Title

Post-breach Monitoring of a Natural Beaver Dam on French Creek

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Final Draft: Post-breach Monitoring of a Natural Beaver Dam on French Creek

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Abstract

Our post-project monitoring research focuses on a natural beaver dam on French Creek in the Scott River Watershed in Siskiyou County, CA. The dam exists on a stretch of the creek with several beaver dam analogues (BDAs), which have been implemented by the Scott River Watershed Council in the hopes of combatting incision in the system and recruiting beaver to maintain the structures. French Creek in particular is an important spawning ground for the threatened coho salmon, so the impacts of the dam on fine sediment are of particular interest. Since the installment of the BDAs on French Creek, a beaver family has colonized the site and built a natural beaver dam. In 2021, high flows led to a breach in this dam. Scott River Watershed Council (Council) developed plans to fortify it using similar techniques used in the nearby BDAs. These plans will be implemented in November 2023, one week after this survey.

This dam breach presented the unique opportunity to analyze the surrounding area before its reconstruction, providing both post-breach and pre-reconstruction information on beaver presence, groundwater levels, channel morphology, and sediment grain size. We found evidence of continued beaver activity at the site. Groundwater levels were lower compared to pre-breach data from 2020. Sediment grain size was bimodal directly below the breached dam as compared to an upstream site with imported gravels, potentially indicating a release of fine sediment during the breach. Given the impact of fine sediment on salmon spawning, these fluxes of sediment should be carefully studied and managed. Comparable cross-section data did not exist for the studied reach, so we cannot draw conclusions about the impact of the breach on these metrics, though they may be used going forward to assess the influence of the artificial dam repair.

1. Problem Statement

Throughout the Scott River Watershed in Siskiyou County, CA, efforts have been underway since 2014 to combat incision in both Scott River and one of its tributaries, French Creek (Charnley 2018). To this end, beaver dam analogues (BDAs) have been installed with the hope of mimicking the positive effects of beaver dams on groundwater and channel morphology, as well as recruiting beavers to colonize the site and maintain the initial dam analogue (C. Gilmore, Scott River Watershed Council, personal communication, November 2023). French Creek, and the entire Scott River watershed, have been negatively affected by logging, mining, water extraction, and other human impacts. Beaver dams and BDAs, are known to help with sediment retention, raise water tables, and overall help to restore riparian systems. These long-term restoration functions help to create a stable habitat for both the beavers, salmon, and an overall resilient ecosystem, through a form of process-based restoration. This approach has been successful at French Creek, a third-order tributary of Scott River, where a beaver den and natural beaver dam have been established (B. Stapleton, landowner, personal communication, November 2023).

Beyond the overall positive ecosystem impacts, the function of BDAs in retaining fine sediment is an important component in their connection to salmon habitats. French Creek is a key spawning ground for the threatened Southern Oregon Northern California Coho salmon (*Oncorhynchus kisutch*), which prefer gentle-gradient gravel-bed channels in which to spawn, both of which can be key functions of BDAs (NOAA Fisheries 2014, C. Gilmore, Scott River Watershed Council, personal communication, November 2023). The high water quality and longitudinal connectivity of French Creek make it suitable for coho spawning, even in severe

drought years, making it a critical refugium for the threatened species (Scott River Watershed Council, 2021).

The streambed of the Scott River system demonstrates a bimodal distribution of particle sizes, with cobbles and fine sediment–predominantly decomposed granite–representing the modes (Scott River Watershed Council 2021). In French Creek, this decomposed granite is particularly problematic because it can prevent the emergence of salmon alevins from the intragravel environment after hatching (C. Gilmore, Scott River Watershed Council, personal communication, October 2023). This makes it distinct from <1mm fine sediment, which can clog the intragravel water flow itself (Kondolf 2000).

In 2021, high flows led to a breach in the natural beaver dam at the French Creek site (C. Gilmore, Scott River Watershed Council, personal communication, October 2023). The beavers are now rebuilding the damaged dam, though water still flows through the breach (Figure 1). We performed this research the week before the Scott River Watershed Council planned to repair the breach with the installation of vertical posts, which they hope the beavers will build upon and maintain (example pictured in Figure 2). This positions our project to provide unique insights regarding the response of the stream to the breach. Our research addresses how the channel form, groundwater levels, and sediment coarseness were impacted by the 2021 natural beaver dam breach. We hope it may serve as a baseline to inform how the later installment of vertical posts affects the system, to further show the positive impacts of BDAs on French Creek, and the entire watershed.

2. Methods

2.1 | *Initial Site Assessment*

We worked with the Executive Director of the Scott River Watershed Council, Charnna Gilmore, to attain access to the private restoration site on French Creek. We interviewed her about the restoration efforts across the basin and history of the various sites, including the 2021 breach in the dam at French Creek and the Council's future plans to repair it. We also conducted an interview with the landowner of the site, Betsy Stapleton, and discussed the evidence of beaver presence on her land, including some drag trails, the location of the beaver den, and wildlife camera footage. We also learned of the presence of a groundwater well transect near the dam from these interviews.

2.2 | *Pebble Counts*

We measured pebble counts immediately downstream of the dam breach (where a pulse of fine sediment would be expected to be released) as well as upstream past the beaver den, in an area where there were several engineered log jams. In this area, there was also coarse sediment that was imported for the benefit of the salmon (Nash et al. 2021, C. Gilmore, Scott River Watershed Council, personal communication, November 2023). Per the methods outlined in Kondolf and Lisle (2016), we waded across the river and selected pebbles from directly in front of our boots at regular intervals. We passed these pebbles through a gravelometer. The smallest square that the pebble could pass through was taken to be the size range for that pebble. We returned all of the pebbles to the stream once they were measured. We took measurements until at least one hundred pebbles were sampled. The percentage of each size category was calculated, as well as cumulative percentage (e.g. "35% finer than 4mm").

2.3 | *Cross-Sections*

We selected four positions along the river to perform cross-sections: Site 1 at the groundwater well (selected for its known elevation), Site 2 just above the dam and Site 3 just below the dam, and Site 4 upstream of the groundwater well (Figure 3). Site 1 is 31’9” downstream of Site 4. Site 2 was 64’9” downstream of Site 1, and Site 3 was 15’ downstream of Site 2. We situated Sites 2 and 3 as close to the beaver dam as possible.

To document cross-sections, we used standard methods detailed in Harrelson et al. (1994), though we did not monument our cross-sections with pins or other markers as we failed to receive permission from the landowner at the time of the survey. At each cross-section site, we set up the auto-level and strung the measuring tape across the river, roughly perpendicular to the banks, with some areas being obstructed by vegetation. One researcher read from the level while the other advanced across the river with a rod, stopping for readings at 2 ft intervals as well as additional points of interest such as the start of the water. These measurements were recorded and later compared to the well elevations to determine the elevation of each point along the cross-section. Cross-sections were related to one another through backshots to the cross-section including the point of known elevation (the well).

2.4 | *Groundwater Measurements*

To compare with the Scott River Watershed Council’s groundwater data, we measured groundwater at a preestablished groundwater well transect using a groundwater probe (Figure 10). To compare to ground elevation, we measured the height of the lip of the well. Then, the probe was lowered into the well until the tone indicated it had reached the water level, and the values on the probe were read at the lip of the well. Each team member repeated the measurement at each of the three wells along the transect, and measurements were taken once on

each of the two days and averaged by well. We calculated water surface elevation (WSE) by subtracting the well height from our probe measurement and subtracting that value from the ground elevation (measured using a smartphone). We requested internal groundwater well data from before 2021 from the Scott River Watershed Council and compared it to our readings. This allowed us to infer patterns and see potential effects of the dam breach. Their WSE data was calculated by adding sensor elevation to the depth that it detected (Figure 11). We compared this data with the published gage height data of Scott River to determine any trends (USGS, 2023).

2.5 | *Beaver Presence/Absence Survey*

We searched for evidence of continued beaver activity in the area to confirm the beavers had not abandoned the site. Such evidence included drag trails, scent mounds, chew sticks, and droppings, as detailed in prior reports (Scott River Watershed Council 2023). We also questioned the landowner about prior beaver activity, and were provided with videos from game cameras that showed beavers in the creek.

3. Results

3.1 | *Pebble Counts*

At the upstream site with imported gravel, we observed a roughly normal distribution of grain size centering around the 32-44mm size bracket (Table 1, Figures 4 and 5). The grain size downstream of the dam breach demonstrated a strongly bimodal distribution with peaks in the <4mm and 64-89mm size brackets (Table 2).

3.2 | *Cross-sections*

The cross-sections consistently demonstrated a relatively shallow, broad channel (Figures 6, 7, 8, 9). Cross Section 3 (below the breach) featured the smallest below-water area at 19.8 ft^2. (Figure 8, Table 3). The shallower channel below the dam may be an indication of the impact of the fine sediment released in the breach, and also is in line with our findings on the velocity.

3.3 | *Groundwater*

The groundwater measured at well 3 was roughly 1.5 ft lower than historical measurements from early November 2020, before the dam breach (Table 4). Wells 1 and 2 (titled MFMW 19 and MFMW 20 by the Council) demonstrated a WSE increase of 3.9’ and 3.7’ respectively. This occurred against a backdrop of a 0.79’ increase in the gage height at Scott River (USGS, 2023).

3.4 | *Beaver Presence/Absence Survey*

We found a variety of evidence suggesting continued beaver activity at the site, including a drag trail (Figure 12), gnawed vegetation (Figure 13), and chew sticks (Figure 14). These findings correspond with past observations suggesting no cessation in beaver activity since they had established a den at the site (B. Stapleton, landowner, personal communication, November 2023).

4. Discussion

4.1 | *Overview*

Given the dynamism of river systems and particularly beaver dams, continued rigorous monitoring is necessary. In particular, aggradation can not be estimated from a single snapshot in

time. Capturing data about the state of the river prior to the planned restoration effort of reinforcing the dam will allow further study of its impacts on groundwater, sediment, and channel morphology. Though limited, our data will become part of a collection that provides key context for future studies of this system.

In light of the French Creek's role as a spawning ground for coho salmon, particular care should be taken in reinforcing the beaver dam so future fluxes of fine sediment such as the one we observed directly downstream of the breach may be averted.

4.2 | *Limitations*

Though our calculated WSEs differ from historical values at similar dates, it should be noted that historical data features swings of up to four feet, which exceeds our measured WSE changes. That said, comparison against Scott River, which increased less over this time than the groundwater at French Creek, suggests that some signal from the beaver dam breach may be seen in the WSE values.

Further, our cross-sections were taken without the benefit of preexisting cross-sections, and we did not place any pins. This may reduce the accuracy and replicability of our cross-sections. Conclusions regarding aggradation or downcutting could not be made without prior data.

Finally, pebble counts may not provide a complete view of reach-scale conditions and are subject to variability (Kondolf et al., 2016).

4.3 | *Future Work*

Given the importance of French Creek to coho salmon, we would recommend a more granular assessment of gravel suitability and distribution such as a facies map (Kondolf et al., 2016). Such a map would provide greater insights into potential challenges to coho salmon throughout their reproductive cycle, as well as the evolution of the conditions in the channel in response to the beaver dam repair.

5. Conclusions

Prior to the 2023 reinforcement of the breached natural dam, beavers were still active at the French Creek site. Pebble counts demonstrated a large amount of ultrafine sediment directly below the dam, suggesting a release during the breach as well as potential mobilization of the mid-sized (32-44mm) clasts observed at the upstream site. Alternatively, the absence of said mid-sized clasts may be attributed to the importation of gravels to the upstream site. Conclusions could not be made regarding the morphology due to a lack of comparable cross-sections, though our work may provide context for future studies of the channel morphology immediately around the natural beaver dam and documentation of baseline conditions for future studies.

Although our cross-sections cannot be directly compared to historical data, we believe that they still provide key insight into the way that the creek changes above and below the dam, with the channel being wider and deeper above the dam than below. This information could be compared to future observations after the reconstruction of the dam, to analyze the changes as a whole, rather than the changes along exact cross-sections of the creek. Similarly, we believe that the large amount of fine sediment below the dam is an important indicator of the negative impacts the breach had on the creek, and is another factor to consider monitoring in the future, and can be compared to our data before the reconstruction.

Despite these reservations, we believe that our data provides a benchmark for French Creek before the reconstruction process, and could help provide insight into the benefits of the BDA construction, to further show the positive impacts of BDAs on French Creek and the Scott River Watershed as a whole.

6. References Cited

Charnley, S. 2018. Beavers, Landowners, and Watershed Restoration: Experimenting with Beaver Dam Analogues in the Scott River Basin, California. *US Department of Agriculture Northwest Climate Hub.* 44 pp.

Harrelson, C. C., Rawlins, C. L., & Potyondy, J. P. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. https://doi.org/10.2737/rm-gtr-245

Kondolf, G. M. 2000. Assessing salmonid spawning gravel quality. *Transactions of the American Fisheries Society*, *129*(1), 262–281. https://doi.org/10.1577/1548-8659(2000)129<0262:assgq>2.0.co;2

Kondolf, G. M., Lisle, T., & Piégay, H. 2016. Measuring bed sediment. In *Tools in fluvial geomorphology* (pp. 278–305). essay, John Wiley & Sons.

Nash, C. S., Grant, G. E., Charnley, S., Dunham, Jason B., Gosnell, H., Hausner, M. B., Pilliod, D. S., & Taylor, J. D. 2021. Great expectations: Deconstructing the process pathways underlying beaver-related restoration. *BioScience*, *71*(3), 249–267.

NOAA Fisheries. 2014. Final Recovery Plan for the Southern Oregon/ Northern California Coast Evolutionarily Significant Unit of Coho Salmon (Oncorhynchus kisutch). *National Oceanic and Atmospheric Administration.* 1841 pp.

Scott River Watershed Council. 2021. French Creek Instream & Off Channel Enhancement Project. Report to California Department of Fish & Wildlife Fisheries Restoration Grant Program. 79 pp.

Scott River Watershed Council. 2023. Scott River Fisheries Monitoring Project - Field Tech note. https://static1.squarespace.com/static/5fbadbe960151b0e314912a4/t/651258c38441fc36dc716360/1695701195531/Scott+River+Direct+Observation+Report_Summer2023_compressed.pdf

Scott River Watershed Council. 2023. Effectiveness & Validation Monitoring of the Scott River Beaver Dam Analogues Final Report 2023. Report to California Department of Fish & Wildlife Fisheries Restoration Grant Program. 32 pp.

United States Geological Survey. 2023. Scott R NR Fort Jones CA - 11519500 Gage height, feet. https://waterdata.usgs.gov/monitoring-location/11519500/#parameterCode=00065&showMedian=true&startDT=2020-11-01&endDT=2020-11-02.

7. Tables and Figures

Figure 1. Looking upstream at the breach in the natural beaver dam on French Creek. 11/5/23, Etna, CA.

Figure 2. Example of vertical reinforcement posts in a BDA installed by Scott River Watershed Council. 11/4/23, Etna, CA.

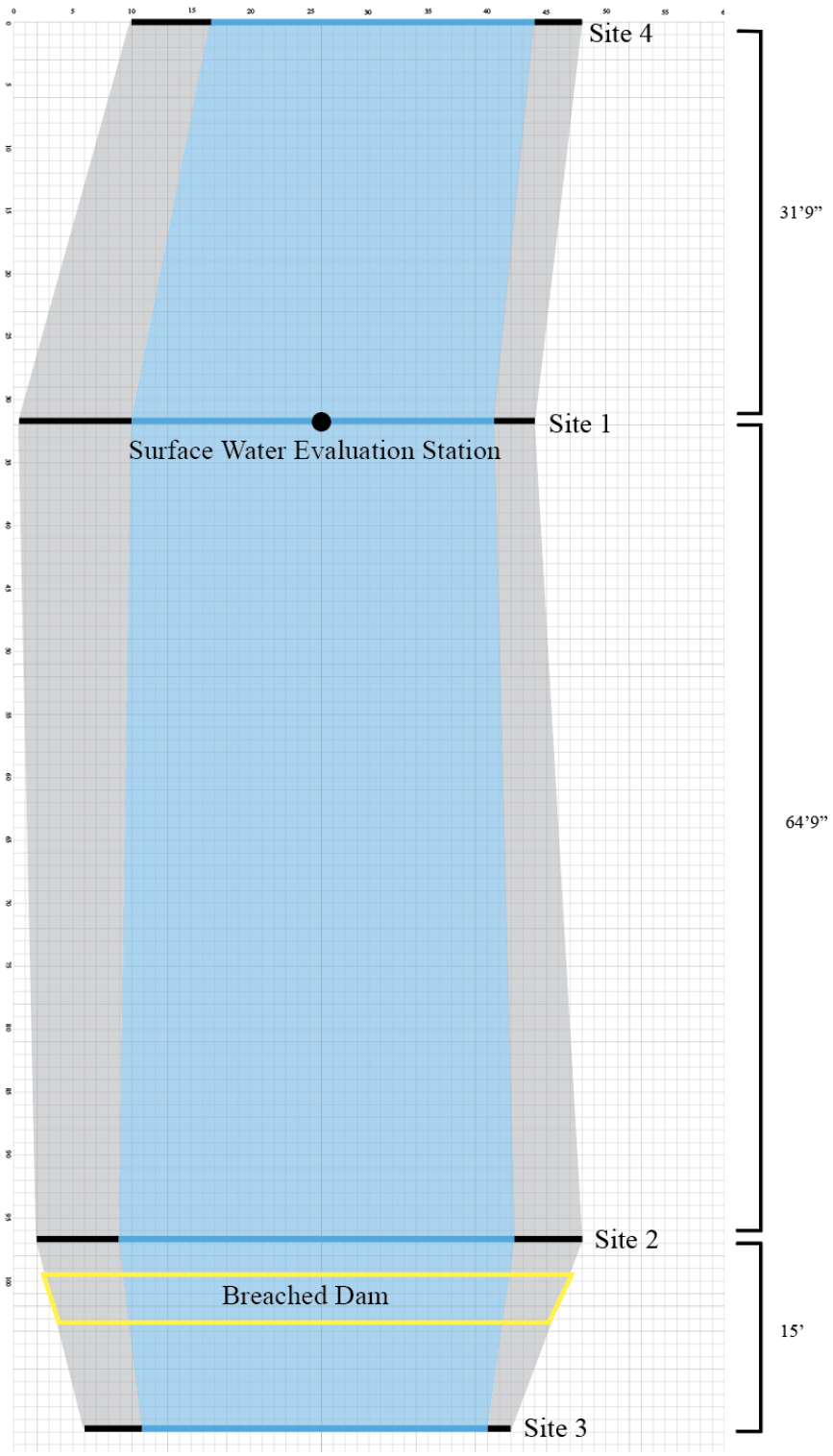


Figure 3. Cross-section locations.

Site 1: French Creek: Location of BDAs with imported gravel				
size (mm)	count	%	cum%	finer than
>360	0	0.00%	100.00%	infinity
256 - 359	0	0.00%	100.00%	359
180 - 255	0	0.00%	100.00%	255
128 - 179	0	0.00%	100.00%	179
90 - 127	0	0.00%	100.00%	127
64 - 89	6	5.50%	100.00%	89
45 - 63	22	20.18%	94.50%	63
32 - 44	39	35.78%	74.31%	44
22.5 - 31	25	22.94%	38.53%	31
16 - 22.4	11	10.09%	15.60%	22.4
11.3 - 15	5	4.59%	5.50%	15
8 - 11.2	1	0.92%	0.92%	11.2
4 - 7	0	0.00%	0.00%	7
<4	0	0.00%	0.00%	4

Table 1. Pebble count at upstream French Creek site. n = 109.

Site 2: French Creek: Location of Breached Beaver Dam				
size (mm)	count	%	cum%	finer than
>360	0	0.00%	100.00%	infinity
256 - 359	0	0.00%	100.00%	359
180 - 255	0	0.00%	100.00%	255
128 - 179	7	6.48%	100.00%	179
90 - 127	11	10.19%	93.52%	127
64 - 89	20	18.52%	83.33%	89
45 - 63	7	6.48%	64.81%	63
32 - 44	3	2.78%	58.33%	44
22.5 - 31	3	2.78%	55.56%	31
16 - 22.4	1	0.93%	52.78%	22.4
11.3 - 15	0	0.00%	51.85%	15
8 - 11.2	4	3.70%	51.85%	11.2
4 - 7	4	3.70%	48.15%	7
<4	48	44.44%	44.44%	4

Table 2. Pebble count downstream of natural beaver dam breach at French Creek. n = 108.

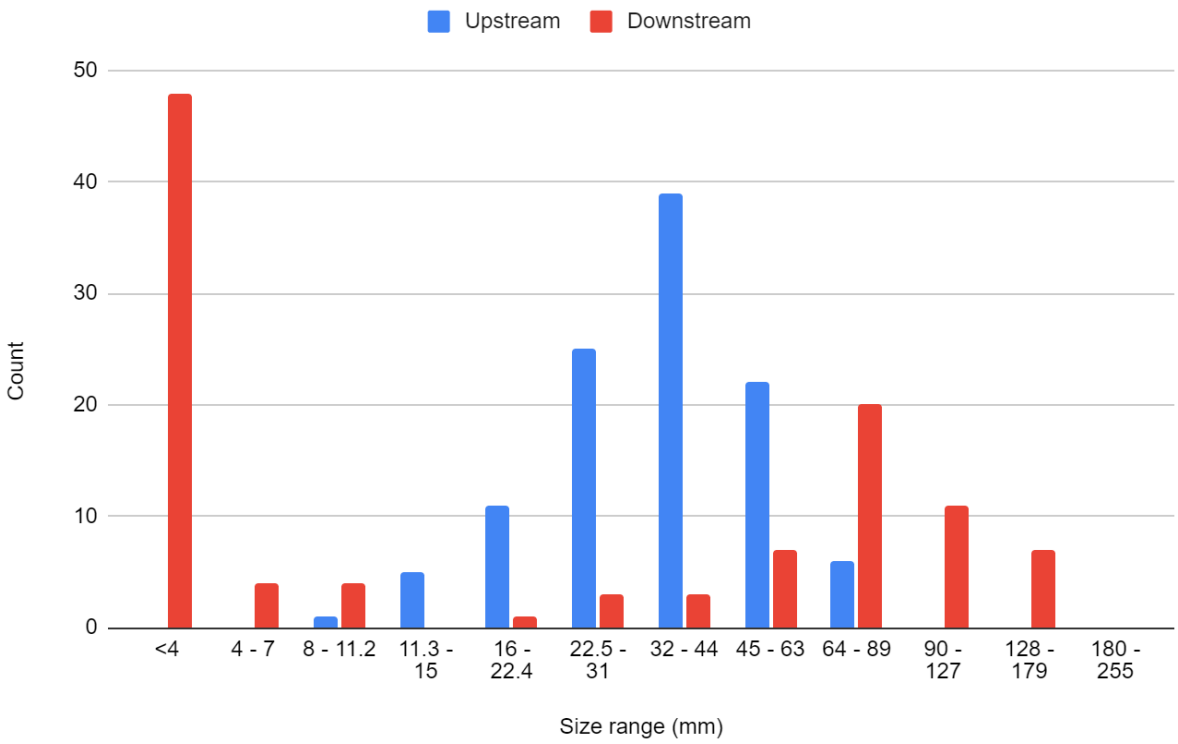


Figure 4. Histogram of grain size at upstream and downstream sites.

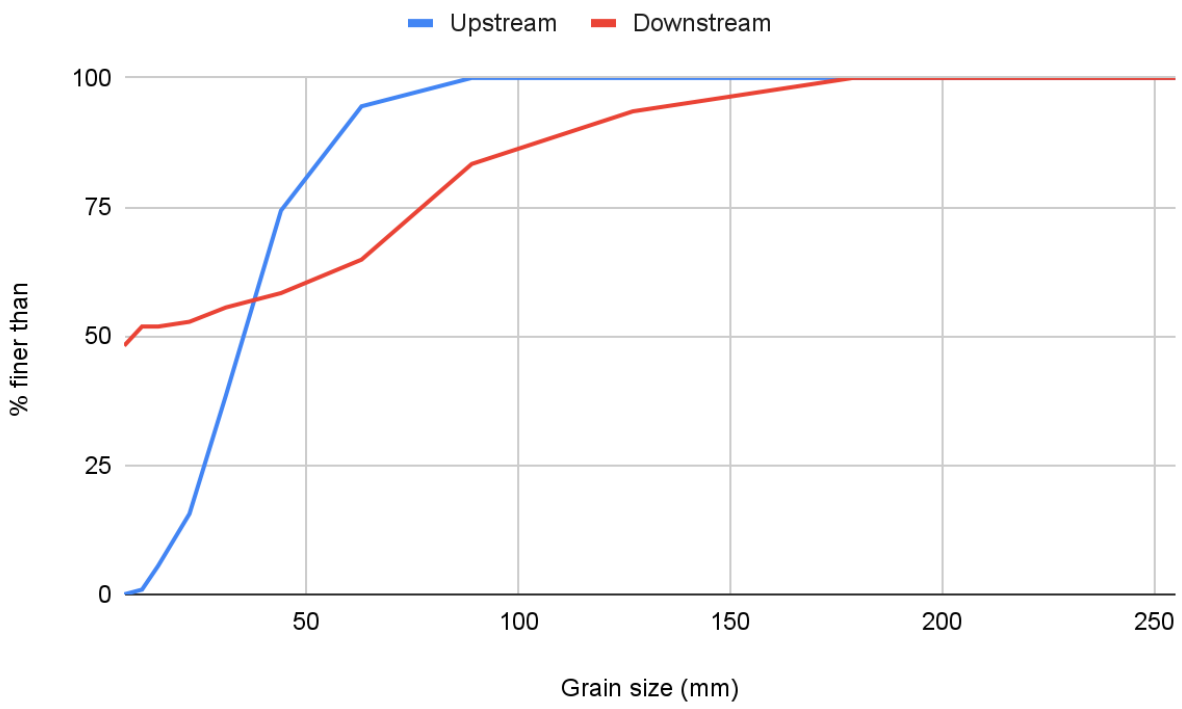


Figure 5. Cumulative grain size distribution at upstream and downstream sites.

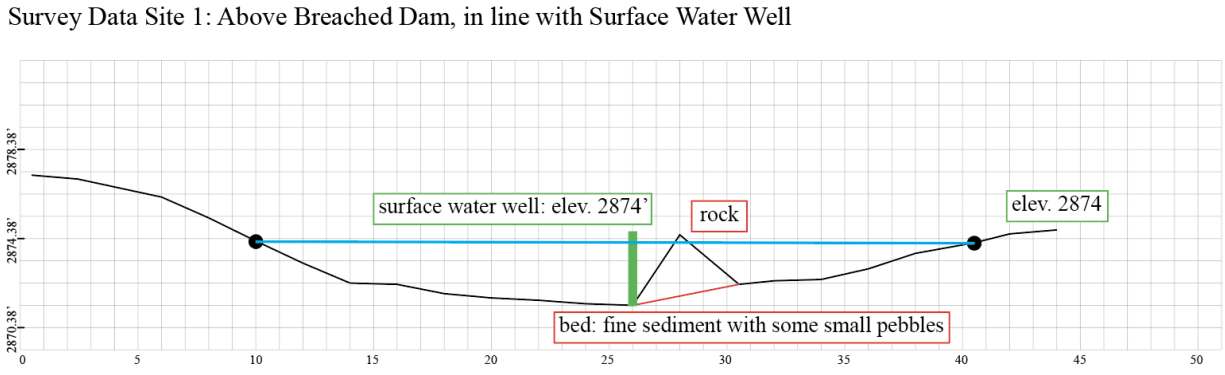


Figure 6. Cross-section 1.

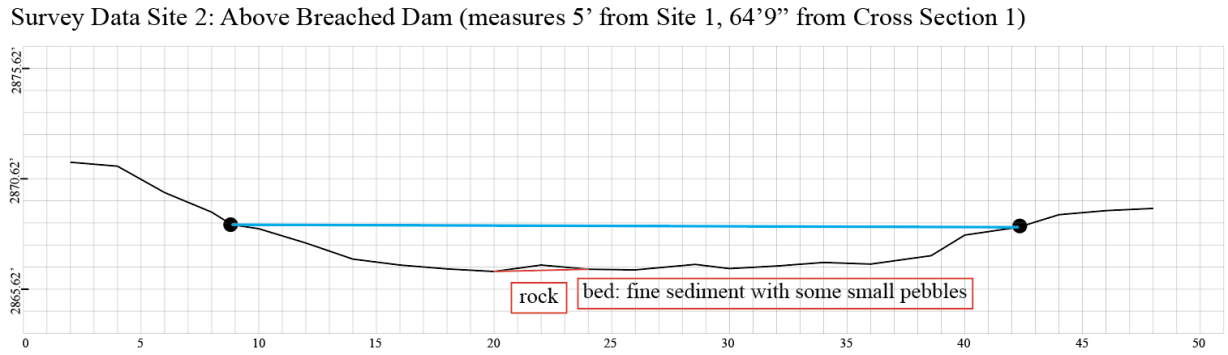


Figure 7. Cross-section 2.

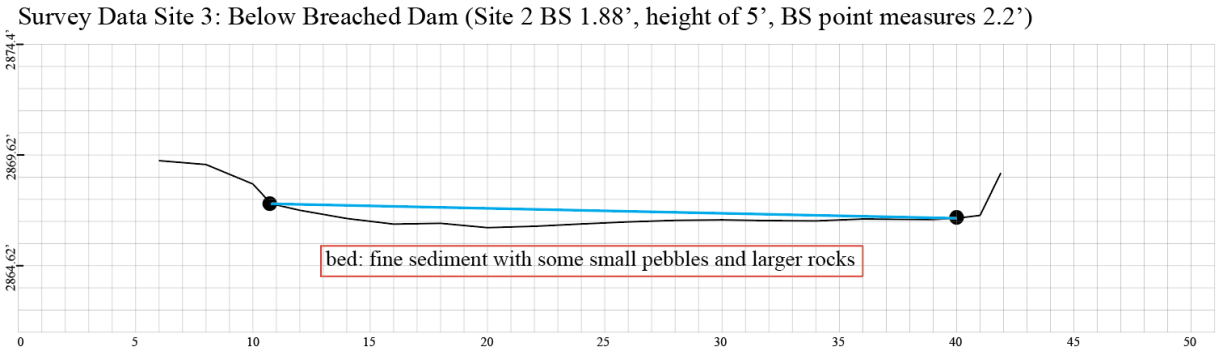


Figure 8. Cross-section 3.

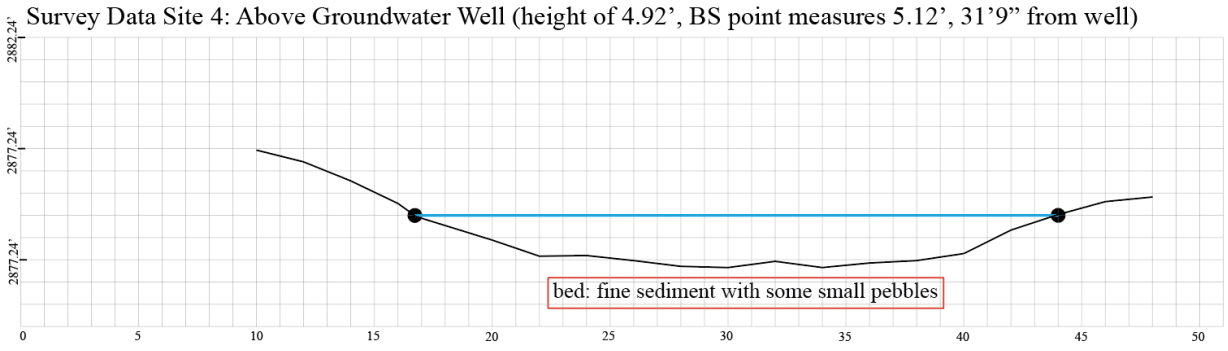
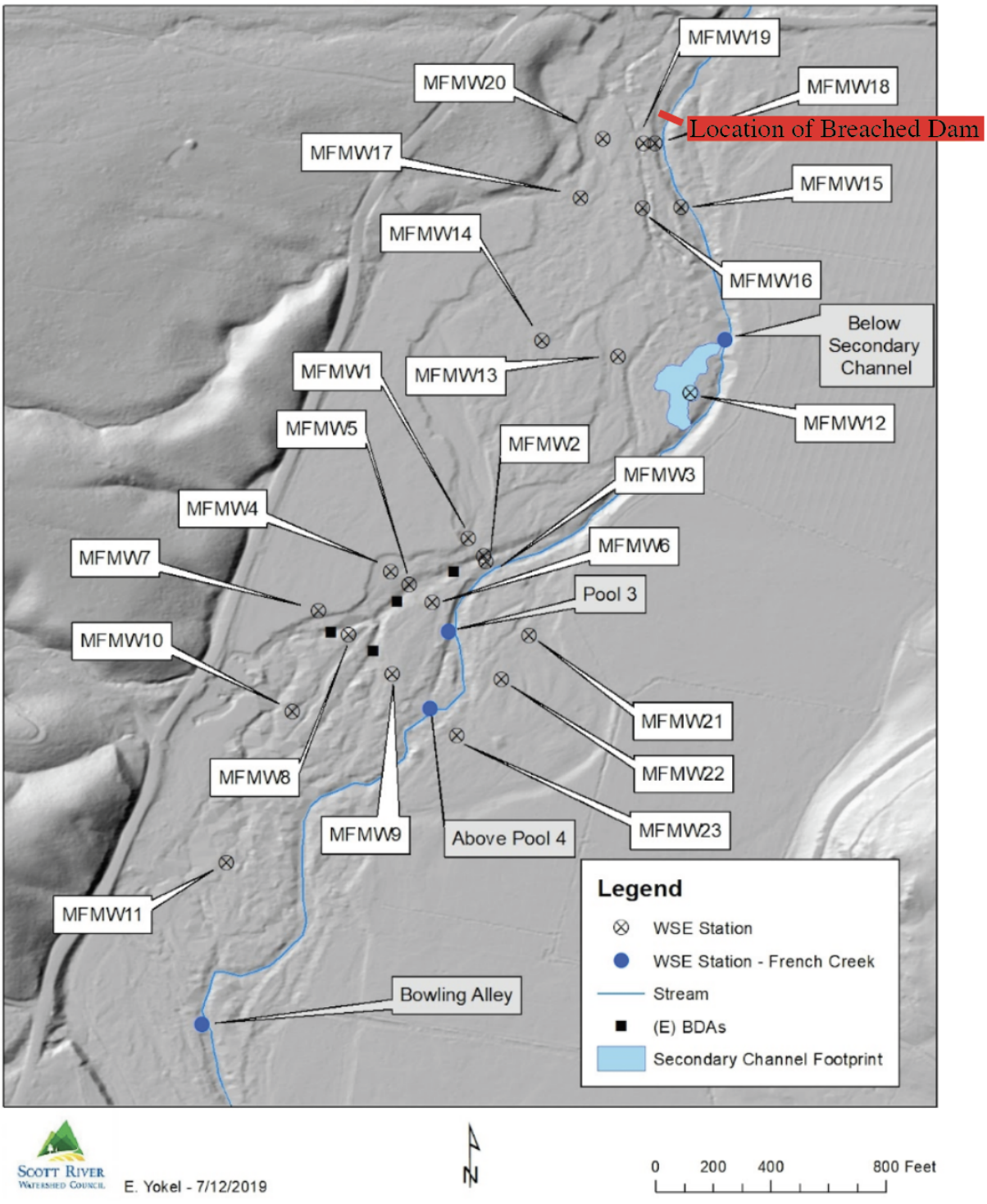


Figure 9. Cross-section 4.

WSE Monitoring Stations - Mid French Creek



Scott River Watershed Council

E. Yokel - 7/12/2019

Figure 10. Map of groundwater wells on French Creek. Well FC2.9 is labeled here as MFMW18. Downstream is at the top of the map. (email communication, Olivia Smith, Scott River Watershed Council)

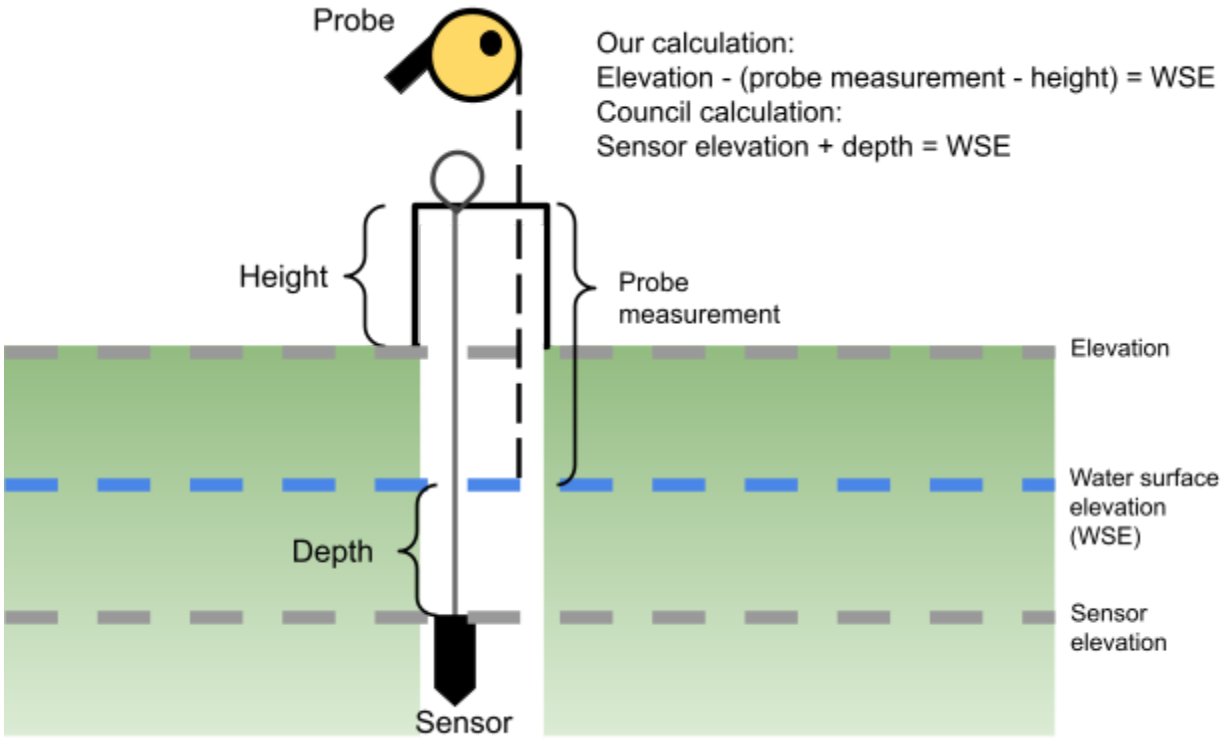


Figure 11. Visual representation of well and calculation methods for WSE.

Groundwater:						
Our Data (November 2023, post-breach)						
Well:	Location:	Elevation (ft.):	Height (ft.):	Probe Measurement (ft.):	WSE (ft.):	Scott River gage height (ft.)
Well 1	41°24'8" N 122°52'6" W	2882	1.075	5.775	2877.2	4.49
Well 2	41°24'8" N 122°52'5" W	2881	0.94	5.22	2876.7	4.49
Well 3 (surface water)	41°24'8" N 122°52'4" W	2874	3.32	2.82	2871.18	4.49
Historical Data (November 2020, pre-breach)						
Well:	Location:	Sensor elevation		Depth (ft.):	WSE (ft.):	Scott River

		(ft.):			gage height (ft.)
FC2.9	41°24'8" N 122°52'4" W	2872	1.32	2873.3	3.7
MFMW19	41°24'7.9" N 122°52'4.9" W	2872	1.03	2873	3.7
MFMW20	41.40224683 -122.8684123	2872	0.8	2872.8	3.7

Table 4. Groundwater measurements and corresponding depth in Scott River. (USGS, 2023, O. Smith, Scott River Watershed Council, personal communication, December 2023).

Figure 12. Drag trail at French Creek site. 11/4/23. Etna, CA.

Figure 13. Gnawed vegetation indicating likely beaver presence. 11/4/23. Etna, CA.

Figure 14. Chew stick found at French Creek site indicating beaver presence. 11/4/23. Etna, CA.

Acknowledgements

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