Central
Coast
Watershed
Studies

CCoWS

Carmel River Reroute and Dam Removal Fish Passage Assessment (Summer2018)

Publication No. WI-2018-07
30 August 2018
Revised
02 April 2019

Doug Smith (Ph.D.)
Mikaela Bogdan
Joseph Klein
Anthony Terzoli

The Watershed Institute

School of Natural Sciences
California State University
Monterey Bay
https://csumb.edu/watershed

100 Campus Center, Seaside, CA,
93955-8001
831 582 4696 / 4431

Contact:
dosmith@csumb.edu

Executive Summary

San Clemente Dam was removed in 2015. A key goal of dam removal was to improve longitudinal mobility of all forms and life stages of *Oncorhynchus mykiss*. A step-pool and plane-bed channel constructed to provide design critera fish passage in 2015 was rearranged into a more random pattern of boulder distribution in high flows of winter 2017. Fish passage for steelhead and resident rainbow trout remains a primary concern at this time. We assessed fish passage opportunities in summer 2018.

The occurrence of either of the following conditions (based on draft monitoring approach developed by NMFS and CDFW in March of 2017) will represent a potential barrier:

1) 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 and the horizontal width is less than 3 feet.
2) 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 location and geometry of fifty-one single (or continuous) impediments to fish passage were recorded when the discharge was approximately 17 cfs on July 10, 2018. Most of the potential barriers were documented by hand-held camera. Key areas of concern were subsequently documented and analyzed using small unmanned aerial system (sUAS) video and high resolution structure-from-motion (SfM) photogrammetry on July 15, 2018. Our assessment shows that the project reach contains potential barriers to adult steelhead passage at 17 cfs.

While the CRRDR channel was originally designed to provide adult steelhead and rainbow trout passage at low flow conditions, future studies could instead focus on passage conditions at higher flows, more typical of those encountered by steelhead during the spawning season.

Acknowledgements

Funding for this work was provided by AECOM. We appreciate the technical assistance of Steven McNeely and Katherine Dudney.

This report may be cited as:

Smith D., Bogdan, M., Klein J., and Terzoli, A. 2018. Carmel River Reroute and Dam Removal Fish Passage Assessment (Summer 2018). Watershed Institute, California State University Monterey Bay, Publication No. WI-2018-07, 43 pp.

Table of Contents

1 Introduction

San Clemente Dam was removed from the Carmel River in 2015. Specific objectives of the Carmel River Reroute and Dam Removal (CRRDR) project were to improve conditions for all life stages of both resident (rainbow trout) and anadromous (steelhead trout) forms of *Oncorhynchus mykiss* (NMFS, 2013), create riparian wetland habitat for California red-legged frog (*Rana draytonii*), and to improve downstream aquatic habitat by renewing bed load and large wood transport through the former dam and reservoir site (Harrison et al. 2018; Boughton et al. 2016).

Dam removal typically leads to complex changes in the associated river system (East et al. 2015; Harrison et al. 2018). Geomorphic changes associated with San Clemente Dam removal furthers the need for monitoring at the CRRDR site. This report assessed fish passage impediments throughout the CRRDR project reach in summer of 2018 through a visual survey followed by more detailed mapping of a subset of typical sites. The reconnaissance survey was augmented with low altitude small unmanned aerial system (sUAS) video. Mapping and geomorphic surveys were based upon high-resolution aerial photogrammetry. Locations along the river reference the original section specifications related to the constructed channel (Fig. 1).

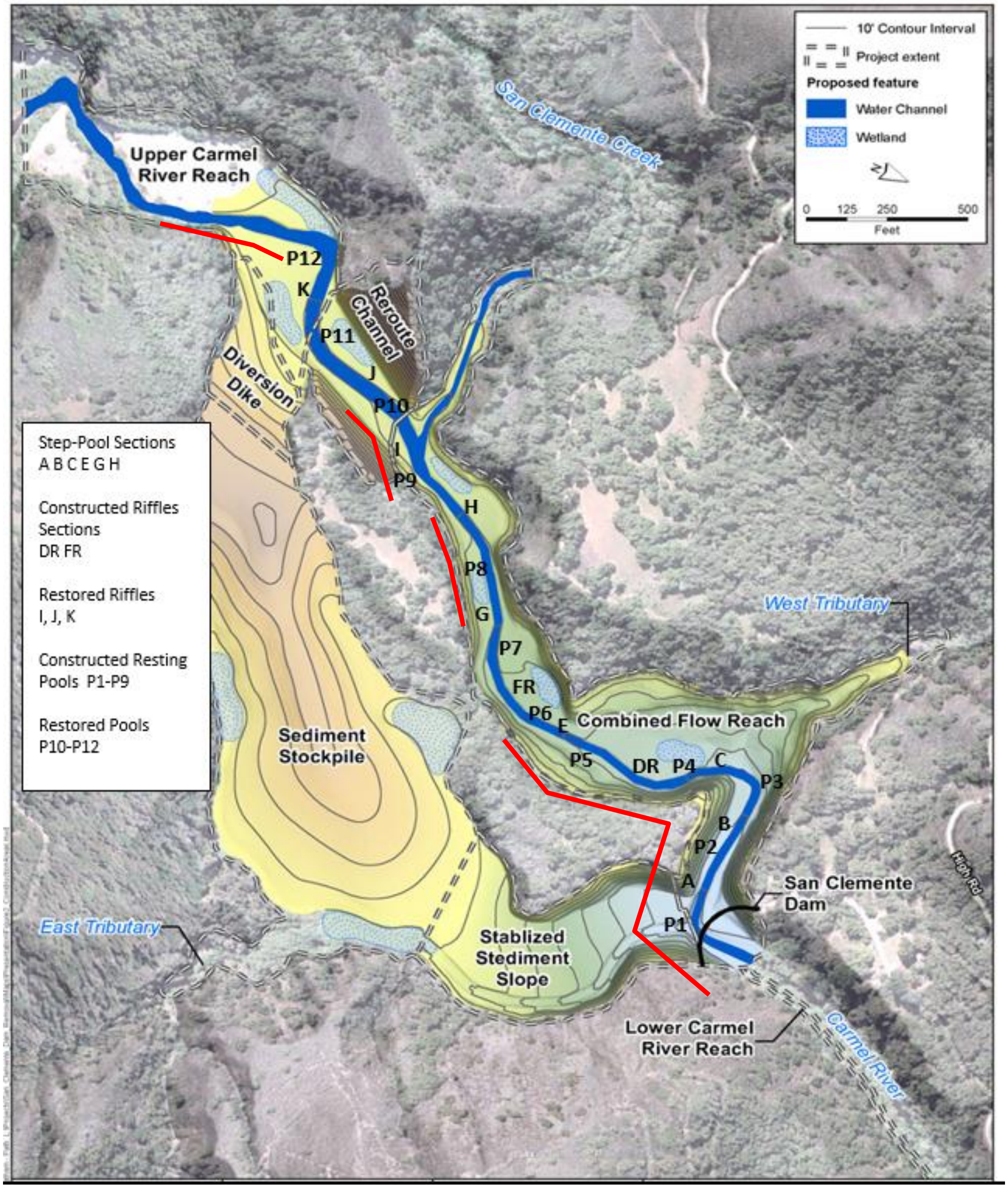


Figure 1. Map of the Carmel River Dam Removal and Reroute Project shows the Upper Carmel Reach, Reroute Reach, and Combined Flow Reach. Red lines indicate regions with photogrammetry from 7/15/18 (figure modified from URS 2012; CSUMB 2016).

2 Methods

2.1 River Discharge During Assessment

The CRRDR constructed channel was originally designed to foster adult fish passage at flows as low as 15 cfs. The post-construction monitoring plan (AECOM 2018) indicated that the passage assessment should be conducted at between 16 and 30 cfs. The first year assessment of fish passage was therefore timed to address the capacity for fish passage at a challenging flow, near 16 cfs.

2.2 Visual Assessment

Potential barriers to fish passage (impediments) were visually assessed along the length of the project site on July 10, 2018 at 17 cfs (1.88 ft stage at Sleepy Hollow

Potential barriers to fish passage (impediments) were visually assessed along the length of the project site on July 10, 2018 at 17 cfs (1.88 ft stage at Sleepy Hollow gage). A leveling rod was used to measure water depth, jump height and channel width (Figs. 2 and 3). Notes were taken at each location deemed to be a potential fish passage impediment. We based our assessment on criteria presented in the CRRDR post-construction monitoring plan (AECOM, 2018).

1. A potential barrier exists at a given cross section if the average depth is less than one foot or the width is less than three feet. If there are multiple passage corridors in the cross section, assess the one that is most conducive to passage.

2. A potential barrier exists where a hydraulic drop spans the wetted channel width, and the jump height exceeds one foot or the downstream launching pool is less than two feet deep. This is a potential barrier if jump behavior is required to pass the feature due to absence of an identifiable subsurface passage corridor.

While not explicit in the CRRDR monitoring plan, we did not indicate impaired passage where the flow was less than one-foot depth if the shallow conditions were forced by flow accelerating over a jump crest. However, landing pools of less than one foot depth were noted as an impediment.

Impediments that did not meet the stated minimum passage criteria were loosely grouped into those that were likely impassable to adult fish, and those that were passage impediments, but passable by a healthy steelhead, in our opinion. Examples of impediment sites that were not full barriers to passage are shown in Figures 2 and 3.

The impediment sites were sequentially numbered from downstream to upstream. While most numbers represent a specific single impediment, we also gave single site numbers to “areas” where single impediments were very closely spaced or where the limiting condition was virtually continuous along the length of the channel. Examples of continuous impairment exist where gravel riffles are too shallow for 10’s of meters along the length of the channel. Each site was given uncorrected handheld GPS coordinates and identified on hard copy orthophotos in the field. More accurate UTM coordinates were assigned to each site in the office by reference to a georeferenced orthophoto in ArcMap. Ground-based photos were captured at each site with the exception of sites 36, 43 and 46. The digital photo file names relate to the site number best viewed in the photo. The site data positions and descriptions were converted to an ArcGIS attribute table (Appendix A) and plotted in ArcMap.

Figure 2. Using leveling rod to measure water depth at impediment site #22.

Figure 3. Using leveling rod to approximate channel width at the water surface at impediment site #4.

2.3 sUAS-based Data Sets

sUAS video was used to capture the hydraulic condition at most sites. Each site number in the data table is referenced to a time stamp in one of three videos (Appendix A). Two videos presented with this report were captured on July 14, 2018 at a discharge of 15 cfs (1.82 ft stage at Sleepy Hollow gage). A third video is presented with this report to augment the other two. It shows some of the sites on May 29, 2018 at a discharge of 30 cfs (2.13 ft stage at Sleepy Hollow gage).

On July 15, 2018, four 30 m altitude missions captured overlapping still photographs for structure-from-motion (SfM) photogrammetry (red lines in Figure 1). The river discharge was 15 cfs (1.83 ft stage at Sleepy Hollow gage). "Pools" and "Section" names refer to original naming scheme shown in Figure 1. The four flights spanned the following elements.

- from pool 1 to pool 6
- from section G to section H
- mouth of San Clemente Creek (between pools 9 and 10)
- from pool 12 to within the reservoir reach

The resulting orthophotos and digital surface models (DSM) data sets have 8mm pixels. Those local high-resolution data sets were used to create figures in this report. Where noted in the report, some figures show 90 m altitude data flown on 5/29/18 at 30 cfs.

Digital surveys of the DSMs (cross-sections and profiles) of a subset of sites are provided in Appendix B.

3 Results

Fifty-one areas failed to meet the passage design criteria at 17 cfs (Fig. 4). While most sites failed only one of the design criteria elements, eleven sites were complex impediments involving up to 28 m of either continuous or very closely spaced problem spots. Shallow depth (whether or not associated with a jump) was the most common problem observed on July 10 at 17 cfs (Fig. 5).

We subdivided the CRRDR into five reaches defined by a single impairment or the most common kind of impairment (Fig. 4). "Pools" and "Section" names refer to original naming scheme shown in Figure 1.

- Reach A—from pool 1 to pool 3
- Reach B—section C
- Reach C—from pool 4 to section E
- Reach D—Pool 8
- Reach E—Pool 9 to upstream end of project

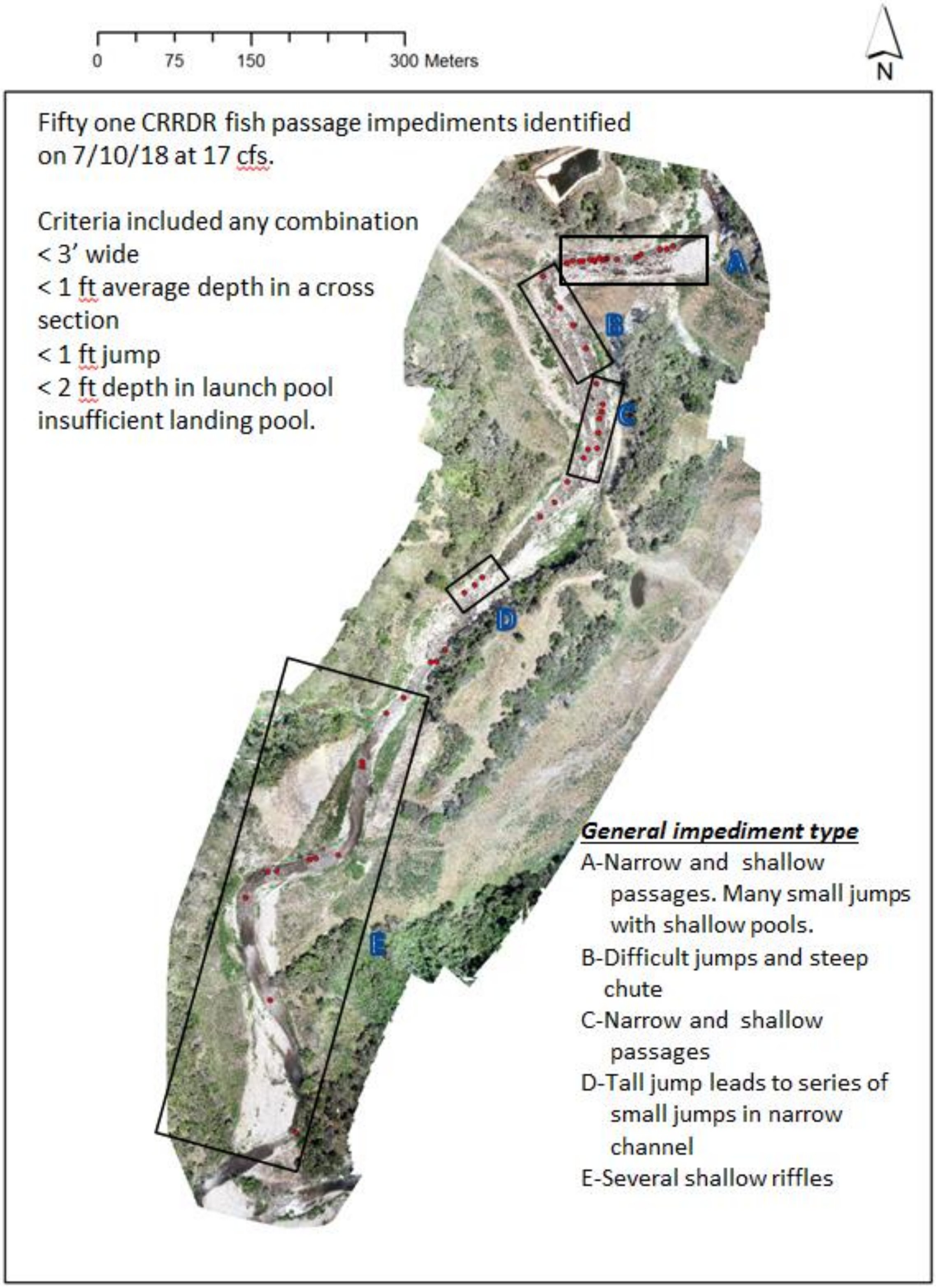


Figure 4. Overview of impediment sites identified by foot traverse at 17 cfs. Some individual site markers represent a reach of relatively close-spaced impediments.

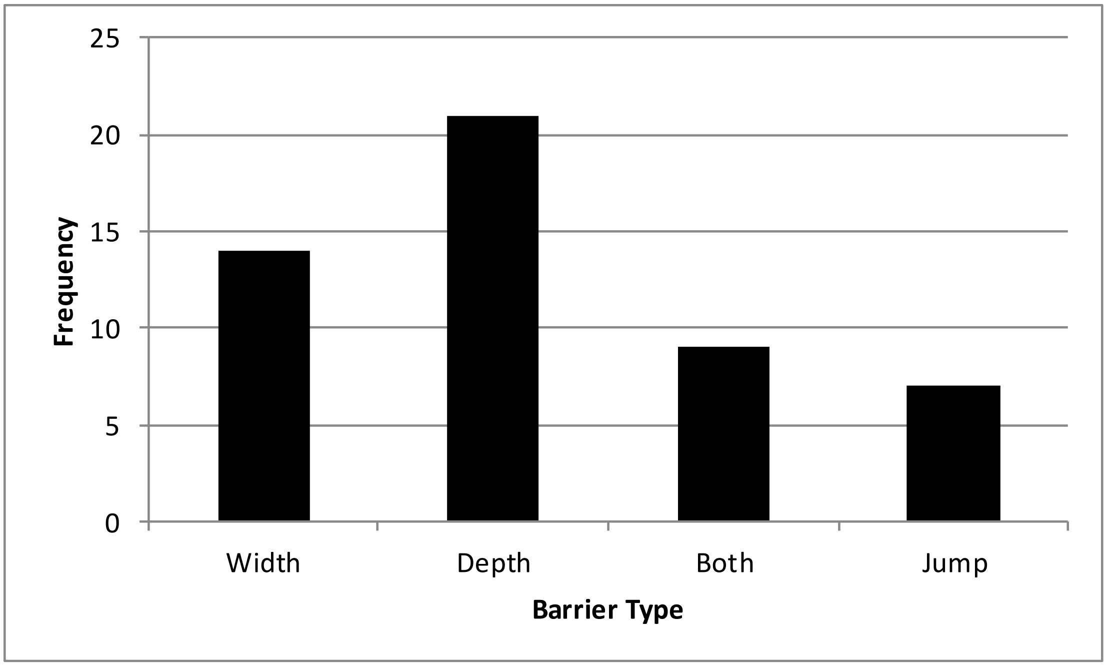


Figure 5. Frequency of type of passage impediment within the CRRDR:

The following descriptions and figures reference the lettered reaches (A-E) of Figure 4. Reach A is characterized by many narrow passages and small jumps (Figs. 3, 6 and 7). The passages are typically less than 3 ft wide, and the jumps typically have shallow launching pools or shallow landing pools (Fig. 8). Appendix B-1 through B-4 show digital models and digital surveys in Reach A.

Figure 6. Orthophoto of Reach A. Flow is left to right. Q=17 cfs

Figure 7. Close view of orthophoto of Reach A at 17 cfs. Flow is left to right.

Figure 8. Shallow launch pool for short jump at site #2 in Reach A.

Reach B (Fig. 9) starts with a jump that exceeds design criteria at site 19 (Fig. 10). The reach includes a 7% grade cascade comprising three jumps (Fig. 11). Only the first jump (site #20) was considered to be an impediment in the cascade (Fig. 12). Appendix B-5 is a digital longitudinal profile through the steep chute in Reach B.

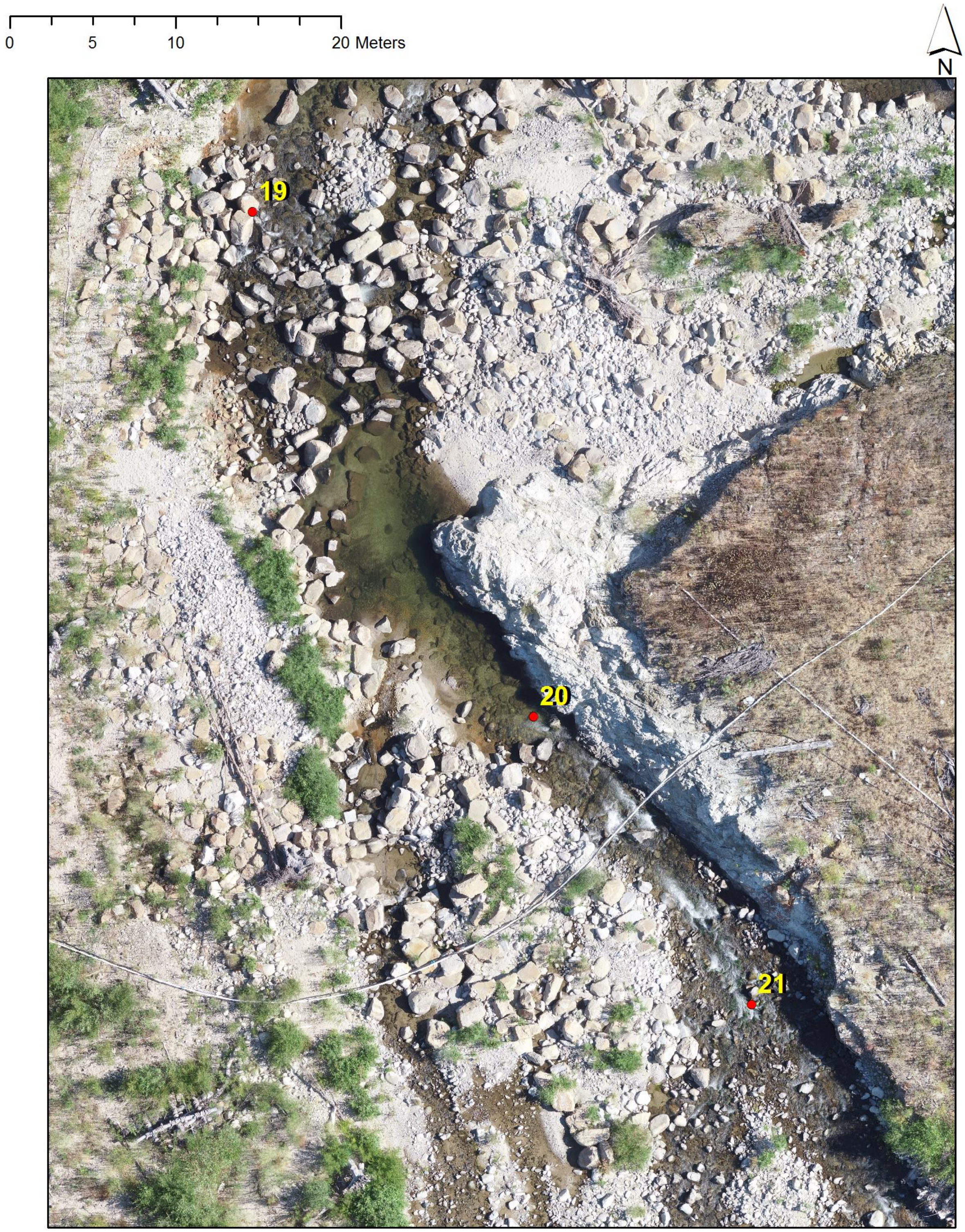


Figure 9. Orthophoto of Reach B. Flow is to the north. Q=17 cfs.


Figure 10. Jump at site #19.

Figure 11. Orthophoto of cascades in Reach B comprised three small jumps, starting with site #20. Flow is to the north. Q=17 cfs.

Figure 12. Narrow passage at site #20 leads to a steep chute that was passable at 17 cfs.

Reach C (Fig. 13) is dominated by a wide shallow channel. Sites 21, 22, and 23 respectively extend 25 m, 10 m and 10 m upstream because of continuous shallow and narrow channel conditions. Figure 2 shows a typical section with average depth less than 1 ft in site 22. Site 23 includes blocked passages through the original random boulder placements and channel margin inherited from the CRRDR constructed channel (Figs. 14 and 15). Appendix B-6 is a digital cross section showing typical conditions in Reach C.

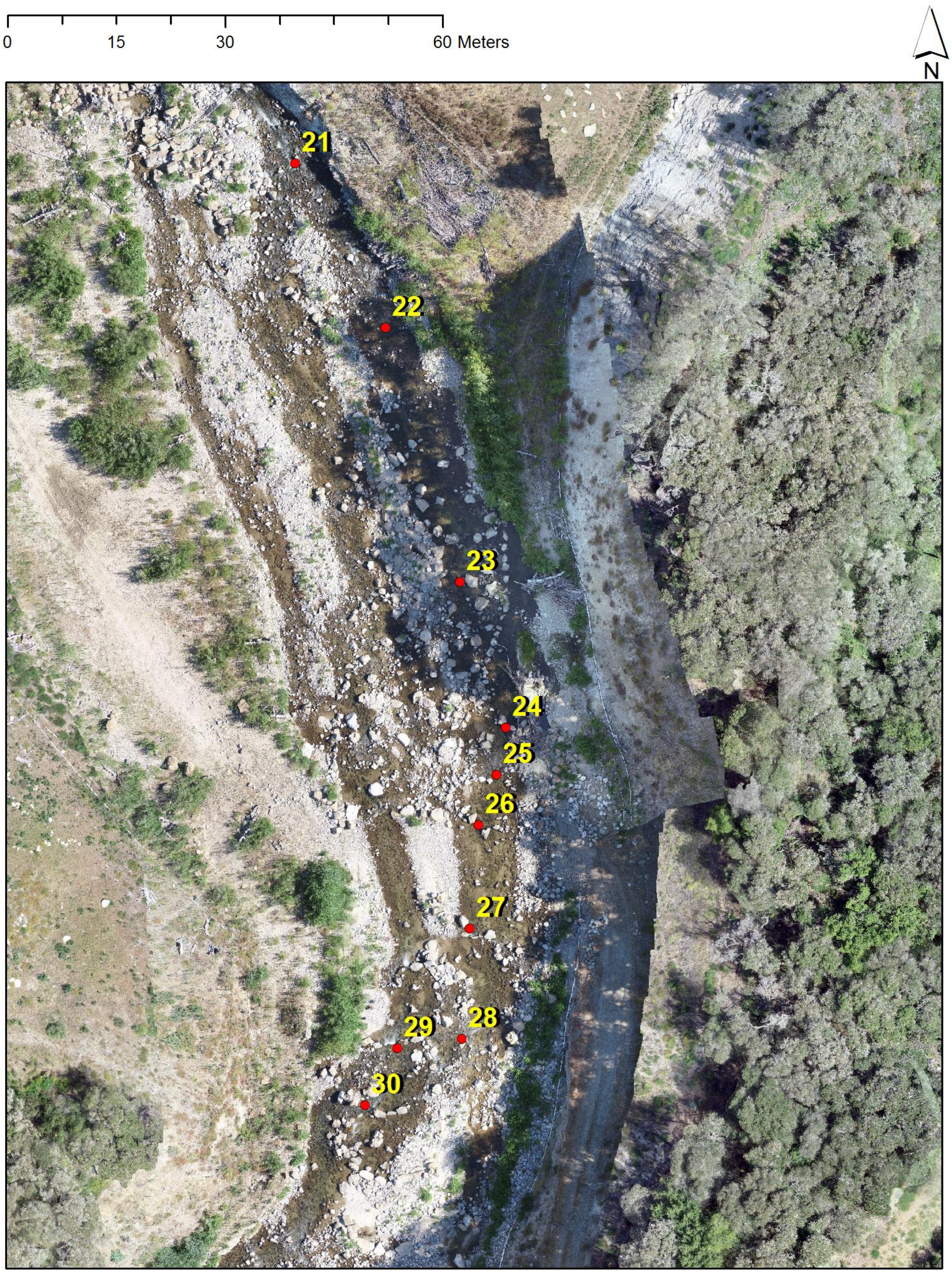


Figure 13. Orthophoto of Reach C. Flow is north. Q=17 cfs

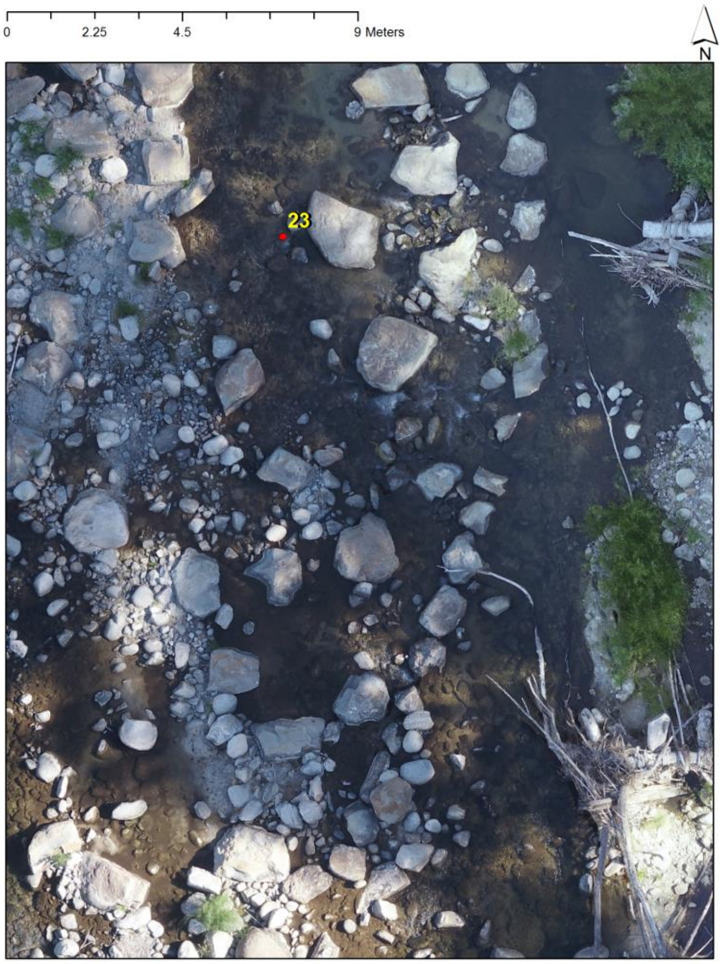


Figure 14. Orthophoto of site #23 in Reach C. Q= 17 cfs

Figure 15. Close up of site #23. Barrier is formed by the large boulders and intervening cobbles located between the two people. Best passage was located outside view to right.

Reach D comprises a series of jumps (Fig. 16). Site 34 is a short jump with shallow water. Site 35 starts with a jump that exceeds 2 ft followed by a steep 19 m long reach with several smaller jumps (Figs 17 and 18). Appendix B-7 is a digital longitudinal profile through the steep chute in Reach D.

Figure 16. Orthophoto of Reach D. Flow is northwest. Q=17 cfs.

Figure 17. Level rod indicates a 1 ft deep launching pool for a greater than 2 foot tall jump at site #35.

Figure 18. View upstream at site #35 chute above the tall jump. Best passage opportunity is along left channel (right side of photo).

Reach E is the relatively low-gradient river segment extending from below the San Clemente Creek mouth to the upstream end of the CRRDR project (Fig. 19). The chief impediment in this reach is the presence of shallow water on wide gravel riffles and bars in the riffle-pool sequences (Figs. 20 to 24). A tributary mouth bar at the terminus of San Clemente Creek formed a significant barrier to San Clemente at 17 cfs (Fig. 22). The launching pool is 0.5 ft deep, the jump height is 1.5 ft from the water surface, and there is no landing pool. Approximately 1 cfs was flowing from San Clemente Creek. Appendix B-8 and B-9 provide a digital cross section and longitudinal profile through site 41 at the San Clemente mouth in Reach E.

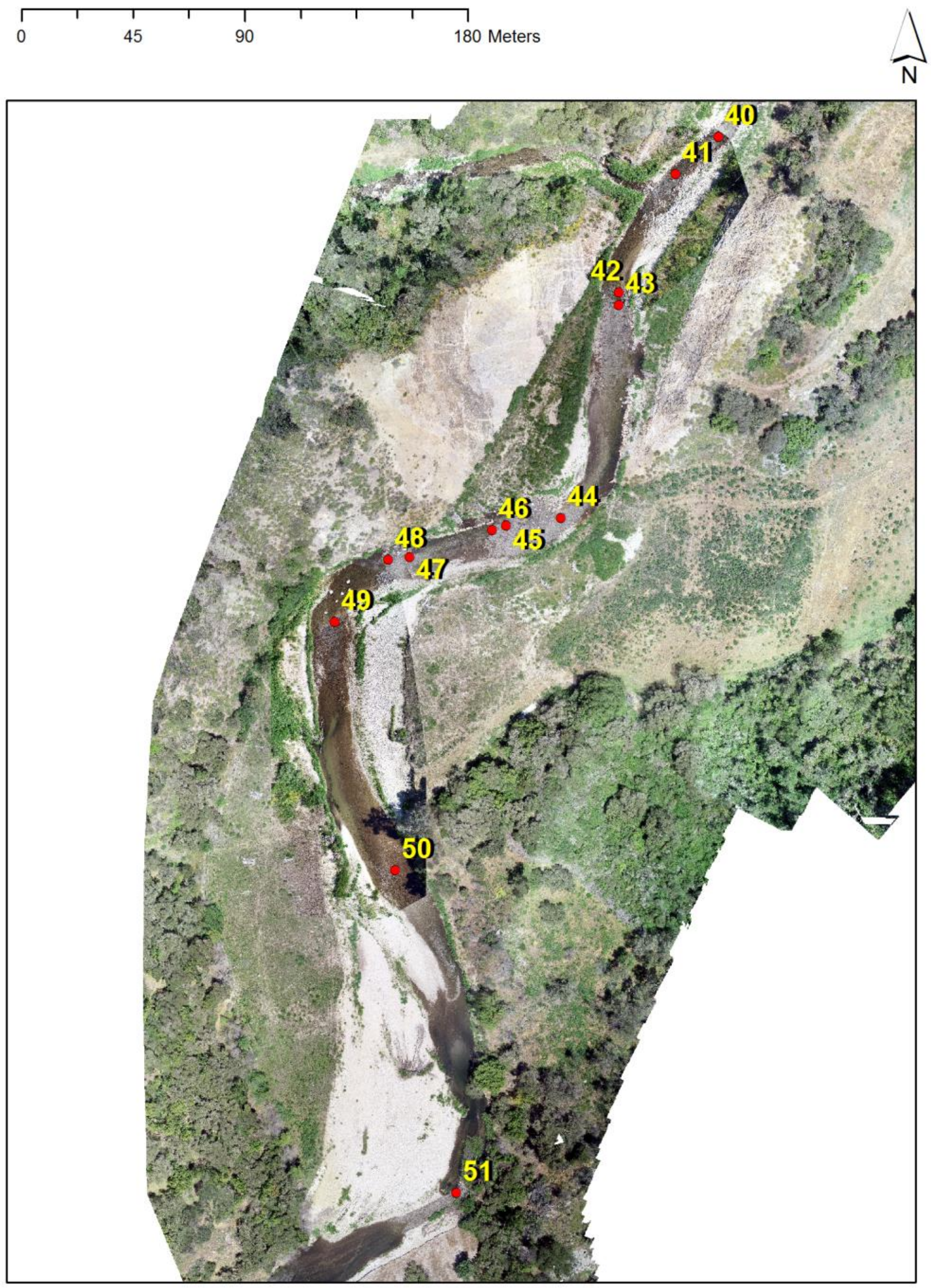


Figure 19. Orthophotos of Reach E . Flow is north. Q= 17 cfs at sites 41, 42, 43, 49 and 50 (July 15 imagery). Q= 30 cfs at other sites in the view (May 29 imagery).

Figure 20. Orthophoto of Site # 41. Flow is north. Q= 17 cfs. The impediment is a steep shallow riffle crossing the mouth of San Clemente Creek. Note dry boulder and gravel ridge forming a barrier to the entrance to San Clemente Creek.

Figure 21. Site #41 is a shallow riffle passing the mouth of San Clemente Creek.

Figure 22. Difficult passage into San Clemente Creek mouth. San Clemente Creek flows toward the camera through a narrow passage located to left of person.

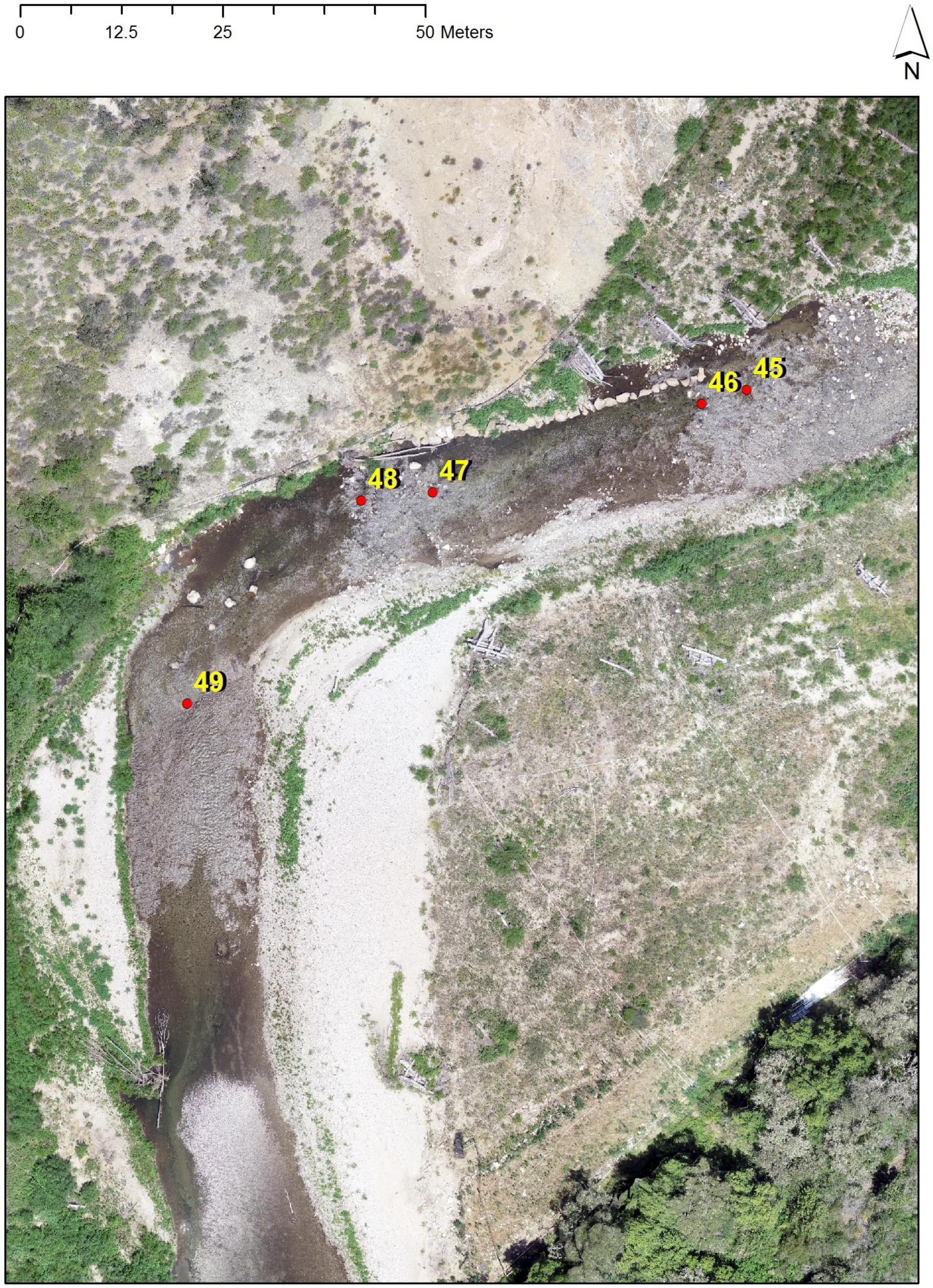


Figure 23. Shallow riffles formed barriers to migration in Reach E at 16 cfs. Orthophoto shows site at 30 cfs on 5/29/18.


Figure 24. Shallow riffle at site #49. Q= 17 cfs

4 Discussion

The 2018 CRRDR fish passage assessment identified 51 sites on the Carmel River that fell below the minimum prescribed design criteria for fish passage at a discharge of approximately 17 cfs. This discharge was at the low end of the monitoring range prescribed in the CRRDR post-construction monitoring plan (AECOM, 2018). While many of the 51 impediments were likely passable by healthy adult steelhead (e.g., Fig. 2), a few sites would have been very challenging, especially in areas with several closely spaced, or continuous, impediments (Fig. 24; Appendix A).

While our data indicate that adult steelhead would have a difficult time navigating through the CRRDR site at a discharge of 17 cfs, further reconnaissance work indicates that similar barriers (mainly shallow riffles) exist both upstream and downstream of the CRRDR. The CRRDR is not unlike the natural Carmel River at this low-flow condition. Unless the channel geometry changes, we believe that the second-year survey (2019) would produce nearly identical results to the first (2018), if conducted at a similar low flow condition.

While the CRRDR channel was originally designed to provide adult steelhead and rainbow trout passage at low flow conditions, future studies could instead focus on passage conditions at higher flows, more typical of those encountered by steelhead during the spawning season. Steelhead are winter-run spawners that gain access to the river once the lagoon is breached by high flows or machinery. The water year 2016 hydrograph for Sleepy Hollow provides guidance on typical winter flows (Fig. 25). Water year 2016 had somewhat typical conditions with a few frontal storms providing winter flow and no exceptionally high peaks. The average base flow in 2016 at the Sleepy Hollow gage following the second of the January peaks but before the onset of the first March peak was 59 cfs. We recommend that the year two fish passage assessment be conducted at a flow near 60 cfs. The Carmel River is safely wadable at 60 cfs, so the survey could be conducted at that flow.

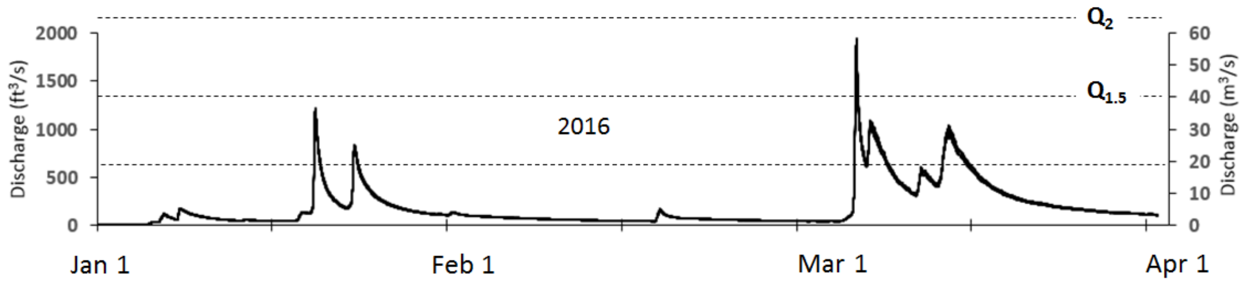


Figure 25. Sleepy Hollow hydrograph from 2016 water year.

5 References

AECOM. 2018. Carmel River Reroute and San Clemente Dam Removal Post-Construction Activity Plan, Habitat Monitoring & Reporting Plan. 66p.

Boughton DA, East A, Hampston L, Kiernan J, Leiker, S, Mantua N, Nicol C, Smith D, Urquhart K, Williams T, Harrison L. 2016. Removing a dam and re-routing a river: Will expected benefits for Steelhead materalize in Carmel River, California? NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-553. US Department of Commerce. Southwest Fisheries Science Center, Santa Cruz, CA. 89 pp.

[CSUMB] Marson L, Besson J, Biordi C, Conlen A, DeWolf K, Gravelle M, Hubbard H, MacSween L, Santos R, Sosa M, Thompson K, Trejo-Arce J, Smith D. 2016. First Year Assessment of the Carmel River Reroute and Dam Removal Project. Division of Science and Environmental Policy. Senior Thesis Report, 101 pp. http://ccows.csumb.edu/pubs/reports/CCoWS_GEOL460_CarmelRiverRestorationYearOneAssess_160528.pdf

East AE, Pess GR, Bountry JA, Magirl CS, Ritchie AC, Logan JB, Randle TJ, Mastin MC, Minear JT, Duda JJ., Liermann MC., McHenry ML., Beechie TJ., Shafroth PB. 2015. Large-scale dam removal on the Elwha River, Washington, USA: River channel and floodplain geomorphic change. Geomorphology 246: 687-708.

Harrison, L.R., East, A.E., Smith, D.P., Logan, J.B., Bond, R., Nicol, C., Williams, T.H., Boughton, D.A., Chow, K. and Luna, L. 2018. River response to large-dam removal in a Mediterranean hydroclimatic setting: Carmel River, California, USA. Earth Surface Processes and Landforms, DOI: 10.1002/esp.4464. https://doi.org/10.1002/esp.4464..

[NMFS] National Marine Fisheries Service. 2013. Biological Opinion, The Carmel River Reroute and San Clemente Dam Removal Project at the San Clemente Dam on the Carmel River. National Marine Fisheries Service Southwest Region. North Central Coast Office, Tracking Number 2013/9633.

6 Appendix A: Site Data

A-1: Site Locations

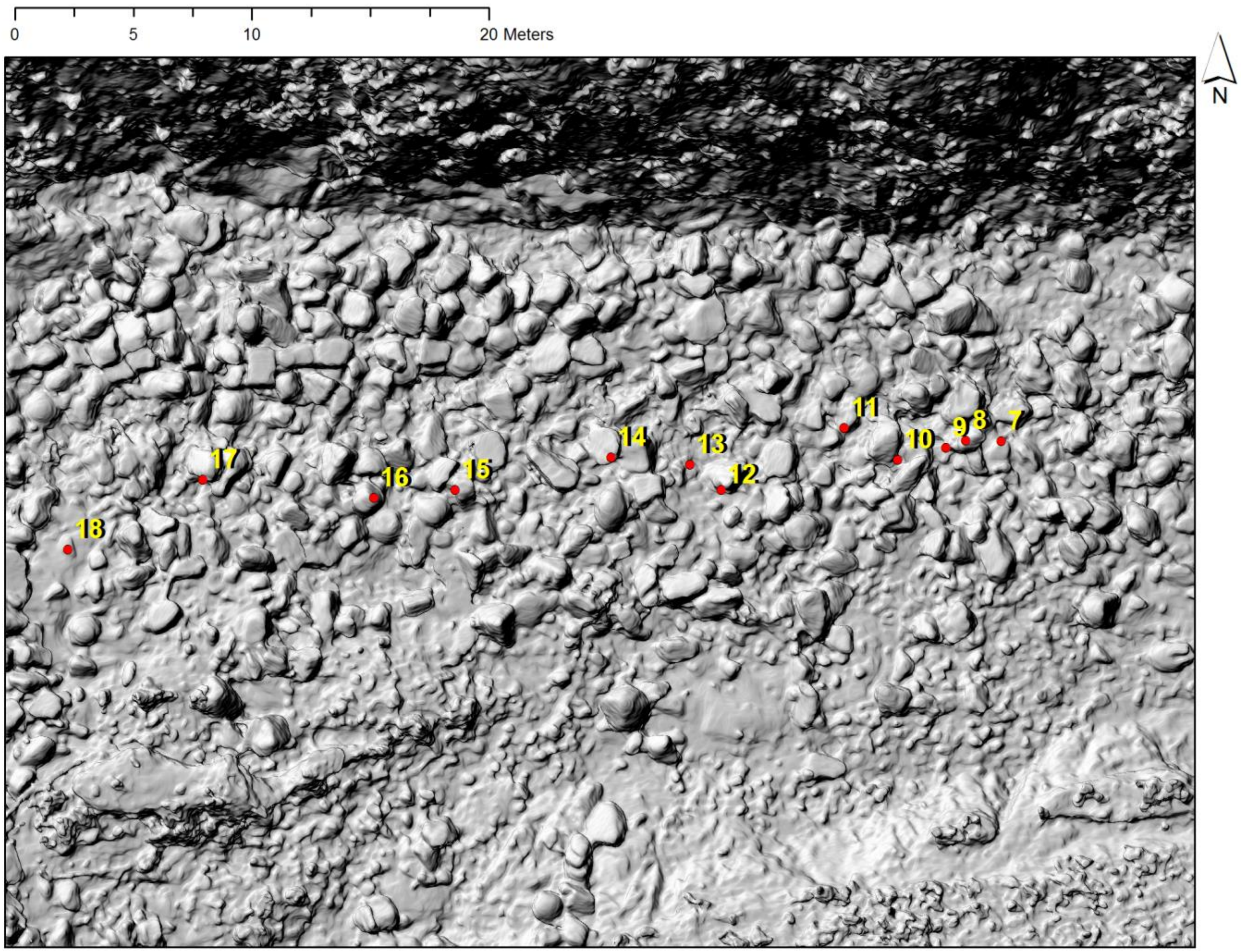
site	E	N
1	615726.4	4033061.8
2	615720.9	4033058.7
3	615713.4	4033058.2
4	615694.8	4033054.1
5	615690.1	4033050.6
6	615671.7	4033048.8
7	615661.3	4033049.3
8	615659.8	4033049.3
9	615658.9	4033049.0
10	615656.9	4033048.5
11	615654.6	4033049.8
12	615649.5	4033047.2
13	615648.1	4033048.3
14	615644.8	4033048.6
15	615638.2	4033047.2
16	615634.8	4033046.9
17	615627.6	4033047.7
18	615621.9	4033044.7
19	615598.6	4033032.1
20	615615.6	4033001.7
21	615628.8	4032984.3
22	615641.3	4032961.6
23	615651.5	4032926.7
24	615657.8	4032906.6
25	615656.5	4032900.1
26	615654.1	4032893.2
27	615652.9	4032878.9
28	615651.8	4032863.7
29	615642.9	4032862.4

site	E	N
30	615638.4	4032854.6
31	615622.9	4032831.1
32	615609.9	4032810.9
33	615596.5	4032796.6
34	615539.4	4032737.6
35	615532.0	4032730.1
36	615521.7	4032722.5
37	615502.8	4032667.0
38	615494.5	4032654.8
39	615489.3	4032654.2
40	615462.3	4032619.4
41	615445.2	4032604.4
42	615422.4	4032556.8
43	615422.2	4032551.7
44	615398.8	4032465.8
45	615376.7	4032462.6
46	615371.2	4032460.9
47	615338.0	4032449.9
48	615329.2	4032448.9
49	615307.7	4032423.9
50	615332.0	4032323.6
51	615356.8	4032193.5

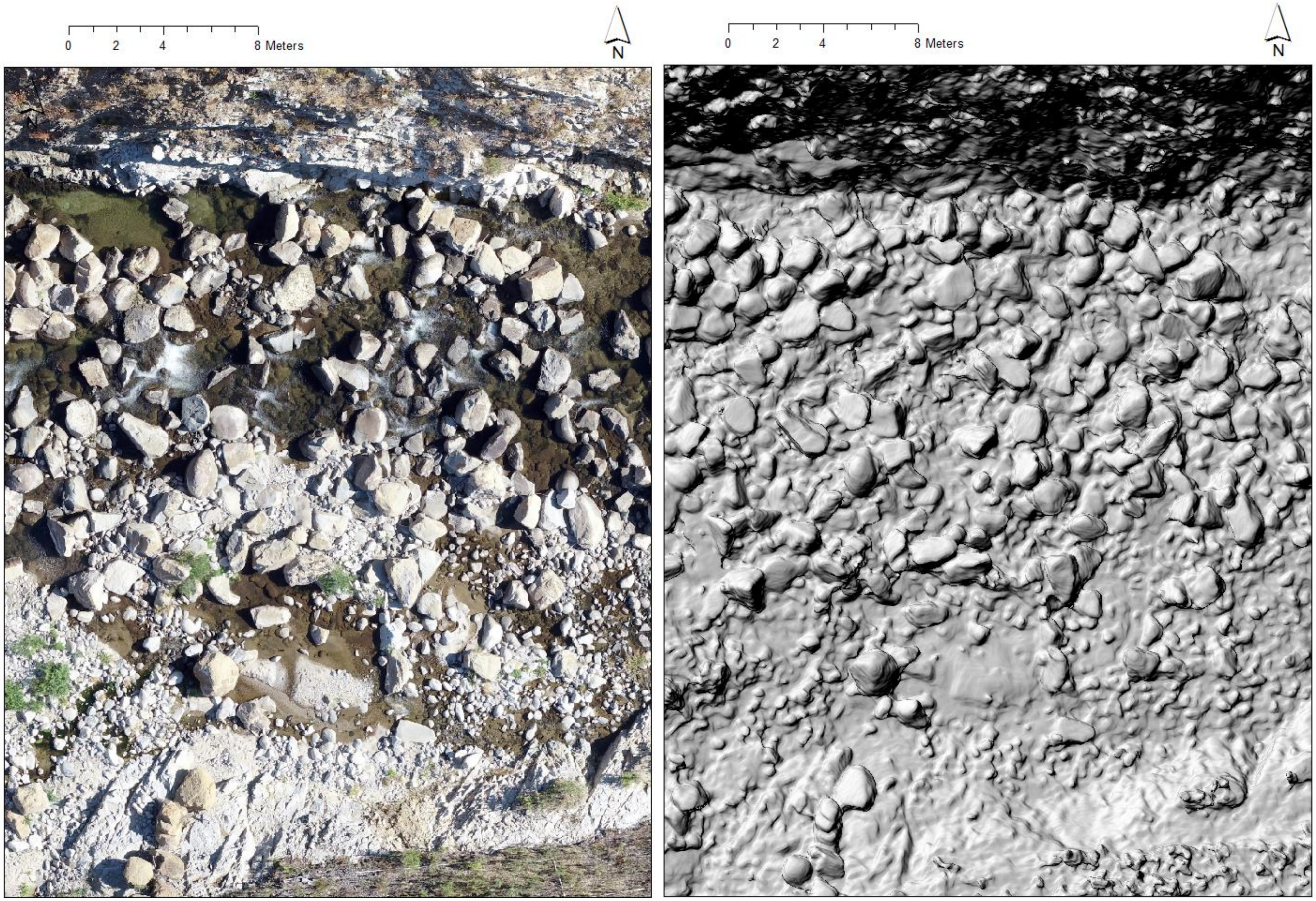
A-2: Site Details

site	width (ft)	depth (ft)	problem	real	video/time	notes
1	<3	<1	Both		180714_lower/1:59	Two entries, both too narrow
2	<3	~1	Width		180714_lower/2:03	Not enough (landing?) pools, too narrow for passage
3	<3	>1	Width		180714_lower/2:20	
4	<3	<2	Width		180714_lower/2:39	Too narrow, too shallow for jump
5	>3	<1	Depth		180714_lower/2:50	
6	<3	<1	Both		180714_lower/3:14	Too narrow/shallow for entry/jump
7	<3	>1	Width		180714_lower/3:25	
8	<1	>1	Width		180714_lower/3:27	Slot beneath rock ledge
9	<3	<1	Both		180714_lower/3:30	
10	~1	<1	Depth		180714_lower/3:32	Multiple paths <3ft but water deep enough on avg across all paths
11	<3	>1	Width		180714_lower/3:33	Two passages too narrow
12	>3	<1	Depth		180714_lower/3:41	
13	<3	>1	Width		180714_lower/3:44	
14	<3	1	Jump	x	180714_lower/3:48	No landing pool
15	<3	<1	Both		180714_lower/3:56	
16	>3	<2	Jump		180714_lower/4:02	
17	>3	>1	Jump		180714_lower/4:10	Jump >1ft
18	>3	<1	Width		180714_lower/4:18	
19	<3	<2	Jump	x	180714_lower/4:37	Multiple difficult jumps; broad jump leading to difficult passage
20	<3	~2	Width		180714_lower/5:06	Multiple paths <3ft but water deep enough on avg across all paths
21			Depth	x	180714_lower/5:24	25 m long reach; shallow riffle; multiple shallow jumps/pools
22		<1	Depth		180714_lower/5:47	10 m long reach; broad, shallow reach
23	<3	<1	Both	x	180714_lower/6:09	10 m long reach; Multiple jumps and poor landing pools
24	<3	~1	Width		180529_CRRDR_mid_30cfs/0:33	Multiple passages, <2ft pools for jumps
25	<3	>1	Width		180529_CRRDR_mid_30cfs/0:32	
26	<3	>1	Width		180529_CRRDR_mid_30cfs/0:29	
27	<3	<1	Both		180529_CRRDR_mid_30cfs/0:24	Multiple passages w/one >1ft depth
28		<1	Jump		180529_CRRDR_mid_30cfs/0:52	No jump pool, >1ft jump
29		~1	Jump		180529_CRRDR_mid_30cfs/0:55	<1ft pool; 1ft jump
30	<3	~1	Width		180529_CRRDR_mid_30cfs/1:00	
31	<3	~1	Width		180529_CRRDR_mid_30cfs/1:05	
32		<1	Depth		180529_CRRDR_mid_30cfs/1:12	~.5ft depth, general zone of <1ft depth for passage
33		<1	Depth		180529_CRRDR_mid_30cfs/1:13	~10ft zone of <1ft passage
34		<1	Depth		180529_CRRDR_mid_30cfs/1:52	1ft jump
35		~2	Jump		180714_middle/1:19	19 m long series of jumps, with >1ft jump at downstream end
36		<1	Depth	x	180714_middle/1:30	18 m long reach; shallow, broad reach, <1ft deep
37		<1	Depth		180529_CRRDR_mid_30cfs/2:26	Two short jumps; 1-1.5ft jump pools
38		<1	Depth		180529_CRRDR_mid_30cfs/2:31	Shallow jump/land pools
39	<3	<1	Both		180529_CRRDR_mid_30cfs/2:33	Shallow rapids
40	~3	<1	Depth	x	180529_CRRDR_mid_30cfs/2:34	
41	<3	<1	Both		180529_CRRDR_mid_30cfs/2:50	20 m long reach; Multiple paths <3ft width; shallow rapids
42		<1	Depth		180529_CRRDR_mid_30cfs/3:06	Shallow riffle
43		<1	Depth		on other videos	20 m long reach; shallow riffle; .5ft depth
44		<1	Depth		180714_upper/0:00	20 m long reach; riffle
45		<1	Depth	x	180714_upper/0:12	Shallow barrier
46		<1	Depth		180714_upper/0:13	Multiple paths
47		<1	Depth		180714_upper/0:39	Multiple paths
48	<3	<1	Both		180714_upper/0:40	Multiple paths
49		<0.5	Depth	x	180714_upper/1:00	26 m long reach; shallow riffle in reservoir reach
50		<1	Depth	x	180714_upper/1:22	28 m long reach; shallow riffle in reservoir reach
51		<1	Depth	x	on other videos	25 m long reach; shallow riffle in reservoir reach

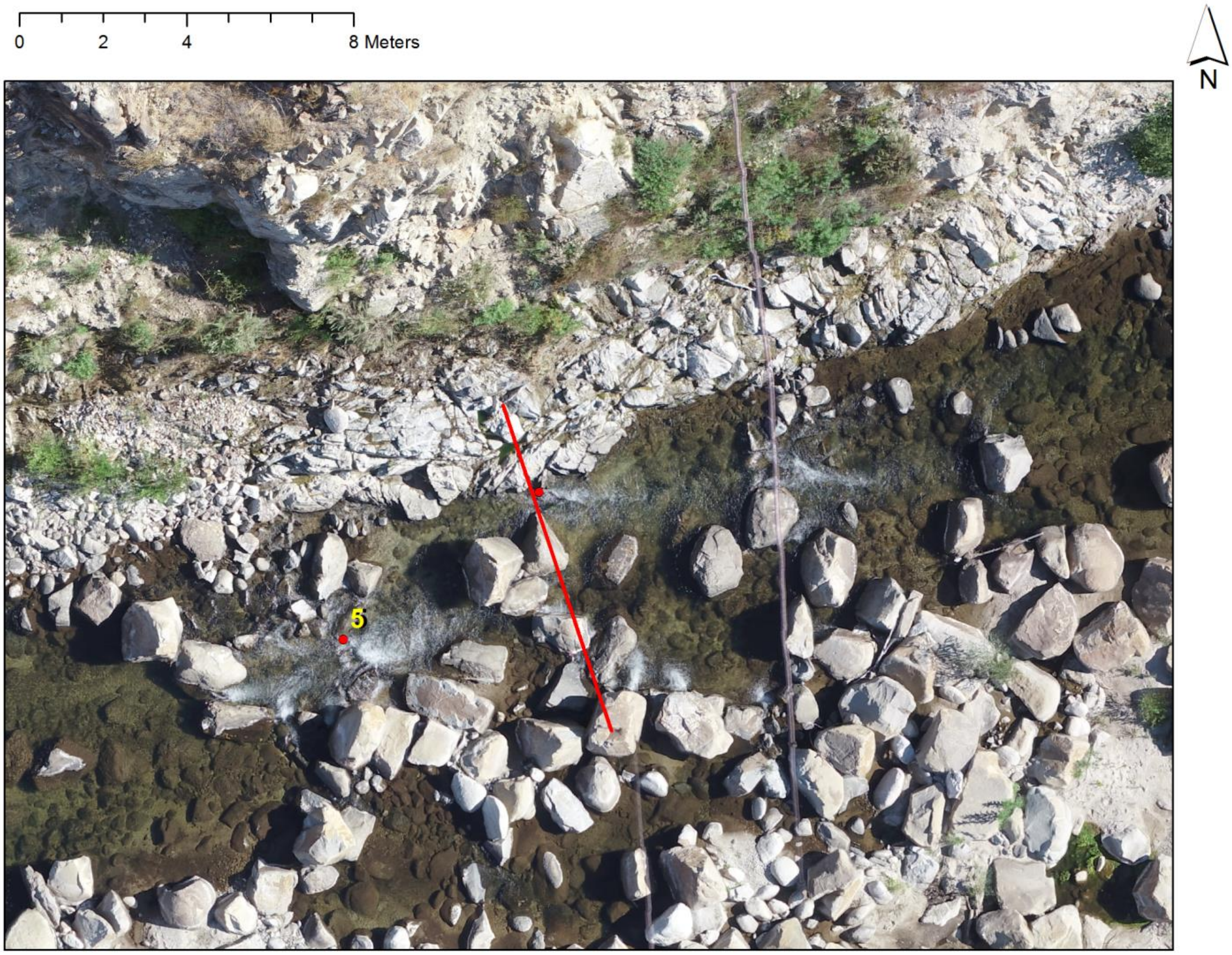
7 Appendix B

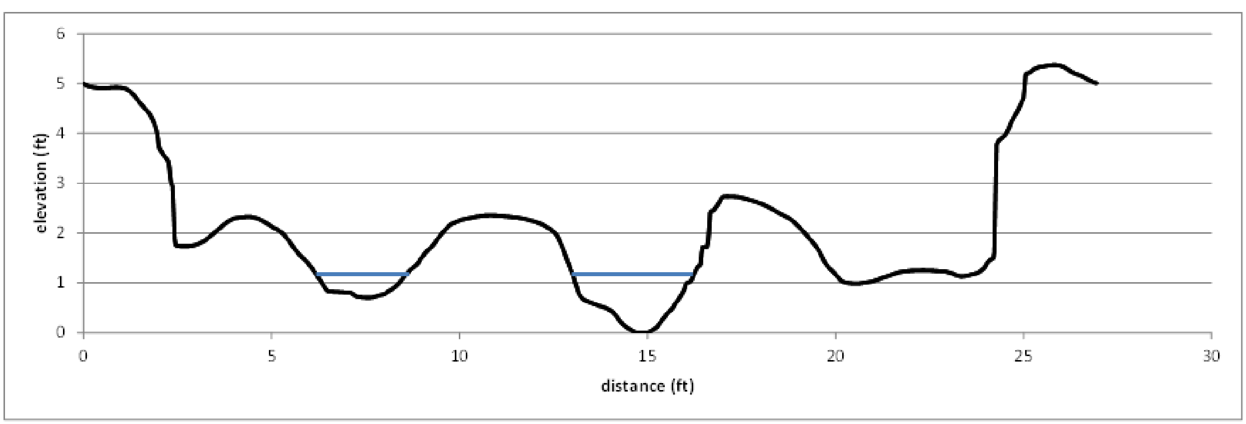


B-1: Hillshade reveals physical complexity typical of the Reach A boulder field. DSM from 8 mm pixel SfM photogrammetry.

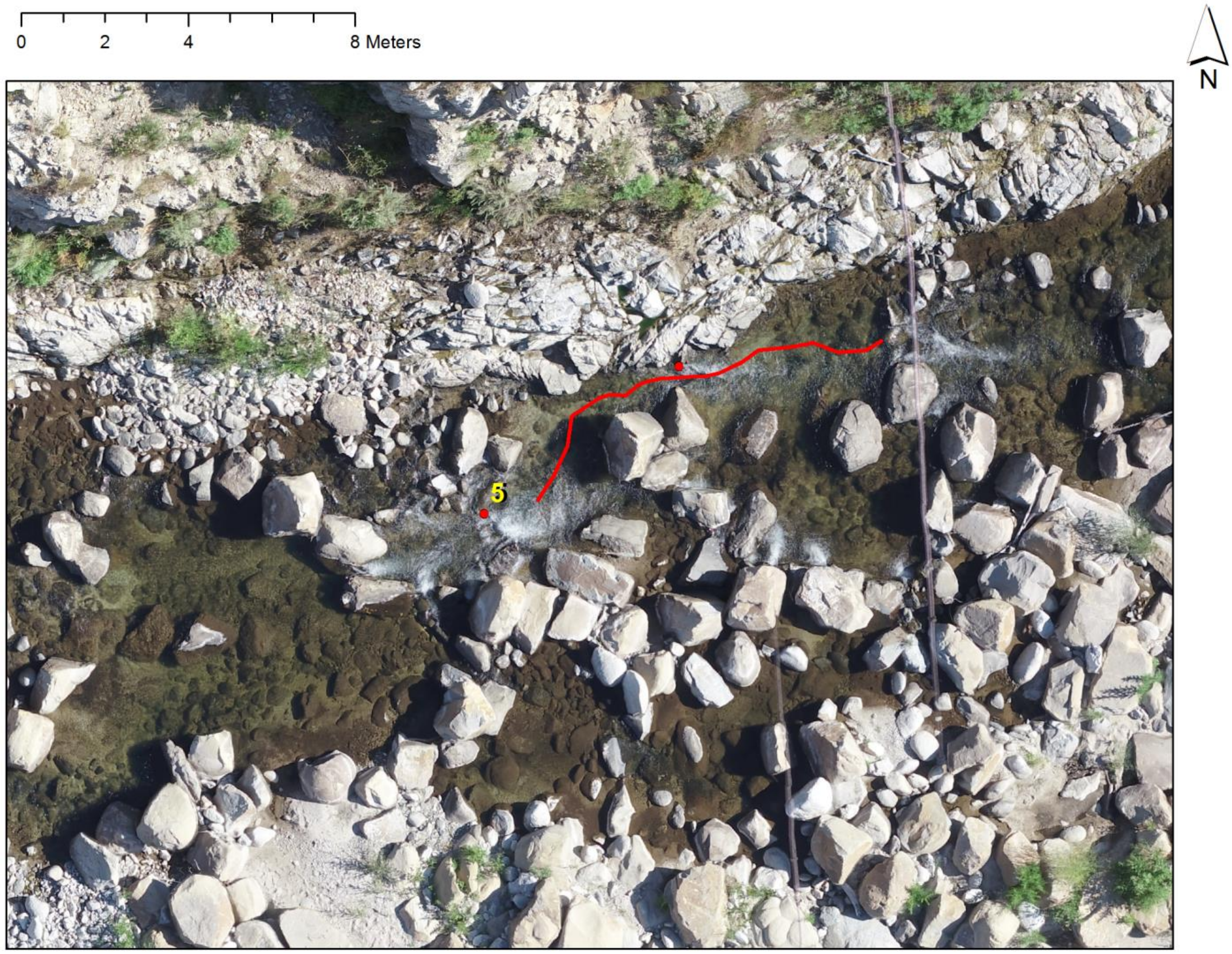


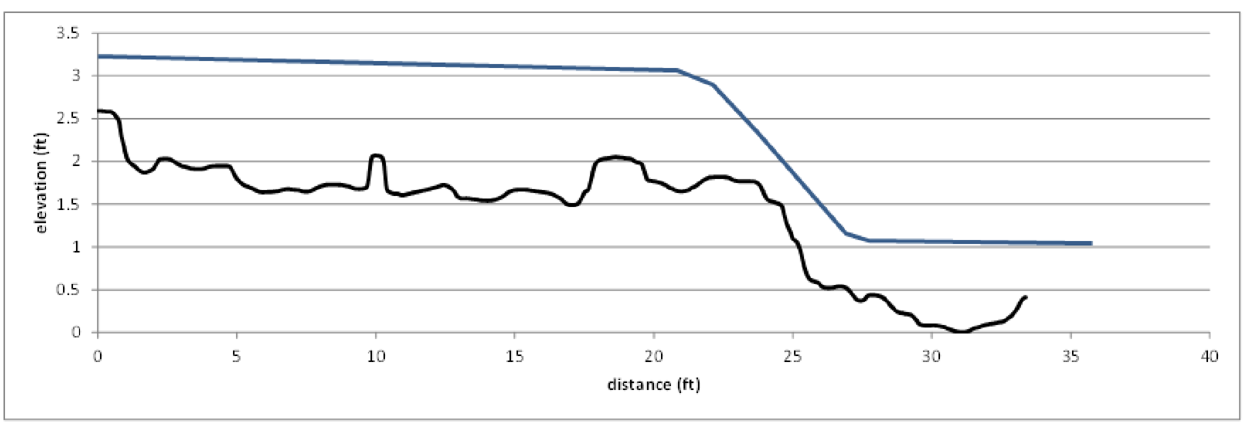
B-2. Left: Orthophoto of portion of Reach A. Right: Hillshade of same location showing the typical physical complexity of the project area. Flow is 15 cfs on 7/15/18



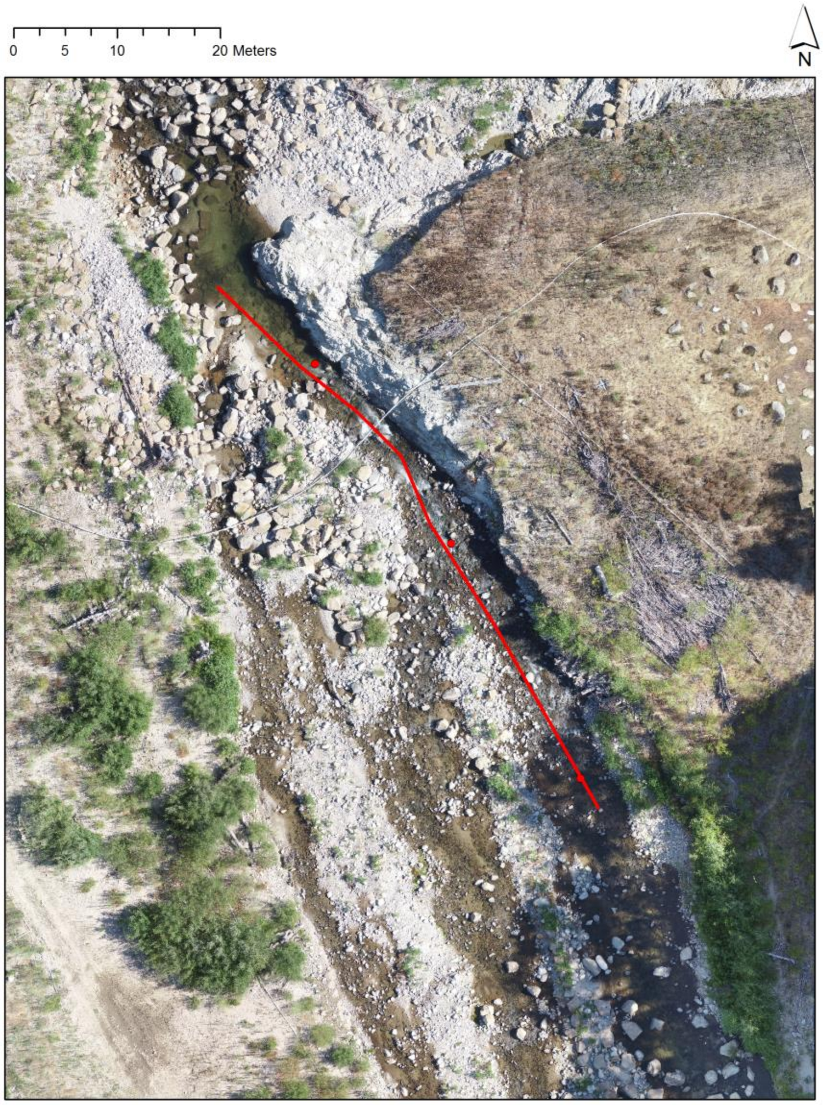


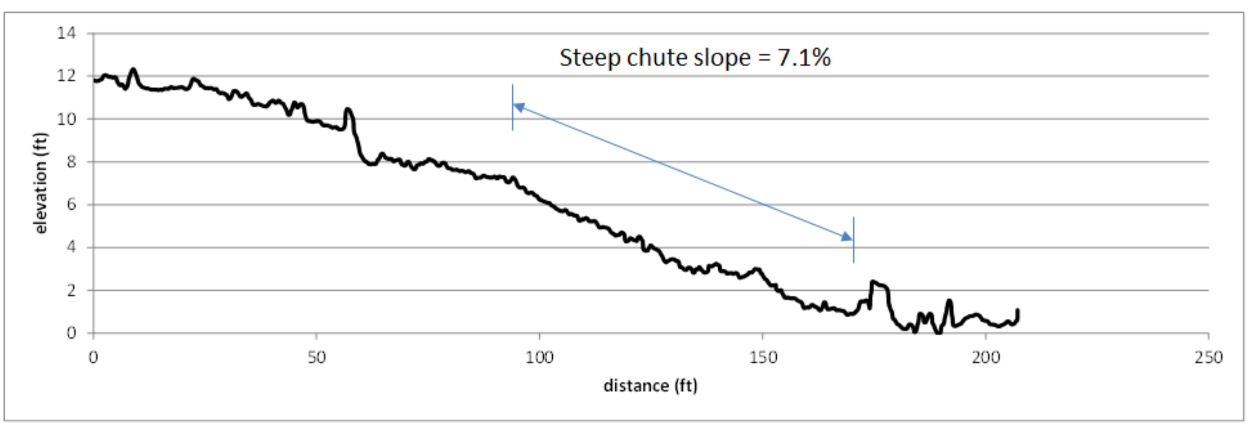
B-3. Cross section through site #4. Shallow water in left channel is at crest of small jump. Deeper water in right channel is blocked upstream. Water surface estimated from orthophoto. Q = 15 cfs.



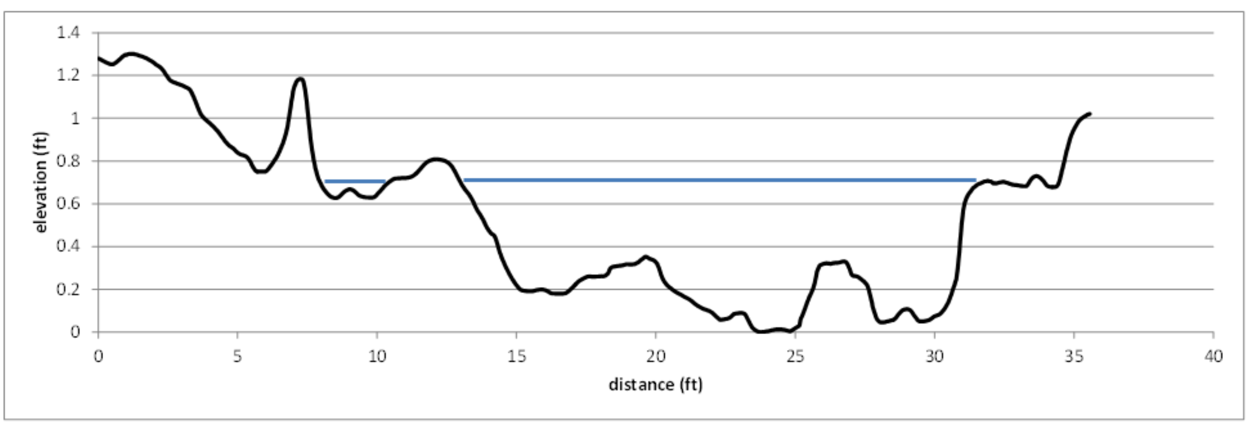


B-4. Bottom: Longitudinal profile through site #4. Water surface approximated from orthophoto at 15 cfs.

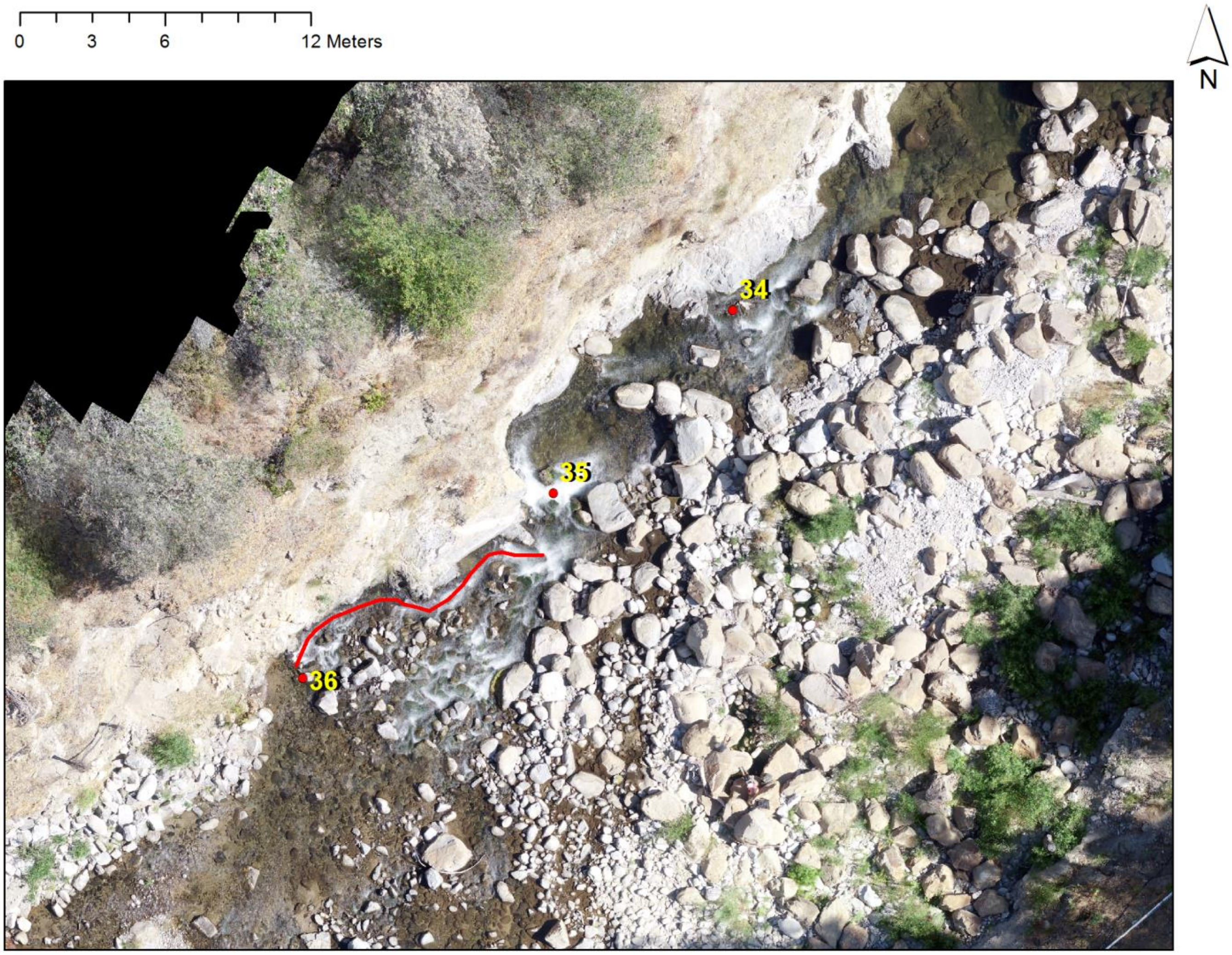


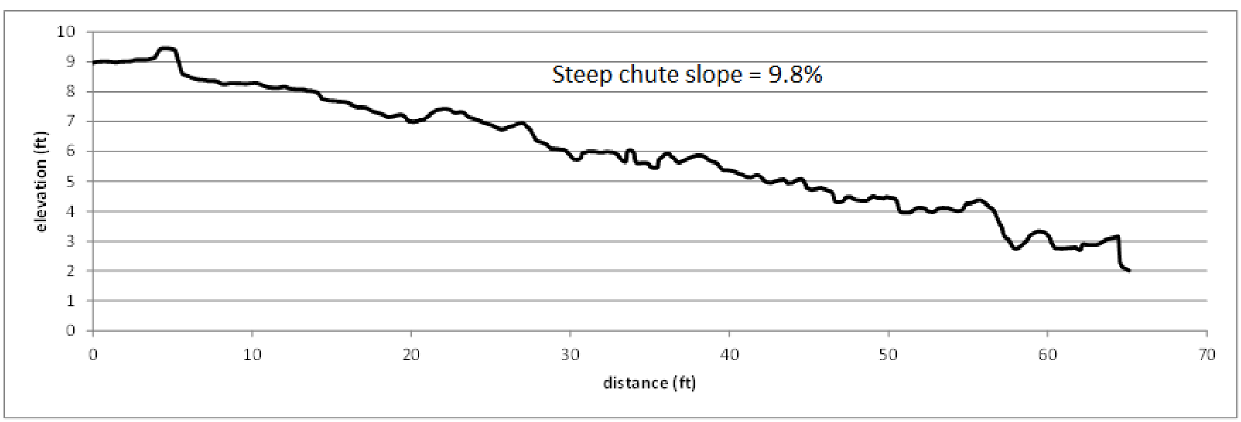


B-5. Longitudinal profile through Reach B. This is the original location of the "Section C" step-pool sequence. Flow is from south to north. Northern red dot is entrance to steep reach, potential barrier #20. Profile extends through sites #20, #21, and #22. Q = 15 cfs.

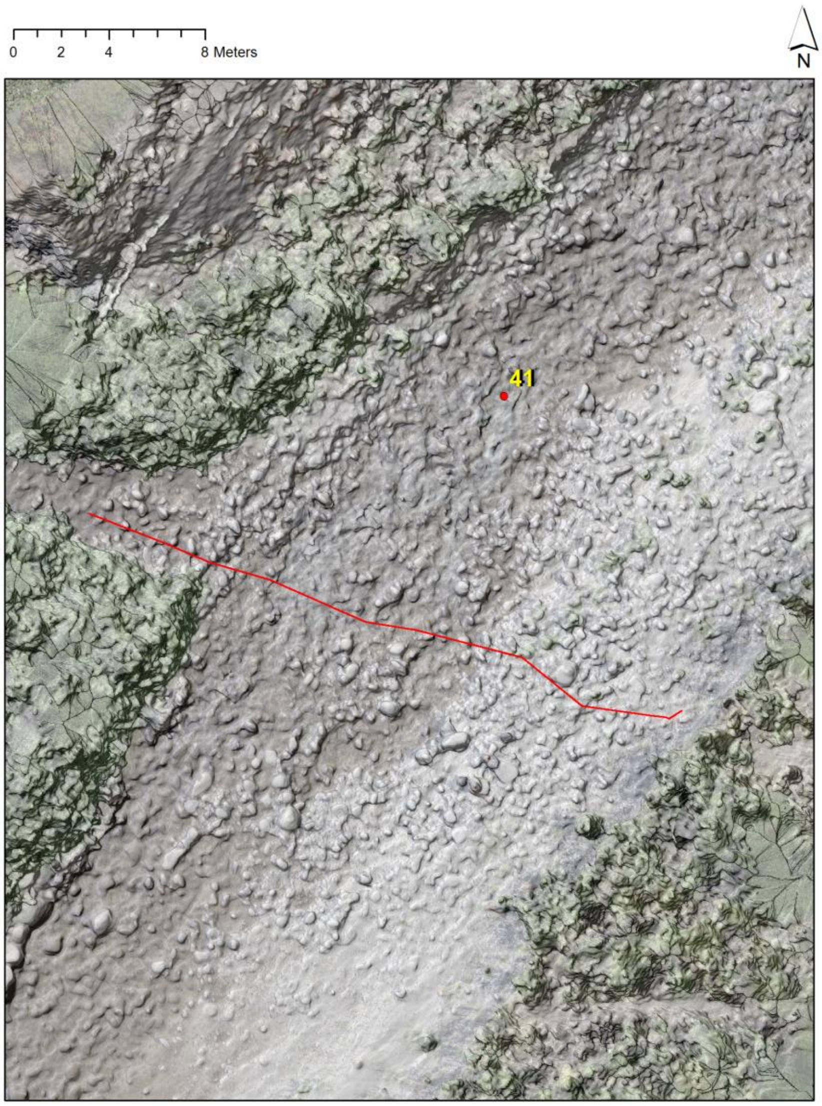


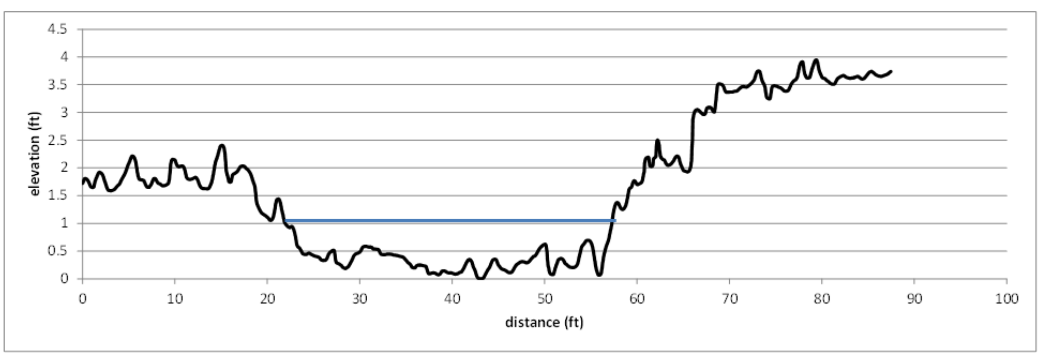
B-6. Typical shallow cross section in Reach C. Flow is from south to north. Water surface approximated from orthophoto at Q=15 cfs



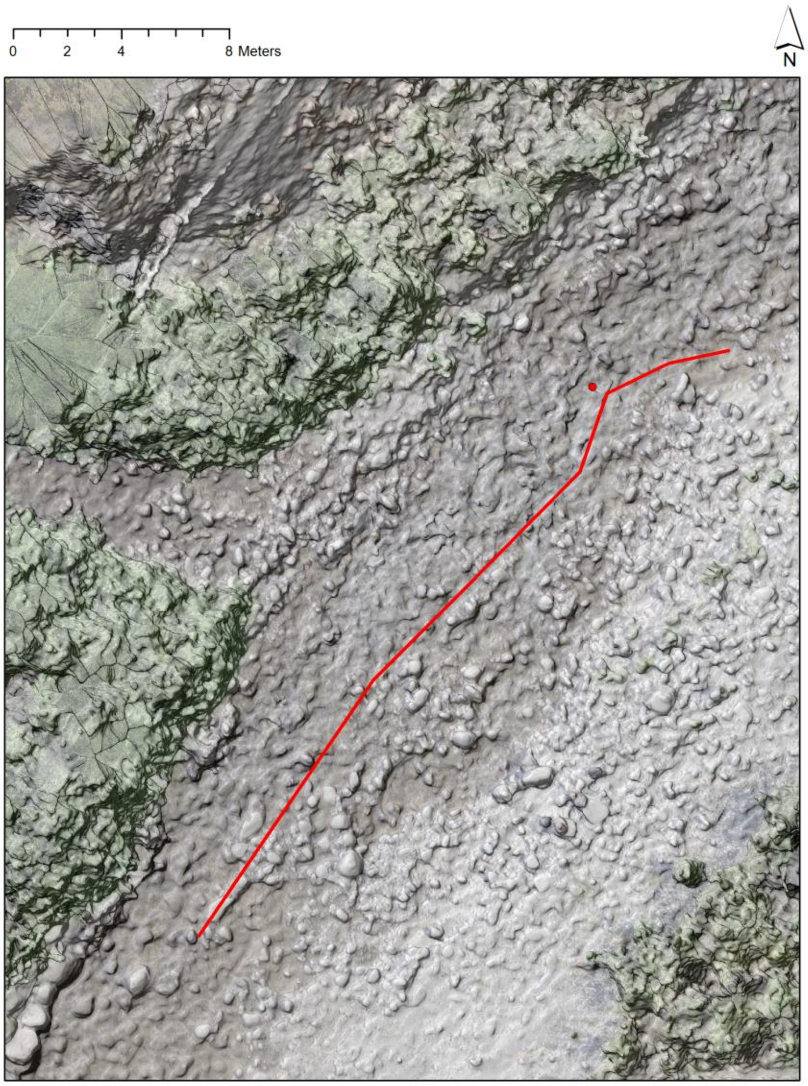


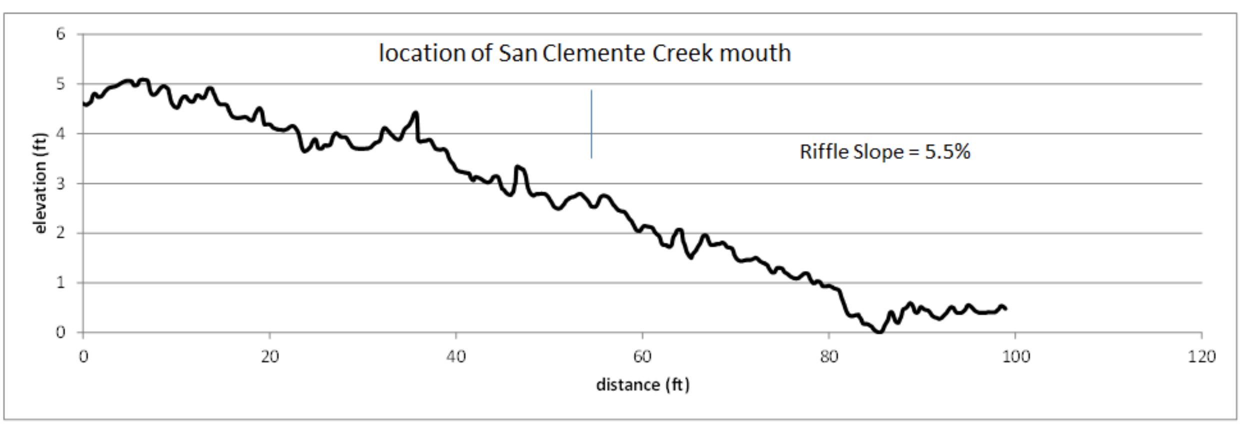
B-7. Top: Longitudinal profile of site# 35. Flow is northwest. Q = 15 cfs





B-8. Top: combined hillshade and orthophoto reveals bed complexity at site #41 riffle. Cross section begins 15 m up San Clemente Creek mouth. Water surface is estimated from orthophoto at Q = 15 cfs.





B-9. Longitudinal profile of site #41 riffle at San Clemente Creek mouth.