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Memorandum

DATE: 20 May 2020
TO: Roland Sanford, Chris Lee, and Rich Marovich, Solano County Water Agency (SCWA)
FROM: Tim Salamunovich, TRPA Fish Biologists
RE: Results of October 2019 lower Putah Creek fish surveys **(FINAL)**

TRPA Fish Biologists staff have been sampling the fish fauna of lower Putah Creek using tote barge electrofishing since August 1991. Students from the University of California at Davis (UCD) have been regularly sampling the creek near campus using a combination of boat/backpack electrofishing, seining, and gill netting each fall since 1978. Following the May 2000 Putah Creek Accord, Normandeau continued surveying multiple sites along the creek each October as part of an annual fish monitoring program under the aegis of the Lower Putah Creek Coordinating Committee. The Accord requires releases of late fall supplemental flows to attract anadromous fish into lower Putah Creek to spawn. Another stipulation requires elevated natural or managed flows in the late winter or spring to enhance native fish spawning opportunities in the lower basin. A database containing all the raw fish monitoring data (individual fish lengths and weight data by site and survey date) for the entire period of record is regularly updated and managed by TRPA and provided to both the Solano County Water Agency (SCWA) and UCD personnel. The data through 2008 was the focus of a scientific publication that demonstrated the recovery of native fishes in the upper 12.5 miles of the creek (upstream of Pedrick Road [County Road 98]) following the prolonged low-flow drought that occurred in the late 1980's and early 1990's and the native fish rearing and spawning flows instituted under the Accord (Kiernan et al. 2012).

The TRPA crew sampled ten sites at nine locations (two sites at Winters Park) along 19 miles of the lower creek between Putah Diversion Dam (PDD) and Mace Boulevard (County Road 104; Figure 1) on 15-17 October 2019. Two additional sites near the UCD campus (Figure 1) were sampled on 26 October 2019 by a UCD fisheries class, and the results were generously provided for review. This memo report will present the results of these two recent sampling efforts.

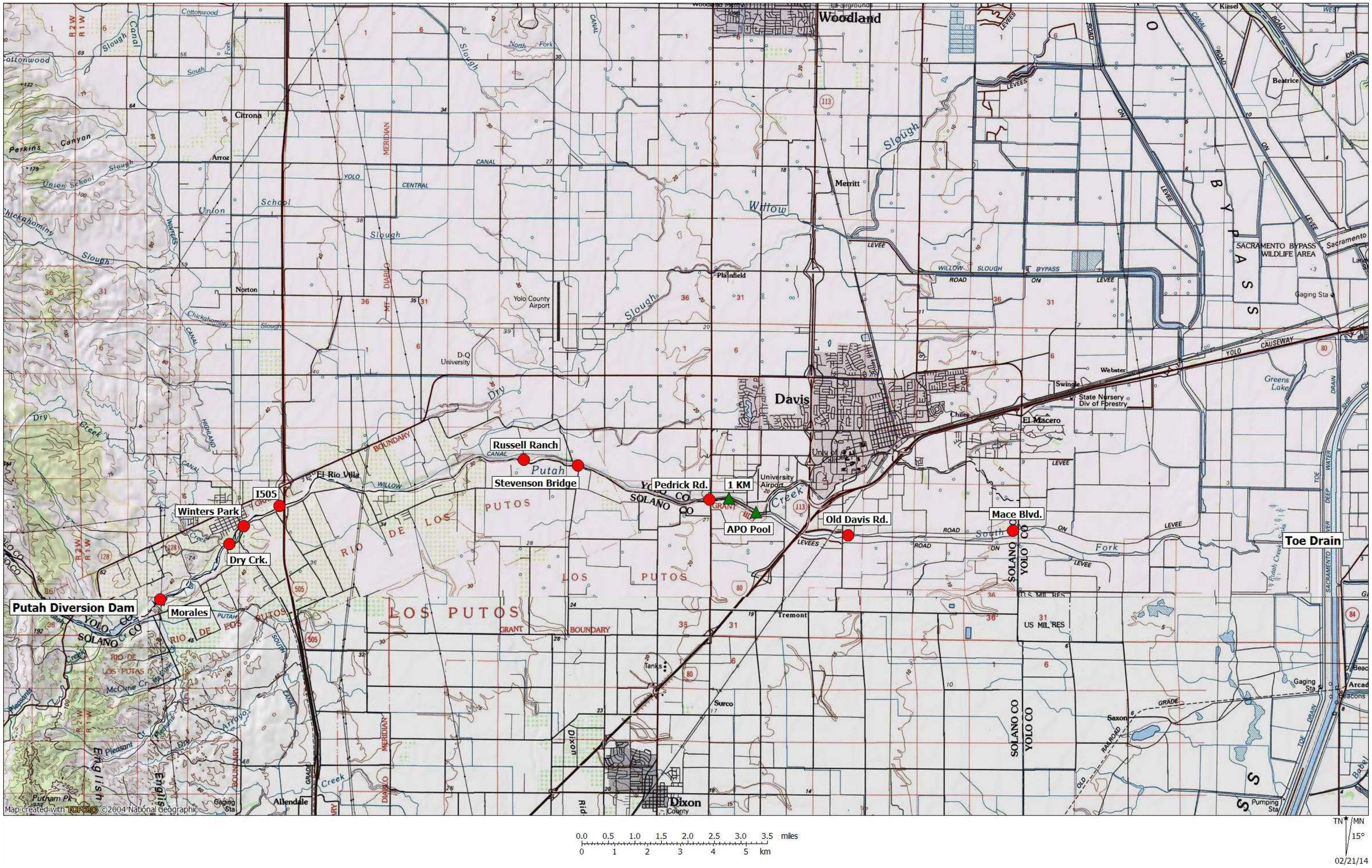

Figure 1. Map showing the nine TRPA (red circles) and two UCD (green triangles) locations surveyed along lower Putah Creek in October 2019.

The objective of fish monitoring surveys is to determine the distribution and relative abundance of fish populations in lower Putah Creek. At six of the sites, biologists captured fish using a Smith-Root gas powered generator and pulsator (model 2.5 GPP) operated out of a small pram. Two biologists wading alongside the pram used electrofishing probes to attract and stun fish. Two additional biologists netted and captured stunned fish and transferred them to buckets located in the front of the pram. A fifth person rowed or pulled the pram and was responsible for shutting off the electric current in the event of a mishap. During the 2019 survey, the generator broke down on the third survey day and two battery-powered Smith-Root model LR-20B backpack electrofishers were used to capture fish at the remaining sites (Winters Putah Creek Park weirs, Dry Creek, and Putah Diversion Dam).

Sampling efforts emphasized the margins of the creek around instream cover and overhead vegetation, and additional effort was allocated to open water portions of the creek. Total effort expended at each site was made approximately equal by a combination of measurements of stream area and shocking seconds. The Winters Putah Creek Park site had been altered during the high winter and spring flows of early 2019 that resulted in extensive sand deposition throughout the area that buried the boulder weirs where previous surveys concentrated effort. Limited sampling was conducted at these locations.

All stunned fish were netted and held in 5-gallon buckets of creek water equipped with small bait-bucket aerators. Captured fish were periodically transferred to a live cart until the completion of sampling. Fish were identified and measured to the nearest millimeter using either fork length (FL) or total length (TL). A sub-sample of the catch was also weighed to nearest 0.1 gram to determine condition factors (length-weight ratios) prior to release. All rainbow trout captured during the surveys were weighed to evaluate condition factor. Condition factor is a commonly used measure of the trout population health. The condition factor compares the length and weight relationship of individual fish to assess their physical condition (Everhart et al. 1975). Higher condition factors indicate heavier fish for a given length. Trout were anesthetized in weak CO_2 solution prior to handling to reduce movement and injury during the measurement and weighing process. After handling, all trout recovered in an aeration bucket until fully mobile prior release back into the creek.

Two additional sites (the Alpha Phi Omega [APO] pool and the 1 Kilometer [1 KM] sites) were sampled by students of the UCD Wildlife, Fish, & Conservation Biology class on 26 October 2019 (Figure 1). UCD used a variety of capture gear including beach seines, gillnets, minnow traps and a boat shocker (equipped with a 5.0 GPP) at the APO Site; and backpack electrofishers at the 1 KM Site. Fish were identified, enumerated, and most were measured to standard length (SL) and released.

As specified in the Accord, flows in Putah Creek at Interstate 80 (I80) Bridge near Davis are monitored and dam releases to the lower creek are adjusted to maintain minimum flows of at least 5 cfs (or higher) at the I80 Bridge throughout the year (Table 1). This flow requirement ensures maintenance of a live stream throughout 15.5 miles of the lower basin, even during dry and critically dry water years. In addition, the Accord includes supplemental flow releases into the lower basin to attract anadromous salmonids in the late fall and early spring releases to promote native fish spawning (if they do not occur naturally).

Table 1. Mean daily flow requirements for Putah Creek at Interstate 80.

Month	Minimum Flow Requirement (cfs)
October	5
November/December	10
January/February	15
March	25
April	30
May	20
June/July	15
August	10
September	5

Mean daily flow in lower Putah Creek (measured at the PDD release point) during the 2019 Water Year (WY) is shown in Figure 2. WY 2019, which ended two weeks prior to sampling, was classified as a wet water year in the Sacramento basin according to the Sacramento Valley 40-30-30 Hydrologic Classification Index (DWR California Data Exchange Center, Water Supply Index WSIHIST). WY 2019 was the second wet water year in the Sacramento Valley in the last three years and resulted in an extended period of uncontrolled spills from Monticello Dam (Lake Berryessa) upstream of the project area from 26 February through 5 May 2019 (Figure 2).

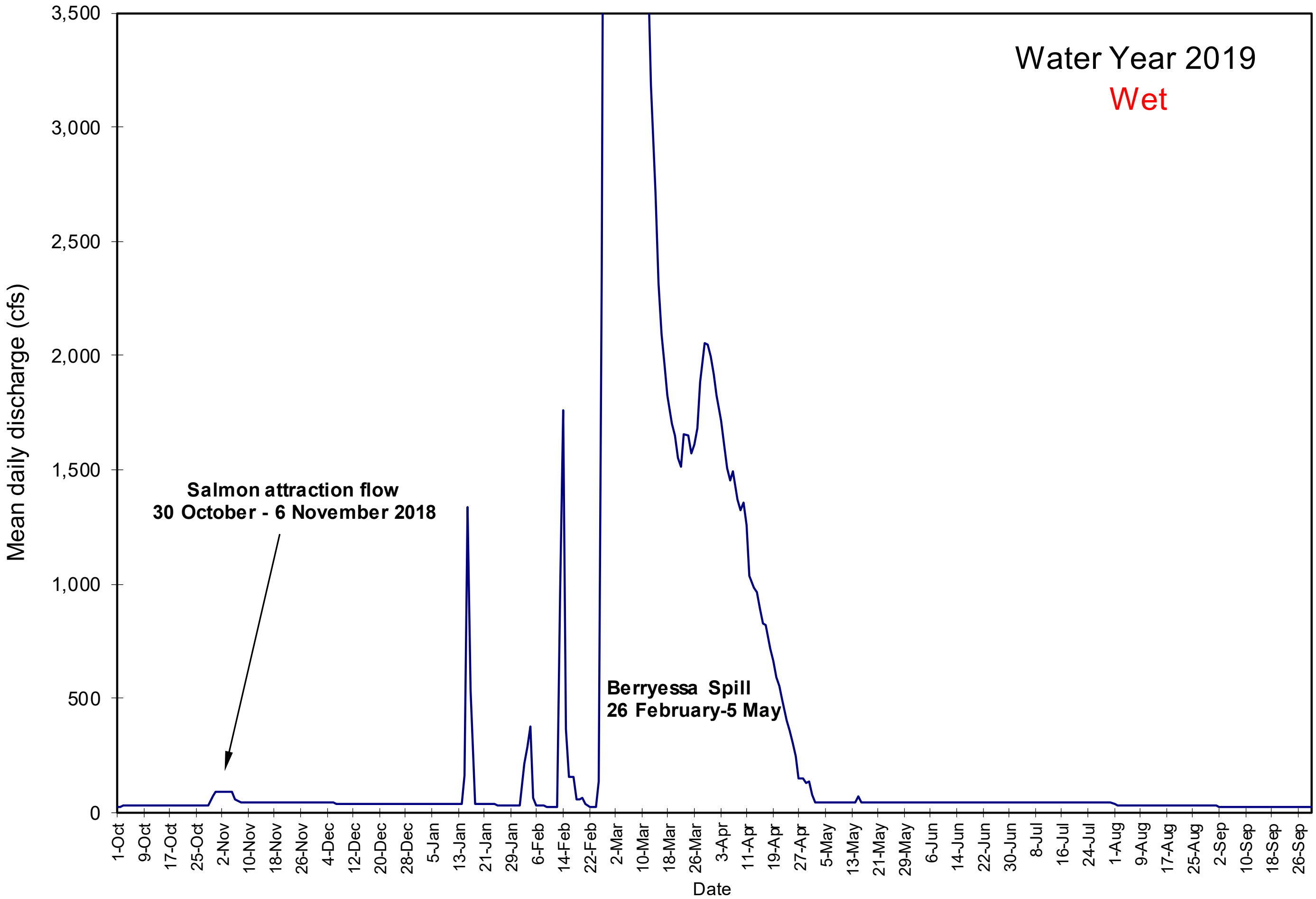

Figure 2. Estimates of the mean daily discharge (in cubic feet per second [cfs]) released into lower Putah Creek at the Putah Diversion Dam during the 2019 Water Year and prior to the October 2019 survey. Streamflows in excess of 3,500 cfs occurred during the fourteen days between 27 February and 12 March, with a peak maximum daily streamflow of 8,757 cfs on 28 March 2019. Data from the US Bureau of Reclamation Mid-Pacific Region, Central Valley Office, Reservoir Operations Reports.

The mean annual flow in the lower basin was 468 cubic feet per second (cfs), or ten times the mean annual flow noted the previous WY 2018. The maximum flow during WY 2019 was 8,757 cfs on 28 March 2019 cfs and it occurred as part of the spill flows from the glory hole at Monticello Dam (Figure 3). Typical managed flows in the 43 to 20 cfs range prevailed from early May through the October surveys. The exceedance flows for WY 2019 are shown in Table 2. The high flow events and resulting dam spills flows were the result of a wet winter when

33.5 inches of rain were recorded at SCWA's PDO gage between December through March [BOR 2019]), which filled Lake Berryessa and caused spill from the Monticello Dam glory hole into Putah Creek for much of the late winter and spring (Figure 3). Monticello spill, plus accretion from Cold Canyon, Pleasants, McCune and Dry creeks, contributed to the extended period of high flow in lower Putah Creek during the late winter and early spring of 2019.

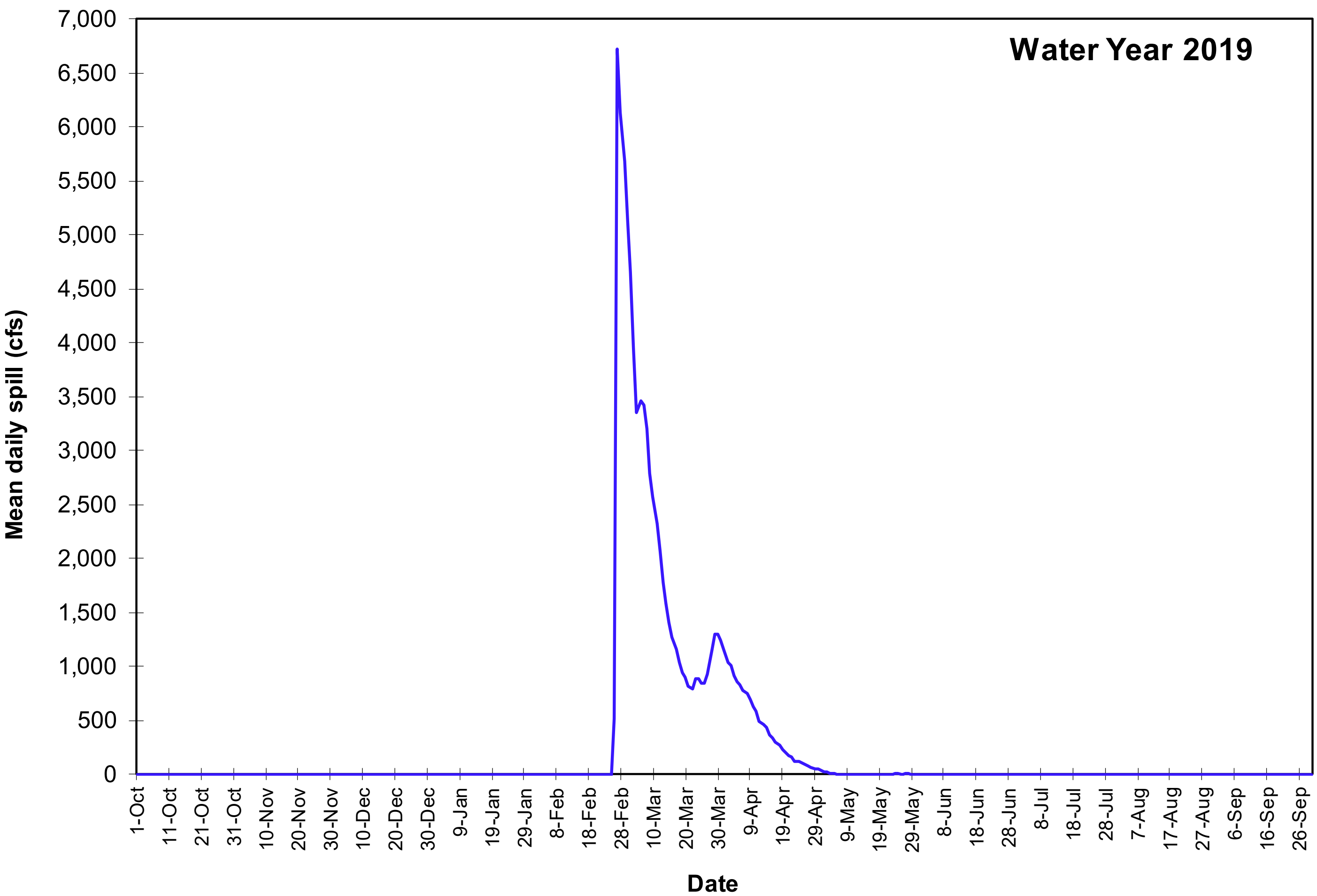

Figure 3. Mean daily spill from Lake Berryessa Glory Hole into Putah Creek during the 2019 Water Year.

Table 2. Number of days that mean daily releases from Putah Diversion Dam exceeded certain values during the 2019 Water Year (1 October 2018–30 September 2019). Data from USBR Mid-Pacific Region, Central Valley Operations Website.

Exceedance (cubic feet per second)	Number of Days
≥ 7,500 cfs	4
≥ 5,000 cfs	10
≥ 2,500 cfs	16
≥ 1,000 cfs	48
≥ 500 cfs	59
≥ 250 cfs	66
≥ 100 cfs	76
≥ 50 cfs	91
≥ 30 cfs	327

Stream flows during the mid-October 2019 TRPA fish monitoring surveys varied and decreased according to distance downstream from the PDD release site, ranging from 23.2 cfs at the Putah Diversion Dam to 9.1 cfs at Mace Boulevard (Table 3). The UCD surveys occurred in late October, immediately prior to the Fall 2018 salmon attraction flows and were around 10.7 cfs at the I-80 gage (Table 3).

Table 3. River mile location, sample date, survey time, stream flow, water temperature, dissolved oxygen concentration, conductivity, and salinity at time of survey for the twelve lower Putah Creek study sites during the October 2019 fish monitoring surveys. River mile location is the distance upstream of point where creek enters Toe Drain.

Site	River Mile	Date	Time	Flow 1/ (cfs)	Temp (°C)	DO (mg/L)	Cond (µS/cm)	Salinity (ppt)
Putah Diversion Dam	25.4	10/17/19	1305	23.2	12.9	9.79	239	0.1
Dry Creek confluence	23.0	10/17/19	1030	18.0	12.5	9.58	237	0.1
Winters Park (upper weir)	22.5	10/17/19	1605	12.8	13.9	8.49	244	0.1
Winters Park (lower weir)	22.2	10/17/17	1455	13.3	14.3	7.96	248	0.1
Interstate 505 Bridge (I505)	21.5	10/16/19	1505	12.7	13.6	9.59	200	0.1
Russell Ranch	16.2	10/16/19	1155	12.3	13.6	9.45	311	0.2
Stevenson Road Bridge	15.4	10/16/19	0922	11.7	13.3	10.4	317	0.2
Pedrick Road Bridge	12.6	10/15/19	1615	11.8	15.3	13.0	330	0.2
1 Kilometer Site (1 KM)	12.1	10/26/19	1230	10.7	---	---	---	---
Alpha Phi Omega (APO) Pool	11.8	10/26/19	1415	10.7	15.6	9.10	420 2/	---
Old Davis Road Bridge	9.8	10/15/19	1338	10.5	14.5	9.46	325	0.2
Mace Boulevard Bridge	6.4	10/15/19	1018	9.1	13.5	7.92	383	0.2

1/ Flow data provided by Solano County Water Agency 2/ temperature-corrected specific conductivity

Water temperatures measured during the October surveys varied by site as a function of both the time of day and the distance downstream of the Putah Diversion Dam release point (Table 3). The temperatures ranged from 12.5° to 15.6°C (54.5° to 60.1°F). Water conductivity (a measure of total dissolved solids) did not vary in the upper four miles of the project area, then remained higher (but stable) in the fifteen miles downstream of the Interstate 505 (I505) Site. Dissolved oxygen levels were relatively high and exceeded 7.9 mg/L at all the sites.

The Fall 2019 fish surveys of twelve sites along lower Putah Creek captured a total of 3,504 fish representing 25 species (Table 4). Four California native fish species: Sacramento pikeminnow (*Ptychocheilus grandis*), Sacramento sucker (*Catostomus occidentalis*), tule perch (*Hysterocarpus traskii*), and prickly sculpin (*Cottus asper*) made up over fifty-four percent of the total catch in the lower basin (Figure 4). The most abundant non-native species included bluegill sunfish (*Lepomis macrochirus*), largemouth bass (*Micropterus salmoides*), redear sunfish (*L. microlophus*), and Mississippi silverside (*Menidia audens*) which contributed over thirty-six percent of the total catch.

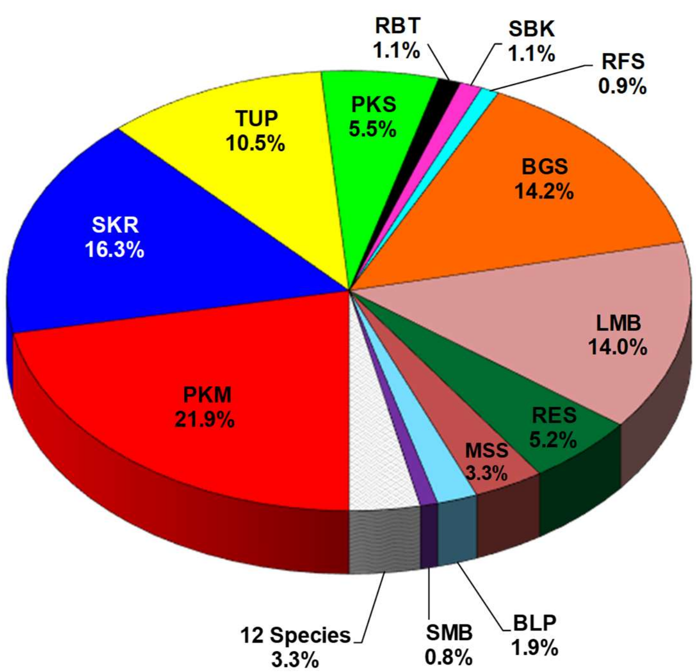

Figure 4. Percentage of total catch by fish species for the October 2019 lower Putah Creek fish surveys. Data includes both TRPA and UCD survey data.

Table 4. Capture data for the October 2019 TRPA and UCD fish monitoring surveys on lower Putah Creek.

Fish	PDD	DRY	WPK	I505	RR	STEVE	PED	1KM	APO	OLD	MACE	Total
Native Fishes												
Pacific lamprey (PLR)			4 (87-115 TL)						1 (112 TL)			5
Sacramento pikeminnow (PKM)		4 (50-91 FL)	21 (39-73 FL)	57 (35-319 FL)	339 (38-282 FL)	68 (33-246 FL)	264 (48-290 FL)	6 (62-170 SL)	4 (173-490 SL)	2 (109-121 FL)	2 (262-272 FL)	767
Hitch (HTC)						1 (135 FL)	2 (83-85 FL)			3 (83-97 FL)	13 (54-162 FL)	19
Sacramento sucker (SKR)	11 (52-246 FL)	103 (33-139 FL)	84 (45-184 FL)	86 (42-367 FL)	186 (48-286 FL)	31 (62-223 FL)	43 (85-310 FL)		21 (284-460 SL)		6 (204-305 FL)	571
Rainbow trout (RBT)	28 (131-501 FL)	8 (188-320 FL)	1 (191 FL)									37
Threespine stickleback (SBK)	22 (22-56 TL)	13 (30-48 TL)	2 (32-42 TL)									37
Prickly sculpin (PKS)	14 (41-101 TL)	48 (43-113 TL)	35 (43-105 TL)	50 (40-90 TL)	8 (47-63 TL)		17 (45-90 TL)	10 (37-105 SL)	3 (35-42 SL)	4 (48-91 TL)	5 (55-109 TL)	194
Riffle sculpin (RFS)	6 (68-95 TL)	8 (60-100 TL)	3 (62-80 TL)	13 (43-102 TL)								30
Tule perch (TP)		24 (62-135 FL)	12 (62-84 FL)	49 (49-75 FL)	157 (71-114 FL)	106 (75-130 FL)	18 (95-122 FL)		1 (115 SL)		1 (109 FL)	368
Exotic Fishes												
Black bullhead (BLBH)										1 (152 TL)	2 (164-182 TL)	3
Channel catfish (CCF)											1 (90 FL)	1
Golden shiner (GSH)									22 (54-84 SL)			22
Goldfish (GLF)											1 (180 FL)	1
Common carp (CRP)									9 (470-650 SL)		2 (219-261 FL)	11
Mississippi silverside (MSS)									2 (69-72 SL)	52 (43-95 FL)	62 (31-71 FL)	116
Western mosquitofish (MSQ)			1 (30 TL)					2 (30-34 SL)	6 (21-35 SL)		1 (43 TL)	10
Bluegill (BGS)			2 (74-89 FL)		1 (124 FL)		2 (123-140 FL)	5 (38-91 SL)	127 (19-135 SL)	113 (29-130 FL)	249 (33-131 FL)	499
Redear sunfish (RES)								9 (42-100 SL)	116 (28-200 SL)	18 (80-152 FL)	38 (53-183 FL)	181
Green sunfish (GSF)						2 (122-131 FL)	1 (120 FL)		2 (40-82 SL)	10 (64-104 FL)	7 (67-115 FL)	22
Inidentified lepomids									14 (20-46 SL)			14
Smallmouth bass (SMB)					2 (83-130 FL)	7 (65-97 FL)	10 (60-224 FL)	2 (77-83 SL)	5 (69-352 SL)	2 (87-99 FL)	1 (64 FL)	29
Spotted bass (SPB)										1 (185 FL)		1
Largemouth bass (LMB)		2 (131-140 FL)		2 (85 FL)	8 (56-205 FL)	7 (70-115 FL)	78 (45-285 FL)	29 (43-65 SL)	82 (39-370 SL)	115 (52-258 FL)	168 (50-224 FL)	491
White crappie (WCR)											1 (95 FL)	1
Black crappie (BCR)								1 (114 SL)	2 (230 SL)		4 (86-105 FL)	7
Bigscale logperch (BLP)	1 (93 TL)						1 (79 TL)	2 (83-97 TL)	9 (70-87 SL)	32 (86-130 TL)	22 (88-125 TL)	67
Total # Individuals	82	210	165	257	701	222	436	66	426	353	586	3,504
# native fish	81	208	162	255	690	206	344	16	30	9	27	2,028
# exotic fish	1	2	3	2	11	16	92	50	396	344	559	1,476
Total # species	6	8	10	6	7	7	10	9	16	12	19	25
# native species	5	7	8	5	4	4	5	2	5	3	5	9
# exotic species	1	1	2	1	3	3	5	7	11	9	14	16
Shannon's Diversity (ln)	1.536	1.476	1.458	1.524	1.167	1.275	1.262	1.714	1.799	1.666	1.643	2.266
Eveness (H'/Hmax)	0.857	0.710	0.633	0.850	0.600	0.655	0.548	0.780	0.649	0.670	0.558	0.704

Thirty-seven rainbow trout (*Oncorhynchus mykiss*) were captured in the fall surveys, or just over one percent of the total catch (Table 4; Figure 4). While rainbow trout were most abundant at the most upstream PDD site, they were present at all three sample sites in the upper three miles of the survey area. No rainbow trout were captured downstream of Winters Park during the 2019 survey.

Of the native species captured during the October 2019 survey, some species, such as rainbow trout, threespine stickleback (*Gasterosteus aculeatus*) and riffle sculpin (*C. gulosus*) were limited to the upper half of the study area (Table 4). The native pikeminnow, sucker, prickly sculpin, and tule perch were more widely distributed, and were found throughout the lower basin. Hitch (*Lavinia exilicauda*), a native minnow, were only found in the lower half of the study area in 2019. Moyle (2002) states that trout and riffle sculpin require cold water, which is why they are typically only abundant in the upper few miles of the lower Putah Creek study area, closer to the coldwater releases from the Putah Diversion Dam. Suckers and prickly sculpin while capable of thriving in cool water, are tolerant of warmer water temperatures (Moyle 2002), which explains their wider distribution throughout the lower Putah Creek basin.

Of the total fish captured in the October 2019 survey, 58 percent (2,028 fish from nine species) were native fish endemic to the Sacramento River basin, while 42 percent (1,476 fish from sixteen species were non-native, or exotic fishes (Table 4; Figure 4).

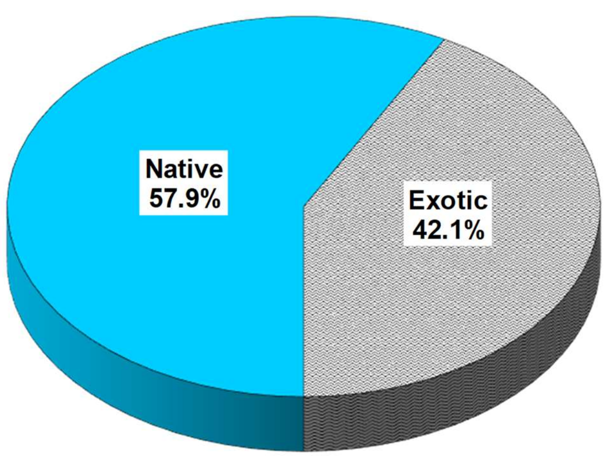

Figure 5. Percentage of total catch by native versus non-native (or exotic) species for the October 2019 lower Putah Creek fish survey. Data includes both TRPA and UCD data.

The overall spatial distribution of fishes from the October 2019 survey remains similar to recent prior surveys and continues to demonstrate that lower Putah Creek supports a highly diverse fish fauna. Native fish continue to dominate the 12.7 miles of the lower basin between the PDD at Winters and the Pedrick Road Bridge Site near Davis (Table 4; Figure 6). About 0.5 miles downstream from Pedrick, at the 1KM Site, exotic species are more abundant and in the twelve miles of creek downstream of the 1KM Site, non-native fish dominate Putah Creek (Figure 6). Despite the prolonged periods of high flow in the Putah Creek basin during 2019, native fish did not appear to have been able to expand their distribution in lower Putah creek. Non-native fish continue to dominate the fish populations downstream of Pedrick Road. This consistent pattern for native fish dominance at Pedrick Road and sites upstream, and non-native fish dominance about a half mile downstream at the 1KM Site, is likely a result of some environmental factor such as summer water temperatures that appear to limit the downstream extent of the native fish fauna, which tend to prefer and thrive in cooler water temperatures compared to the non-native fishes, which tend to consist of slow-water pond species that are more tolerant of higher summer water temperatures. The Pedrick and 1 KM sites are at the interface where the native/exotic species meet and interact. The 2019 catch data show that native fish continue to dominate the catch in the upper 12.7 miles of the study area between the PDD and Pedrick Bridge (Table 4). In fact, only seven non-native fish (all bluegill sunfish) were captured in the upper 4.0 miles of the study area, and native fish made up over 97 percent of the total catch at the six study sites located in the upper ten miles of the study area from PDD to Stevenson Bridge Road (Table 4).

Despite the wet water year and higher than normal late winter and early spring flow conditions during WY 2019, the percentage of native fish at Pedrick Road did not increase from that noted in WY 2018, which was classified as a below normal water year. In fact, following the wet WY 2019, native fish abundance actually *decreased* at both the Pedrick Road and 1KM sites from those noted in the previous WY 2018 (Figure 7).

The spatial distribution of exotic fishes in the lower basin also varied by species (Table 4). Channel catfish (*Ictalurus punctatus*), goldfish (*Carassius auratus*), spotted bass (*Micropterus punctulatus*) and white crappie (*Pomoxis annularis*) were limited to single locations in the lower basin, while carp (*Cyprinus carpio*) and black bullhead (*Ameiurus melas*) were documented at

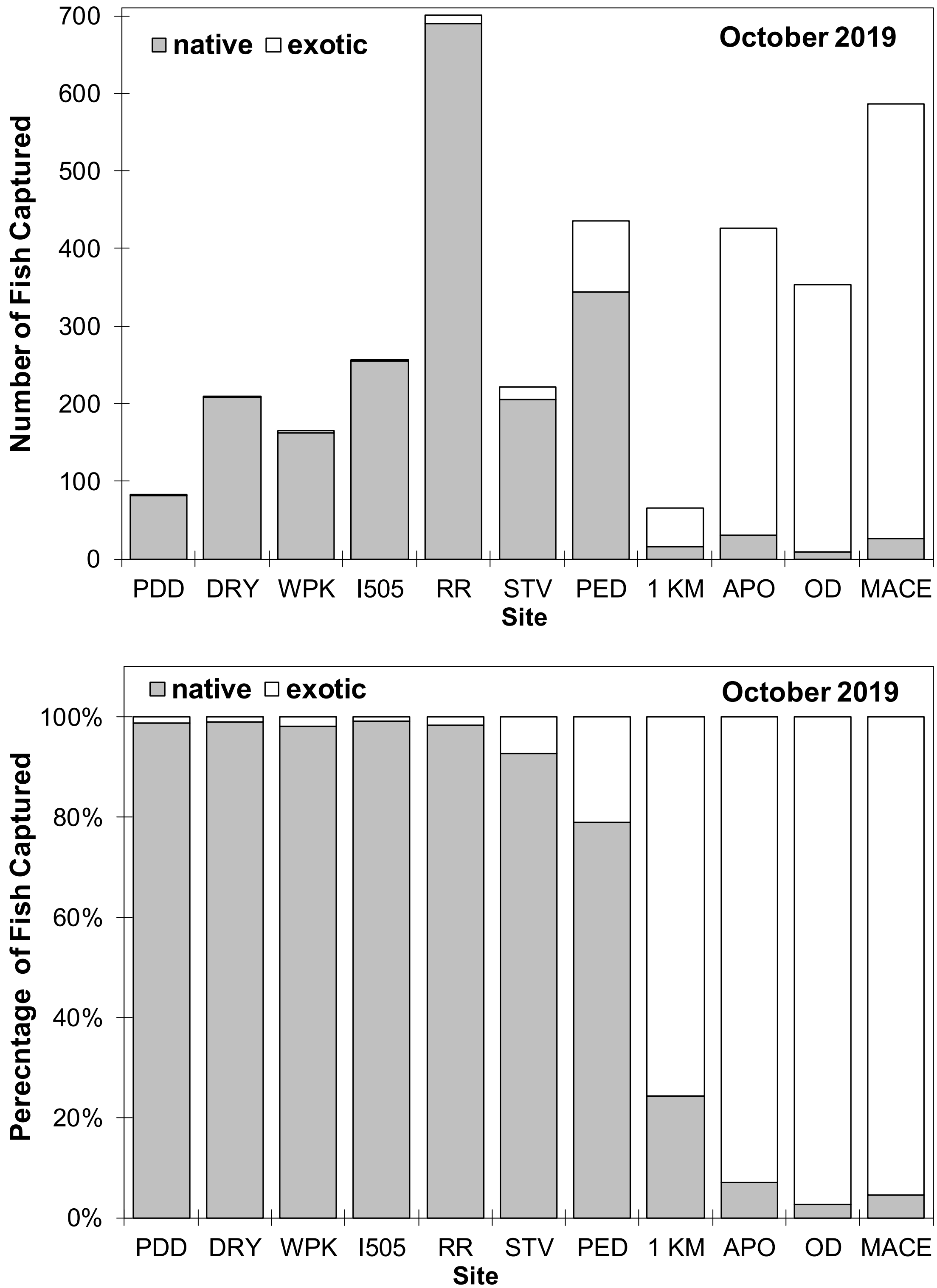

Figure 6. Number (top) and percentage (bottom) of native and exotic fish captured at lower Putah Creek study sites during the October 2019 fish surveys.

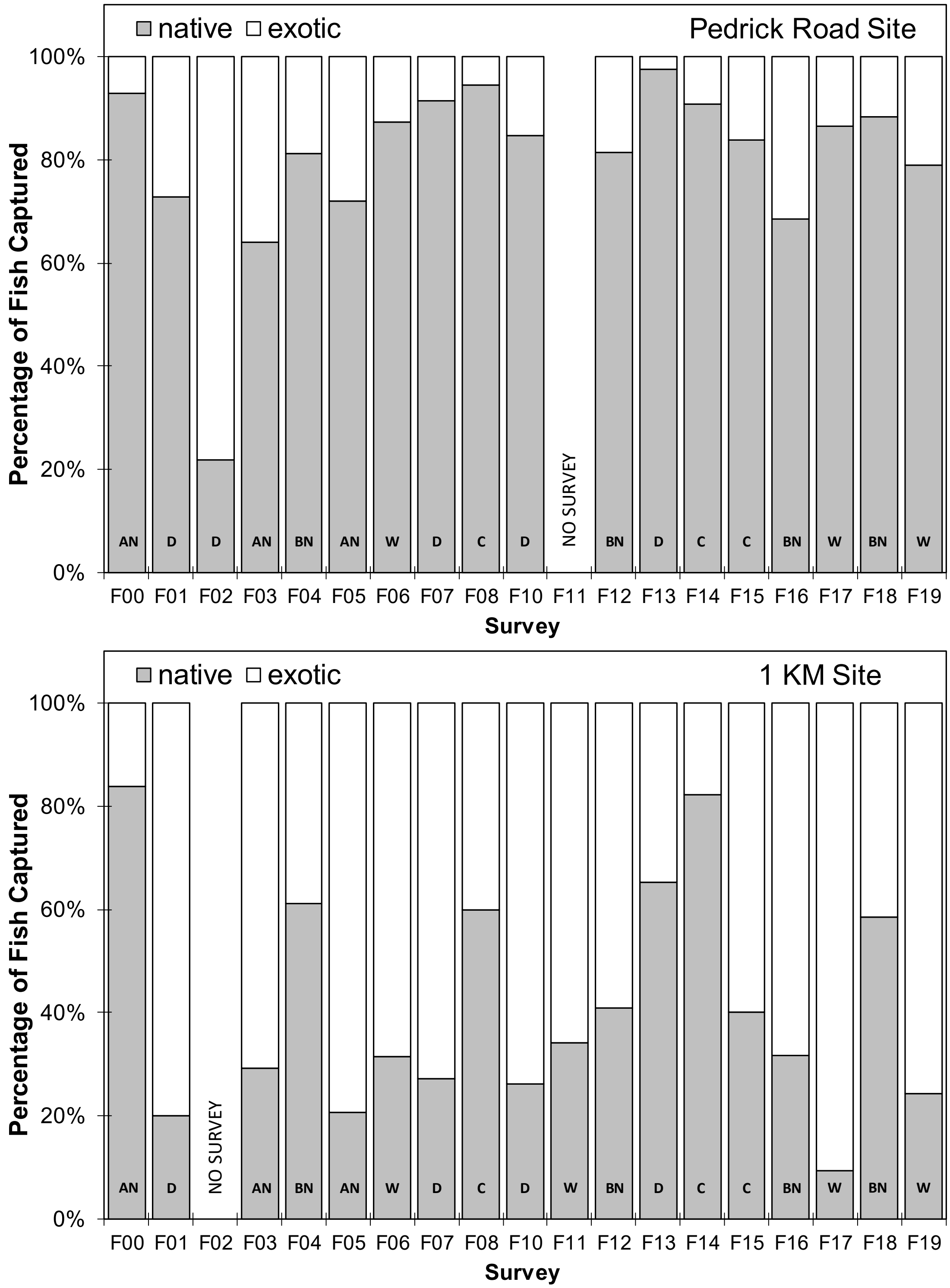

Figure 7. Percentage native and exotic fish captured at the Pedrick Road Site (top) and the 1 KM Site (bottom) during Fall fish surveys since 2000. Sacramento Valley Water Year Types: W = wet; AN = above normal; BN = below normal; D = dry; C = critical.

only two sites (Table 4). Largemouth bass and bluegill sunfish, on the other hand, were widely distributed in the 2019 surveys and were captured at nine and seven of the eleven survey sites, respectively. While these two exotic sunfish had a relatively wide distribution, their highest densities occurred along the lower 6.0 miles of the survey area, downstream of Pedrick Road (Table 4).

The increasing abundance of non-native "panfish" to the total catch of fish in lower Putah Creek noted during the past several years continued in 2019. This "panfish" group is comprised of the smaller sunfish of the genus *Lepomis* and includes bluegill, green sunfish, redear sunfish, warmouth (*L. gulosus*), and various hybrids forms (referred to here as "lepomids"). Prior to 2010, green sunfish and bluegills were among the most common species of fish found in lower Putah Creek. In the six fall surveys conducted between 2003 and 2008, lepomids made up 28.1 percent of the total captured fish and averaged 1,462 lepomids per survey. In the six complete, basin-wide surveys between 2010 and 2016, lepomids had declined to only 4.4 percent of the total captures and averaged only 199 lepomids per survey. During the 2019 survey, a total of 716 lepomids were captured, or over 20 percent of the total catch (Table 4).

The scarcity of lepomids in 2012 through 2016 is especially surprising since these five water years were all classified as below normal (or drier) in the Sacramento Valley, with few periods of natural high flows that are considered to interfere with sunfish spawning. Non-native sunfish species usually thrive during these low flow and warm water conditions. The increase of sunfish since 2017 was surprising given the higher than normal winter and spring flows in 2017 and 2019, which would have been expected to disrupt their spawning. It appears that these sunfish populations are in a natural cycle of increasing abundance among the Putah Creek fish populations.

The 2019 electrofishing survey included the Winters Putah Creek Nature Park site, which represents a relatively new sample site along lower Putah Creek that has been surveyed only since 2012. In November 2011, a channel realignment and floodplain restoration project (Winters Park Project) was completed along a 3,700-foot long section of Putah Creek. This project was designed to restore natural channel form and function, enhance habitat of native species and improve public access in a reach that had been mined extensively for gravel and otherwise enlarged, straightened and dammed for flood conveyance and seasonal water storage. This project included removing an historic concrete low flow barrier (Winters Percolation Dam built in 1938 [Sears 2010]), reconfiguring the creek channel to a narrower and shallower meandering form, lowering elevation of the inset floodplain, and replanting native plants along the riparian corridor. Three existing riffles were augmented with additional gravel substrates and 14 new riffles were created at 200-foot intervals by importing 2,000 tons of salmon spawning gravel mix (Rich Marovich, personal communication). It was anticipated that this channel realignment project would eliminate the extensive areas of large deep pool habitat that acted as a heat sink and harbored large predatory non-native basses, and instead create hydraulically diverse and cooler water habitat that would benefit native fish, including salmonids. Fish salvage and relocation efforts conducted in the project area in September 2011 (prior to construction) found only one rainbow trout in this section of Putah Creek (Peter Moyle, personal communication). Since the November 2011 channel restoration, rainbow trout have regularly been captured in this area. However, the high flows associated with Lake Berryessa spills during the late winter and early spring of 2019 resulted in sand deposition throughout the Winters Park channel restoration area that filled in many of the pools and covered many of the gravel riffles. The upper weir site was largely buried (Plate 1). Despite this habitat change a rainbow trout was still documented at the Winters Park upper weir site (Table 4).

Only thirty-seven rainbow trout were captured during the fall 2019 survey. It is not clear if this was due to reduced abundance or the fact that backpack electrofishers were used following the gas powered pulsator equipment loss at the upstream sites where trout reside. It is likely the change in equipment and the difference in voltage output and lower capture efficiencies using the backpack was responsible for fewer trout in 2019.

Despite the reduction in the catch, the rainbow trout that were captured had a robust body form and appeared to be healthy and in good condition. The average condition factor for the rainbow trout was 1.32, and individual values ranged from 1.14 to 1.52. These values are considered quite high compared to other streams and indicate a healthy and robust trout population (Plate 1).

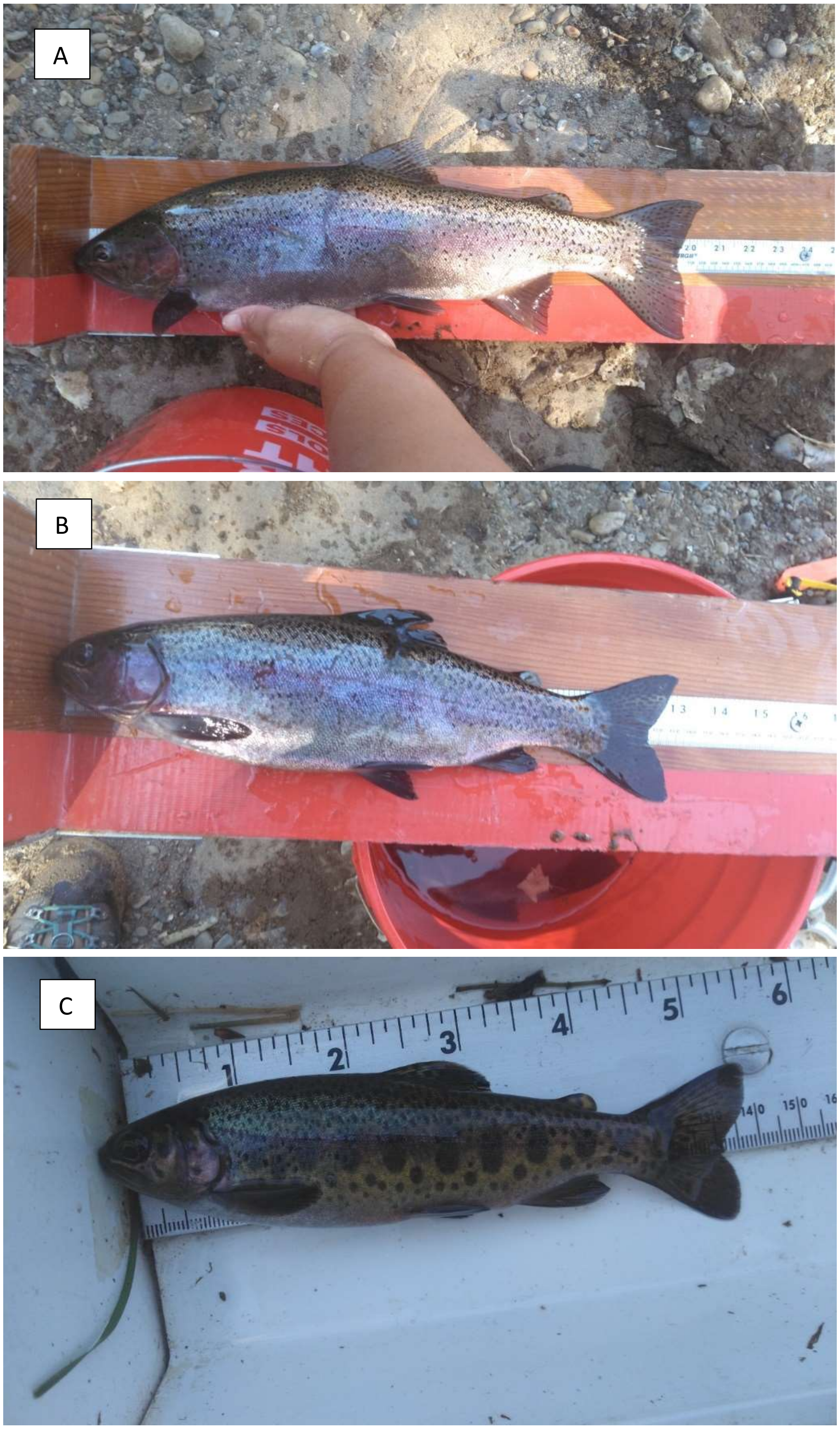

Plate 1. Rainbow trout captured at the Putah Diversion Dam Site, 17 October 2019;
A: Length = 19.7 inches / Condition Factor (CF) = 1.23; B: Length = 12.4 inches / CF = 1.42;
C: Length = 5.2 inches / CF = 1.47.

Despite an estimated spawning escapement of 550 adult Chinook salmon into lower Putah Creek during the late-fall of 2018 (Hansen 2019), no juvenile Chinook salmon were captured ten months later during the October 2019 surveys. Over-summer rearing juvenile Chinook have been noted during past fall fish surveys (Salamunovich 2017a, 2019). While most juvenile Chinook salmon smolt and migrate during the first three months after hatching, some juveniles can remain in cold water areas through their first summer and then migrate to the Delta and ocean during first rains of the fall and early winter as yearlings (Moyle 2002).

The absence of juvenile Chinook among the October 2019 fish captures may indicate poor over-summer rearing conditions, though this is unlikely, as rainbow trout, which have similar habitat requirements, were captured in the upper survey sites during the October 2019 surveys (Table 4). As discussed above, the high condition factors documented for rainbow trout indicated robust individuals and good over-summer rearing conditions. The lack of juvenile Chinook in the October surveys was more likely the result of poor survival of juveniles from the 2019 cohort. Rotary screw trapping conducted by UC Davis in the winter and spring of 2018 did not start catching newly emergent Chinook salmon fry until mid-February and peak catches did not occur until early March (Figure 8; Chapman et al. 2018; Miner et al. 2019). Winter and spring snorkel surveys conducted along lower Putah Creek to assess the distribution and abundance of newly emergent salmon fry confirm that the peak Chinook fry emergence occurs between mid-February and early March (Salamunovich 2017b, 2018).

The excessive flows (3,500+ cfs) in lower Putah Creek resulting from the Lake Berryessa spill during the 2019 WY occurred during the two-week period from 27 February through 12 March and coincided with late incubation and peak salmon fry emergence from the gravels. The screw trap data also suggested that the newly emergent juvenile Chinook are typically less than 40 mm in length through late March (Figure 8), a size that have limited swimming abilities and would be vulnerable to extended high flows, such as those that occurred during late February and early March 2019.

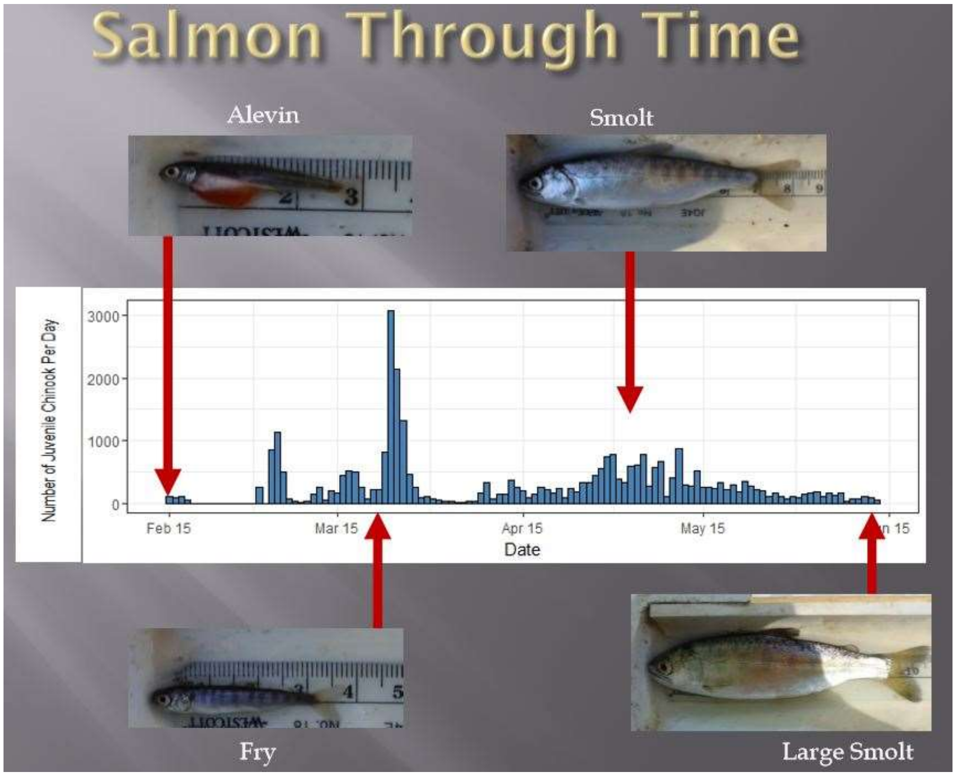

Figure 8. Histogram showing daily catches of juvenile Chinook salmon in lower Putah Creek during the 2018 low flow water year, with indications of salmon size over time. Taken from UCD Davis Power Point Presentation (Chapman et al. 2018).

In both 2017 and 2019, high flows delayed the UCD rotary screw trap deployment until early May (Miner et al. 2019). In 2018 the screw trap was able to operate over the entire winter/spring season. A comparison of the UCD rotary screw trapping for the three years over the same period of operation for all three years (7 May through 9 June) showed that over 9,000 salmon were captured in the trap during this period in 2018, a low flow (below normal) water year. Compare that high abundance to that observed during the same period in the high flow water years of 2017 or 2019, when 172 juvenile salmon were captured over the same 5 week period in 2017, and only 26 juvenile salmon were captured in 2019. It appears that high flows associated with the uncontrolled flows from Lake Berryessa have profound effects on salmon rearing in lower Putah Creek and result in either fewer salmon surviving through late spring, or earlier migration (either voluntary or involuntary) from the system.

Snorkel surveys conducted along Putah Creek before and after the WY 2019 high flows noted significant habitat changes at many of the survey sites. A long side channel area below the PDD known to support large numbers of rearing Chinook fry in 2016 and 2018 was completely filled in and destroyed during the high spills of 2019 (Plate 2). Spawning gravel deposits located near Dry Creek were scoured during the WY 2109 high flows, with the loss of salmon redds, incubating eggs and pre-emergent fry (Plate 3). At Winters Park, large areas of spawning gravel and cobble substrates that were augmented with salmon spawning substrates during the 2011 channel restoration were completely covered in newly deposited fine sediments and sand, presumably capping and smothering any existing salmon redds (Plate 4).

It appears that the high flows associated with the Lake Berryessa glory hole spills in late February and early March 2019 probably destroyed most of the salmon fry production prior to their emergence and that those juvenile salmon that did emerge prior to, or during, the high flows, most were likely prematurely washed downstream as vulnerable alevin or fry life stages, with limited chance of survival during outmigration.

In conclusion, the fall 2019 fish surveys following a wet 2019 Water Year showed that native fish populations continue to thrive in the thirteen miles of Putah Creek from the Putah Diversion Dam to downstream of Pedrick Road and non-native fishes continue to dominate the six miles between Pedrick Road and Mace Boulevard. The WY 2019 high flows did not appear to result in a downstream extension of native fish fauna. It appears that the current Accord flow regime is supporting healthy native fish populations in the Putah Creek basin. Continued fall fish monitoring should indicate how the fish populations respond to the changing water year types and the continuing benefits of the Accord flow regime.

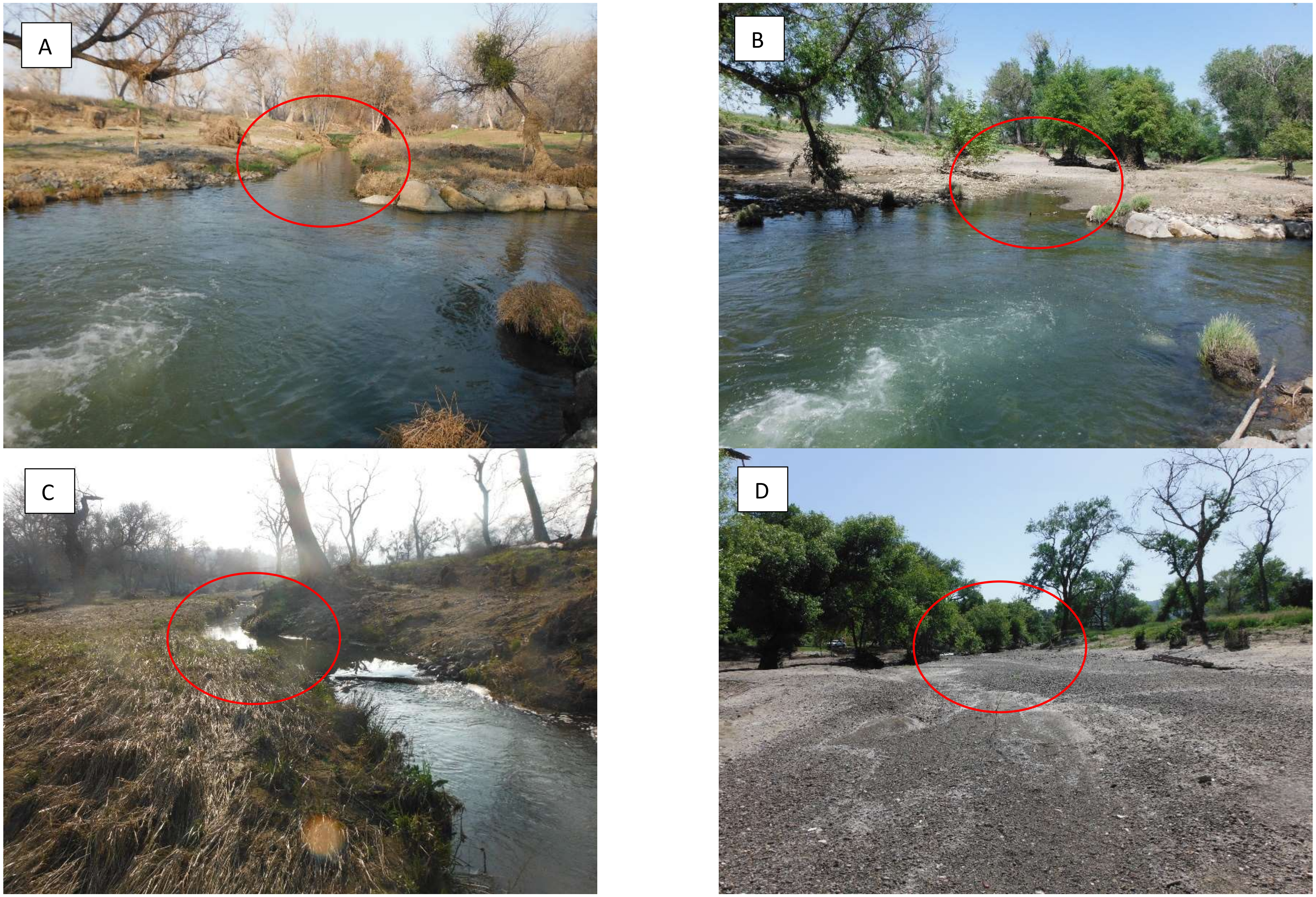

Plate 2. Images showing 500-foot long side channel with premier fry rearing habitat before and after late winter WY 2019 Lake Berryessa spill flows. Image A: mouth of side channel 30 January 2019; Image B: mouth of side channel 2 May 2019; Image C: middle of side channel 30 January 2019; Image D: middle of side channel 2 May 2019.

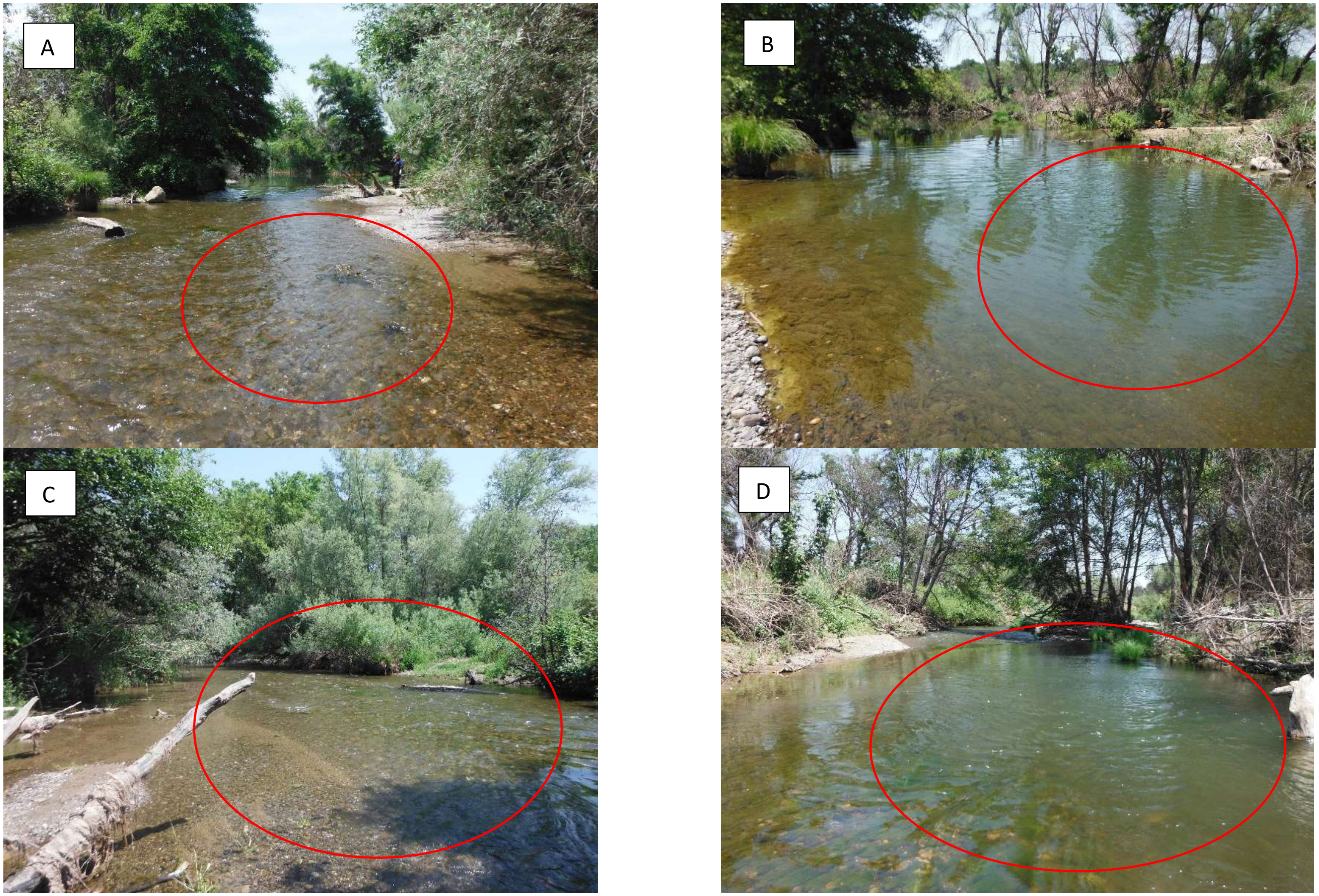

Plate 3. Images showing scour in Putah Creek near mouth of Dry Creek after late winter WY 2019 Lake Berryessa spill flows. Image A: view upstream on 10 May 2018, note clean shallow gravel/cobble habitat; Image B: same view on 30 May 2019, note scour hole and fine sediment on margins; Image C: view downstream on 26 April 2018, note shallow gravel/cobble habitat; Image D: same view on 30 May 2019, note scour hole and loss of gravel substrates.

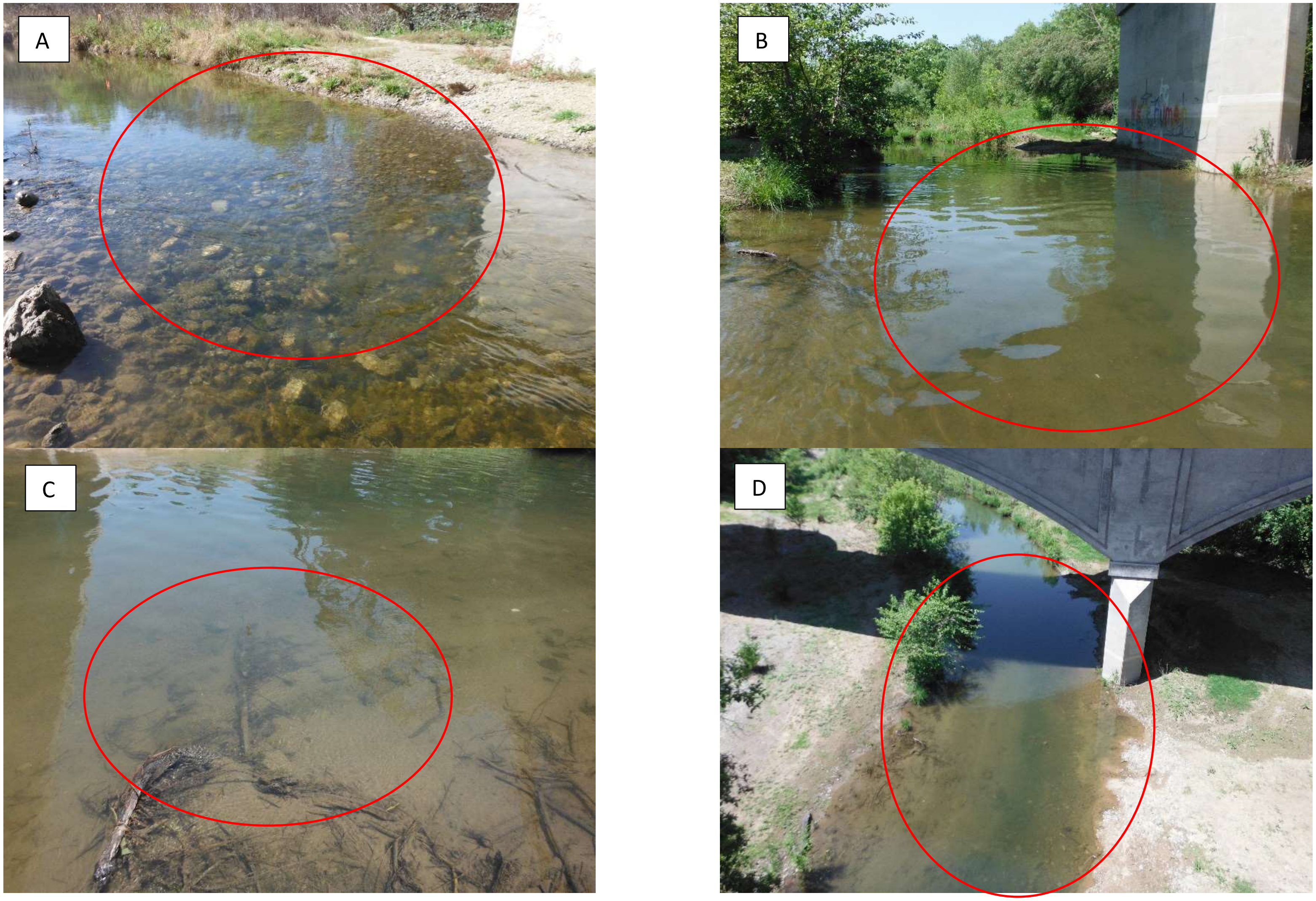

Plate 4. Images showing fine sediment deposition in Putah Creek below Winters Bridge after late winter WY 2019 Lake Berryessa spill flows. Image A: view on 15 February 2018, note clean shallow gravel/cobble habitat; Image B: same view on 30 May 2019, note scour hole and fine sediment on margins; Image C: view of fine sediment, 30 May 2019; Image D: view of channel below Winters Bridge, 30 May 2019, note fine sediment and lack of coarse substrates.

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