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Memorandum

DATE: 4 November 2020
TO: Roland Sanford, Rich Marovich, Chris Lee and Justin Pacual, Solano County Water Agency (SCWA)
FROM: Tim Salamunovich, TRPA Fish Biologists
RE: Fall 2019 and Summer 2020 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. Streamflow in Pleasants Creek is intermittent and is typically limited to winter and spring following rainfall events. 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 backwater from Lake Solano (Photograph 4). Upstream of small agricultural road ford, that delimits the downstream 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).

Research has suggested that bank failure and erosion and failure has accelerated since the construction of Monticello Dam because reduced flows on mainstem Putah Creek 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

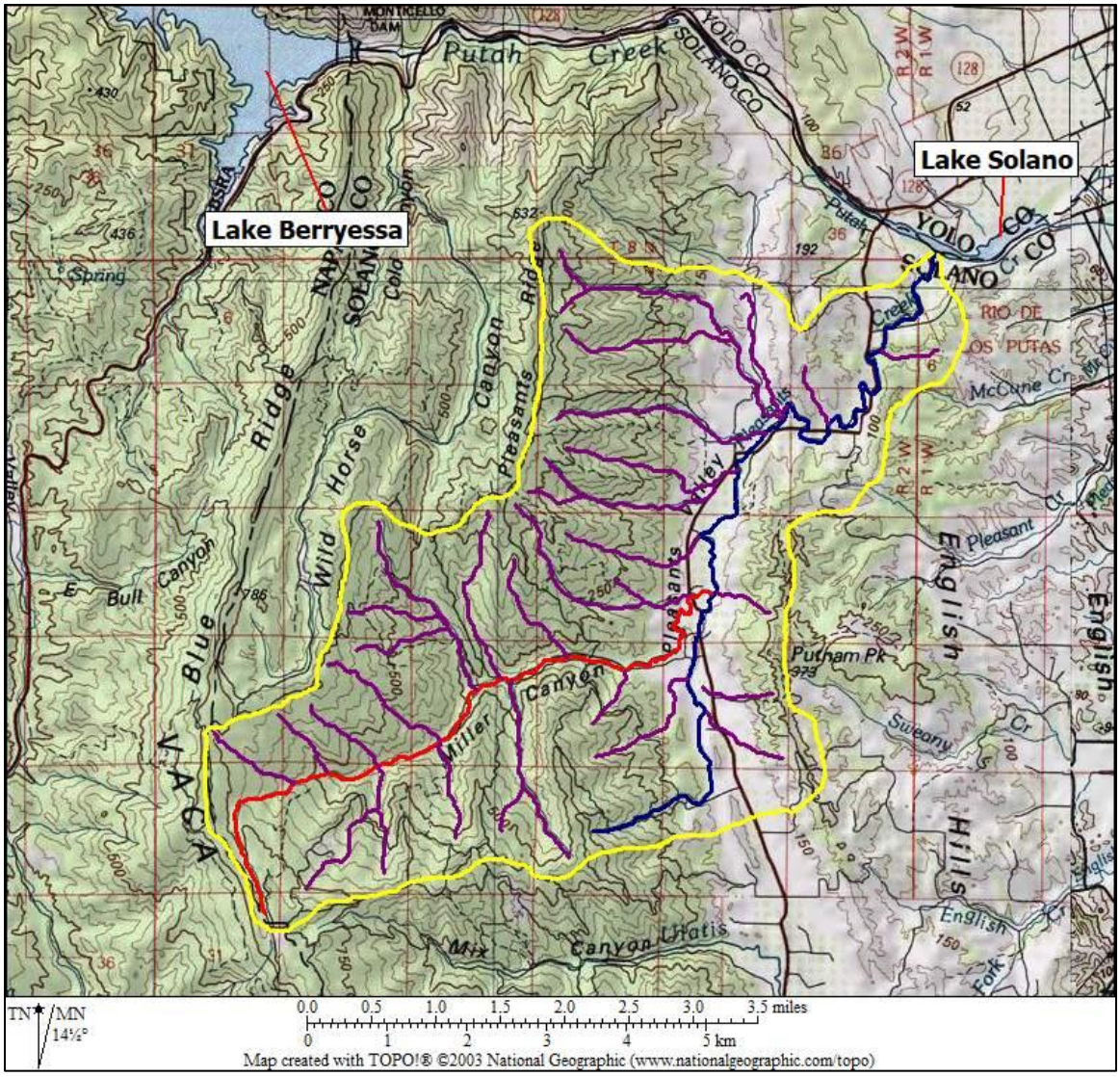

Figure 1. Map showing the Pleasants Creek basin. The blue line is the Pleasants Creek channel; red line shows the Miller Canyon channel; purple lines show unnamed tributaries; and the yellow line delimits the watershed.

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

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

and wildlife potential and has been targeted as a candidate basin for habitat restoration (EDAW 2005). Much of the basin is composed of grassland/oak habitat. There is little information on aquatic species in the basin. While there is some information on fishes present, there is no available information on their actual distribution or abundance in the basin. The UC Davis California Fish websites lists six fish types from five species for Pleasants Creek:

- Central Valley steelhead (*Oncorhynchus mykiss*)
- Coastal rainbow trout (*O. mykiss*)
- Hardhead (*Mylopharodon conocephalus*)
- California roach (*Hesperoleucus symmetricus*)
- Sacramento pikeminnow (*Ptychocheilus grandis*)
- Sacramento sucker (*Catostomus occidentalis*)

Steelhead are no longer present since there is no fish passage at the Putah Diversion Dam. Hardhead, a large native minnow which were reported in Putah Creek prior to the Solano Project, have not been documented in the Lake Solano area for over sixty years

(TRPA 1992). Hardhead tend to reside in large deep pool habitats (Moyle 2002), which don't exist in Pleasants Creek, so it is highly unlikely this species is present in this basin.

Solano County Water Agency (SCWA), which manages the Solano Project, has studied the erosion problems in Pleasants Creek and is promoting restoration projects to limit bank erosion and restore the historical channel configuration. As part of these investigations, TRPA was contracted to conduct preliminary surveys to document information on the existing aquatic resources in the basin.

Methods

Much of the Pleasants Creek basin is privately owned. TRPA Fish Biologists worked closely with Rich Marovich, the 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 6). 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 fork length (FL) (or total length [TL] for mosquitofish, stickleback, and sculpin).

The length of sample reaches at each site varied based on the length of available isolated pool habitat units. Generally, two or three isolated pools were surveyed at each site consisting of several hundred feet of stream habitat.

Photograph 6. Backpack electrofishing at Site PC-5 on 5 November 2019.

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 early September 2019 SCWA installed data loggers at three locations to record water depths and water temperatures.

It should be noted that surveys provide data on the relative abundance of fishes 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

The original intent was to sample quarterly from Fall 2019 through Summer 2020, 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 have been spawning in Pleasants Creek. Concerns about travelling to conduct field work during the initial phases of the Corona virus pandemic prevented any spring sampling. Based on these constraints only two surveys have been conducted to date, one in early November 2019 and a second in late June 2020.

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 6A-D and 7A-D). The most downstream site, PC-1, was located in the backwater area of Lake Solano. The remaining seven sites were located in the intermittent flow area of the basin and consisted of isolated pool habitats, with long stretches of dry channel in between survey sites. The survey areas varied in length from 75 feet to over 600 feet (Table 1). Site PC-2 consisted of a single isolated pool. The remaining sites, PC-3 through MC-1, consisted of 2-3 isolated pools.

The SCWA data loggers installed in early September recorded hourly measurements of both water depth and water temperature at lower Pleasants Creek near PC-1; in middle Pleasants Creek near PC-4; and in upper Pleasants Creek near PC-6 (Figure 2).

The November 2019 survey followed a wet water year in the Sacramento Valley according to the Sacramento Valley 40-30-30 Hydrologic Classification Index, while the June 2020 survey followed a dry winter (Department of Water Resources, California Data Exchange Center, Water Supply Index WSIHIST). During the 2019 Water Year a total of 40.68 inches of precipitation was recorded at the Solano Irrigation District Putah Diversion Dam Operations Center, compared to only 13.83 inches recorded during the 2020 Water Year to date (U.S. Bureau of Reclamation, Central Valley Operations, Daily Reservoir Data for Lake Solano). This rainfall disparity impacted streamflow and groundwater conditions for the two surveys. Conversations with landowners indicated

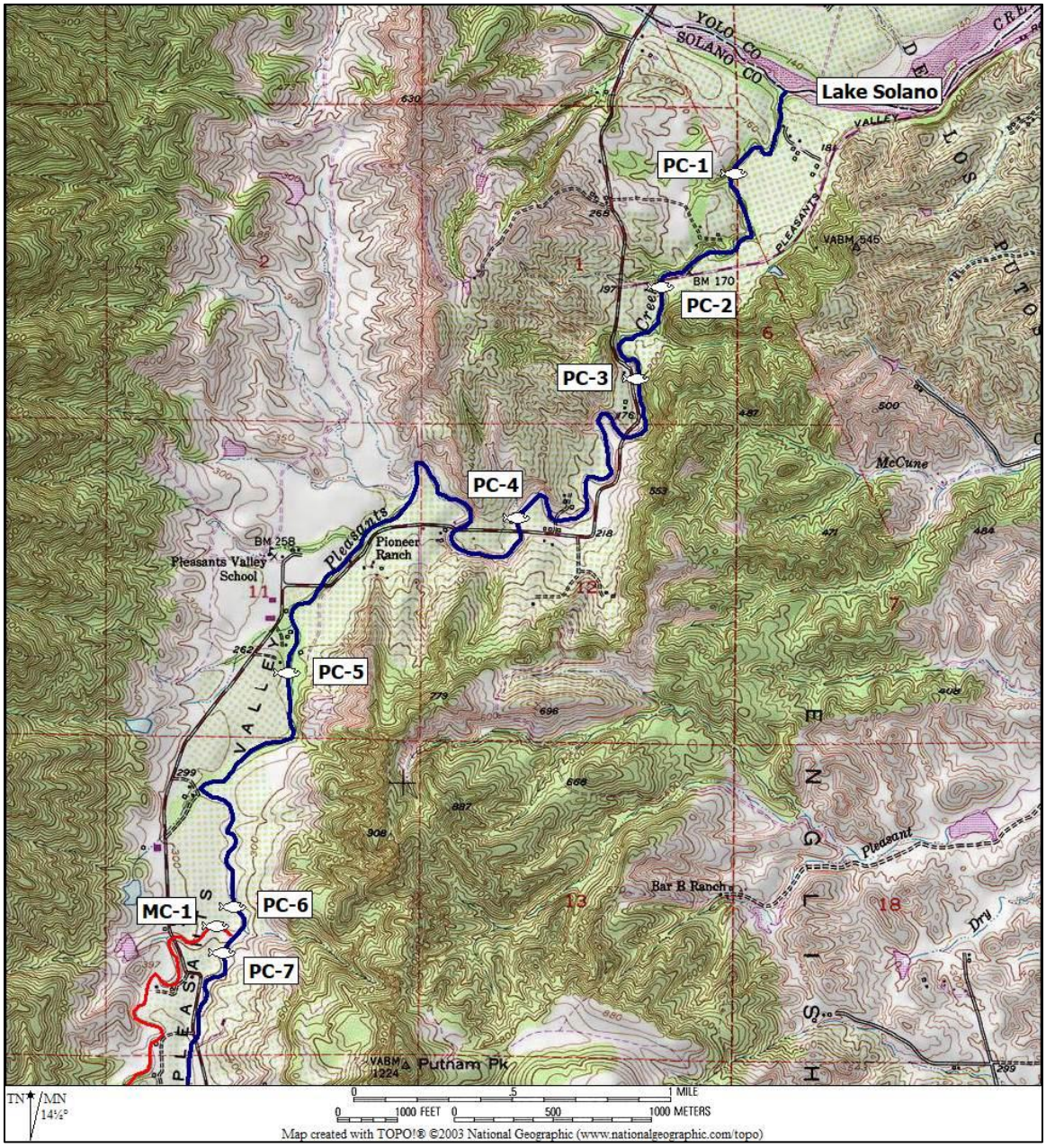

Figure 2. Map of lower Pleasants Creek (blue line) and Miller Canyon (red line) showing the location of the eight fish sampling sites surveyed in early November 2019 and late June 2020.

that there was no continuous streamflow during the winter 2020. It was also noted that several of the pools sampled in the fall of 2019 were considerably smaller and shallower in the late summer 2020 survey.

Photograph 7. Fish survey sites: A. PC-1, 24 June 2020; B. PC-2, 4 November 2019; C. PC-3, 24 June 2020; D. PC-4, 4 November 2019.

Photograph 8. Fish survey sites: A. PC-5, 5 November 2019; B. PC-6, 5 November 2019; C. PC-7, 25 June 2020; D. MC-1, 25 June 2020.

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 2019 and June 2020 Pleasants Creek and Miller Canyon fish surveys.

November 2019	**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	4-Nov-19	9:33	lake BW	619	7.8	46.0	231.6	344.2	0.2	3.87	33.4	6.7
PC-2	1.00	4-Nov-19	11:05	1 isolated pool	75	10.8	51.4	979	1,341	0.7	2.03	18.4	6.8
PC-3	1.50	4-Nov-19	13:25	2 isolated pools	210	9.9	49.8	756	1,060	0.5	6.93	64.6	6.8
PC-4	2.50	4-Nov-19	15:35	2 isolated pools	385	9.7	49.5	946	1,337	0.7	8.14	73.2	7.0
PC-5	4.25	5-Nov-19	8:48	3 isolated pools	295	10.1	50.2	704	983	0.5	1.82	16.6	6.7
PC-6	5.10	5-Nov-19	11:09	3 isolated pools	285	11.6	52.9	623	839	0.4	6.86	65.0	6.8
PC-7	5.30	5-Nov-19	13:00	2 isolated pools	280	11.1	52.0	549	749	0.4	2.09	19.5	6.8
Miller Canyon													
MC-1	0.05	5-Nov-19	14:30	3 isolated pools	422	12.2	54.0	644	854	0.4	5.06	48.1	6.9

June 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	24-Jun-20	9:34	lake BW	420	23.7	74.7	342.7	351.5	0.2	5.68	67.7	6.8
PC-2	1.00	24-Jun-20	11:57	1 isolated pool	75	23.4	74.1	1,130	1,378	0.7	7.09	85.4	6.9
PC-3	1.50	24-Jun-20	13:48	2 isolated pools	310	23.5	74.3	1,030	1,059	0.5	5.14	61.9	6.9
PC-4	2.50	24-Jun-20	16:19	2 isolated pools	415	31.4	88.5	1,552	1,384	0.7	6.16	84.9	11.1
PC-5	4.25	25-Jun-20	8:26	3 isolated pools	175	22.3	72.1	1,037	1,093	0.5	4.20	48.5	6.8
PC-6	5.10	25-Jun-20	10:25	3 isolated pools	380	22.0	71.6	770	816	0.4	2.46	28.7	6.9
PC-7	5.30	25-Jun-20	13:03	3 isolated pools	210	23.0	73.4	724	753	0.4	3.42	40.5	6.8
Miller Canyon													
MC-1	0.05	25-Jun-20	12:00	2 isolated pools	150	23.7	74.7	821	842	0.4	2.28	27.2	6.8

Water Quality

Specific conductivity (temperature adjusted conductivity), salinity and pH concentrations appeared to be relatively stable at each site over time regardless of season (Table 1). The exception was Pleasants Creek site PC-4, where pH measured in late June (11.4) was considerably higher than that noted the previous November (7.0). It is interesting to note that when this site was sampled in June 2020 there was a strong sulfurous odor to the water and a tell-tale gray tinge to the bottom of the pools that may indicate the presence of a hot spring seepage at this a site (Photograph 9).

Photograph 9. View upstream along Pleasants Creek Site PC-4 during 24 June survey when hot springs seepage was suspected based on strong sulfur odor and gray-tinged water (indicated in red ovals).

As might be expected, water temperatures measured at the time of the fish surveys varied between seasons, with cooler temperatures measured in early November 2019 compared to late June 2020 at all eight sites (Table 1). Again, the most extreme difference was noted at the PC-4 site where a water temperature of 31.4 degrees Centigrade (°C) [88.5° Fahrenheit] was noted in late June, compared to a water temperature of 9.7°C (49.5°F) was measured the previous November. It should be noted that this extreme water temperature measured in June, appeared to be associated with an active hot spring seepage at this site.

Dissolved oxygen levels varied by site and some sites had higher levels in June during warmer water temperature compared to November, when cooler water temperatures prevailed (Table 1). 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.

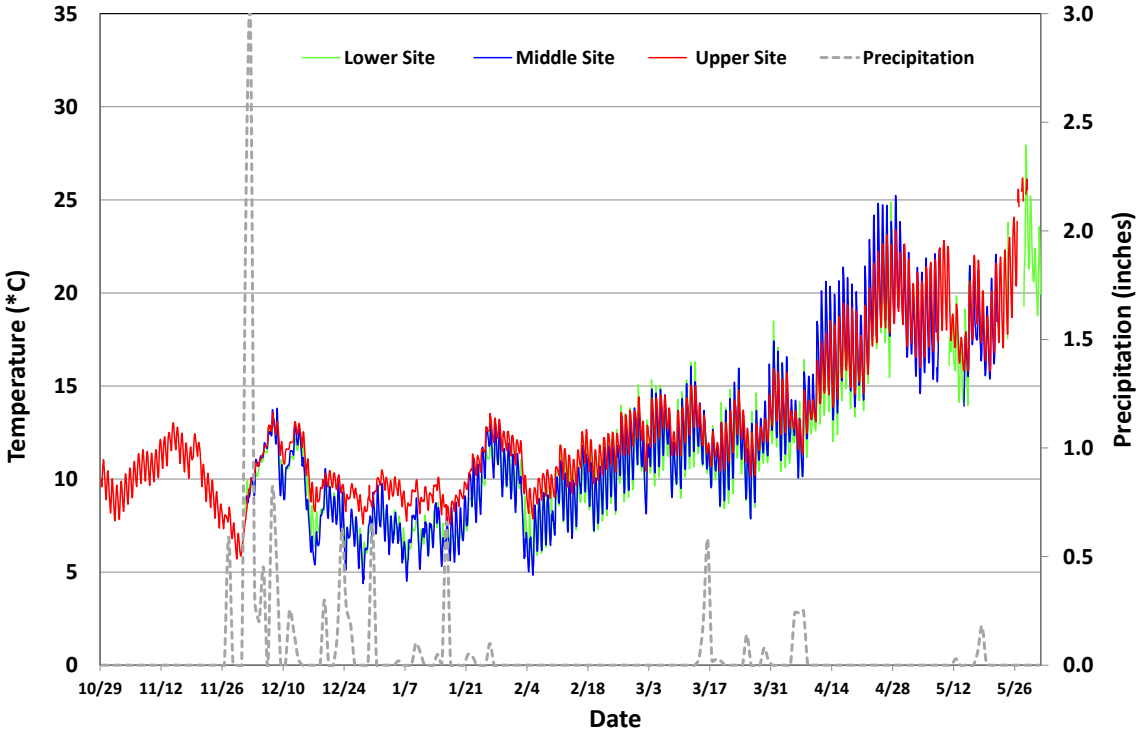

Figure 3. Hourly water temperature readings at three Pleasants Creek locations and daily precipitation records for the nearby Putah Diversion Office Station for 29 October 2019 through 31 May 2020.

The SCWA continuous water temperature data were reviewed, and all inaccurate data recorded when loggers were out of water or too shallow (<0.2 feet [2.4 inches] in depth) were deleted. The remaining valid water temperature records were then plotted for the period of late October through late May (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.

The continuous water temperature data show that water temperatures from the late fall through winter period remained relatively cool and remained below 15°C (59°F; Figure 3). In fact, during the coldest period of winter (between late November and early February) period increases in water temperature tended to occur following significant precipitation events. Beginning in late winter and through the spring water temperatures at all sites gradually increased. Unfortunately, by late spring all the data loggers were either out of water or too shallow to provide accurate water temperatures.

Additional physical and chemical analyses were subsequently conducted by both TRPA and SCWA personnel to determine if ambient water quality conditions and water chemistry at several sites identified from the opportunistic measurements during the late June fish surveys were consistent with geothermal hot spring activity. In mid-July TRPA conducted a preliminary reconnaissance-level water temperature mapping at two isolated pools at Site PC-4 and one isolated pool at Site PC-5 (Figure2). Some additional water conductivity mapping was also conducted at one of the Site PC-4 pools. The water temperature patterns did not show a well-defined geothermal source, but did suggest seepage of unexpectedly warm water (above ambient air temperatures) along a broad area of the pool bottoms that appeared to be correlated with the visible "gray-water" areas along the pool bottoms (Figures 3 and 4).

Based upon these preliminary observations, SCWA water quality staff followed up with a more comprehensive water quality analysis (Pascual 2020). On 30 July 2020 surface water samples were collected from four locations including two suspected geothermal source water pool locations at Site PC-4 (Figure 2). Additional comparative samples

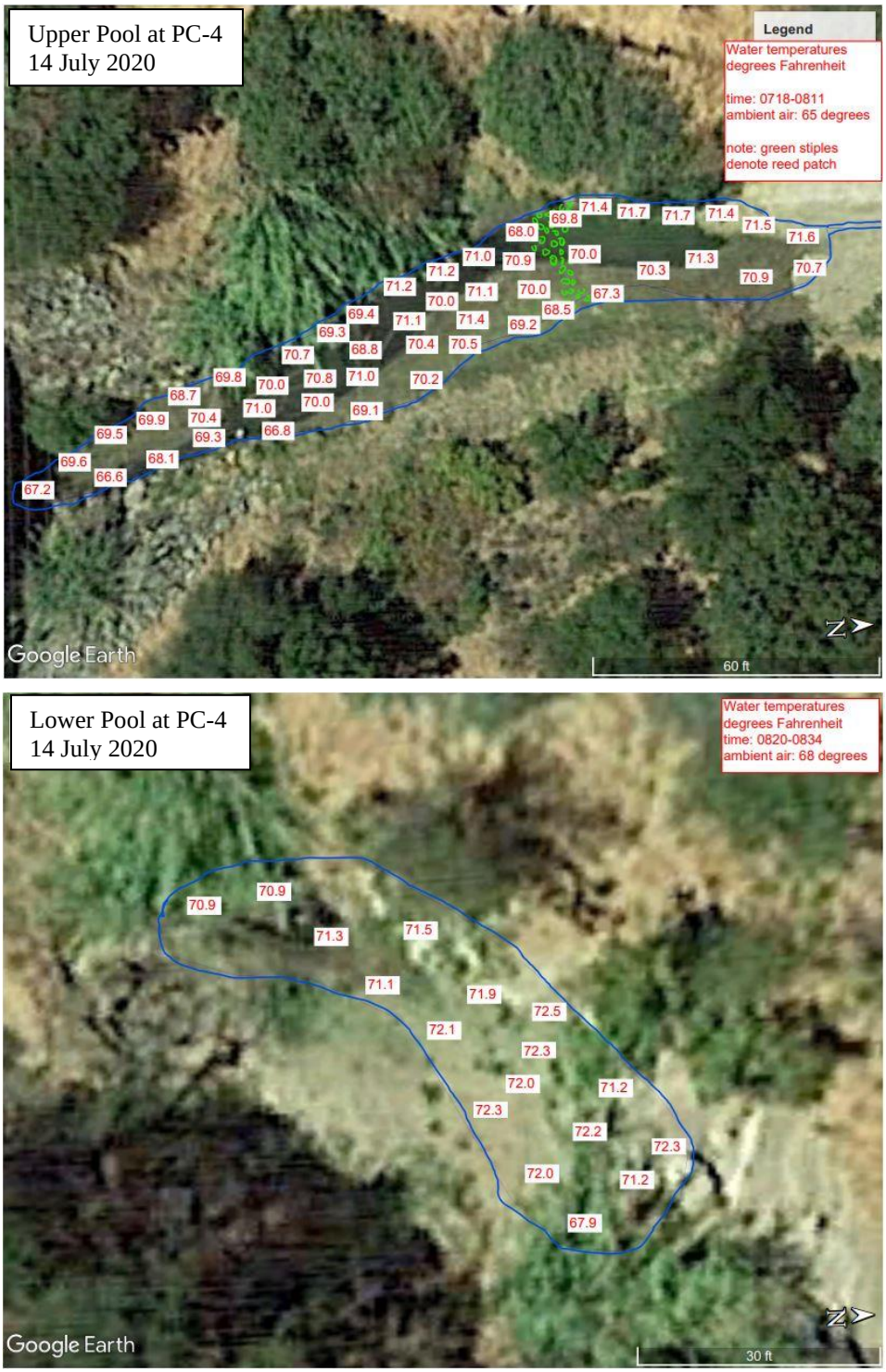

Figure 3. Water temperatures (in degrees Fahrenheit) plotted at discrete locations at the Upper and Lower Pools at Site PC-4 on 14 July 2020. Blue lines denote pool boundary at time of survey; green stipple area denotes a dense reed patch.

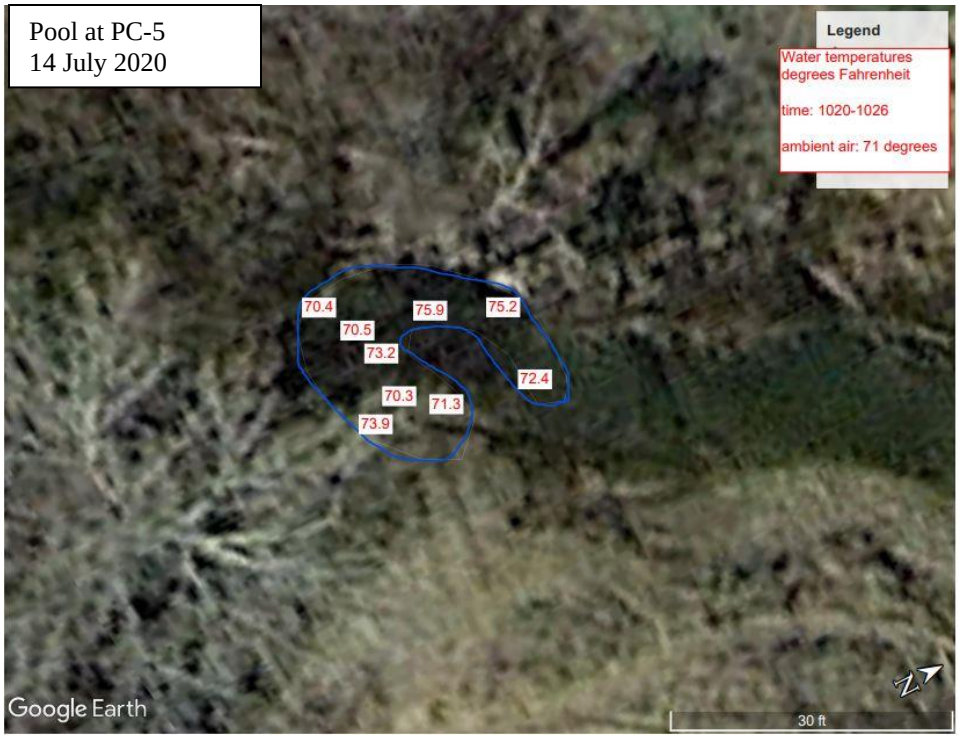

Figure 3. Water temperatures (in degrees Fahrenheit) plotted at discrete locations at the isolated pool at Site PC-5 on 14 July 2020. Blue line denotes pool boundary at time of survey.

were collected at an isolated pool at Site PC-2 and a pool located at the confluence of Pleasants and Miller Canyon near Site PC-7.

All the water samples collected were sent to an independent laboratory for detailed chemical analysis of a variety of parameters that could be indicative of geothermal water that included: total dissolved solids; alkalinity; chloride; sodium; sulfate; aluminum; calcium; iron; magnesium; potassium; nitrate; carbonate; and bicarbonate. Both the pools had elevated levels of sodium, chloride, sulfate (as SO_4), carbonate (as $CaCO_3$) and total dissolved solids, as well as elevated pH levels, and elevated conductivities. These results of the analyses categorize both the upper and lower pools at Site PC-4 as alkali carbonate waters that likely derive from a geothermal source (Pascual 2020).

Fish Monitoring

During both the fall 2019 and the summer 2020 surveys, California native fish dominated the populations at all sites (Tables 2 and 3). During the November 2019 surveys native fish made up almost 94 percent of the total fish captured, while in June 2020, native fish made up 90 percent of the captures. Three native species (Sacramento pikeminnow [*Ptychocheilus grandis*]; California roach [*Hesperoleucus symmetricus*]; and Sacramento sucker [*Catostomus occidentalis*]), made up most of the fishes captured during both surveys. These three dominant native fish species were captured at all eight survey sites during both the fall 2019 and summer 2020 surveys. Three other native fish (hitch [*Lavinia exilicauda*]; threespine stickleback [*Gasterosteus aculeatus*]; and prickly sculpin [*Cottus asper*] were minor components of the fish captures during both the fall and summer fish sampling and were captured at fewer sites.

Non-native fish (also called exotics) made up only a small fraction of the total fish captures in either the fall 2019 (6.2 percent) or summer 2020 surveys (10.0 percent). In both surveys, green sunfish (*Lepomis cyanellus*) made up most of the non-native fishes captured, accounting for 4.0 percent and 9.2 percent of the total fish captures in the November 2019 and June 2020 surveys, respectively (Tables 2 and 3).

Other exotic fish species captured during the two surveys included western mosquitofish (*Gambusia affinis*), bluegill sunfish (*Lepomis macrochirus*), largemouth bass (*Micropertus salmoides*), and spotted bass (*M. punctatus*).

During the November 2019 survey the highest percentage of non-native fish were captured at the PC-1 Site, which was the Lake Solano backwater site (Table 2). During the June 2020 survey the highest percentage of non-native fish were captured at the PC-5 Site.

Table 2. Capture data for the fish monitoring surveys on Pleasants Creek and Miller Canyon, 4-5 November 2019.

	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	2 (43-53 FL)	29 (32-104 FL)	64 (42-118 FL)	50 (50-242 FL)	29 (44-134 FL)	33 (47-116 FL)	37 (45-120 FL)	13 (50-193 FL)	**257**
California roach	17 (36-49 FL)	52 (22-79 FL)	55 (31-57 FL)	38 (35-102 FL)	22 (32-73 FL)	59 (25-102 FL)	72 (23-126 FL)	48 (27-102 FL)	**363**
Hitch					5 (43-58 FL)	1 (65 FL)		1 (128 FL)	**7**
Sacramento sucker	10 (53-63 FL)	35 (43-97 FL)	77 (47-116 FL)	21 (55-104 FL)	37 (52-126 FL)	118 (46-122 FL)	43 (40-85 FL)	11 (47-90 FL)	**352**
Threespine stickleback	7 (24-45 TL)								**7**
Prickly sculpin						1 (92 TL)			**1**
Exotic Fishes									
Western mosquitofish	1 (26 TL)								**1**
Bluegill sunfish			9 (27-152 FL)	1 (48 FL)		1 (103 FL)			**11**
Green sunfish			11 (33-65 FL)	3 (40-58 FL)	12 (32-150 FL)	15 (28-148 FL)		1 (102 FL)	**42**
Largemouth bass	7 (46-57 FL)								**7**
Spotted bass	4 (50-57 FL)								**4**
Total # Individuals	48	116	216	113	105	228	152	74	**1,052**
# native fish	36	116	196	109	93	212	152	73	**987**
# exotic fish	12	0	20	4	12	16	0	1	**65**
Total # species	7	3	5	5	5	7	3	5	**11**
# native species	4	3	3	3	4	5	3	4	**6**
# exotic species	3	0	2	2	1	2	0	1	**5**
Shannon's Diversity (ln)	1.676	1.068	1.360	1.178	1.443	1.221	1.055	0.986	**1.389**
Eveness (H'/Hmax)	0.861	0.972	0.845	0.732	0.897	0.627	0.960	0.613	**0.579**

Table 3. Capture data for the fish monitoring surveys on Pleasants Creek and Miller Canyon, 24-25 June 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									
Sacramento pikeminnow	45 (73-142 FL)	17 (55-228 FL)	41 (57-107 FL)	13 (73-130 FL)	24 (68-161 FL)	38 (66-265 FL)	14 (63-140 FL)	18 (72-105 FL)	**210**
California roach	1 (70 FL)	19 (45-83 FL)	62 (27-73 FL)	45 (23-77 FL)	10 (47-83 FL)	105 (26-106 FL)	15 (39-97 FL)	27 (47-67 FL)	**284**
Hitch	3 (75-102 FL)								**3**
Sacramento sucker	9 (61-107 FL)	115 (63-150 FL)	80 (61-136 FL)	8 (76-127 FL)	46 (77-161 FL)	50 (82-171 FL)	17 (92-137 FL)	15 (65-154 FL)	**340**
Threespine stickleback		1 (36 TL)							**1**
Prickly sculpin	3 (63-75 TL)								**3**
Exotic Fishes									
Western mosquitofish					1 (33 TL)				**1**
Bluegill sunfish	1 (102 FL)				2 (112-113 FL)		2 (130-132 FL)		**5**
Green sunfish	4 (76-114 FL)		7 (63-110 FL)	6 (67-95 FL)	22 (23-152 FL)	41 (37-122 FL)	1 (102 FL)	5 (65-77 FL)	**86**
Largemouth bass							1 (210 FL)		**1**
Total # Individuals	66	152	190	72	105	234	50	65	**934**
# native fish	61	152	183	66	80	193	46	60	**841**
# exotic fish	5	0	7	6	25	41	4	5	**93**
Total # species	7	4	4	4	6	4	6	4	**10**
# native species	5	4	3	3	3	3	3	3	**6**
# exotic species	2	0	1	1	3	1	3	1	**4**
Shannon's Diversity (ln)	1.111	0.749	1.182	1.054	1.370	1.290	1.370	1.256	**1.372**
Eveness (H'/Hmax)	0.571	0.540	0.853	0.760	0.765	0.930	0.764	0.906	**0.596**

Discussion

The Pleasants Creek fish surveys were limited to periods of intermittent flow. Future sampling in the early spring of wet or above normal water years during (or immediately following) periods of active streamflow may provide additional information about habitat use by resident fish species. Despite the intermittent flow conditions that prevailed during both the fall 2019 and summer 2020 surveys, California native fish dominated the populations throughout the Pleasants Creek basin. The dominant species: pikeminnow, roach, and sucker are all known to be moderately tolerant of environmental degradation (May and Brown 2002) and are able to maintain populations in intermittent flow/high water temperature/high conductivity habitats (Moyle 2002). All three species appear to be tolerant on 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 which regularly becomes intermittent during the summer and fall seasons.

There are also reports of resident rainbow trout in upper portions of Miller Canyon where perennial streamflow conditions exist (Rich Marovich, Putah Creek Streamkeepr, personal communication). We were unable to arrange access to these areas for these preliminary surveys. Efforts to get access to the upper Miller Canyon area should continue, so these areas can be included in future fish surveys.

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