surveyed in summer 2018 and site 5 surveyed in 2019.

Figure 6: Site 3 with approximate locations of longitudinal profile (red) and cross section (black). Flow is toward the northwest. Background image is orthophoto obtained 8/31/2019 at a flow of 17 cfs.

Figure 7 . Site 3 field photo. Shallow conditions at riffle crest. View downstream.

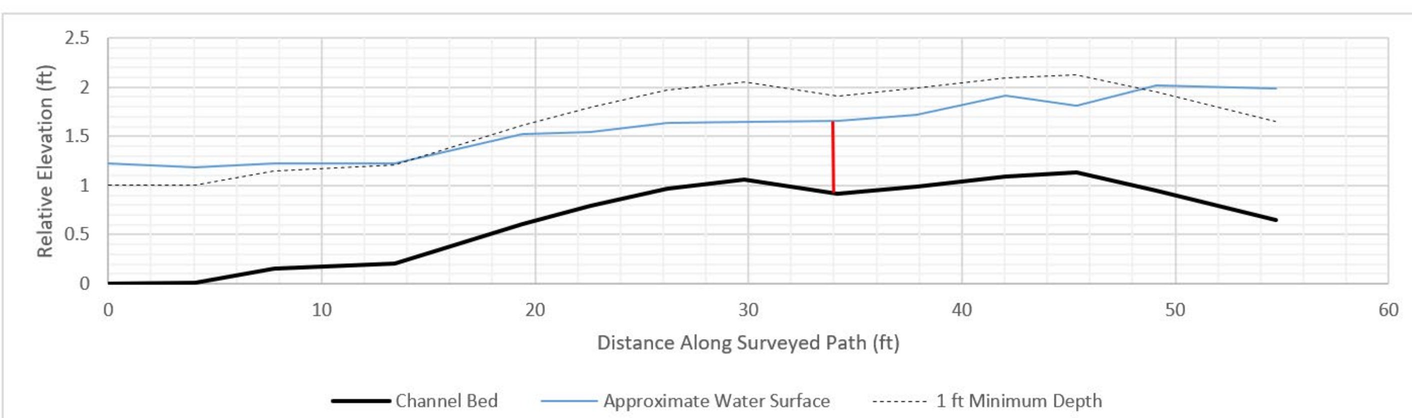

Figure 8. Site 3 longitudinal profile. Red line shows the intersection with cross section.

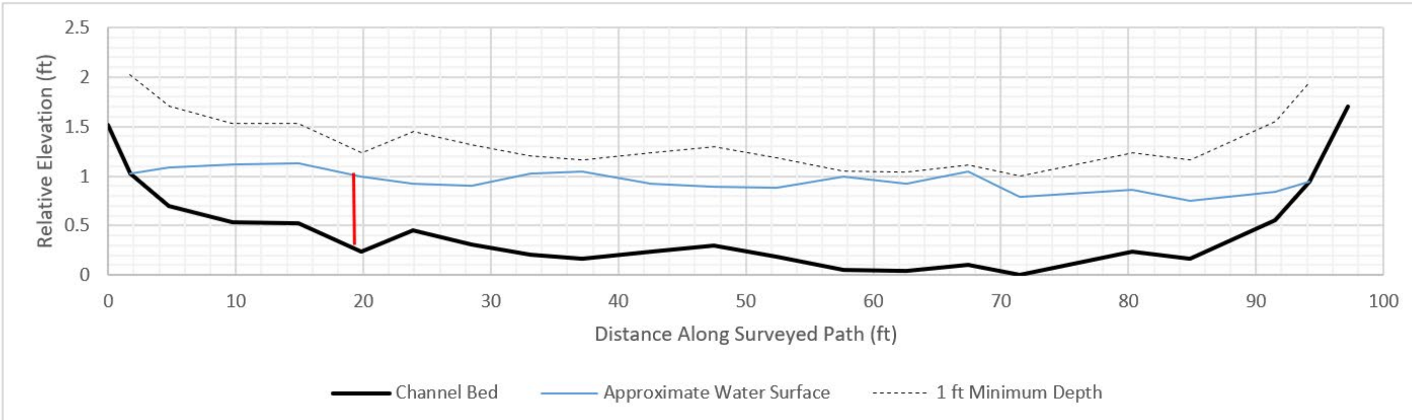

Figure 9. Site 3 cross section survey. Red line shows the intersection with cross section.

Site 5 is a low-gradient riffle located within the reservoir reach 150 ft (65 m) downstream from the upstream limit of the constructed river (Fig. 21). The riffle was deeper than one foot except for a five-foot long reach that was at, or slightly below, the 1-foot minimum depth along the most favorable pathway (Figs. 22, 23, 24). This site was reported as impediment 51 in summer 2018 and impediment 8 in 2019.

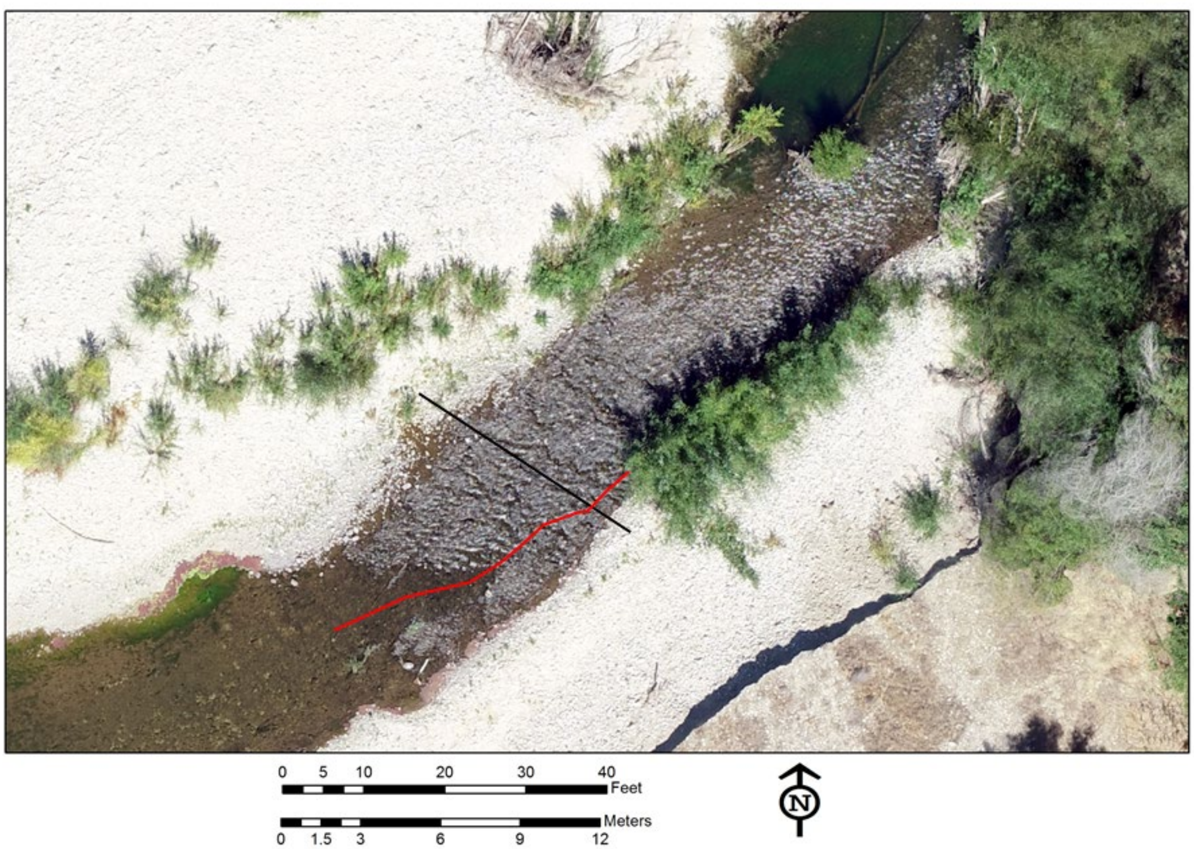

Figure 10. Site 5 with approximate locations of longitudinal profile (red) and cross section (black). Flow is toward the northwest. Background image is orthophoto obtained 8/31/2019 at a flow of 17 cfs.

Figure 11. Site 5 field photo.   Shallow conditions along riffle crest. View upstream.

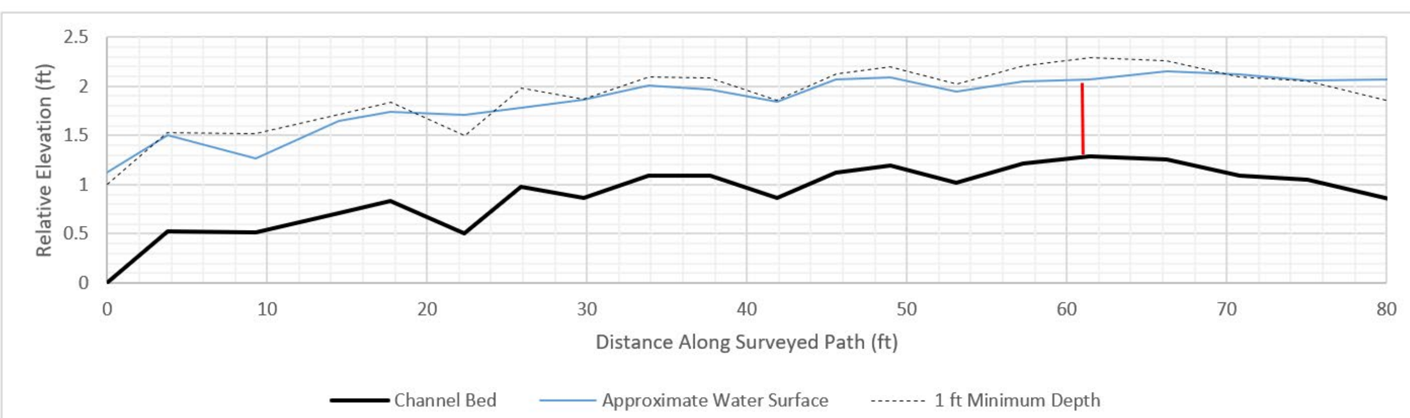

Figure 12. Site 5 longitudinal profile. Red line shows the intersection with cross section.

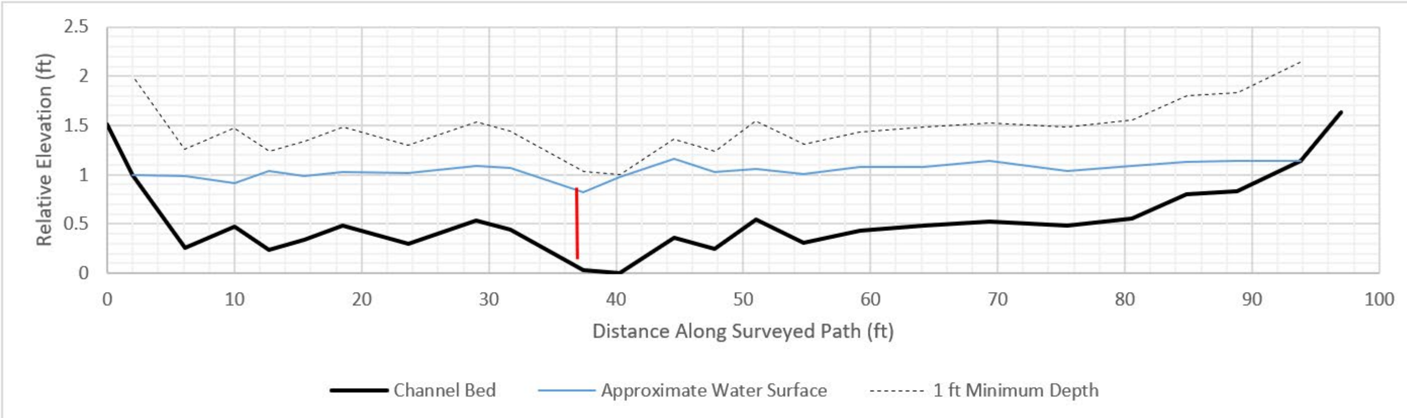

Figure 13. Site 5 cross section survey. Red line shows the intersection with cross section.

4 Discussion

The Carmel River reach constructed in 2015 underwent radical transformation in 2017 and has continued to evolve as boulders gradually translocate during high flows (Smith et al. 2020). The physical limitations to fish migration have diminished during the five years of physical monitoring. The spring 2018 fish passage survey inventoried approximately 51 impediments to adult fish passage at a flow of 17 cfs (Smith et al. 2018). All but seven of those shallow-water impediments were drowned out by deeper water present during the 60 cfs flow in summer 2019 (Smith et al. 2019). The seven sites identified in 2019 fell short of the minimum prescribed design criteria for fish passage by only 0.1 ft, and for only short distances, leading to the conclusion that there were no significant barriers for healthy adult *O. mykiss*. Smith & Bogdan (2020) came to the same conclusion but identified only five sites as potential impediments. And with this report, there are only two sites remaining in 2023 that were shallower than the 1-foot depth threshold. While the reduction of impediments in 2023 may be in part due to the 10 cfs flow increase over the previous survey, the channel is locally evolving to provide better conditions as well.

In 2023 we found the following general conditions. The boulder-rich reach of river between The confluence of San Clemente Creek and the dam site continues to change in years with high-flow events. In general, the existing hydraulic drops continue to be passable by virtue of easy jumping conditions or submerged corridors that do not require jumping. In that same reach, we find that an interdependent combination of side-attached bar deposition and riparian forest encroachment is locally narrowing the channel. The reduced channel width fosters deeper water and improved fish passage conditions.

As in 2020, we found Pacific lamprey nests, including one with a lamprey resting in the nest. The location of the nests near site 5, demonstrates that anadromous species have successfully navigated through the entire length of the constructed river.

Smith & Bogdan (2020), Smith et al. (2020) and the current study provide independent observations demonstrating that the channel geometry is still evolving. Fish passage characteristics at the study area are naturally evolving as both the gravel in the riffle crests and boulders in the steeper reaches continue to move. At this writing, the sediment movement is gradually leading to improved fish passage conditions.

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6 Appendix A: Site Locations

site	E	N
1	615651	4032928
2	615417	4032524
3	615379	4032454
4	615324	4032447
5	615336	4032176

UTM NAD83 (10) meters