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Memorandum

DATE: 9 June 2022
TO: Roland Sanford, Chris Lee, Alex Rabidoux, and Max Stevenson, Solano County Water Agency
FROM: Tim Salamunovich, TRPA Fish Biologists
RE: Fall 2021 through Fall 2021 Pleasants Creek Fish Surveys – Final Report

Background

Pleasants Creek is a small, intermittent, third order stream tributary to Lake Solano (impoundment on Putah Creek) that enters the lake about 1.0 mile upstream of the Putah Diversion Dam (Figure 1). The Pleasants Creek basin, which includes it major tributary, Miller Canyon, has a drainage area of approximately 17.3 square miles. The headwaters of Pleasants Creek originate at about 2,700 feet elevation along the Pleasants and Blue ridges of the Vaca Mountains in northwest Solano County about seven miles north of the City of Vacaville, California. Much of the basin is composed of grassland/oak habitat. Streamflow in Pleasants Creek is intermittent and significant flows are typically limited to winter and spring following rainfall events. Pleasants Creek typically starts to flow in September prior to significant rain events as shorter days and lower air temperatures reduce evapotranspiration of surrounding vegetation and springs begin to flow again. During most years there is no streamflow during the dry summer and fall periods and aquatic habitat is limited to isolated pools fed by subsurface flow and groundwater seepage (Photographs 1 through 3). The lower 2,200 feet of Pleasants Creek is lacustrine backwater habitat from Lake Solano (Photograph 4). Upstream of a small agricultural road ford, that delimits the downstream lake backwater and upstream stream channel, Pleasants Creek channel is narrow and deeply incised and its highly erodible banks serve a sediment source to Lake Solano and Putah Creek (Photograph 5). The average gradient on Pleasants Creek is 20 feet per mile, more than twice as steep as the Interdam Reach, between Monticello Dam and Lake Solano.

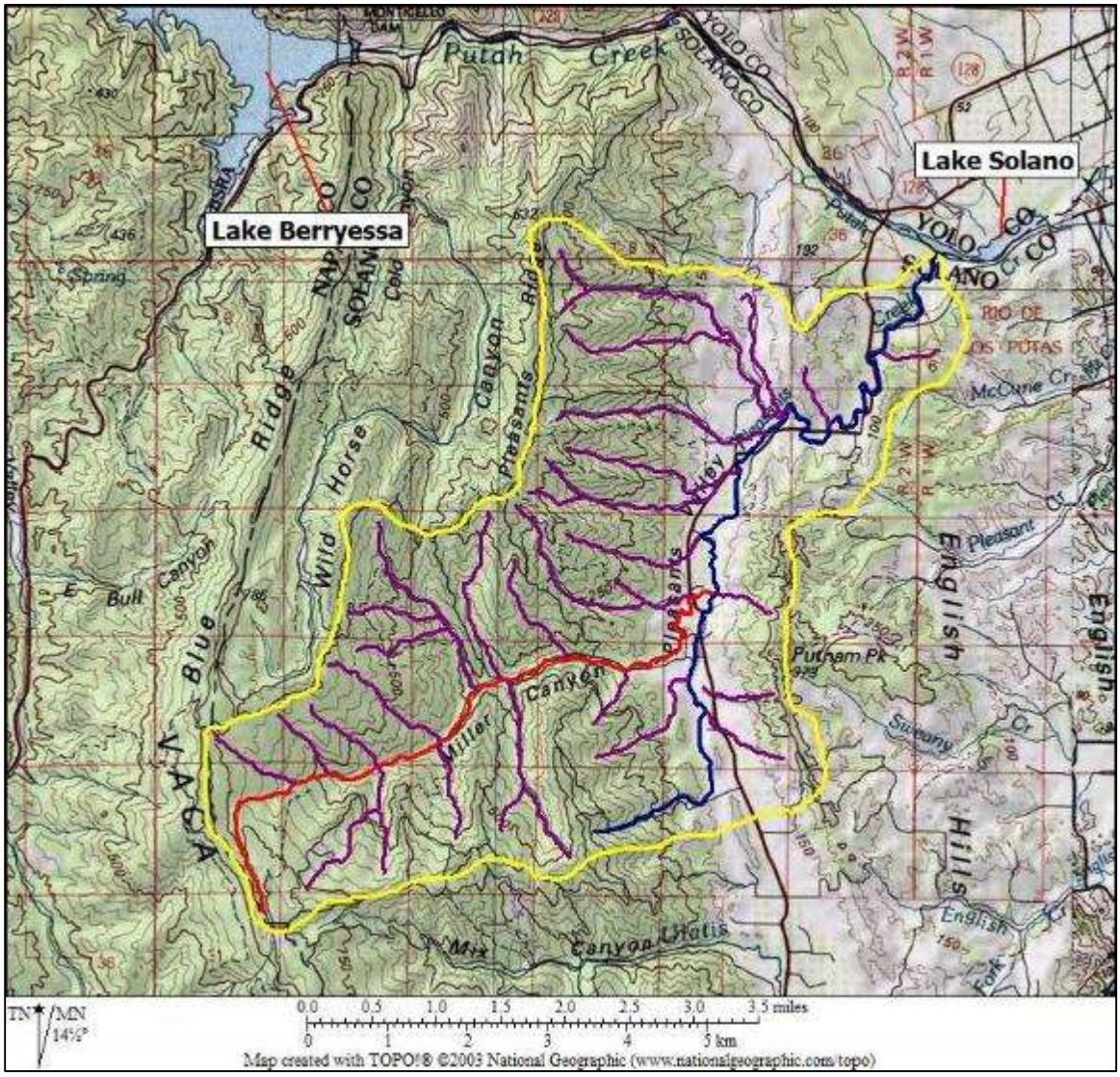


Figure 1. Map showing the Pleasants Creek basin. The blue line is the Pleasants Creek channel; red line shows the Miller Canyon channel; purple lines show unnamed tributaries; and yellow line delimits the watershed.

Photograph 1. Isolated pool in lower Pleasants Creek, RM 3.1, 4 November 2019.

Photograph 2. Isolated pool in lower Pleasants Creek, RM 5.3, 5 November 2019.

Photograph 3. Isolated pool in lower Miller Canyon, RM 0.1, 5 November 2019.

Photograph 4. Backwater portion of lower Pleasants Creek at the farm road ford, RM 0.42, 9 August 2019.

Photograph 5. Pleasants Creek dry stream channel immediately upstream of the farm road ford, RM 0.42, 9 August 2019.

Research has suggested that bank failure and erosion has accelerated since the construction of Monticello Dam due to reduced flows on mainstem Putah Creek that have led to steeper water surface gradients on the tributary creeks during high-flow events, therefore resulting in higher velocity flows and more erosion (EDAW 2005). Pleasants Creek has been identified for low quality riverine habitat, which limits its fish and wildlife potential and has been targeted as a candidate basin for habitat restoration (EDAW 2005). Solano County Water Agency, which manages the Solano Project, has studied the erosion problems in Pleasants Creek and is promoting restoration projects to limit bank erosion and sediment transport with the goal of restoring the historical channel configuration.

There is little information on aquatic species in the basin. While there is some information on fishes that might be present in the Pleasants Creek Basin based on their range (UC Davis California Fish website), there is no available information on which species are currently present nor their actual distribution or abundance in the basin. As

part of these investigations, TRPA was contracted to conduct preliminary surveys to document information on the existing aquatic resources in the basin. The results of the preliminary fish surveys conducted in November 2019 and June 2020 were presented in a prior report (TRPA Fish Biologists 2020). A separate report by SCWA discussed geothermal activity along Pleasants Creek was also prepared (Pascual 2020).

Since the last reported survey in June 2020, several noteworthy changes occurred in the Pleasants Creek Basin that warrant mentioning as they undoubtedly impacted the fish and aquatic habitat along the creek. In mid-August 2020, a wildfire ravaged the entire Pleasants watershed. The fire was originally part of the arson-origin Markley Fire, that eventually grew and merged with several lightning complex fires (the Hennessey, Gamble, Green, Spanish, and Morgan Fires) and eventually became part of the larger LNU Lightning Complex fires that ultimately burned an area of 363,220 acres (568 square miles) in Lake, Napa, Sonoma, Solano, Yolo, and Colusa counties and is the sixth-largest wildfire in the recorded history of California (CalFire 2022). The fire burned in the hills and valleys of Pleasants Creek, damaging, and destroying structures, trees, and rangeland along the creek and all its tributaries (Photographs 6 through 9).

Immediately following the fire, starting in late September 2020, a total of 86 rock vanes were installed (or improved, in the case of Vane #3 at the Martin Ford Road Crossing), for grade control to trap expected mud and ash flows after the LNU Complex Fire burned through the watershed (Photographs 10 through 13). The vanes are distributed between River Miles 0.07 and 4.15 and are spaced based on citing a vane at every foot of elevation gain. The vanes are designed to provide grade control upstream and convergent flows downstream and are intended to retard channel down cutting and widening by directing flow to thalweg and away from banks and should promote substrate deposition upstream of the structures and create persistent scour holes downstream of the vanes. Some of these scour holes retain water over the summer and provide refugia for fish and watering holes for wildlife (Rich Marovich, personal communication). As the bed elevation aggrades, it is hoped that water surfaces upstream of the vanes will be raised and provide more substrate to absorb winter flows

Photograph 6. View of wildfire burning down ridge toward PC-5 downstream, 17 August 2020 (courtesy of Ethel Hoskins).

Photograph 7. View of flat above creek channel at PC-5 after the wildfires of August 2020 (courtesy of Ethel Hoskins).

Photograph 8. View of flat above creek channel at PC-5 after the wildfires of August 2020 (courtesy of Ethel Hoskins).

Photograph 9. View of flat above creek channel at PC-5 after the wildfires of August 2020 (courtesy of Ethel Hoskins).

Photograph 10. View downstream toward rock vane #2, lower Pleasants Creek Site 1, 9 August 2021.

Photograph 11. View upstream toward rock vane #3 (Martin Ford Road Crossing), lower Pleasants Creek Site 1, 31 March 2022.

Photograph 12. View downstream toward rock vane #15, lower Pleasants Creek Site 2, 4 May 2022.

Photograph 13. View upstream toward rock vane #16, lower Pleasants Creek Site 2, 4 May 2022.

and release water back into the channel increasing base flows (Rich Marovich, personal communication). Ongoing monitoring at several nearby well sites will be able to help assess the rock vanes' impacts on groundwater levels in the Pleasants Creek Basin. The original intent was to sample fish populations along Pleasants Creek quarterly, but California Department of Fish and Wildlife biologists expressed concern over any surveys during the winter months (December through April) when rainbow trout from Lake Solano may spawn in Pleasants Creek. To avoid disturbing potential trout spawning no winter surveys were conducted and sampling was limited to three annual surveys: spring, summer, and fall. This report will discuss the results of four surveys conducted on: 9-10 November 2020, 11-12 May 2021, 9-10 August 2021, and 8 November 2021.

Methods

Much of the Pleasants Creek basin is privately owned. TRPA Fish Biologists worked closely with Rich Marovich, the former Putah Creek Streamkeeper, to identify a list of landowners. Contact with landowners was made and while most were willing to allow access along Pleasants Creek, we were unable to get access to Miller Canyon upstream of the Pleasants Valley Road Bridge. Based on our access contacts were able to obtain access to about 5.3 miles of Pleasants Creek and about 0.25 miles of lower Miller Canyon. A reconnaissance site visit was conducted in early August 2019 to evaluate flow conditions and determine where sampling might be conducted. At that time, there was no streamflow and aquatic habitat was limited to intermittent isolated pools that were fed by subsurface flow and groundwater. Eight sites with significant pool habitat were identified for backpack electrofishing.

Fish surveys were conducted using a portable backpack electrofisher to stun and capture fish at sites distributed along Pleasants Creek and Miller Canyon where access could be arranged (Photograph 14). Captured fish were held in a bucket equipped with a small aerator until completion of the survey, at which time they were identified and measured to the nearest millimeter (mm) fork length (FL) (or total length [TL] for mosquitofish, stickleback, and sculpin).

Photograph 14. Backpack electrofishing at Site PC-3 on 8 November 2021.

The length of sample reaches at most sites varied by season based on the length of available wetted channel, with more available habitat in the spring and less in the summer and fall. Only the most downstream Pleasants Creek sample site, which was composed of the Lake Solano backwater area provided the most consistent and stable available habitat. At the other upstream sites, typically two or three isolated pools were surveyed at each site consisting of several hundred feet of stream habitat. Several water quality parameters including water temperature, dissolved oxygen, conductivity, salinity, and pH were measured with hand-held meters at the time of sampling. A small hand-held global positioning system was used to determine latitude/longitude coordinates at both downstream and upstream ends of each sample site. The waypoints were plotted on Google Earth and were used to estimate the survey reach distances. In September 2019 SCWA installed data loggers to record water depths and water temperatures at hourly intervals at three locations along the Pleasants Creek between the Miller Canyon confluence and Lake Solano: lower Pleasants Creek near PC-1; in middle Pleasants Creek near PC-4; and in upper Pleasants Creek near PC-6 (Figure 2).

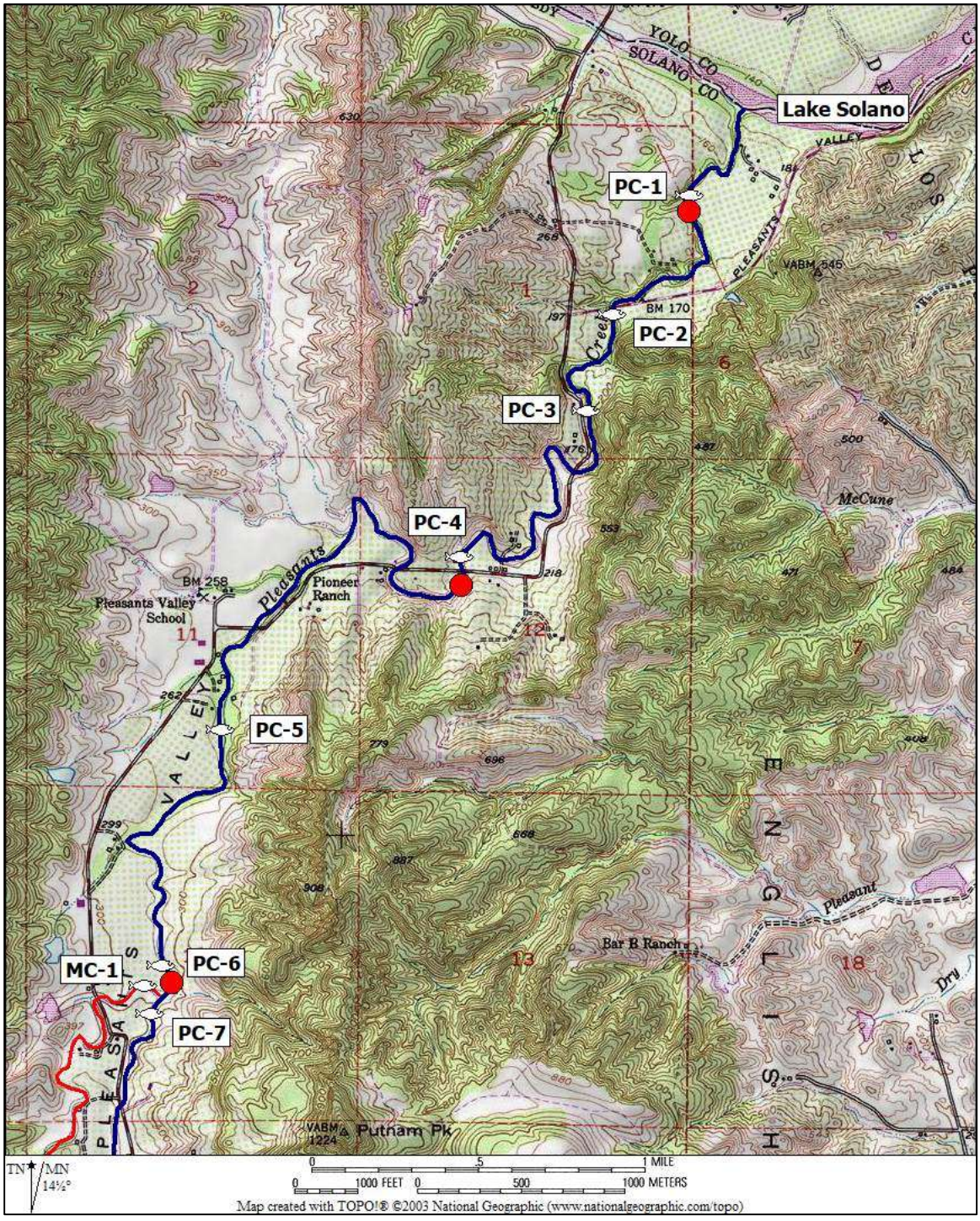


Figure 2. Map of Pleasants Creek (blue line) and lower Miller Canyon (red line) showing the location of the eight fish sampling sites surveyed in early November 2020 through early November 2021 and the three water temperature data logger sites (red dots).

The data were reviewed, and all water temperature data collected when the loggers were at water depths of 0.1 feet or less (1.2 inches) were eliminated prior to plotting.

It should be noted that surveys provide data on the relative abundance of fish at each study sites and should not be construed as suitable for determining population estimates. It was not possible to capture every fish within the study reaches, and electrofishing effectiveness and capture success among the various species and life stages at each site was determined by both conductivity and salinity conditions.

Results

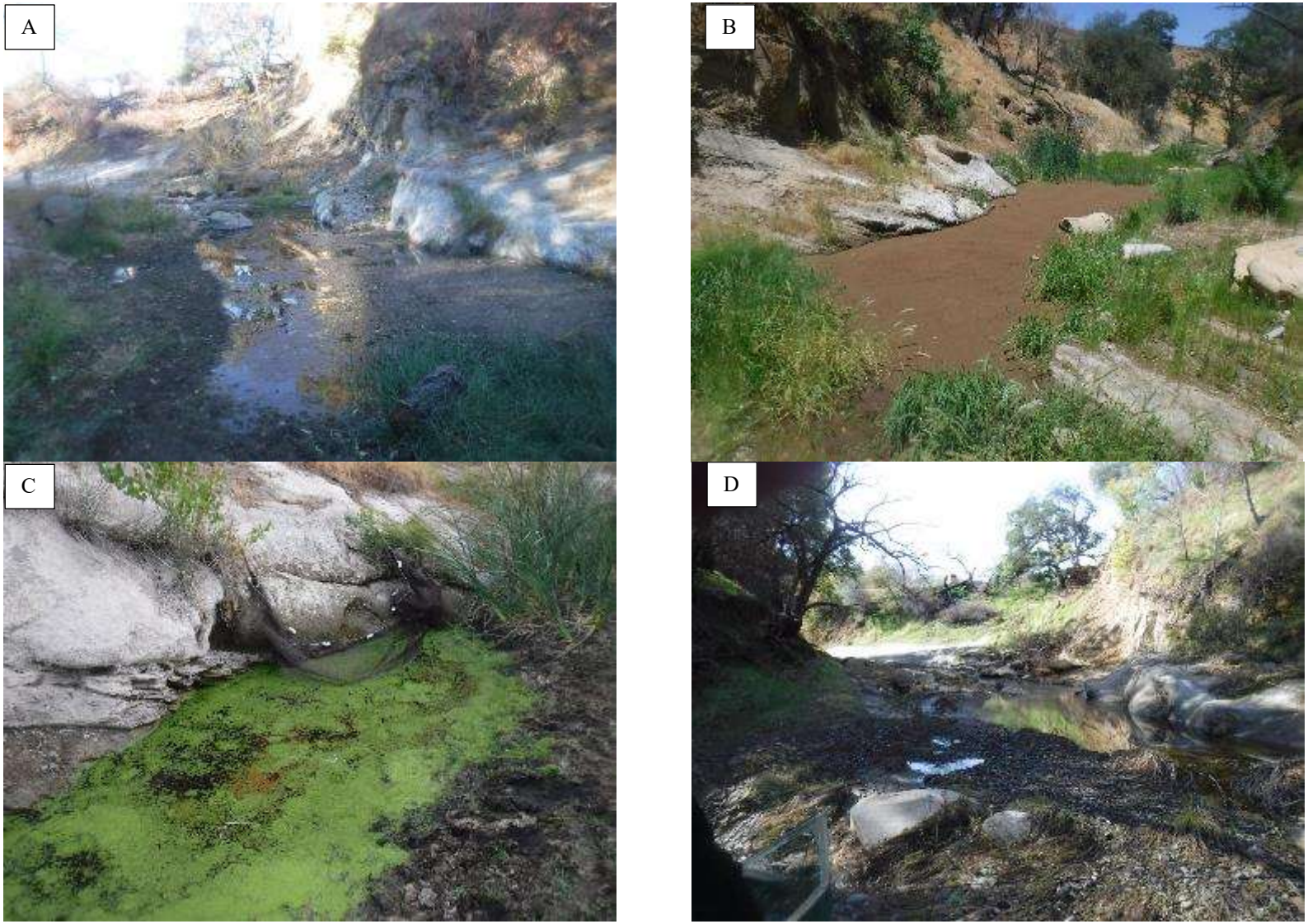
Eight sites were surveyed during each survey, with seven sites located on Pleasants Creek and one site in lower Miller Canyon just upstream of its confluence with Pleasants Creek (Figure 2; Photographs 15 through 22). The most downstream site, PC-1, was located in the backwater area of Lake Solano. The remaining seven sites were in the intermittent flow area of the basin and usually consisted of isolated pool habitats, with long stretches of dry channel in between survey sites, except after significant rainfall, when dry channel areas were shorter in length. The survey areas varied in length across sites and across seasons and ranged from fifteen feet to 1,000 feet (Table 1). Most sites consisted of one to three isolated pools, though this varied seasonally with some sites becoming dry by the time of the summer 2021 survey (Table 1; Photographs 16, 17, 19, & 21).

The November 2020 survey followed a dry water year in the Sacramento Valley according to the Sacramento Valley 40-30-30 Hydrologic Classification Index, while the May and August 2021 surveys occurred during a critical winter (Department of Water Resources, California Data Exchange Center, Water Supply Index WSIHIST). During the 2020 Water Year a total of 13.83 inches of precipitation was recorded at the Solano Irrigation District Putah Diversion Dam Operations Center, and during the 2021 Water Year only 8.16 inches was recorded (U.S. Bureau of Reclamation, Central Valley Operations, Daily Reservoir Data for Lake Solano). Conversations with landowners indicated that there was no continuous streamflow during the winters of 2020 or 2021.

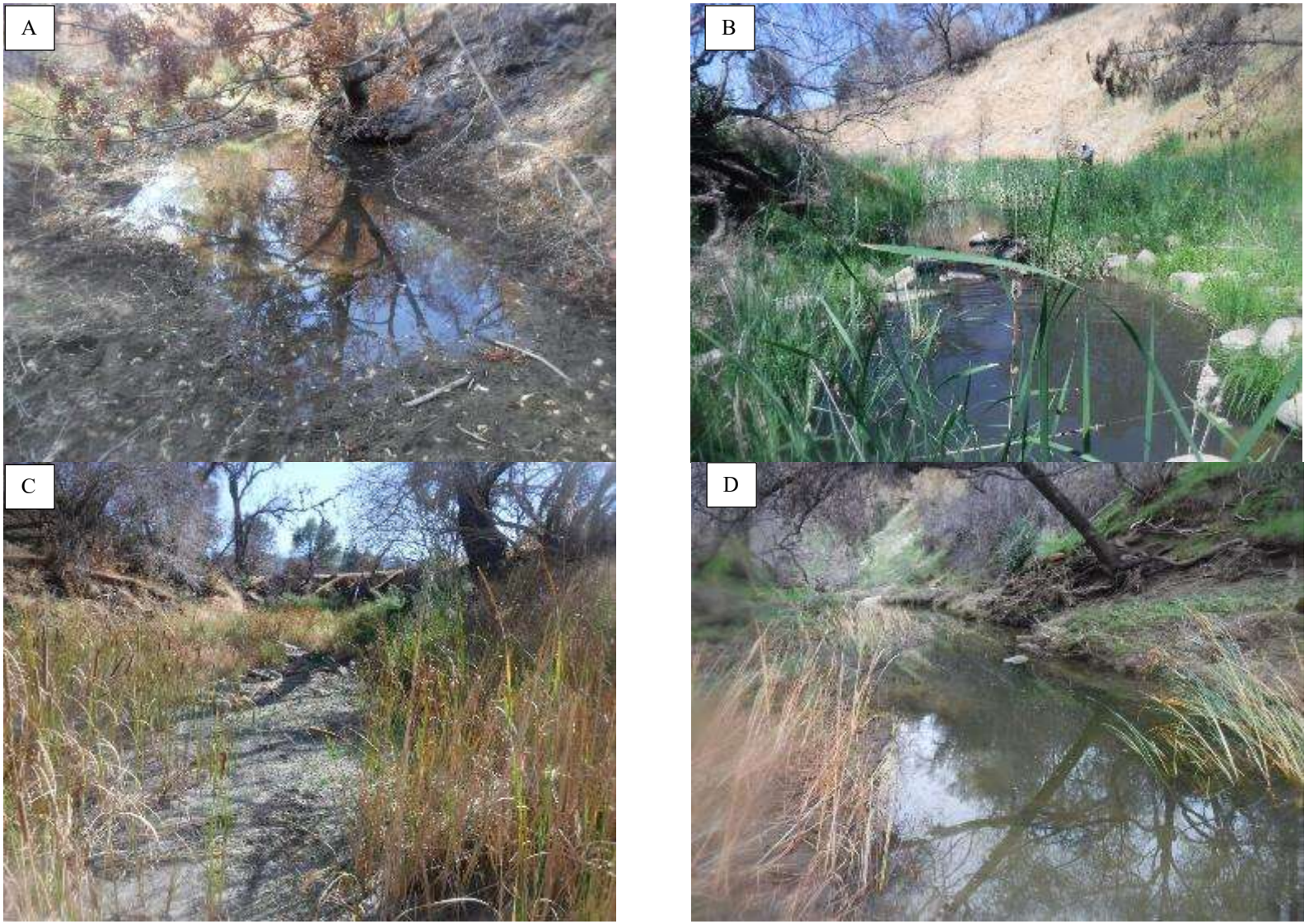
Photograph 15. Pleasants Creek Site 1: A. November 2020; B. May 2021; C. August 2021; D. November 2021

Photograph 16. Pleasants Creek Site 2: A. November 2020; B. May 2021; C. August 2021; D. November 2021 (note recently installed rock vane #17 located just downstream of the former Site 2 Pool [denoted in red circle)]).

Photograph 17. Pleasants Creek Site 3: A. November 2020; B. May 2021; C. August 2021; D. November 2021



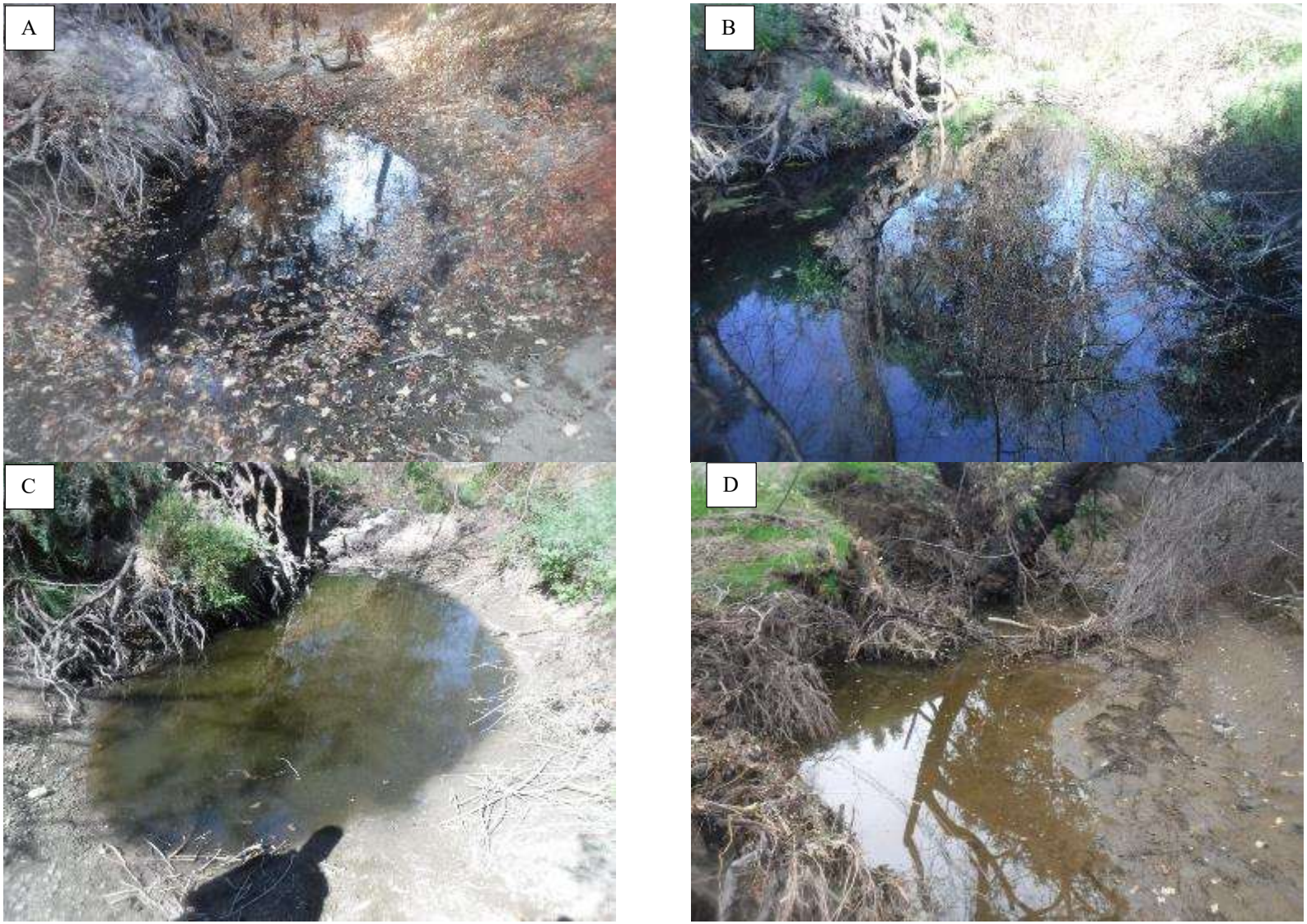
Photograph 18. Pleasants Creek Site 4: A. November 2020; B. May 2021 (note Azolla on pool surface); C. August 2021 (note duckweed on pool surface); D. November 2021



Photograph 19. Pleasants Creek Site 5: A. November 2020; B. May 2021; C. August 2021; D. November 2021

Photograph 20. Pleasants Creek Site 6: A. November 2020; B. May 2021 (note Azolla on pool surface); C. August 2021; D. November 2021

Photograph 21. Pleasants Creek Site 7: A. November 2020; B. May 2021; C. August 2021; D. November 2021



Photograph 22. Miller Canyon Site 1: A. November 2020; B. May 2021; C. August 2021; D. November 2021

Table 1. Survey site identification, river mile location, sample date and time of day, habitat type, site length, water temperature, conductivity, salinity, dissolved oxygen, and pH levels and at time of survey for the November 2020 through November 2021 Pleasants Creek and Miller Canyon fish surveys.

November 2020	**River mile**	**Date**	**Time**	**Habitat**	**Length (ft)**	**Water Temp**		**Conductivity**	**Specific Conductivity**	**Salinity**	**Dissolved Oxygen**		**pH**
						*C	*F	µS/cm	µS/cm	ppt	mg/L	% saturation	
Pleasants Creek													
PC-1	0.35	10-Nov-20	9:45	lake BW	430	5.1	41.2	231.4	372.3	0.2	3.78	30.2	7.5
PC-2	1.00	9-Nov-20	7:25	1 isolated pool	25	6.4	43.5	921	1,427	0.7	---	---	7.5
PC-3	1.50	9-Nov-20	8:09	1 isolated pool	15	7.8	46.0	736	1,098	0.5	---	---	7.8
PC-4	2.50	9-Nov-20	9:52	2 isolated pools	215	6.5	43.7	1,106	1,708	0.9	---	---	8.3
PC-5	4.25	9-Nov-20	11:30	3 isolated pools	48	11.8	53.2	790	1,057	0.5	---	---	7.5
PC-6	5.10	9-Nov-20	12:37	3 isolated pools	260	12.5	54.5	664	873	0.4	---	---	7.8
PC-7	5.30	9-Nov-20	14:45	DRY									
Miller Canyon													
MC-1	0.05	9-Nov-20	14:18	1 isolated pool	25	8.6	47.5	637	931	0.5	---	---	7.7

May 2021	**River mile**	**Date**	**Time**	**Habitat**	**Length (ft)**	**Water Temp**		**Conductivity**	**Specific Conductivity**	**Salinity**	**Dissolved Oxygen**		**pH**
						*C	*F	µS/cm	µS/cm	ppt	mg/L	% saturation	
Pleasants Creek													
PC-1	0.35	11-May-21	11:05	lake BW	430	18.7	65.7	381.7	433.4	0.2	3.00	32.3	7.1
PC-2	1.00	11-May-21	11:40	1 isolated pool	20	18.9	66.0	1,253	1,388	0.7	6.84	73.5	7.3
PC-3	1.50	11-May-21	12:25	2 isolated pools	147	17.3	63.1	924	1,078	0.5	4.55	48.1	7.4
PC-4	2.50	11-May-21	13:20	2 isolated pools	235	21.2	70.2	1,819	1,963	1.0	7.02	79.9	8.7
PC-5	4.25	11-May-21	15:03	3 isolated pools	385	24.8	76.6	1,225	1,230	0.6	5.81	71.2	7.5
PC-6	5.10	12-May-21	8:08	4 isolated pools	240	17.3	63.1	694	814	0.4	4.36	45.8	6.9
PC-7	5.30	12-May-21	9:13	2 isolated pools	205	18.3	64.9	697	799	0.4	3.03	32.6	7.2
Miller Canyon													
MC-1	0.05	12-May-21	8:45	3 isolated pools	147	18.5	65.3	795	910	0.5	3.06	33.1	7.4

Lake BW refers to Lake Solano backwater

Table 1. Survey site identification, river mile location, sample date and time of day, habitat type, site length, water temperature, conductivity, salinity, dissolved oxygen, and pH levels and at time of survey for the November 2020 through November 2021 Pleasants Creek and Miller Canyon fish surveys. (continued)

August 2021	**River mile**	**Date**	**Time**	**Habitat**	**Length (ft)**	**Water Temp**		**Conductivity**	**Specific Conductivity**	**Salinity**	**Dissolved Oxygen**		**pH**
						*C	*F	µS/cm	µS/cm	ppt	mg/L	% saturation	
Pleasants Creek													
PC-1	0.35	9-Aug-21	15:55	lake BW	460	22.1	71.8	370.2	390.0	0.2	3.42	39.7	6.7
PC-2	1.00	9-Aug-21	16:33	DRY									
PC-3	1.50	9-Aug-21	16:38	DRY									
PC-4	2.50	10-Aug-21	8:10	2 isolated pools	175	19.2	66.6	1,685	1,895	1.0	0.33	3.6	6.8
PC-5	4.25	9-Aug-21	17:00	DRY									
PC-6	5.10	10-Aug-21	9:31	4 isolated pools	330	19.5	67.1	924	1,033	0.5	1.81	19.3	6.9
PC-7	5.30	10-Aug-21	11:10	DRY									
Miller Canyon													
MC-1	0.05	10-Aug-21	10:50	1 isolated pool	30	22.0	71.6	804	850	0.4	3.40	39.1	7.1

November 2021	**River mile**	**Date**	**Time**	**Habitat**	**Length (ft)**	**Water Temp**		**Conductivity**	**Specific Conductivity**	**Salinity**	**Dissolved Oxygen**		**pH**
						*C	*F	µS/cm	µS/cm	ppt	mg/L	% saturation	
Pleasants Creek													
PC-1	0.35	8-Nov-21	7:53	lake BW	555	12.0	53.6	404.8	539.0	0.3	7.96	74.1	6.6
PC-2	1.00	8-Nov-21	9:02	2 isolated pool	480	9.8	49.6	537	759	0.4	7.47	66.5	6.6
PC-3	1.50	8-Nov-21	10:13	3 isolated pools	450	10.7	51.3	766	1,055	0.5	5.68	51.6	6.7
PC-4	2.50	8-Nov-21	11:10	2 isolated pools	575	10.0	50.0	914	1,279	0.6	6.55	58.2	6.7
PC-5	4.25	8-Nov-21	15:05	long isolated pool	1000	12.3	54.1	1,039	1,368	0.7	5.77	54.3	7.1
PC-6	5.10	8-Nov-21	12:30	long isolated pool	565	13.9	57.0	847	1,076	0.5	6.16	60.1	6.7
PC-7	5.30	8-Nov-21	13:09	5 isolated pools	185	10.8	51.4	583	801	0.4	6.83	67.7	7.0
Miller Canyon													
MC-1	0.05	8-Nov-21	13:55	4 isolated pools	445	13.0	55.4	658	854	0.4	1.09	10.0	7.0

Lake BW refers to Lake Solano backwater

These consecutive low rainfall years impacted streamflow and groundwater conditions for subsequent surveys and led to the gradual drying of much of Pleasants Creek and Miller Canyon by the summer and early fall.

The November 2021 surveys occurred two weeks following an historic regional rain event, known as a "bomb cyclone", that channeled an atmospheric river into the North Bay Area and resulting in rainfall records throughout the region. The October 21-25, 2021, five-day rainfall total for the Solano Lake gage was 7.8 inches, with 93 percent of the precipitation (7.24 inches) occurring over a forty-eight-hour period on 24-25 October (U.S. Bureau of Reclamation, Central Valley Operations, Daily Reservoir Data for Lake Solano). This burst of precipitation recharged the parched Pleasants Creek basin and resulted in streamflow throughout the basin, so that by the time of the 8 November 2021 survey, while there was no continuous streamflow noted, there was very little dry channel noted along the creek.

Water Quality

Specific conductivity (temperature adjusted conductivity) and salinity were stable at each site over time regardless of season (Table 1). The pH concentrations were relatively stable across sites during the November 2020 and May 2021 surveys but measured lower across each site during the last two surveys.

As might be expected, water temperatures measured at the time of the fish surveys varied between seasons and time of day, with cooler temperatures measured in the fall surveys compared with the spring and summer surveys, and cooler during the morning versus afternoon sampling (Table 1). Again, the most extreme difference was noted at the PC-1 site where a water temperature of 5.31 degrees Centigrade (°C) [41.2° Fahrenheit (°F)] was noted during the November 2020 survey, compared to a water temperature of 22.1°C (71.8°F) that was measured in early August.

Dissolved oxygen levels varied by site and season (Table 1). Not surprisingly dissolved oxygen levels tended to be lower in the August 2020 survey and highest in the November 2021 survey across most sites. Aquatic vegetation and algae, which was

present at most of the isolated pools, may have impacted these readings, especially those collected in the afternoons during peak of photosynthetic oxygen production versus in the morning immediately following the overnight oxygen depletion lag.

The continuous water level and water temperature loggers were last interrogated in late November 2020. SCWA staff attempted to re-locate the loggers again in late May 2022 to retrieve data that could be used in this report. Both the lower and upper data loggers could not be found and only the middle data logger could be re-located. After eliminating inaccurate data recorded when loggers were out of water or too shallow (<0. feet [1.2 inches] in depth), the remaining valid hourly water temperatures were plotted for the period of 9 November 2021 through 8 November 2021 (Figure 3). Contemporaneous precipitation data from the nearby Solano Irrigation District's Putah Diversion Office, located one mile east of Pleasants Creek were also plotted.

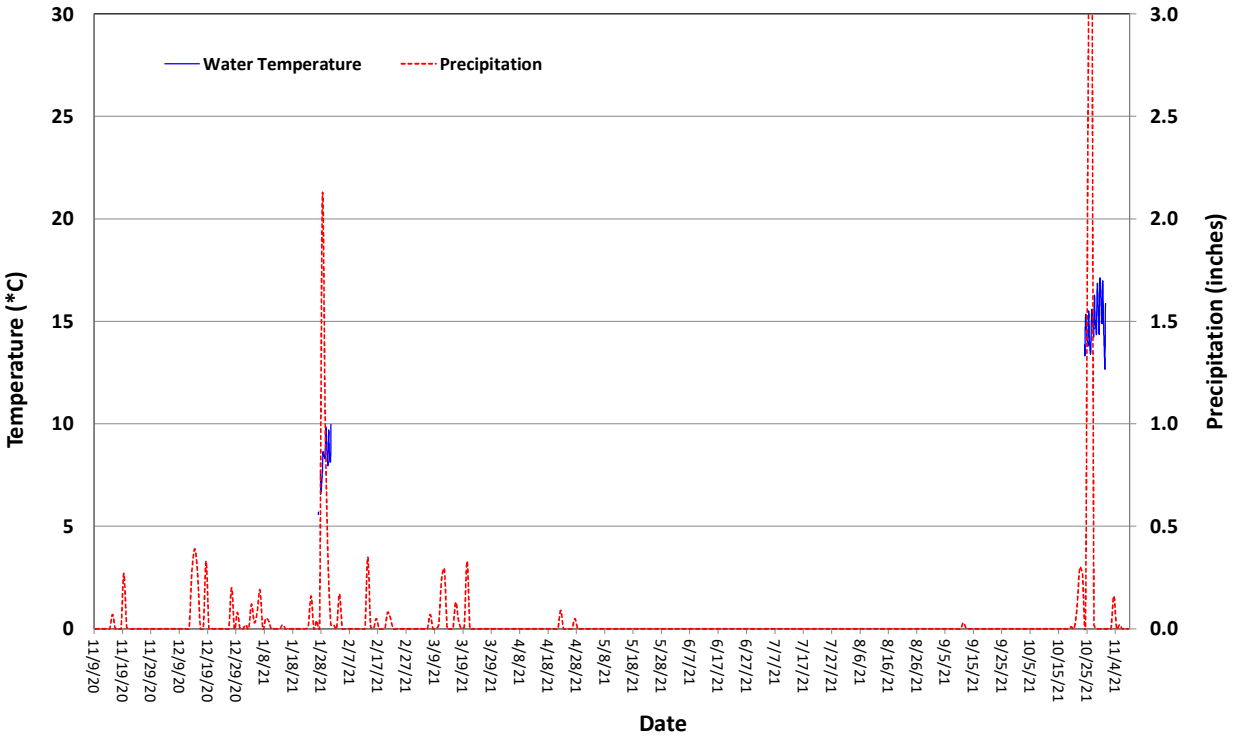


Figure 3. Hourly water temperature readings at Pleasants Creek just upstream of Site PC-4 and daily precipitation records for the nearby Putah Diversion Office Station for 25 September 2020 through 8 November 2021.

The continuous water temperature data show that the logger at the middle Pleasants Creek site was out of water or nearly out of water (i.e., depths <0.1 feet) for 97 percent of the time. Only 272 valid hourly water temperatures over two distinct time periods were collected during the year period between 9 November 2020 and 8 November 2021 (Figure 3). Both the periods when valid water temperatures were recorded (i.e., the logger was in water) occurred immediately following significant rain events in late January 2021 and late October 2021. In late January the water temperatures were all less than 10°C (50°F; Figure 3). In late October 2021, all but one of the water temperature readings were less than 17°C (62.6°F; Figure 3). Not much more information can be gleaned from the sparse temperature records.

Evidence of geothermal seeps along the creek that were noted and confirmed in previous surveys (Pascual 2020; TRPA Fish Biologists 2020) were still detected along several of the survey sites by sulfurous odors and areas of gray water. While the geothermal seeps were detected during all four surveys conducted between November 2020 and November 2021, they did not appear to be as intense as those noted during the June 2020 fish survey or the July 2020 geothermal mapping surveys (TRPA Fish Biologists 2020). The geothermal activity may be tied to local groundwater levels, which appeared to vary across seasons as noted by the presence/absence of water at various sites.

Fish Monitoring

For context, during both the fall 2019 and the summer 2020 Pleasants Creek fish surveys, California native fish dominated the populations at all sites and made up over 90 percent of the total fish captures in both surveys (TRPA 2020). By the time of the November 2020 survey, native fish made up less than 35 percent of the fish captured across all sites (Table 2). Examples of the species captured during this fall 2020 survey can be found in Photographs 23 through 27. During the November 2020 survey, 483 fish from seven species were captured, with over 99 percent of the captures occurring at four of the eight sample sites. Over 95 percent of the fish captured were less than 100

Table 2. Capture data for the fish monitoring surveys on Pleasants Creek and Miller Canyon, 9-10 November 2020.

	Pleasants Creek							Miller Canyon	
Site	PC-1	PC-2	PC-3	PC-4	PC-5	PC-6	PC-7	MC-1	
RM	0.35	1.00	1.50	2.50	4.25	5.10	5.30	0.05	Total
Native Fishes							DRY		
Sacramento pikeminnow			26 (64-95 FL)			2 (90 FL)			28
California roach	1 (79 FL)		45 (43-72 FL)	25 (45-72 FL)		52 (37-82 FL)			123
Sacramento sucker	1 (94 FL)		14 (84-148 FL)						15
Exotic Fishes							DRY		
Western mosquitofish	1 (19 FL)			53 (9-47 FL)					54
Bluegill sunfish	1 (46 FL)								1
Green sunfish			39 (43-118 FL)	4 (40-111 FL)	3 (67-97 FL)	205 (31-149 FL)		1 (46 FL)	252
Largemouth bass	10 (81-114 FL)								10
Total # Individuals	14	0	124	82	3	259		1	483
# native fish	2	0	85	25	0	54		0	166
# exotic fish	12	0	39	57	3	205		1	317
Total # species	5	0	4	3	1	3		1	7
# native species	2	0	3	1	0	2		0	3
# exotic species	3	0	1	2	1	1		1	4
Shannon's Diversity (ln)	0.994		1.305	0.792	0.000	0.545		0.000	1.299
Eveness (H'/Hmax)	0.618		0.942	0.721	0.000	0.496		0.000	0.667

Photograph 23. 95 mm FL Sacramento pikeminnow (native fish) captured at Site PC-3, 9 November 2020.

Photograph 24. 72 mm FL California roach (native fish) captured at Site PC-3, 9 November 2020.

Photograph 25. 137 mm FL Sacramento sucker (native fish) captured at Site PC-3, 9 November 2020.

Photograph 26. 114 mm FL largemouth bass (non-native fish) captured at Site PC-1, 10 November 2020.

Photograph 27. 118 mm FL green sunfish (non-native fish) captured at Site PC-3, 9 November 2020.

mm (3.9 inches) in length. Based on the estimated distance of habitat surveyed (Table 1) to fish captures (Table 2) the overall fish density during this sampling event was 47.4 fish per 100 feet of channel surveyed.

During this fall survey, most of the remnant aquatic habitat at the sample sites was limited to one or two small residual pools. Pleasants Creek upstream of Miller Canyon (Site PC-7) was completely dry (Photograph 21A) and obviously fishless. The lower Pleasants Creek at Site PC-2, which was composed of a single residual pool that had harbored numerous suckers and pikeminnow in previous surveys, was barely wet and no fish were captured (Table 2; Photograph 16A). This site had been obviously impacted by the recent wildfires, with burned and scorched tress and fire debris in the immediate vicinity; it appeared that heavy equipment had recent been reworking the substrates in the stream channel at the site as well. At both sites PC-5 and MC-1 habitat was limited

to small residual pools that harbored only a few non-native green sunfish (*Lepomis cyanellus*), a species known to be tolerant of disturbed or unhospitable aquatic habitats (Moyle 2002).

After a six-month hiatus (i.e., no sampling during the December-April trout spawning period discussed above), a spring survey was conducted on 11-12 May 2021. During this hiatus, significant rainfall occurred in the Pleasants Creek basin (8.31 inches of rainfall as recorded at the nearby Lake Solano gage; U.S. Bureau of Reclamation, Central Valley Operations, Daily Reservoir Data for Lake Solano) that resulted in runoff and streamflow that recharged the residual pool habitat and groundwater, so that there was available pool habitat at all the sample sites by the time of the early May 2021 fish sampling. During the May 2021 survey a total of 69 fish from five different species were captured across all eight sample sites and over 62 percent of the total captures were native fish (Table 3). Again, most of the fish were small, with over 91 percent of the captured fish measuring less than 100 mm (3.9 inches) in length. The estimated fish density for the May 2021 survey was a meager 3.8 fish per 100 feet of channel surveyed (Table 1 and Table 3).

Despite available habitat at all the sites, four of the survey sites had no fish captured. It is especially interesting that these four fishless sites correspond to the sites where no or few fish were captured in the previous November 2020 survey (i.e., PC-2, PC-5, PC-7, and MC-1; Tables 2 and 3). The large decline in overall captures combined with the absence of fish at previously fishless of low occupancy sites despite the recent reestablishment of streamflow and the restoration of aquatic habitat throughout the basin, suggest that recruitment and re-colonization by fish of newly available habitats is very limited in Pleasants Creek. Fish populations in the basin do not appear to be able to quickly respond to and utilize newly available aquatic habitats.

By the time of the summer survey conducted on 9-10 August 2021, much of the Pleasants Creek stream channel was completely dry, including four of the eight survey sites (Table 4; Photographs 16C, 17C, 19C, and 21C). Except for the Lake Solano

Table 3. Capture data for the fish monitoring surveys on Pleasants Creek and Miller Canyon, 11-12 May 2021.

	Pleasants Creek							Miller Canyon	
Site	PC-1	PC-2	PC-3	PC-4	PC-5	PC-6	PC-7	MC-1	
RM	0.35	1.00	1.50	2.50	4.25	5.10	5.30	0.05	Total
Native Fishes									
Sacramento pikeminnow			5 (74-96 FL)						5
California roach			5 (58-76 FL)	18 (52-78 FL)		14 (45-72 FL)			37
Sacramento sucker			1 (106 FL)						1
Exotic Fishes									
Western mosquitofish	1 (30 FL)			5 (29-51 FL)					6
Green sunfish	1 (87 FL)		4 (62-91 FL)	14 (79-124 FL)		1 (66 FL)			20
Total # Individuals	2	0	15	37	0	15	0	0	69
# native fish	0	0	11	18	0	14	0	0	43
# exotic fish	2	0	4	19	0	1	0	0	26
Total # species	2	0	4	3	0	2	0	0	5
# native species	0	0	3	1	0	1	0	0	3
# exotic species	2	0	1	2	0	1	0	0	2
Shannon's Diversity (ln)	0.693		1.265	0.989		0.245			1.157
Eveness (H'/Hmax)	1.000		0.913	0.900		0.353			0.719

Table 4. Capture data for the fish monitoring surveys on Pleasants Creek and Miller Canyon, 9-10 August 2021.

	Pleasants Creek							Miller Canyon	
Site	PC-1	PC-2	PC-3	PC-4	PC-5	PC-6	PC-7	MC-1	
RM	0.35	1.00	1.50	2.50	4.25	5.10	5.30	0.05	Total
Native Fishes		**DRY**	**DRY**		**DRY**		**DRY**		
California roach						7 (37-84 FL)			7
Sacramento sucker	4 (117-171 FL)								4
Exotic Fishes		**DRY**	**DRY**		**DRY**		**DRY**		
Western mosquitofish	23 (12-42 TL)			294 (18-45 FL)					317
Bluegill sunfish	1 (77 FL)								1
Green sunfish	1 (98 FL)					15 (52-120 FL)		24 (16-78 FL)	40
Largemouth bass	1 (82 FL)								1
Total # Individuals	30			294		22		24	370
# native fish	4			0		7		0	11
# exotic fish	26			294		15		24	359
Total # species	5			1		2		1	6
# native species	1			0		1		0	2
# exotic species	4			1		1		1	4
Shannon's Diversity (ln)	0.812			0.000		0.625		0.000	0.529
Eveness (H'/Hmax)	0.505			0.000		0.902		0.000	0.295

backwater (Site PC-1), the summer aquatic habitat remaining in most of the basin was composed of small remnant residual pools (Photographs 18C and 20C).

During the August 2021 survey a total of 370 fish from six species were captured across all four sample sites with water (Table 4), with 97 percent of the total captures being non-native fish. Over 85 percent of the fish captured, including all the fish at Site PC-4, were mosquitofish (*Gambusia affinis*). As was the case with previous surveys, most of the fish were small, with over 98 percent of the captured fish measuring less than 100 mm (3.9 inches) in length. The estimated fish density for the May 2021 survey was 37.2 fish per 100 feet of channel surveyed (Table 1 and Table 4).

The fall 2021 Pleasants Creek fish survey occurred on 8 November 2021, two weeks after the historic regional late October rain event, which resulted in streamflow throughout the watershed and the restoration of aquatic habitat throughout the basin and at all the survey sites (Photographs 15 through 22). As was the case with previous surveys, most of the fish were small, with over 86 percent of the captured fish measuring less than 100 mm (3.9 inches) in length.

Despite the widespread availability of aquatic habitat, only 131 fish from nine distinct species were captured across all eight sample sites (Table 5), with over 60 percent of the total captures being non-native fish. The estimated fish density for the November 2021 survey was very low, only 3.1 fish per 100 feet of channel surveyed (Table 1 and Table 5). In fact, sampling along a 1,000 foot-length of several pool habitats at PC-5 yielded no fish at all. The low fish density in the newly restored aquatic habitat, suggest that recruitment and re-colonization by fish into newly available habitats is very limited in Pleasants Creek. Fish populations in the basin do not appear to be able to quickly respond to and utilize newly available aquatic habitats.

Table 5. Capture data for the fish monitoring surveys on Pleasants Creek and Miller Canyon, 8 November 2021.

	Pleasants Creek							Miller Canyon	
Site	PC-1	PC-2	PC-3	PC-4	PC-5	PC-6	PC-7	MC-1	
RM	0.35	1.00	1.50	2.50	4.25	5.10	5.30	0.05	Total
Native Fishes									
California roach	1 (83 FL)	1 (78 FL)		2 (95-101 FL)		8 (68-108 FL)	15 (50-80 FL)		27
Sacramento sucker	8 (88-207 FL)	1 (188 FL)		1 (173 FL)					10
Threespine stickleback	12 (26-48 TL)								12
Prickly sculpin	3 (79-91 TL)								3
Exotic Fishes									
Western mosquitofish	33 (22-49 TL)								33
Bluegill sunfish	1 (95 FL)								1
Green sunfish	9 (33-136 FL)	2 (108-114 FL)	1 (127 FL)			3 (55-74 FL)	23 (26-77 FL)	4 (56-165 FL)	42
Spotted bass	2 (61-67 FL)								2
Largemouth bass	1 (74 FL)								1
Total # Individuals	70	4	1	3	0	11	38	4	131
# native fish	24	2	0	3	0	8	15	0	52
# exotic fish	46	2	1	0	0	3	23	4	79
Total # species	9	3	1	2	0	2	2	1	9
# native species	4	2	0	2	0	1	1	0	4
# exotic species	5	1	1	0	0	1	1	1	5
Shannon's Diversity (ln)	1.587	1.040	0.000	0.637		0.586	0.671	0.000	1.678
Eveness (H'/Hmax)	0.722	0.946	---	0.918		0.845	0.968	---	0.764

Discussion

The four Pleasants Creek fish surveys were all conducted during periods of intermittent flow, though two of the surveys (early May 2020 and early November 2021) appeared to have occurred not long after periods of active streamflow. Future sampling in the early spring of wet or above normal water years may coincide with periods of actual streamflow and may provide additional information about habitat use by resident fish species during those periods.

While native fish dominated the fish captures in prior surveys conducted in the fall 2019 and summer 2020 (TRPA Fish Biologists 2020), by the time of the fall 2020 survey, non-native fish, mostly green sunfish, were predominant in the limited residual pools available at that time. Green sunfish is a species known to be tolerant of disturbed or unhospitable aquatic habitats (Moyle 2002). The dominant native fish species we noted in the November 2019 and June 2020 surveys: pikeminnow, roach, and sucker are all known to be moderately tolerant of environmental degradation (May and Brown 2002) and can maintain populations in intermittent flow/high water temperature/high conductivity habitats (Moyle 2002). All three species appear to be tolerant of low dissolved oxygen levels (Cech et al. 1990). Villa (1985) found that both Sacramento pikeminnow and suckers were the most abundant fish in Thomes Creek, another Sacramento Valley stream that regularly becomes intermittent during the summer and fall seasons. It appears that the conditions prevailing in Pleasants Creek during the recent surveys from November 2020 and November 2021, that have occurred during dry and critical water years, exceed the tolerances of even these moderately tolerant native species.

By the time of the early May 2021 surveys, there was plentiful aquatic habitat following the winter rains, but very few fish were noted during our survey. Most of the fish captured in the spring 2021 were again native species. However, by the time of the August 2021 surveys, large portions of the basin were again dry, and non-native fish that appear to be more tolerant of stressful summer conditions in the basin were again the dominant fish in the limited remaining aquatic habitats. During the November 2021

survey, which occurred shortly after record rainfall in the area, very few fish were captured, despite the widespread availability of aquatic habitat throughout the basin following the rains. The results from both the May 2021 and November 2021 surveys showed low fish densities through the basin's newly restored aquatic habitat that seems to indicate that recruitment and re-colonization by fish into newly available habitats is very limited in Pleasants Creek. Fish populations in the basin do not appear to be able to quickly respond to and utilize newly available aquatic habitats.

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