El Dorado Irrigation District

El Dorado Hydroelectric Project (FERC No. 184)

2022 BENTHIC MACROINVERTEBRATE MONITORING SURVEYS

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1.0 INTRODUCTION

1.1 Monitoring Requirements

El Dorado Irrigation District (District) owns and operates the El Dorado Hydroelectric Project (Project) on the South Fork American River (SFAR) in El Dorado County, California, under license from the Federal Energy Regulatory Commission (FERC; Project No. 184). As required by the Project 184 License,[1] the District, in coordination with the U.S. Forest Service (FS), the California State Water Resources Control Board (SWRCB), and the Ecological Resources Committee, developed the Project 184 Benthic Macroinvertebrate Monitoring Plan (BMI Plan; District 2010) to monitor potential effects of Project operations on benthic macroinvertebrate (BMI) populations within Project waters.

1.2 Project Background

Per the BMI Plan, the District is required to conduct BMI monitoring in various Project-affected and reference stream reaches throughout Project 184 watersheds. BMI bioassessment surveys are required during the first two years of each five-year period of the current Project 184 License (including 2021 and 2022 which are water years 15 and 16, respectively). BMI monitoring efforts conducted during the Project 184 relicensing process between 1999 and 2001 (ECORP 2002) helped establish the Project's ecological resource objective for BMIs which states that macroinvertebrate indices (metrics) in Project-affected reaches should be similar to those in reference reaches located within and outside of the SFAR and Upper Truckee River (UTR) drainages.

Initial bioassessment surveys conducted in the Project 184 area followed the California Stream Bioassessment Procedure (CSBP) originally developed by the California Department of Fish and Wildlife (CDFW 2003). The Project 184 License (issued in 2006) requires BMI monitoring using the CSBP method or such method as revised in the future. In 2007, the State's *Surface Water Ambient Monitoring Program (SWAMP) Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California* (SWAMP 2007) officially replaced the CSBP as the statewide standard for ambient bioassessment. Therefore, the SWAMP protocol is currently the methodology specified by the language of the BMI Plan; and subsequent BMI monitoring for the first five-year period of the Project 184 License (conducted in years 5 and 6, i.e., 2011 and 2012 [GANDA 2012, 2013]) thus followed the SWAMP protocol. In 2016 and 2017 (years 10 and 11), the District again

[1] *FS Section 4(e) Condition 37; SWRBC 401 Water Quality Certification Condition 13; Project 184 Settlement Agreement Section 7.*

tasked Garcia and Associates (GANDA; now Kleinfelder) to conduct BMI bioassessment surveys following the SWAMP protocol in support of compliance monitoring for the second five-year period of the Project 184 License. This report presents the results for the third five-year period of SWAMP bioassessment surveys conducted by Kleinfelder during 2021 and 2022 (years 15 and 16). Surveys were scheduled for 2021, but could not be completed due to the Caldor Fire; as such, only one bioassessment survey (2022) was conducted during the third five-year period.

2.0 METHODS

2.1 Site Selection

The BMI Plan specifies monitoring at a total of 18 sites in Project-affected reaches and associated reference reaches. These watersheds include the following (some of which contain paired sites located above and below existing diversion points):

- Echo Creek (Site EC-B1)
- Pyramid Creek (Site PY-B1)
- Caples Creek (Site CA-B1)
- Silver Fork American River (Site SV-B2)
- South Fork American River (Site SO-B1)
- No Name Creek (Sites NN-B1 and NN-B2)
- Alder Creek (Sites AR-B1 and AR-B2)
- Bull Creek (Sites BU-B1 and BU-B2)
- Ogilby Creek (Sites OG-B1 and OG-B2)
- Esmeralda Creek (Sites ES-B1 and ES-B2)
- Strawberry Creek (Site SB-B1)
- Sherman Canyon Creek (Site SH-B1)
- Woods Creek (Site WC-B1)

The 18 bioassessment sites are located in the same Project-affected and reference reaches specified in the BMI Plan (see Figure 2.1-1). Global positioning system (GPS) locations for each site are listed in Table 2.1-1. Generally, SWAMP bioassessment sites were located as close as possible to those sites selected previously during 1999-2001 relicensing efforts (ECORP 2002); however, because the SWAMP protocol requires a longer survey reach than the CSBP, the specific site boundaries for SWAMP survey reaches established by GANDA field crews in 2011 may be slightly upstream or downstream from the original areas sampled under the CSBP. All sites sampled in 2022 were identical to those sampled in 2011, 2012, 2016, and 2017 (GANDA 2012, 2013, 2017, 2018).

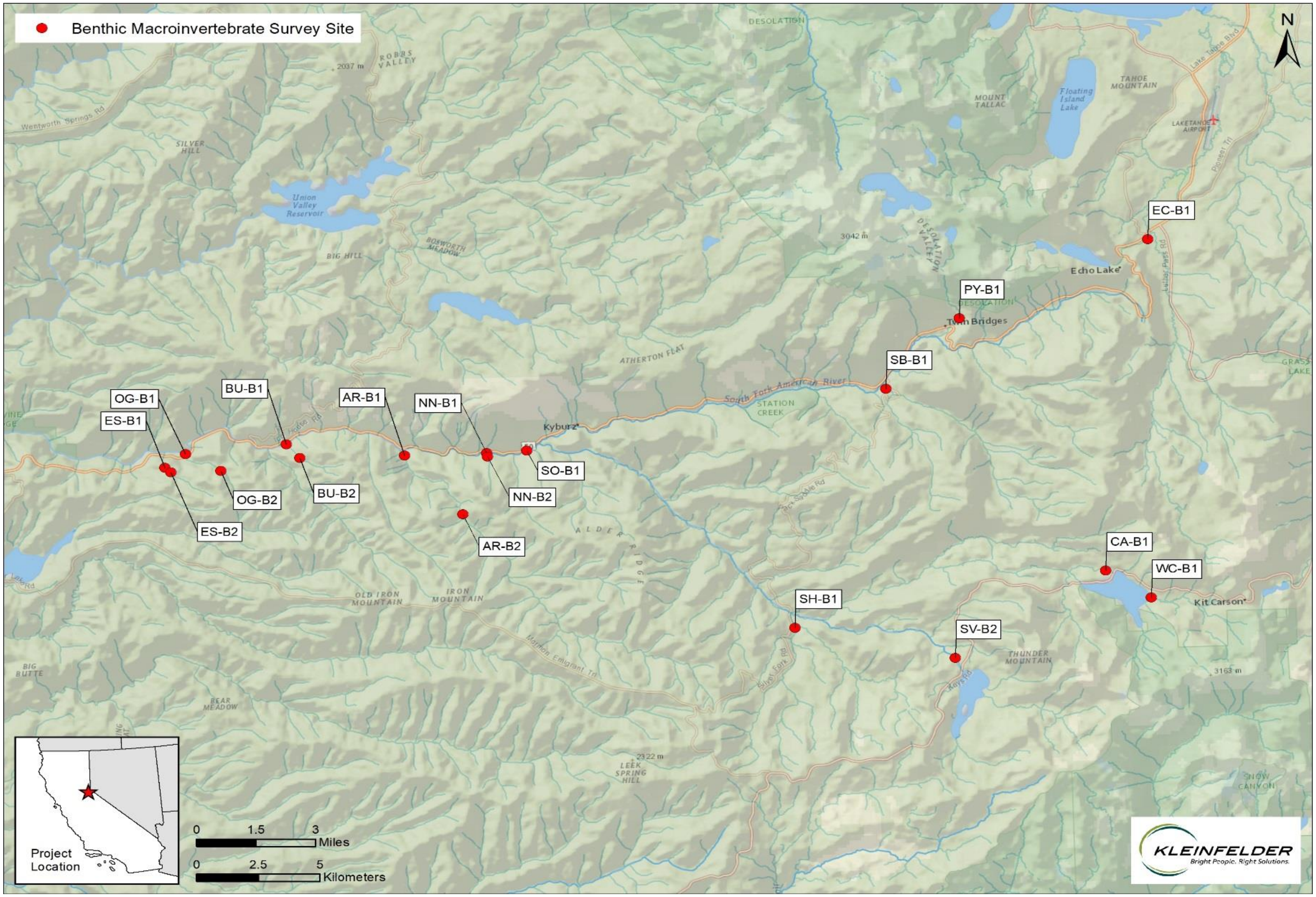

Figure 2.1-1. Project 184 benthic macroinvertebrate monitoring sites.

Table 2.1-1. GPS coordinates for Project 184 macroinvertebrate monitoring sites.

SITE ID	DESCRIPTION	UTM	DOWNSTREAM BOUNDARY		UPSTREAM BOUNDARY	
		ZONE	EASTING	NORTHING	EASTING	NORTHING
AR-B1	Alder Creek below diversion	10S	0727783	4293846	0727817	4293722
AR-B2	Alder Creek above diversion	10S	0730155	4291140	0730155	4291030
BU-B1	Bull Creek below diversion	10S	0722997	4294368	0723080	4294280
*BU-B2	Bull Creek above diversion	10S	0723542	4293736	0723612	4293646
CA-B1	Caples Creek below Caples Lake	10S	0756231	4288551	0756345	4288557
EC-B1	Echo Creek below Lower Echo Lake	10S	0757934	4303807	0757821	4303759
ES-B1	Esmeralda Creek below diversion	10S	0718078	4293288	0718115	4293217
ES-B2	Esmeralda Creek above diversion	10S	0718311	4293066	0718332	4292992
NN-B1	No Name Creek below diversion	10S	0731124	4293956	0731140	4293874
NN-B2	No Name Creek above diversion	10S	0731153	4293794	0731173	4293746
OG-B1	Ogilby Creek below diversion	10S	0718909	4293906	0718893	4293859
*OG-B2	Ogilby Creek above diversion	10S	0720346	4293141	0720413	4293075
PY-B1	Pyramid Creek below Lake Aloha	10S	0750294	4300162	0750292	4300308
SB-B1	Strawberry Creek near SFAR confluence	10S	0747312	4296920	0747420	4296859
SH-B1	Sherman Canyon Creek	10S	0743619	4285914	0743689	4285807
SO-B1	South Fork American below Kyburz Diversion	10S	0732748	4294072	0732883	4294117
SV-B2	Silver Fork American below Silver Lake	10S	0750132	4284527	0750229	4284442
WC-B1	Woods Creek above Caples Lake	10S	0758071	4287309	0758190	4287291

**Sites BU-B2 and OG-B2 were not sampled in 2022 due to insufficient flows.*

2.2 Benthic Macroinvertebrate Sampling

Teams of two to four Kleinfelder biologists conducted all BMI sampling following the SWAMP protocol. Field sampling was performed between September 26th and October 5th, 2022. Sites consisted of 150-meter (m) survey reaches wherever possible. Consistent with the SWAMP protocol, shorter survey reaches were established at smaller tributaries including Esmeralda Creek (ES-B1 and ES-B2), No Name Creek (NN-B1 and NN-B2), and Ogilby Creek (OG-B1) in order to avoid barriers or other confounding areas (e.g., steep waterfalls, cliff areas, culverts, etc.). At each of these smaller tributary sites, there were numerous pool-riffle sequences to sample within the established survey reach. For larger streams (wetted width greater than 20 m), SWAMP protocol recommends increasing site length. There was one site where wetted width was consistently greater than 20 m (Site SO-B1 on the SFAR below Kyburz Diversion Dam). However, the total survey reach length was not increased at this site because sufficient representative habitat was present within the 150-m reach and extending the site would have only added large, deep pool habitat that could not be sampled.

At sites located at elevations below 6,500 feet (ft) (PY-B1, SO-B1, NN-B1 and 2, AR-B1 and 2, BU-B1 and 2, OG-B1 and 2, ES-B1 and 2, SB-B1, SH-B1), BMI samples were collected as reach-wide benthos (RWB) samples. RWB samples were compilations of 11 one-square-foot (1-ft^2) kick samples collected at the 11 main transects comprising the SWAMP survey reach. At sites near or above 6,500 ft (EC-B1, CA-B1, SV-B2, WC-B1), BMI samples were collected as both RWB samples and targeted riffle composite (TRC) samples. RWB samples were collected as described above; TRC samples were compilations of eight 1-ft^2 kick samples collected at eight randomly selected riffle locations within each SWAMP survey reach. Decisions regarding which sample types to collect at which locations were made by the District in consultation with CDFW's SWAMP bioassessment coordinator. Two of the 18 sites (BU-B2 and OG-B2) were not sampled in 2022 due to insufficient flows.

All benthic samples were collected using a Wildco® 18-by-9-inch stream-bottom sampler fitted with a 0.5-millimeter (mm) (500 micron) mesh bag. Samples were collected from downstream to upstream before physical habitat measurements were taken to prevent excessive bottom trampling. At sites where both types of samples were collected, TRC and RWB samples were collected simultaneously in two separate nets while moving from downstream to upstream between transects. All samples were elutriated and cleaned in the field, placed in jars, labeled, and preserved in 10 percent formalin.

2.3 Physical Habitat Characterization

Physical habitat parameters (bankfull and wetted width, bankfull height, water depth, substrate composition, cobble embeddedness, algal cover, riparian vegetation, instream habitat complexity, canopy cover, human influence, bank stability, etc.) were evaluated at a combination of 11 primary and 10 secondary cross-sectional transects located along the survey reach. The "full" level of effort for physical habitat characterization as described in the SWAMP protocol was performed at all sites. Stream gradient at each site was measured using a clinometer and stadia rod (with eye-level marked) positioned at water's surface from transect to transect; compass bearings between transect mid-points were also measured. The upper, middle, and lower portions of each SWAMP survey reach were documented with photographs taken in both the upstream and downstream directions, and both ends of each survey reach were marked using GPS.

2.4 Laboratory Protocol

All benthic samples were processed and identified by Jon Lee Consulting. The laboratory subsampling procedure allowed separation of large/rare specimens from finer subsampled material so that more accurate estimations of the whole-sample taxa lists could be made. All samples were subsampled to a minimum of 600 individuals, although the last grid section (i.e., the aliquot containing the 600th individual) was always picked through and identified in its entirety to allow accurate estimation of the total sample abundance (and thus benthic density); therefore, in practice typically 625-675 organisms per sample were identified in the laboratory. This higher level of effort (identifying a minimum of 600 instead of 500 individuals from each sample) is recommended to ensure that closer to 500 clearly identifiable specimens are achieved after excluding any ambiguous and/or immature specimens. All specimens were identified to Level II standard taxonomic effort (STE) as defined by the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT), which generally corresponds to the genus-species level for most insects, and slightly less rigorous effort (i.e., class, family, or tribe/subfamily) for certain other taxa groups (Level II STE for California taxa is defined in SAFIT [2006]).[2]

[2] *Since the establishment of SAFIT and the associated standardization of taxonomy/guidelines for identifying California invertebrate groups, 10 percent Quality Assurance/Quality Control (QA/QC) checks for taxonomic accuracy have been discontinued as the Project reference collection for SFAR samples (which was previously QA/QC'd) will be curated indefinitely by Jon Lee Consulting. Samples are preserved and kept for a period of 2 years after processing in case any additional QA/QC is desired.*

2.5 Data Analysis

2.5.1 Standard Macroinvertebrate Metrics

Summary metrics for each replicate sample were calculated using a Microsoft Access database. Metrics are measurable attributes of macroinvertebrate communities that are known to change in response to disturbance or impairment of the stream environment. Metrics included standard richness, composition, tolerance/intolerance, and functional feeding group measures (see Table 2.5-1). All sample metrics were calculated from 500-organism fixed-count samples generated from the complete laboratory-identified taxa lists for each sample (500-count taxa lists are the standard for metric calculation and benthic data analysis). Sample data were randomly re-sampled and standardized in this manner to achieve uniformity in count between all samples (i.e., so that the number of taxa would be accurately represented for each site at a standardized level of effort, regardless of how many organisms were originally identified in the laboratory from each different sample).

2.5.2 Hydropower Index of Biotic Integrity (IBI)

In order to reduce the complexity of the information contained in the numerous metrics that describe each sample, data were compiled into a single multi-metric index, the Hydropower Index of Biotic Integrity, or Hydropower IBI (Rehn 2010). This IBI was developed by the CDFW Aquatic Bioassessment Laboratory (ABL) to be sensitive to the cumulative effects of hydropower operations on stream benthic communities. The seven component metrics of the Hydropower IBI (ET taxa richness, %intolerant individuals, %scrapers, %non-insect taxa, Shannon diversity, %predators, and %tolerant individuals) were chosen from over 80 candidate metrics calculated using a combined dataset from nine separate studies of regulated rivers in California managed for hydropower. Values for these constituent metrics were scored (0-10) according to specific thresholds (defined in Table 2.5-2) and final Hydropower IBI scores were achieved by summing the constituent metric scores and adjusting the index to a 100-point scale.

Note that although this IBI was originally developed using only TRC-type samples, IBI scores were calculated for both TRC and RWB samples for all Project 184 SWAMP data because published and unpublished analyses suggest that RWB and TRC methods can produce generally comparable results across a broad range of settings within California (Van Buuren and Ode 2008). Therefore, it was assumed that RWB samples collected during this study contained sufficient riffle material for Hydropower-IBI analysis. Further details regarding development of the Hydropower IBI are provided in Rehn (2010).

Table 2.5-1. Biological metrics used to describe benthic samples. Listed responses are for generalized ecological impairment.

METRIC	DESCRIPTION OF METRIC	RESPONSE TO IMPAIRMENT
RICHNESS-TYPE MEASURES		
# Total Taxa	Total number of taxa	Decrease
# Ephemeroptera Taxa	Number of mayfly taxa	Decrease
# Plecoptera Taxa	Number of stonefly taxa	Decrease
# Trichoptera Taxa	Number of caddisfly taxa	Decrease
# Diptera Taxa	Number of taxa in the order Diptera (true flies)	Variable
# Chironomid Taxa	Number of taxa in the dipteran family Chironomidae	Increase
# ET Taxa*	Number of taxa in the orders Ephemeroptera (mayflies) and Trichoptera (caddisflies)	Decrease
# EPT Taxa	Number of taxa in the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)	Decrease
Shannon Diversity*	General measure of sample diversity that incorporates richness and evenness (ln-based)	Decrease
Shannon Evenness	Measure of how evenly taxa abundances are distributed	Decrease
Density (#/ft^2)	Estimated total number of individuals per square foot area	Variable
COMPOSITION-TYPE MEASURES		
% EPT	Percent composition of EPT taxa	Decrease
% Sensitive EPT	Percent composition of EPT taxa with tolerance values 0-3	Decrease
% Baetidae	Percent of individuals in mayfly family Baetidae	Increase
% Chironomidae	Percent of individuals in midge family Chironomidae	Increase
% Hydropsychidae	Percent of individuals in caddisfly family Hydropsychidae	Increase
% Dominant Taxon	Percent of sample comprised of individuals from the most common taxon	Increase
% Non-Insect Taxa*	Percent of taxa that are non-insect taxa	Increase
TOLERANCE / INTOLERANCE MEASURES		
% Tolerant Individuals*	Percent of individuals that are highly tolerant of impairment as indicated by tolerance values of 8, 9, or 10	Increase
% Intolerant Individuals*	Percent of individuals that are highly intolerant of impairment as indicated by tolerance values of 0, 1, or 2	Decrease
Weighted Tolerance Value	Value between 0 and 10, weighted by abundances of organisms designated as tolerant or intolerant	Increase
FUNCTIONAL FEEDING GROUP MEASURES		
% Filterers	Percent of individuals that filter fine particulate matter	Increase
% Scrapers*	Percent of individuals that graze upon periphyton	Variable
% Collectors	Percent of individuals that collect/gather fine particulate matter	Increase
% Shredders	Percent of individuals that shred coarse particulate matter	Decrease
% Predators*	Percent of individuals that feed on other organisms	Variable
% Macrophyte Herbivores	Percent of individuals that feed on plants	Variable
% Piercer Herbivores	Percent of individuals that pierce plants	Variable
% Omnivores	Percent of individuals that feed on various food items	Variable
% Parasites	Percent of individuals that parasitize other organisms	Variable
MULTI-METRIC INDEX		
Hydropwer-IBI	Composite index of 7 key metrics* selected to be sensitive to cumulative effects of hydropower operations (scores out of 100)	Decrease
CSCI	Multi-metric and multi-variate predictive model indicating depatrure from site-specific reference conditions (scores near 1.0 best)	Decrease

**One of the seven metric components of the Hydropower IBI.*

Table 2.5-2. Scoring ranges for constituent metrics of the Hydropower IBI. Thresholds shown are for 500-organism fixed-count samples identified to SAFIT Level II STE (Rehn 2010).

SCORE	# ET Taxa Richness	% Intolerant Individuals	% Scrapers	% Non-Insect Taxa	Shannon Diversity	% Predators	% Tolerant Individuals
0	0–4	0–5	0–2	≥20	≤2.35	0–7	≥18
1	5–6	6–9	3–7	19	2.36–2.47	8	16–17
2	7	10–13	8–11	17–18	2.48–2.60	9	15
3	8–9	14–17	12–15	16	2.61–2.72	10	13–14
4	10–11	18–21	16–19	15	2.73–2.84	11	12
5	12–13	22–25	20–23	14	2.85–2.96	12	10–11
6	14–15	26–29	24–27	13	2.97–3.08	13	9
7	16–17	30–33	28–31	11–12	3.09–3.20	14	7–8
8	18	34–37	32–35	10	3.21–3.33	15	6
9	19–20	38–41	36–39	9	3.34–3.49	16	4–5
10	≥21	≥42	≥40	≤8	≥3.50	≥17	≤3

For interpreting Hydropower IBI scores, a traditional impairment threshold was set two standard deviations (22 points) below the IBI's reference mean (74) at a score of 52, based on recommendations from ABL (Andy Rehn, CDFW ABL, personal communication). Per this scheme, Hydropower IBI scores can generally be considered from "good" to "very poor" in the ranges listed in Table 2.5-3 below (although these categories are not perfectly equal, they are based on statistical properties of the IBI's reference distribution).

Table 2.5-3. Scoring ranges for general interpretation of Hydropower IBI scores.

HYDROPOWER IBI SCORING RANGE	GENERAL THRESHOLD FOR INTERPRETATION
74–100	"GOOD"
53–73	"FAIR"
26–52	"POOR"
0–25	"VERY POOR"

2.5.3 California Stream Condition Index (CSCI)

In addition, the next-generation index for monitoring stream health in California, known as the California Stream Condition Index (CSCI), was calculated for 2022 data. SWAMP and the SWRCB have established the CSCI as the statewide standard for macroinvertebrate data analysis. The CSCI combines the best of multi-metric techniques (such as the Hydropower IBI and other multi-metric indices [MMIs] which aggregate measures of ecological structure and function) with the best of predictive multi-variate techniques (such as observed vs. expected [O/E] models which assess taxonomic completeness). The CSCI was developed with a much larger, more representative dataset than other indices (which makes it applicable statewide) covering a broader range of environmental variability among natural stream types. Additionally, the CSCI sets biological benchmarks for a given site based on that site's specific geographic and environmental settings (further details regarding CSCI development and application can be found in SWAMP's CSCI technical memorandum (Rehn et al. 2015) and the CSCI's final publication (Mazor et al. 2016).

Geographic information system (GIS) analyses (watershed delineations) and R-based CSCI calculations were performed by Moss Landing Marine Laboratory (MLML). Data entry and analysis of all 2022 SWAMP Stream Habitat Characterization Forms was also performed by MLML (physical habitat metrics were calculated using the SWAMP Bioassessment Reporting Module). The data center at MLML helped develop the CSCI and other SWAMP data analysis tools; therefore, their involvement provides the highest level of confidence, superior data formatting, and expert quality assurance/quality control (QA/QC) built into the analysis. Taxonomy data were provided in the basic "flatfile" format requested for SWAMP data submissions, and output was received in standard spreadsheet format.

Scoring thresholds were calibrated during CSCI development so that the mean score of reference sites would be "1," while scores that approach "0" would indicate departure from reference conditions and degradation of biological conditions. CSCI scores greater than 1 indicate greater taxonomic richness and more complex ecological function than predicted for a site given its natural environmental setting. For interpreting CSCI scores, Rehn et al. (2015) established thresholds based on the 30th, 10th, and 1st percentiles of CSCI scores in the reference site distribution. These thresholds divide the CSCI scoring range into four categories for interpreting biological condition ranging from "likely intact" to "very likely altered" as described in Table 2.5-4 below. The construction of predictive models for the O/E and MMI components of the CSCI is described further in Rehn et al. (2015).

Table 2.5-4. Scoring ranges for general interpretation of CSCI scores.

CSCI SCORING RANGE	GENERAL THRESHOLD FOR INTERPRETATION
≥0.92	"LIKELY INTACT"
0.80–0.91	"POSSIBLY ALTERED"
0.63–0.79	"LIKELY ALTERED"
≤0.62	"VERY LIKELY ALTERED"

3.0 RESULTS

3.1 Benthic Macroinvertebrate Summary

In 2022, it is estimated that nearly 132,000 benthic macroinvertebrates were collected from 16 sites in the Project 184 area (in TRC and RWB samples combined). Of these individuals, 13,760 specimens were identified, representing 220 different taxa from 91 families and 19 taxonomic orders (per SAFIT Level II STE). The most common taxa included mayflies of the genus *Micrasema*, the nemourid stonefly *Zapada cinctipes*, mayflies of the genus *Ephemerella*, aquatic earthworms of the class Oligochaeta, the ubiquitous mayfly *Baetis tricaudatus*, and caddisflies of the genus *Lepidostoma*. Complete taxa lists for 500-organism fixed-counts are presented in Appendix A.

The average number of taxa per sample for all sites (including both TRC and RWB samples) was 55, including an average of 25 EPT taxa. Shannon Diversity averaged 2.99 and Shannon Evenness averaged 0.75. Percent EPT averaged 62 percent (45% of which were sensitive EPT) and the dominant taxon comprised 22 percent of the average sample. Tolerant and intolerant individuals comprised 6 and 43 percent of the average sample, respectively. The mean weighted tolerance value was 3.5. On average, collectors were the dominant functional feeding group (33%), followed by shredders (19%), scrapers (15%), predators (15%), filterers (10%), and other FFGs (8%). Macroinvertebrate density averaged 528 individuals/ft^2 for all samples. Mean Hydropower IBI score for all 2022 samples was 64 ("fair") and mean CSCI score was 1.08 ("likely intact"). A summary of biological metrics for 500-organism fixed-counts from all 2022 TRC and RWB samples is presented in Table 3.1-1.

3.2 Physical Habitat Summary

A summary of physical habitat data collected at each site in 2022 is presented in Tables 3.2-1 and 3.2-2. Site photographs from 2022 are compiled in Appendix B. Copies of original 2022 SWAMP field datasheets are provided in Appendix C.

Table 3.1-1. Summary of 2022 macroinvertebrate data from Project 184 monitoring sites.

2022 SWAMP BIOASSESSMENT	PROJECT-AFFECTED SITES													REFERENCE SITES									AVERAGES	
	AR-B1 RWB	BU-B1 RWB	CA-B1 RWB	CA-B1 TRC	EC-B1 RWB	EC-B1 TRC	ES-B1 RWB	NN-B1 RWB	OG-B1 RWB	PY-B1 RWB	SO-B1 RWB	SV-B2 RWB	SV-B2 TRC	AR-B2 RWB	BU-B2 RWB	ES-B2 RWB	NN-B2 RWB	OG-B2 RWB	SB-B1 RWB	SH-B1 RWB	WC-B1 RWB	WC-B1 TRC	PROJECT	REFERENCE
RICHNESS-TYPE MEASURES																								
# Total Taxa	45	69	36	37	55	58	65	64	60	57	47	44	39	63	N/S	61	56	N/S	61	70	56	53	52	60
# EPT Taxa	21	29	18	19	26	29	27	26	32	29	24	19	16	31	N/S	23	25	N/S	35	34	15	18	24	26
# ET Taxa	13	19	10	11	20	21	15	17	21	20	18	12	12	21	N/S	14	15	N/S	23	23	11	12	16	17
# Ephemeroptera Taxa	9	6	5	6	9	9	7	8	8	8	12	8	7	11	N/S	6	5	N/S	12	13	5	5	8	8
# Plecoptera Taxa	8	10	8	8	6	8	12	9	11	9	6	7	4	10	N/S	9	10	N/S	12	11	4	6	8	9
# Trichoptera Taxa	4	13	5	5	11	12	8	9	13	12	6	4	5	10	N/S	8	10	N/S	11	10	6	7	8	9
# Diptera Taxa	12	26	12	10	23	21	24	19	14	18	8	14	11	17	N/S	23	19	N/S	17	21	27	25	16	21
# Chironomid Taxa	9	14	9	6	16	14	17	13	9	13	5	10	7	13	N/S	16	12	N/S	8	14	21	16	11	14
Shannon Diversity	2.04	3.52	2.47	2.50	3.02	2.92	3.50	3.13	3.28	3.02	2.77	2.72	2.66	3.07	N/S	3.60	3.12	N/S	3.22	3.32	3.04	2.97	2.89	3.19
Shannon Evenness	0.54	0.83	0.69	0.69	0.75	0.72	0.84	0.75	0.80	0.75	0.72	0.72	0.73	0.74	N/S	0.88	0.78	N/S	0.78	0.78	0.76	0.75	0.73	0.78
Density (#/ft^2)	1158	281	1340	1817	340	615	360	295	411	320	220	562	793	570	N/S	372	137	N/S	462	286	84	147	655	294
COMPOSITION-TYPE MEASURES																								
% EPT	83	53	75	68	71	79	59	52	69	79	60	68	67	66	N/S	51	68	N/S	81	67	17	13	68	52
% Sensitive EPT	77	39	56	57	54	47	50	48	60	57	53	43	38	52	N/S	37	45	N/S	45	35	9	6	52	33
% Baetidae	3	7	2	2	4	5	2	3	6	9	3	6	10	2	N/S	4	22	N/S	14	8	1	1	5	7
% Chironomidae	5	17	4	3	11	9	11	5	20	4	3	3	1	16	N/S	12	8	N/S	5	10	47	60	7	23
% Hydropsychidae	2	3	0	0	7	17	0	2	2	4	1	3	3	3	N/S	0	6	N/S	19	1	0	0	3	4
% Dominant Taxon	56	9	31	31	24	17	16	18	14	20	15	25	24	19	N/S	17	21	N/S	18	19	25	19	23	20
% Non-Insect Taxa	16	12	11	19	7	7	12	17	12	7	13	14	21	13	N/S	16	12	N/S	5	6	14	13	13	11
TOLERANCE / INTOLERANCE MEASURES																								
% Tolerant Individuals	3	11	3	14	2	2	4	3	4	2	4	4	7	2	N/S	11	2	N/S	1	1	17	15	5	7
% Intolerant Individuals	77	31	55	57	52	43	39	41	46	56	53	43	36	52	N/S	28	43	N/S	44	37	10	7	48	32
Weighted Tolerance Value	2.0	4.0	3.0	3.3	3.0	3.3	3.2	3.3	3.1	2.9	2.9	3.4	3.8	3.0	N/S	3.8	3.4	N/S	3.2	3.4	5.5	5.8	3.2	4.0
FUNCTIONAL FEEDING GROUP MEASURES																								
% Filterers	8	9	4	17	11	18	2	5	6	6	18	8	10	23	N/S	6	2	N/S	23	7	6	2	9	10
% Scrapers	13	15	6	4	4	11	17	12	22	15	34	18	18	21	N/S	18	13	N/S	15	36	2	2	15	15
% Collectors	11	27	52	42	29	26	37	30	23	42	16	37	36	11	N/S	40	45	N/S	32	32	52	48	31	37
% Shredders	6	23	10	12	38	34	21	33	17	25	16	25	25	16	N/S	14	20	N/S	15	11	8	4	22	13
% Predators	5	18	17	18	14	7	20	19	14	10	8	11	10	7	N/S	17	16	N/S	12	10	29	38	13	18
% Other FFGs	57	9	11	5	4	4	3	1	17	1	9	1	1	21	N/S	5	4	N/S	3	4	3	6	9	7
MULTI-METRIC INDEX																								
Hydropower-IBI	44	73	61	44	76	67	79	69	80	73	66	57	43	67	N/S	63	74	N/S	80	83	40	43	64	64
CSCI	1.01	1.08	0.93	0.94	1.20	1.18	1.04	1.03	1.14	1.27	1.07	1.08	0.99	1.16	N/S	0.90	1.00	N/S	1.29	1.28	0.99	1.02	1.07	1.09

N/S= Site not sampled in 2022 due to lack of flow.

Table 3.2-1. Summary of reach-wide physical habitat measurements from 2022 Project 184 macroinvertebrate monitoring sites.

	2022 SWAMP BIOASSESSMENT	AR-B1	AR-B2	BU-B1	BU-B2	CA-B1	EC-B1	ES-B1	ES-B2	NN-B1	NN-B2	OG-B1	OG-B2	PY-B1	SB-B1	SH-B1	SO-B1	SV-B2	WC-B1
REACH-WIDE MEASUREMENTS *(measured once per site)*																			
GENERAL	Site Elevation (m)	1082	1511	1002	N/S	2367	1948	1159	1182	1164	1197	945	N/S	1921	1733	1722	1199	2193	2388
GENERAL	Evidence of Recent Rainfall	no	no	no	N/S	no	no	no	no	no	no	no	N/S	no	no	no	no	no	no
GENERAL	Evidence of Fires (<500m)	no	yes	yes	N/S	yes	no	no	no	yes	yes	no	N/S	yes	no	yes	no	yes	no
GENERAL	Dominant Land Use[2]	F	F	F	N/S	F	F	F	F	F	F	F	N/S	F	F	F	F	F	F
GENERAL	Reach Length (m)	150	150	150	N/S	150	150	100	100	100	60	50	N/S	150	150	150	150	150	150
GENERAL	Reach Slope (%)	4.8	3.8	11.8	N/S	1.6	6.0	6.3	4.3	17.1	28.0	6.8	N/S	2.2	4.8	3.2	2.4	2.5	4.8
GENERAL	Reach Sinuosity	1.2	1.3	1.2	N/S	1.3	1.2	1.3	1.4	1.3	1.3	1.0	N/S	1.0	1.1	1.1	1.0	1.1	1.2
GENERAL	Discharge (cfs)	< 1	< 1	< 1	N/S	21	< 1	< 1	< 1	< 1	< 1	< 1	N/S	13	< 1	< 1	73	72	< 1
RBP[1]	Epifaunal Substrate/Cover (0-20)	18	19	15	N/S	18	17	19	17	18	13	17	N/S	19	18	19	17	18	17
RBP[1]	Sediment Deposition (0-20)	16	17	9	N/S	19	16	18	18	17	16	11	N/S	20	16	18	16	19	16
RBP[1]	Channel Alteration (0-20)	20	20	19	N/S	19	17	19	20	19	16	19	N/S	20	20	20	19	19	20
WATER QUAL	Sample Date	9/28	9/29	10/4	N/S	10/5	9/30	10/3	10/3	10/4	10/4	10/3	N/S	10/4	10/5	9/28	9/26	10/5	9/29
WATER QUAL	Sample Time	1400	1015	1130	N/S	0915	0930	1015	1130	1300	1445	1430	N/S	0930	1430	1200	1300	1200	1330
WATER QUAL	Water Temperature (°C)	20.0	16.0	15.2	N/S	15.2	11.2	13.8	16.5	17.8	18.0	18.0	N/S	11.0	17.5	15.2	19.5	18.0	16.5

[1]RBP= Rapid Bioassessment Protocol visual habitat scoring scheme (0–20 points) developed by the EPA for qualitative evaluation of key habitat factors as Optimal (20–16), Suboptimal (15–11), Marginal (10–6), or Poor (5–0). EPA-RBP scoring for select factors retained as part of the SWAMP protocol for consistency with CSBP and earlier methods; [2]Dominant Land Use: F= Forest (other non-applicable categories include Agriculture, Rangeland, Urban/Industrial, Suburb/Town, and Other); N/S= Site not sampled in 2022 due to lack of flow.

Table 3.2-2a. Summary of transect-based physical habitat measurements from 2022 Project 184 macroinvertebrate monitoring sites.

	2022 SWAMP BIOASSESSMENT	**AR-B1**	**AR-B2**	**BU-B1**	**BU-B2**	**CA-B1**	**EC-B1**	**ES-B1**	**ES-B2**	**NN-B1**	**NN-B2**	**OG-B1**	**OG-B2**	**PY-B1**	**SB-B1**	**SH-B1**	**SO-B1**	**SV-B2**	**WC-B1**
TRANSECT-BASED MEASUREMENTS *(measured at multiple cross-sectional transects within site)*																			
CHANNEL	Mean Wetted Width (m)	11.1	7.1	2.2	N/S	7.9	5.3	1.8	1.5	1.7	2.0	3.2	N/S	7.2	6.4	8.8	30.6	8.8	4.5
	Mean Bankfull Width (m)	22.9	13.3	7.7	N/S	9.6	9.0	2.7	3.3	5.2	5.3	6.0	N/S	10.6	9.0	12.0	35.9	11.8	7.8
	Mean Bankfull Height (m)	0.60	0.60	0.60	N/S	0.50	0.50	0.50	0.50	0.50	0.50	0.60	N/S	0.50	0.50	0.50	0.40	0.50	0.50
	Mean Depth (cm)	22.0	18.6	5.5	N/S	21.5	9.0	3.6	4.7	2.6	1.8	4.8	N/S	23.4	15.1	20.3	22.7	15.9	23.1
BED	Median Particle Size (D_{50}) (mm)	348	351	0.03	N/S	67	122	31	21	0.03	208	189	N/S	196	163	86	189	192	18
	Mean Cobble Embeddedness (%)	8	13	1	N/S	8	2	29	32	0	0	28	N/S	13	14	28	11	14	3
	% Bedrock (>4m)	31	40	18	N/S	22	8	7	0	21	50	37	N/S	32	40	11	15	22	14
	% Boulder, large (>1m-4m)	1	1	0	N/S	0	0	0	0	0	0	0	N/S	0	0	2	5	0	0
	% Boulder, small (>25cm-1m)	22	12	4	N/S	5	11	7	0	7	0	7	N/S	9	6	21	23	15	7
	% Cobble (>64mm-25cm)	10	8	10	N/S	25	55	29	27	5	2	20	N/S	30	10	20	27	44	7
	% Gravel, coarse (>16-64mm)	12	9	3	N/S	20	17	23	30	2	1	14	N/S	2	2	7	4	8	26
	% Gravel, fine (>2-16mm)	9	17	8	N/S	8	7	14	24	5	6	12	N/S	16	21	14	17	6	14
	% Sand + % Fines (0-2mm)	14	14	57	N/S	21	2	21	19	61	41	10	N/S	11	21	25	10	6	32
	CPOM Presence (%)	66	71	89	N/S	74	62	73	92	83	70	80	N/S	53	44	71	49	34	87
	Mean Microalgae Thickness (mm)	0.3	0.3	0.1	N/S	0.3	0.3	0.3	0.3	0.1	0.2	0.3	N/S	0.3	0.2	0.2	0.3	0.3	0.2
	Attached Macroalgae Presence (%)	0	8	20	N/S	38	9	0	0	21	22	0	N/S	32	26	1	0	33	0
	Unattached Macroalgae Presence (%)	0	0	0	N/S	0	0	0	0	0	0	0	N/S	0	0	0	0	0	0
	Macrophyte Presence (%)	38	16	2	N/S	9	1	1	2	28	42	8	N/S	2	15	66	14	6	3
BANK	Stable Banks (%)	100	100	45	N/S	100	100	82	55	100	95	100	N/S	100	100	100	100	100	100
	Vulnerable Banks (%)	0	0	18	N/S	0	0	0	14	0	5	0	N/S	0	0	0	0	0	0
	Eroded Banks (%)	0	0	36	N/S	0	0	18	32	0	0	0	N/S	0	0	0	0	0	0

N/S= Site not sampled in 2022 due to lack of flow. CPOM= coarse particulate organic matter (leaves, bits of woody debris, etc.)

Table 3.2-2b. Summary of transect-based physical habitat measurements from 2022 Project 184 macroinvertebrate monitoring sites.

	2022 SWAMP BIOASSESSMENT	AR-B1	AR-B2	BU-B1	BU-B2	CA-B1	EC-B1	ES-B1	ES-B2	NN-B1	NN-B2	OG-B1	OG-B2	PY-B1	SB-B1	SH-B1	SO-B1	SV-B2	WC-B1
TRANSECT-BASED MEASUREMENTS cont'd *(measured at multiple cross-sectional transects within site)*																			
HABITAT TYPE	Cascade/Fall (%)	7	11	11	N/S	0	6	2	0	22	30	16	N/S	4	12	3	2	0	2
	Rapid (%)	2	0	0	N/S	3	0	0	0	5	5	1	N/S	11	6	0	9	18	0
	Riffle (%)	15	10	18	N/S	19	20	35	70	50	8	16	N/S	21	17	12	18	23	14
	Run (%)	21	13	41	N/S	74	39	52	11	14	42	41	N/S	55	44	16	65	58	27
	Glide (%)	0	0	0	N/S	0	0	0	0	0	0	0	N/S	0	0	0	0	0	8
	Pool (%)	46	59	30	N/S	4	24	11	18	9	15	26	N/S	8	19	63	6	2	43
	Dry Channel (%)	5	4	0	N/S	0	6	0	0	0	0	0	N/S	0	1	3	0	0	3
HABITAT COMPLEXITY	Filamentous Algae (%)	3	11	0	N/S	10	11	2	0	2	0	0	N/S	11	1	11	0	11	8
	Aquatic Macrophytes (%)	9	8	8	N/S	6	5	5	1	9	8	0	N/S	3	10	11	11	10	1
	Boulders (%)	11	11	11	N/S	11	11	11	4	11	11	10	N/S	11	10	11	11	11	11
	Woody Debris >3m (%)	2	0	7	N/S	6	5	11	8	11	8	7	N/S	0	2	1	3	7	4
	Woody Debris <3m (%)	8	1	11	N/S	9	10	11	10	11	11	10	N/S	8	8	2	7	9	10
	Undercut Banks (%)	0	0	8	N/S	10	0	11	8	8	2	2	N/S	2	1	0	0	6	6
	Overhanging Vegetation (%)	11	11	11	N/S	11	11	11	10	11	9	7	N/S	10	11	11	11	11	11
	Live Tree Roots (%)	0	0	8	N/S	5	1	10	8	2	4	2	N/S	5	0	0	3	1	0
	Artificial Structures (%)	5	0	3	N/S	2	5	0	0	1	0	0	N/S	1	1	0	5	0	0

N/S= Site not sampled in 2022 due to lack of flow.

Table 3.2-2c. Summary of transect-based physical habitat measurements from 2022 Project 184 macroinvertebrate monitoring sites.

	2022 SWAMP BIOASSESSMENT	AR-B1	AR-B2	BU-B1	BU-B2	CA-B1	EC-B1	ES-B1	ES-B2	NN-B1	NN-B2	OG-B1	OG-B2	PY-B1	SB-B1	SH-B1	SO-B1	SV-B2	WC-B1
TRANSECT-BASED MEASUREMENTS cont'd *(measured at multiple cross-sectional transects within site)*																			
RIPARIAN	Mean Total Canopy Cover (%)	38	8	94	N/S	16	46	97	97	91	96	73	N/S	50	39	41	7	14	22
	Trees/Saplings (>5m high) (%)	6	1	6	N/S	12	17	36	30	48	4	4	N/S	17	11	7	15	7	4
	Shrubs/Saplings (0.5-5m high) (%)	15	8	19	N/S	37	9	41	35	48	8	31	N/S	10	12	10	17	16	33
	Woody Shrubs/Saplings (<0.5m high) (%)	25	43	28	N/S	53	28	44	42	12	14	45	N/S	41	33	36	46	33	37
	Herbs/Grasses (<0.5m high) (%)	9	14	9	N/S	21	12	20	18	27	7	22	N/S	18	18	22	28	12	13
	Barren Soil/Duff (<0.5m high) (%)	38	26	31	N/S	11	40	53	50	49	72	38	N/S	39	46	48	22	31	15
HUMAN INFLUENCE	Walls/Rip-Rap/Dams (%)	0	0	1	N/S	0	0	0	0	0.0	0	0	N/S	0	0	0	0	0	0
	Buildings (%)	0	0	< 1	N/S	0	0	0	0	< 1	0	0	N/S	0	0	0	0	0	0
	Pavement/Cleared Lot (%)	0	0	< 1	N/S	0	< 1	0	0	0	0	0	N/S	0	0	0	0	0	0
	Road/Railroad (%)	<1	0	0	N/S	0	< 1	0	0	< 1	0	0	N/S	0	0	0	< 1	0	0
	Pipes/(Inlet/Outlet) (%)	<1	0	< 1	N/S	0	0	0	0	1	1	0	N/S	0	0	0	0	0	0
	Landfill/Trash (%)	0	0	0	N/S	0	0	0	0	0	0	0	N/S	0	0	0	0	0	0
	Park/Lawn (%)	0	0	0	N/S	0	0	0	0	0	0	0	N/S	0	0	0	0	0	0
	Row Crops (%)	0	0	0	N/S	0	0	0	0	0	0	0	N/S	0	0	0	0	0	0
	Pasture/Range (%)	0	0	0	N/S	0	0	0	0	0	0	0	N/S	0	0	0	0	0	0
	Logging Operations (%)	0	0	0	N/S	0	0	0	0	0	0	0	N/S	0	0	0	0	0	0
	Mining Activity (%)	0	0	0	N/S	0	0	0	0	0	0	0	N/S	0	0	0	0	0	0
	Vegetation Management (%)	0	0	0	N/S	0	0	0	0	0	0	0	N/S	0	0	0	0	0	0
	Bridges/Abutments (%)	< 1	0	0	N/S	0	0	0	0	0	0	0	N/S	< 1	0	0	0	0	0
	Orchards/Vineyards (%)	0	0	0	N/S	0	0	0	0	0	0	0	N/S	0	0	0	0	0	0

SWAMP bioassessment sites mostly ranked in the "optimal" to "suboptimal" range in terms of available epifaunal substrate and cover, sediment deposition, and channel alteration (rapid bioassessment [RPB] scores are ranked by category as poor, marginal, suboptimal, or optimal; see Table 3.2-1). Only lower Bull Creek (BU-B1) had an RBP sediment deposition score in the marginal range. Stream gradient ranged from low (1.6% slope at Caples Creek [CA-B1]) to very high (28.0% slope at upper No Name Creek [NN-B2]). Sites were typically dominated by run and pool habitats. Mean wetted width ranged from 1.5 m (at upper Esmerelda Creek [ES-B2]) to 30.6 m (at the SFAR below Kyburz Diversion [SO-B1]). Mean depth ranged from 2 centimeters (cm) (at upper No Name Creek [NN-B2]) to 23 cm (at Pyramid Creek [PY-B1]).

Substrate was dominated by cobble at most sites and median particle size (D_{50}) ranged from < 1 mm (fines) at BU-B1 and NN-B1 to 351 mm (boulder) at AR-B2. Coarse particulate organic matter (CPOM) presence was high at most sites (34%–92%), microalgae thickness averaged less than 1 mm (0.1–0.3 mm), and attached macroalgae presence ranged from 0 to 38 percent. Stream banks averaged 92 percent stable.

Mean total canopy cover ranged from 7 percent (at SO-B1) to 97 percent (at BU-B1, ES-B1, and ES-B2) and the riparian zone was dominated by alder and willow shrubs at most sites. Human influences encountered in the vicinity of survey reaches included rip-rapped banks, cabins, campgrounds, roads, diversion pipes, and bridge abutments (defined as "walls/rip-rap/dams," "buildings," "pavement/cleared lot," "roads/railroads," "pipes [inlet/outlet]," and "bridges/abutments" on the SWAMP survey form, respectively).

Water temperatures ranged from 11.0 to 20.0°C during our surveys. Discharge ranged from less than 1 cubic foot per second (cfs) in several smaller creeks to 73 cfs in the mainstem SFAR during our surveys.

4.0 DISCUSSION

4.1 Comparisons between Reference Reaches and Project-affected Reaches (2022)

Overall, samples collected from Project-affected reaches scored slightly lower on average in terms of certain richness, composition, tolerance, and functional feeding group measures than those collected from reference reaches during 2022 SWAMP surveys (Table 3.1-1). Although some variation was apparent among individual metrics and samples, scores for the multi-metric Hydropower-IBI averaged the same in references reaches and Project-affected reaches (64, "fair") in 2022. Hydropower IBI scores ranged from a low of 40 ("poor") for the RWB sample from the Woods Creek (WC-B1) to a high of 83 ("good") for the RWB sample from the Sherman Canyon Creek (SH-B1) (Table 3.1-1). CSCI scores averaged slightly higher in references reaches (1.09) than Project-affected reaches (1.07), both in the highest "likely intact" range (Figure 4.1-1). CSCI scores ranged from a low of 0.90 ("possibly altered") for the RWB sample from the Esmerelda Creek (ES-B2) to a high of 1.29 ("likely intact") for the RWB sample from the Strawberry Creek site (SB-B1) (Table 3.1-1).

To a certain extent, CSCI and IBI scores and component metric values would be expected to be higher at unregulated vs. regulated sites regardless because most reference sites are located nearer to headwater reaches where biological integrity tends to be naturally higher than in downstream reaches where most Project-affected sites are located. As such, it is likely that many of the observed differences in metric averages between Project-affected reaches and reference reaches primarily reflect ecological differences between upstream and downstream locations (i.e., underlying differences in stream hydrology, substrate, morphology, gradient, riparian influences, etc.) rather than Project-related differences.

Total taxa richness averaged 15 percent higher in reference reaches versus Project-affected reaches (60 vs. 52 total taxa, respectively). Richness of individual samples ranged from a high of 70 taxa collected in the RWB sample from upper Sherman Canyon Creek (SH-B1), to a low of 36 taxa collected in the RWB sample from Caples Creek (CA-B1). Shannon Diversity was relatively high at all site in 2022, but averaged slightly higher (10%) at reference sites versus Project-affected sites (3.19 vs. 2.89, respectively). Diversity of individual samples ranged from 3.60 in the RWB sample from Esmeralda Creek (ES-B2) to 2.04 in the TRC sample from lower Alder Creek (AR-B1). Macroinvertebrate density was lower on average in reference reaches than Project-affected reaches (294 vs. 655 individuals/ft^2, respectively). Among individual samples, density was lowest in the RWB sample from Woods Creek (WC-B1) (84 individuals/ft^2) and highest in the TRC sample from Caples Creek below Caples Lake (CA-B1) (1,817 individuals/ft^2) (Table 3.1-1).

Composition measures were variable overall among reference and Project-affected sites. Average values for most composition measures were similar for reference and Project-affected reaches (Table 3.1-1). The average percent composition of tolerant organisms was very low for all samples (6%) and the average percent composition of intolerant organisms was moderate (43%). Thus, average weighted tolerance value was also moderate (3.5). Tolerance measures were similar between Project-affected and reference sites (Table 3.1-1). Functional feeding group measures were similar overall among reference and Project-affected reaches (Table 3.1-1).

The average composition of the major taxonomic groups differed among reference reaches and Project-affected reaches in 2022. In terms of the major insect orders, mayflies (Order Ephemeroptera), stoneflies (Order Plecoptera), and caddisflies (Order Trichoptera) were slightly more abundant on average in samples from Project-affected reaches, whereas beetles (Order Coleoptera) and true flies (Order Diptera) were more abundant on average in samples from reference reaches (Figure 4.1-2). Non-insect taxa were much less abundant overall than insects, although aquatic earthworms (Class Oligochaeta), freshwater mites (Class Acari), and snails (Class Gastropoda) were slightly more abundant on average in reference reaches, and clams (Order Bivalvia) were more abundant on average in samples from Project-affected reaches (Figure 4.1-3).

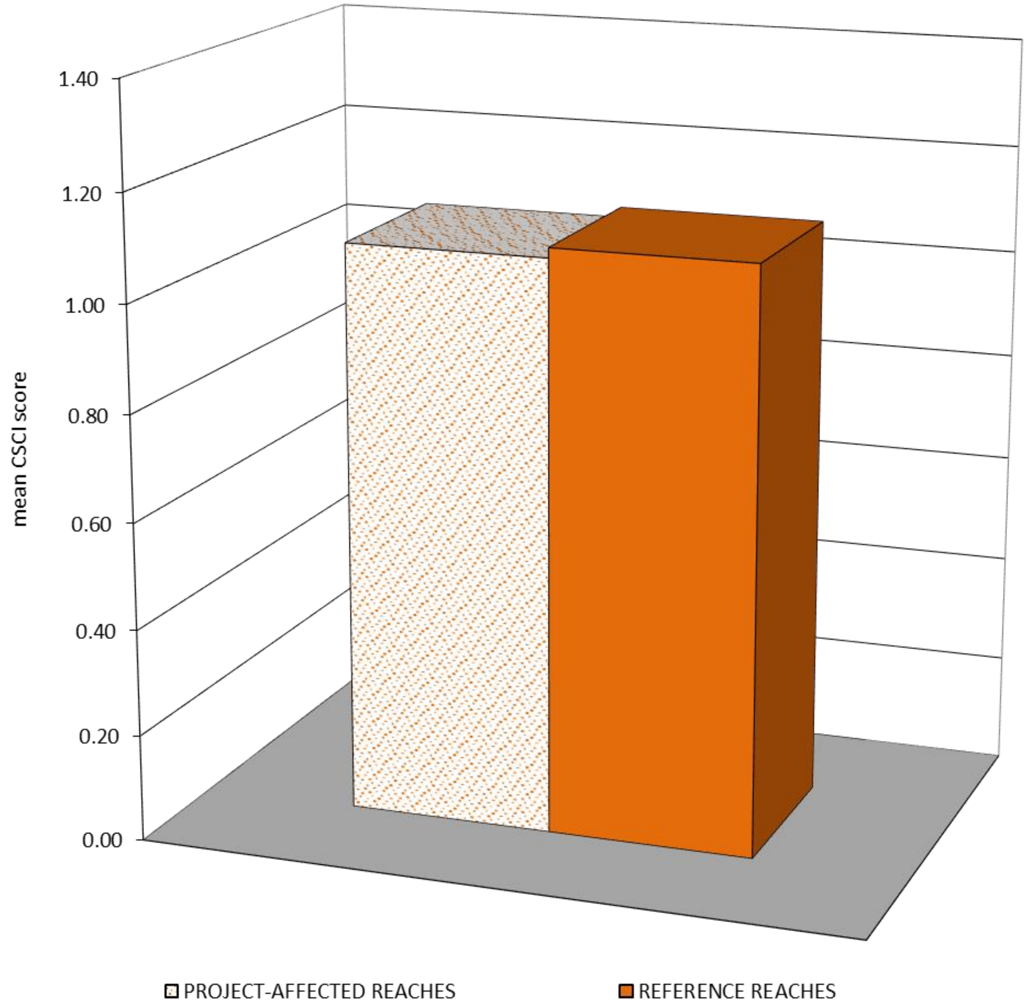

Figure 4.1-1. Mean CSCI scores in Project-affected vs. reference reaches (2022).

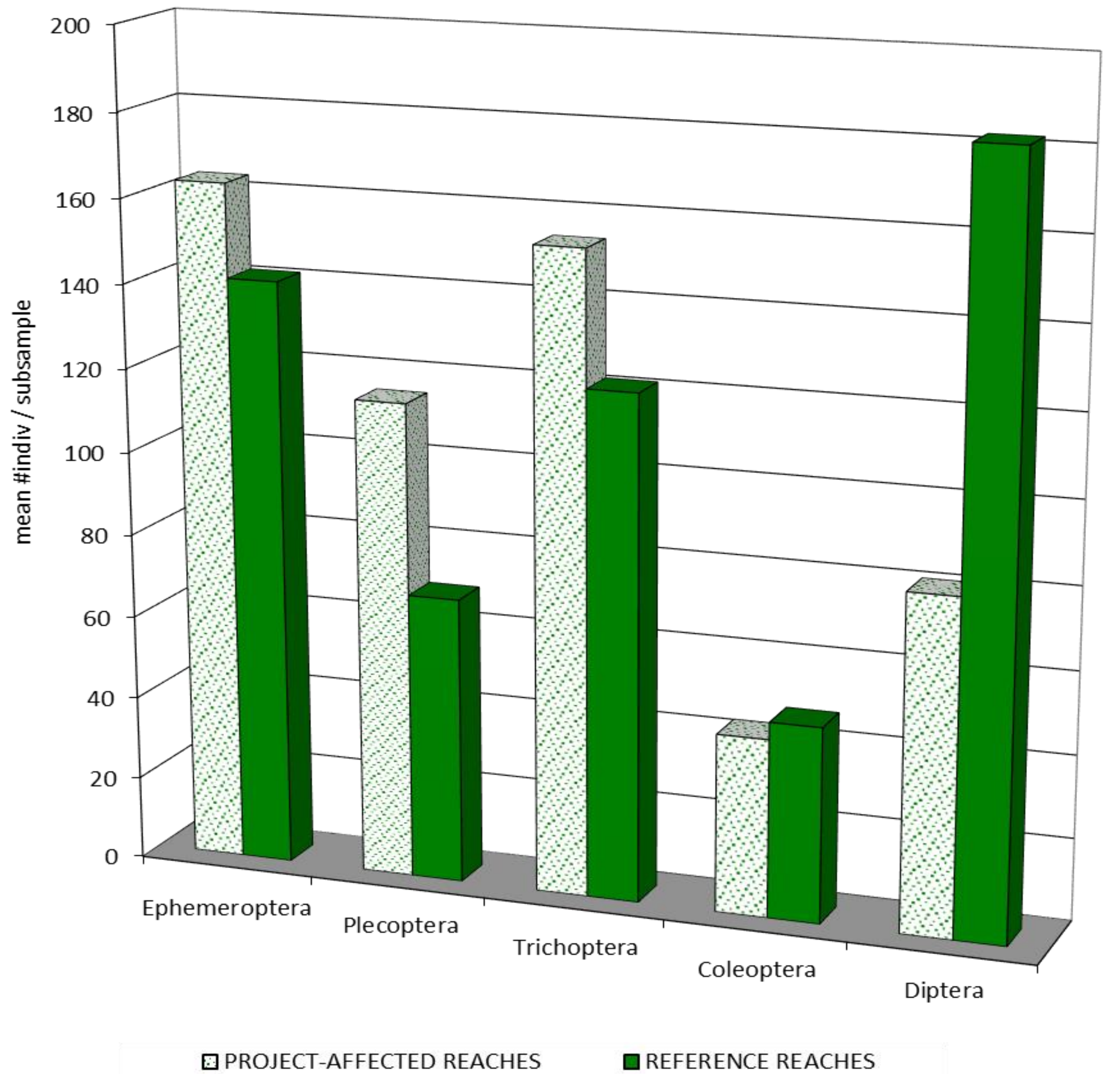

Figure 4.1-2. Abundance of major insect orders in Project-affected vs. reference reaches (2022).

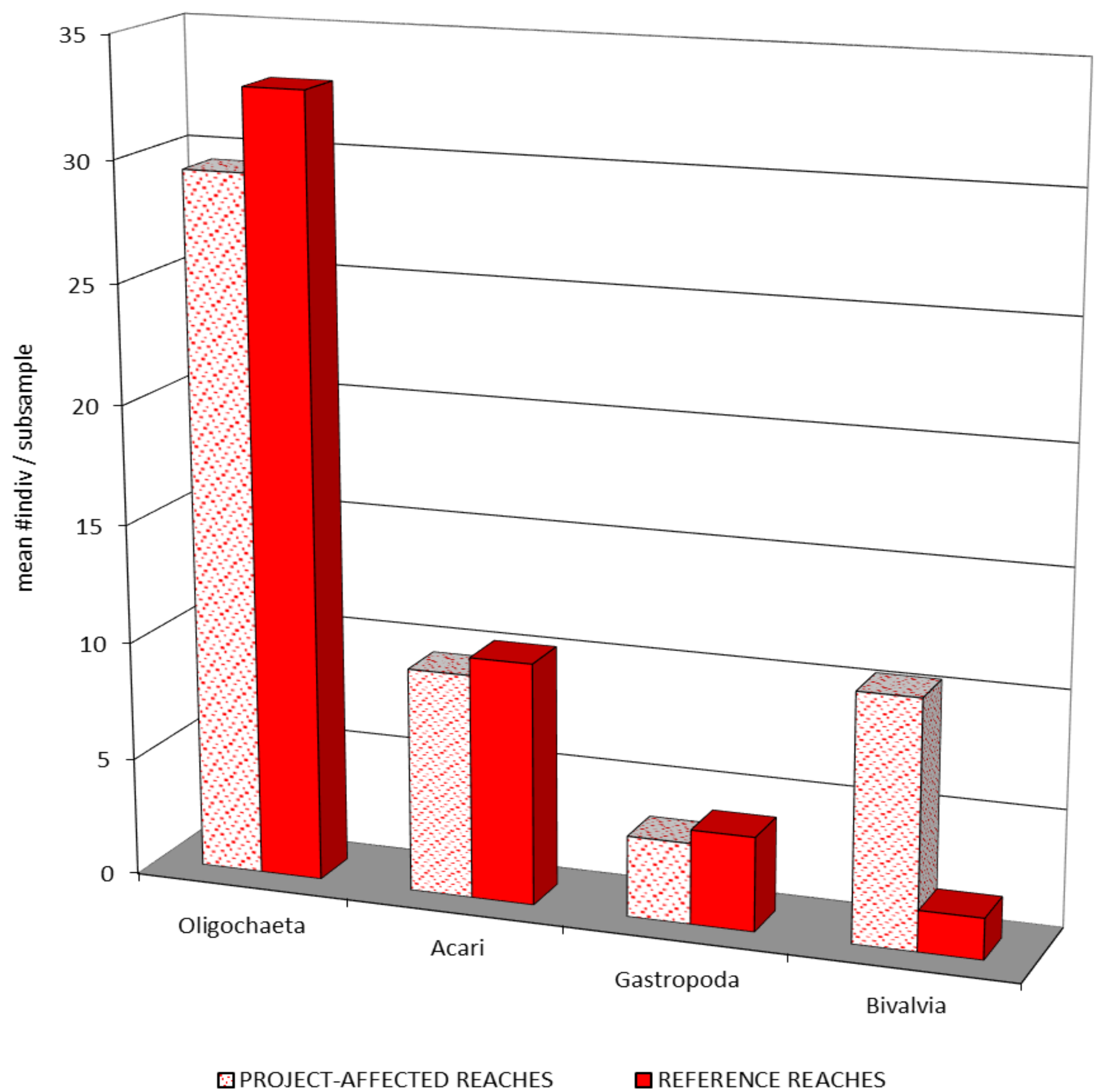

Figure 4.1-3. Abundance of major non-insect classes in Project-affected vs. reference reaches (2022).

4.2 Comparisons between Study Years (2011-2012 vs. 2016-2017)

Results from the first 5-year study period (2011 and 2012 data), second 5-year study period (2016 and 2017 data), and third 5-year study period (2022 data) were similar overall. More EPT taxa were present during the second and third 5-year periods than the first, but EPT overall composition was similar between years. Most other individual richness, composition, tolerance/intolerance, and functional feeding group measures were similar on average (Table 4.2-1). Mean Hydropower IBI scores were slightly lower in 2016 and 2017 and 2022 than in 2011 and 2012 (Figure 4.2-1); however, mean differences between Project-affected reaches and reference reaches were very similar within each period, and mean IBI scores were all in the "fair" to "good" range. Mean CSCI scores were similar between 5-year periods, but averaged slightly higher in reference than Project-affected reaches (Figure 4.2-2); however, nearly all CSCI scores were in the highest "likely intact" range. As such, it appears that differences in CSCI and IBI scores, along with some between-year differences in individual metrics, are well within the range of potential natural (inter-annual) variability. Note, for example, that the second 5-year study period was characterized by several consecutive drought years prior to 2016. Regardless, bioassessment data such as these adequately characterize existing biological and physical habitat conditions in Project watersheds for given years and study periods, while providing valuable information for comparisons with future bioassessment data.

Table 4.2-1. Summary of macroinvertebrate metrics from the three 5-year study periods.

PROJECT 184 SWAMP BIOASSESSMENT	2011		2012		1st 5-YR AVERAGE		2016		2017		2nd 5-YR AVERAGE		2022		3rd 5-YR AVERAGE	
	PROJECT	REFERENCE	PROJECT	REFERENCE	PROJECT	REFERENCE	PROJECT	REFERENCE	PROJECT	REFERENCE	PROJECT	REFERENCE	PROJECT	REFERENCE	PROJECT	REFERENCE
RICHNESS-TYPE MEASURES																
# Total Taxa	44	55	45	50	44	53	54	58	42	45	48	52	52	60	52	60
# EPT Taxa	8	9	8	7	8	8	26	26	25	28	25	27	24	26	24	26
# ET Taxa*	8	11	7	9	7	10	18	18	17	17	17	17	16	17	16	17
# Ephemeroptera Taxa	8	9	8	7	8	8	8	8	9	9	8	9	8	8	8	8
# Plecoptera Taxa	13	16	13	18	13	17	8	8	9	10	8	9	8	9	8	9
# Trichoptera Taxa	9	9	9	11	9	10	10	10	8	8	9	9	8	9	8	9
# Diptera Taxa	16	18	16	14	16	16	16	21	7	9	12	15	16	21	16	21
# Chironomid Taxa	23	28	23	24	23	26	12	13	3	3	8	8	11	14	11	14
Shannon Diversity*	2.90	3.16	2.85	3.06	2.88	3.11	2.98	2.84	2.66	2.61	2.82	2.72	2.89	3.19	2.89	3.19
Shannon Evenness	0.77	0.79	0.75	0.78	0.76	0.79	0.75	0.70	0.72	0.68	0.74	0.69	0.73	0.78	0.73	0.78
Density (#/ft^2)	437	256	633	552	535	404	591	818	447	510	519	664	655	294	655	294
COMPOSITION-TYPE MEASURES																
% EPT	73	72	60	68	67	70	54	45	75	81	64	63	68	52	68	52
% Sensitive EPT	55	50	47	41	51	46	40	26	56	60	48	43	52	33	52	33
% Baetidae	6	6	3	4	5	5	8	13	7	8	7	11	5	7	5	7
% Chironomidae	8	8	12	13	10	11	16	16	9	10	12	13	7	23	7	23
% Hydropsychidae	5	2	1	2	3	2	4	3	4	2	4	3	3	4	3	4
% Dominant Taxon	22	20	12	12	17	16	22	28	26	32	24	30	23	20	23	20
% Non-Insect Taxa*	12	7	13	10	12	8	14	10	15	10	14	10	13	11	13	11
TOLERANCE / INTOLERANCE MEASURES																
% Tolerant Individuals*	3	1	2	1	2	1	9	2	3	1	6	1	5	7	5	7
% Intolerant Individuals*	51	46	45	39	48	43	37	26	50	45	43	35	48	32	48	32
Weighted Tolerance Value	2.9	2.9	3.3	3.1	3.1	3.0	3.9	4.3	3.1	3.0	3.5	3.7	3.2	4.0	3.2	4.0
FUNCTIONAL FEEDING GROUP MEASURES																
% Filterers	6	4	10	4	8	4	17	24	7	4	12	14	9	10	9	10
% Scrapers*	16	31	12	28	14	30	10	13	15	30	12	22	15	15	15	15
% Collectors	32	27	36	30	34	29	30	33	36	27	33	30	31	37	31	37
% Shredders	20	17	19	16	20	16	22	12	19	26	21	19	22	13	22	13
% Predators*	18	18	15	19	17	19	15	16	15	9	15	13	13	18	13	18
% Other FFGs	8	3	7	3	8	3	7	3	7	4	7	3	9	7	9	7
MULTI-METRIC INDEX																
Hydropower-IBI	69	81	64	75	66	78	57	66	61	68	59	67	64	64	64	64
CSCI	N/A	N/A	N/A	N/A	N/A	N/A	1.04	1.02	1.05	1.08	1.04	1.05	1.07	1.09	1.07	1.09

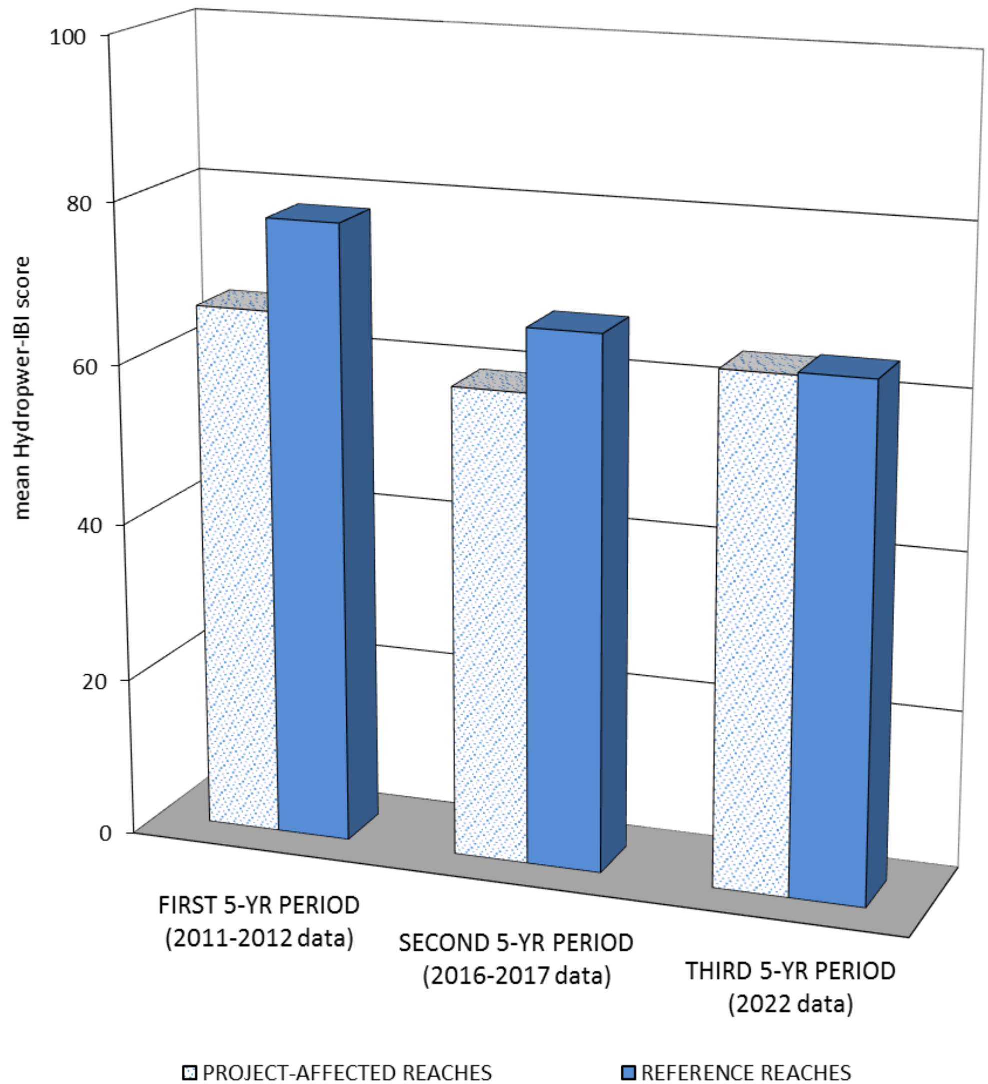

Figure 4.2-1. Mean Hydropower IBI scores in Project-affected vs. reference reaches by study period.

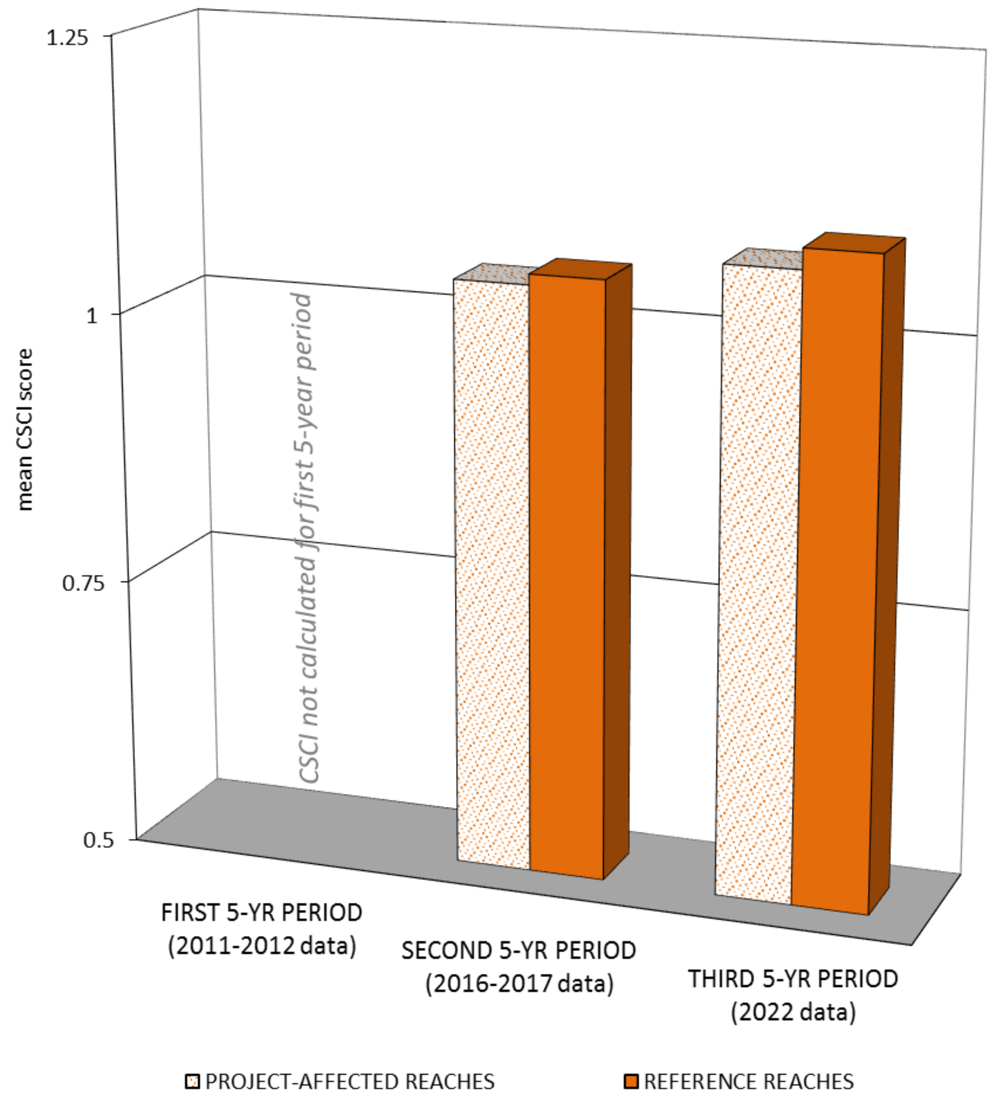

Figure 4.2-2. Mean CSCI scores in Project-affected vs. reference reaches by study period.

5.0 CONCLUSIONS

Bioassessment data collected in 2022 (as well as during previous study years) indicate that Project 184 watersheds generally support relatively robust BMI communities (in terms of richness, composition, tolerance, and functional feeding group measures) characterized by good overall water quality. Physical habitat conditions were predominantly in the "optimal" to "suboptimal" range. No major differences between 5-year study periods were evident. Overall, these data suggest that biological integrity in Project-affected and reference reaches is adequately similar, with most differences likely reflecting ecological differences between upstream and downstream locations (i.e., underlying differences in stream hydrology, substrate, morphology, gradient, riparian influences, etc.) rather than Project-related differences.

6.0 RECOMMENDATIONS

Over the course of conducting the 2011, 2012, 2016, 2017, and 2022 bioassessment work, Kleinfelder has developed the following recommendations for consideration in future monitoring efforts:

- Better reference sites are needed for certain paired Project-affected sites (i.e., Ogilby Creek, Caples/Woods Creek, Alder Creek) such that bioassessments may better isolate Project-related differences as opposed to simply measuring underlying ecological differences. Currently, such paired comparisons are not ecologically valid due to inherent differences in stream hydrology, substrate, morphology, gradient, and riparian influences between upstream and downstream sites. For example, upper Ogilby Creek (OG-B2) is consistently dry with zero surface flow for most of each summer, whereas lower Ogilby Creek (OG-B1) is perennial; Woods Creek (WC-B1) is a steep, headwater stream that becomes intermittent in low snowpack years, whereas Caples Creek is a low-gradient and higher-order perennial stream; and upper Alder Creek (AR-B2 near the headwaters) is nearly three miles upstream of lower Alder Creek (AR-B1) which has much different stream morphology, gradient, substrate, and site elevation.
- The collection of TRC samples could be omitted as RWB samples alone should suffice. SWAMP continues to focus on RWB samples only and the initial modification of the protocol to target riffles in order to ensure adequate representation of the benthos at steeper, higher elevation sites for this Project does not appear necessary.
- When sampling in consecutive years, physical habitat data collection could be minimized in the second year (although benthic samples and water quality data should continue to be collected at each site both years). Most of these sites are characterized by very stable stream morphology such that channel aggradation/degradation or meander is unlikely. Thus, perhaps only a subset of transects (e.g., transects A, F, and K only) could be re-measured the second

year to verify key aspects of the physical habitat characterization as opposed to repeating the full effort (labor associated with full physical habitat measurements comprises the vast majority of all field labor during a standard SWAMP effort). If conditions appear to have changed from one year to the next at a given site (e.g., due to a landslide, bank failure, or other erosive event), the full level of effort could be repeated at that site to capture such local changes.

7.0 REFERENCES

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Appendix A

500-organism Fixed-count Taxa Lists (2022)

APPENDIX A. 2022 Project 184 SWAMP Bioassessment 500-Organism Fixed-Count Taxa Lists

Final SAFIT ID	**AR-B1 RWB**	**AR-B2 RWB**	**BU-B1 RWB**	**CA-B1 RWB**	**CA-B1 TRC**	**EC-B1 RWB**	**EC-B1 TRC**	**ES-B1 RWB**	**ES-B2 RWB**	**NN-B1 RWB**	**NN-B2 RWB**	**OG-B1 RWB**	**PY-B1 RWB**	**SB-B1 RWB**	**SH-B1 RWB**	**SO-B1 RWB**	**SV-B2 RWB**	**SV-B2 TRC**	**WC-B1 RWB**	**WC-B1 TRC**
Ablabesmyia																			8	
Agapetus		1													4					
Agraylea					1		2						1							
Alotanypus								1	4											
Ameletus		1										7	2		4	4	2		1	3
Ametor											1									
Amiocentrus aspilus		1	4			13	15					3	1	2						5
Ampumixis dispar												2								
Anacaena															1					
Anagapetus			1					9	12	5	4	34								
Anchycteis			2						1	3	4									
Antocha						1	1										1			
Apatania				4	4	1													3	1
Apedilum																			5	
Arctopsyche grandis													5	4						
Asellus																	8	12		
Atherix pachypus													7	2						
Atractides			1					1												2
Atrichopogon			1					1		1		1								
Attenella delantala							1							6						
Baetis	2									1					3	2				
Baetis tricaudatus	13	6	30	8	8	18	27	2	2	11	106	30	47	70	31	11	31	50	2	4
Bezzia/ Palpomyia			1		1	3	1	1	1				5	3	1		2		5	32
Boreochlus											1				1					
Brillia	1	1	33			1	4	18	12	6	6	28	1	2					7	5
Brundiniella			3						2	1	1				1					
Calineuria californica	1	2	3			9	8	10	13			11	3	2	7	5	5			
Caloparyphus/ Euparyphus			1								1									
Capniidae					1					9	11	2		2	4				18	2
Caudatella												1								
Caudatella hystrix					1	2								1						
Centroptilum		3													1	1			1	
Ceratopogonidae																				2
Chelifera/ Metachela			1	1	4				2		3	1								
Cheumatopsyche	3	1																		
Chironomini													1							
Chloroperlidae			3	4	4			17	3	2	1	1					1			
Cinygma								4		3										
Cinygmula	6	34	1	18	16	15	39	13	17			2	14	10	93	17	2	3		6
Cleptelmis addenda		1				3							22	3	1	5	10	12	1	
Cloeodes		1	1												4	1				
Cordulegaster dorsalis		1	19					1	9	40	10				1					
Corydalidae			2	1	1			3				1								
Corynoneura		1				1	1	1			1								24	95
Cricotopus	1	4		2	3	9	8						1	8	4	1	2		3	
Cryptochia											2									
Cryptolabis															1					
Cultus	1	2														1	4	1		
Cyclothyas										2	4									
Diamesa				1	1	1														
Dicranota		2			1	2	1	2			3			1	3			1	3	6
Diphetor hageni			3					10	16	2	6				2		1	2		
Dixa			3			1	2		2	3	5		1		5					
Dolophilodes		1	1				1			1		1	5	18						

Final SAFIT ID	AR-B1 RWB	AR-B2 RWB	BU-B1 RWB	CA-B1 RWB	CA-B1 TRC	EC-B1 RWB	EC-B1 TRC	ES-B1 RWB	ES-B2 RWB	NN-B1 RWB	NN-B2 RWB	OG-B1 RWB	PY-B1 RWB	SB-B1 RWB	SH-B1 RWB	SO-B1 RWB	SV-B2 RWB	SV-B2 TRC	WC-B1 RWB	WC-B1 TRC
Doroneuria baumanni						5	2						1							
Drunella						4	4													
Drunella doddsii						2	2							1		1				
Drunella grandis																1				
Drunella pelosa													1	29	1					
Drunella spinifera														1						
Empididae			1																	
Epeorus	26	32				3	1			1		1	33	25	18	76	15	13		1
Ephemerella	31	20		155	153	10	12	22	20	3		18	66	12	54	34	25	13	1	
Ephemerellidae											1									
Estelloxus									2											
Eubrianax edwardsii	2	8					1					1	1	9	30	3	40	20		
Eucapnopsis brevicauda		1												2	1					
Eukiefferiella		3	1	2		6	8	3	3	2	5	16	1	4			4	1	1	1
Farula										1	44	1								
Ferrissia																	1	2		
Frisonia picticeps		1											1	1						
Glossosoma													6	3						
Glutops			1					4												
Gumaga						15	8								3					
Gyraulus		1	23						14											
Hemerodromia	1																			
Hesperoconopa														1						2
Hesperoperla pacifica	2		3					3	2	11	14			1		1				
Heterlimnius			13					79	84	92	62	2								
Heteroplectron californicum			5			2	1		4			1			1					
Hexatoma						1											5	15	6	11
Hydra		2	1														2	1	4	
Hydraena							1								2	1				
Hydropsyche	5	15	14			35	83			1	2	9	15	90	4	3	16	14		
Hydroptila		1		54	26	11	4								2	1	1		10	17
Hydrovolzia											1									
Hydryphantidae										1										
Hygrobates	2	1				1										1			2	
Ironodes	2	9	46	4	1	1	8	56	37	42	16	69	17	8	3		12	25		
Isoperla		1						1				14		1	1	2	12	10		
Juga								5	7	7										
Krenosmittia								1												
Lara								1	1	2	2	1	1	6	2				1	1
Larsia	1																			
Lebertia		3			2	3				3			3		3	9		2	3	1
Lepidostoma	28	37	4	11	2	121	71	2				9	9	20	13	77	2	1	10	
Leuctridae				4	2															1
Limnephilidae																				1
Limnophyes																				3
Malenka			6							18	7	2								
Maruina lanceolata	2	1	1				2							1		5				
Meringodixa chalonensis			4							2										
Micrasema	281	97	39			3	2	7	9	1	13	71	3	8	6	44		1	1	1
Micropsectra			3	3	3	1	1	1	2	1	1	11	2	3	8		3	1	15	5
Microtendipes pedellus group																	1			
Microtendipes rydalensis group			2			4	1		1			3			3				2	3
Mideopsis								1	1	1	1									
Molophilus																			1	1
Moselia infuscata								16	29	2	1	3								
Mystacides						1														
Nanocladius								2												
Narpus			1					2		3					1					2
Neophylax				1												9				
Neoplasta			6	1		2	1	2	2	1		2		3	2	1				
Ochrotrichia							1													
Octogomphus specularis	1		6						6	6		8								
Oligochaeta	2	4	25	71	33	50	37	21	16	15	8	9	25	5	6	10	23	17	123	44
Oligophlebodes						1								1	1					
Ophiogomphus																1				

Final SAFIT ID	AR-B1 RWB	AR-B2 RWB	BU-B1 RWB	CA-B1 RWB	CA-B1 TRC	EC-B1 RWB	EC-B1 TRC	ES-B1 RWB	ES-B2 RWB	NN-B1 RWB	NN-B2 RWB	OG-B1 RWB	PY-B1 RWB	SB-B1 RWB	SH-B1 RWB	SO-B1 RWB	SV-B2 RWB	SV-B2 TRC	WC-B1 RWB	WC-B1 TRC
Optioservus	11	12					1							3	22	46	1	1	2	
Ordobrevia nubifera	6	1										1								
Oreodytes																1			3	
Oreogeton								3	1	1	1	2								
Orohermes crepusculus		6				3	1						1	4	1	2	7			
Oroperla barbara		1		1										3						
Orthocladiinae			2							1										
Orthocladius complex	1					2	1			1	2					4			28	56
Orthocladius lignicola																1				
Ostracoda			8		1		2	11	18			1							4	1
Pagastia						1	3	1	1	2	6		2							1
Paracladopelma																	1			
Paracricotopus											1									
Paraleptophlebia	1	9	23	15	5	7	3	18	32	6	6	2	32	10	20	2	78	72	24	6
Paraleuctra			2					1												
Parametriocnemus	1		6	1		1	4	4	3	6	14	20		2	3				11	13
Paraphaenocladius								1												
Parapsyche			3					1	2	7	26	1								
Paratanytarsus																			5	1
Parochlus																				1
Pentaneura	2	3	4							1			1		4		1		19	46
Pericoma/ Telmatoscopus														1						
Perlinodes aurea	1															1				
Phaenopsectra	1	1	1						2						1				3	
Pisidium			1	14	64				9	6	4		6			1	7	17		
Platysmittia																			4	
Polycentropus			1					3	1			1	3		2			1	7	2
Polypedilum				1			1		3	1			1					1		
Potthastia gaedii group		1				12	1													
Potthastia longimana group													3				1			
Probezzia									1											
Procloeon	1	1																		
Prostoma	7															7				
Protzia	1		3							3		1								
Psectrocladius						1													1	
Pseudochironomus						1									1					
Pteronarcys princeps			2					1	3		2			1						
Rhabdomastix																				2
Rheocricotopus		1	1					4	6	1					4				1	
Rheotanytarsus	7	51						1					1	1	2	10	1	1		1
Rhithrogena	4	2												6	1	5				
Rhyacophila angelita group															1					
Rhyacophila arnaudi														2		1				
Rhyacophila betteni group		1	4			7	4	3	1	6	7	5	3	5						1
Rhyacophila brunnea group			2	6	2		1			1	1	3	10				1	1	1	
Rhyacophila grandis group			2																	
Rhyacophila hyalinata group												2		12						
Rhyacophila sibirica group								13	6	3	1		2							
Sanfilippodytes										1										
Sialis								1							2				5	1
Sierraperla cora											1									
Simulium	16	36	20	3	21	10	5	2		15	5	4	2	8	23	76	14	19	9	4
Skwala				2	3										1		1		3	3
Soyedina			23					6	5	20	24	4	1							
Sperchon	2	2	4							1		1			2			1	2	3
Sperchonopsis	1											2	1						1	1
Stempellina										1										
Stempellinella		1	7									9							2	
Stenocolus scutellaris																1				
Stygothrombium		1						1	1											
Susulus venustus								1												
Sweltsa	1	5	1	52	56	19	7	13	6			1	2	2	13	2	10	5	2	2
Synorthocladius			3					2	3						10				2	
Tabanidae									1											
Taeniopterygidae	3						4							2	8					1
Tanytarsus	9	9		1	1	4	1	1	2			5	2		4		1	1	14	3

Final SAFIT ID	AR-B1 RWB	AR-B2 RWB	BU-B1 RWB	CA-B1 RWB	CA-B1 TRC	EC-B1 RWB	EC-B1 TRC	ES-B1 RWB	ES-B2 RWB	NN-B1 RWB	NN-B2 RWB	OG-B1 RWB	PY-B1 RWB	SB-B1 RWB	SH-B1 RWB	SO-B1 RWB	SV-B2 RWB	SV-B2 TRC	WC-B1 RWB	WC-B1 TRC
Testudacarus					2															
Thaumaleidae											1									
Thienemanniella																1				
Thienemannimyia group				4	3	7	3	2	4				3	1				1	14	3
Tipula		3	1																4	12
Torrenticola	3	2		2	1	9	4	5	3			6		8	1	5	2	7	1	8
Trichoclinocera															1					
Turbellaria				11	12		1	5	5	2	2	6		1						
Tvetenia bavarica group		4	2	4	4	2	6	6	3		1	9	3	5			1	1		
Utaxatax										2	1									
Wiedemannia													1	1				5		
Wormaldia		1	2					4	17		1									
Yoraperla		1			1		1			1		1	8		1					
Zaitzevia parvula	4	2		1						1			3	10	4	6	19	27	1	
Zaitzevia posthonia													2							
Zapada cinctipes	2	36	17	25	32	50	81	32	13	72	32	20	100	42	22		123	122	2	7
Zapada columbiana	1																			
Zapada frigida				1		1	1						1	1	2					
Zapada oregonensis group		6	21	11	24	1	2	27	5	31	11	16	5		5					
Zavrelimyia		1	15					4	7	1	2	1			2				64	63

Appendix B

2022 Site Photographs

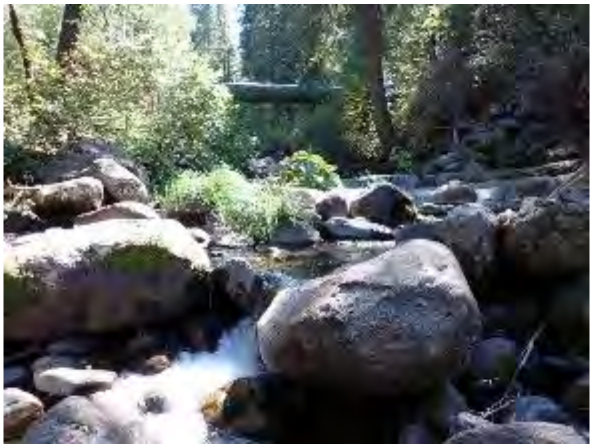

FIGURE AR-B1-1. Looking upstream from the bottom transect (A) at Site AR-B1

FIGURE AR-B1-2. Looking downstream from the bottom transect (A) at Site AR-B1

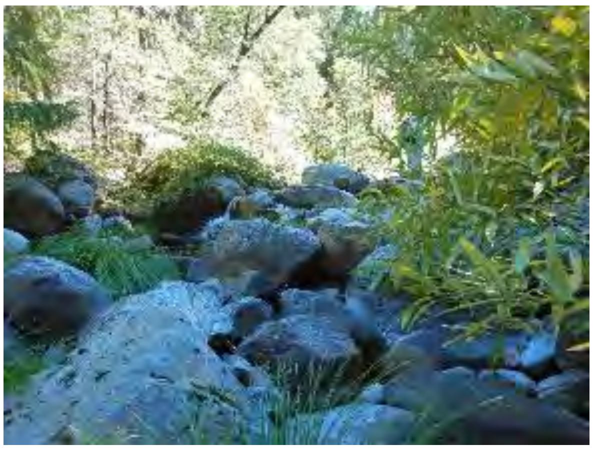

FIGURE AR-B1-3. Looking upstream from the middle transect (F) at Site AR-B1

FIGURE AR-B1-4. Looking downstream from the middle transect (F) at Site AR-B1

FIGURE AR-B1-5. Looking upstream from the upper transect (K) at Site AR-B1

FIGURE AR-B1-6. Looking downstream from the upper transect (K) at Site AR-B1

FIGURE AR-B2-1. Looking upstream from the bottom transect (A) at Site AR-B2

FIGURE AR-B2-2. Looking downstream from the bottom transect (A) at Site AR-B2

FIGURE AR-B2-3. Looking upstream from the middle transect (F) at Site AR-B2

FIGURE AR-B2-4. Looking downstream from the middle transect (F) at Site AR-B2

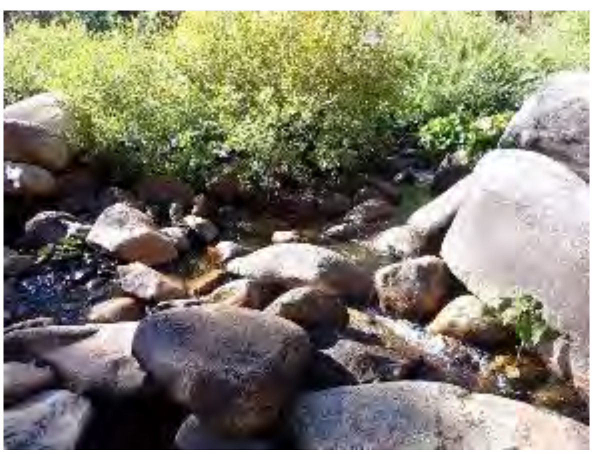

FIGURE AR-B2-5. Looking upstream from the upper transect (K) at Site AR-B2

FIGURE AR-B2-6. Looking downstream from the upper transect (K) at Site AR-B2

FIGURE BU-B1-1. Looking upstream from the bottom transect (A) at Site BU-B1

FIGURE BU-B1-2. Looking downstream from the bottom transect (A) at Site BU-B1

FIGURE BU-B1-3. Looking upstream from the middle transect (F) at Site BU-B1

FIGURE BU-B1-4. Looking downstream from the middle transect (F) at Site BU-B1

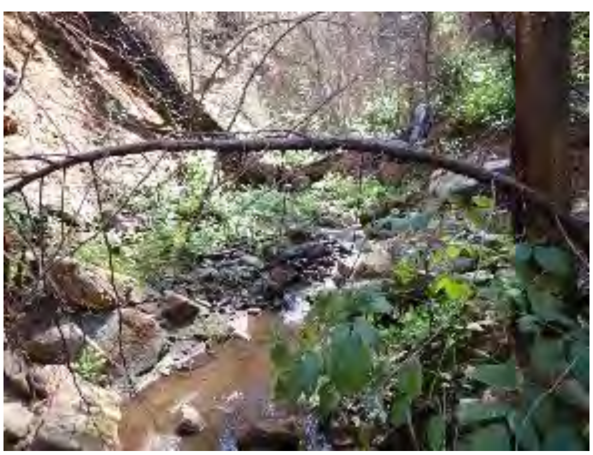

FIGURE BU-B1-5. Looking upstream from the upper transect (K) at Site BU-B1

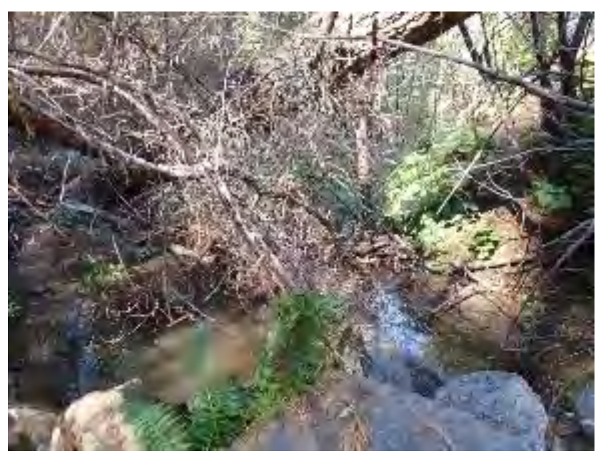

FIGURE BU-B1-6. Looking downstream from the upper transect (K) at Site BU-B1

FIGURE BU-B2-1. Looking upstream from the bottom transect (A) at Site BU-B2

FIGURE BU-B2-2. Looking downstream from the bottom transect (A) at Site BU-B2

FIGURE BU-B2-3. Looking upstream from the middle transect (F) at Site BU-B2

FIGURE BU-B2-4. Looking downstream from the middle transect (F) at Site BU-B2

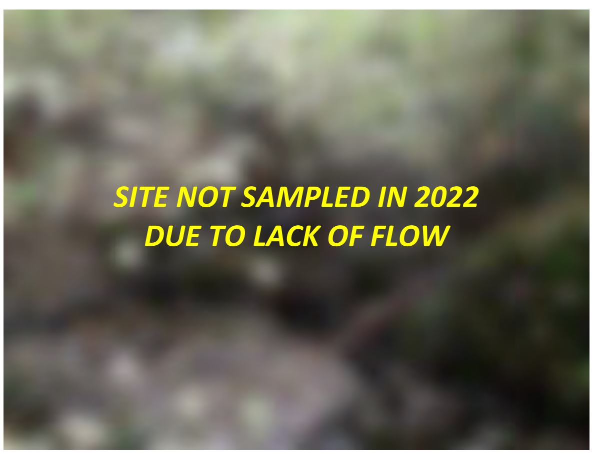

FIGURE BU-B2-5. Looking upstream from the upper transect (K) at Site BU-B2

FIGURE BU-B2-6. Looking downstream from the upper transect (K) at Site BU-B2

FIGURE CA-B1-1. Looking upstream from the bottom transect (A) at Site CA-B1

FIGURE CA-B1-2. Looking downstream from the bottom transect (A) at Site CA-B1

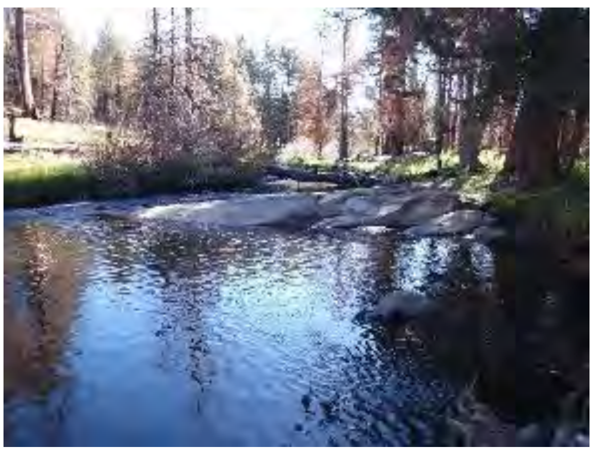

FIGURE CA-B1-3. Looking upstream from the middle transect (F) at Site CA-B1

FIGURE CA-B1-4. Looking downstream from the middle transect (F) at Site CA-B1

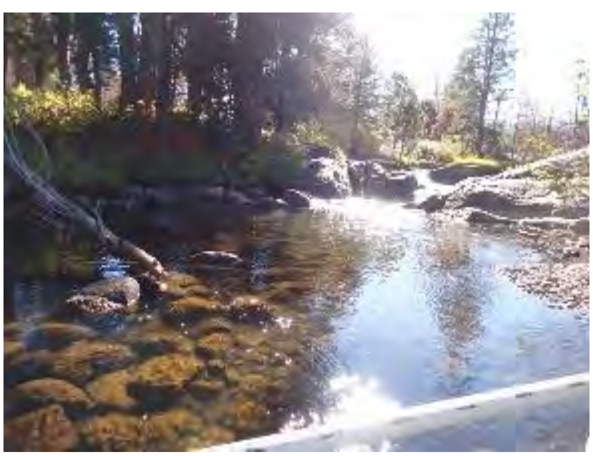

FIGURE CA-B1-5. Looking upstream from the upper transect (K) at Site CA-B1

FIGURE CA-B1-6. Looking downstream from the upper transect (K) at Site CA-B1

FIGURE EC-B1-1. Looking upstream from the bottom transect (A) at Site EC-B1

FIGURE EC-B1-2. Looking downstream from the bottom transect (A) at Site EC-B1

FIGURE EC-B1-3. Looking upstream from the middle transect (F) at Site EC-B1

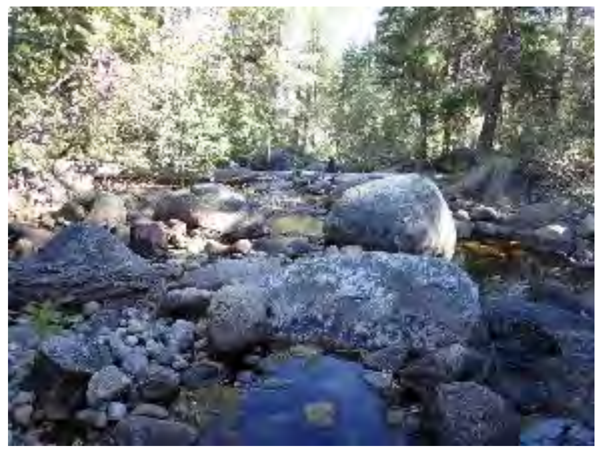

FIGURE EC-B1-4. Looking downstream from the middle transect (F) at Site EC-B1

FIGURE EC-B1-5. Looking upstream from the upper transect (K) at Site EC-B1

FIGURE EC-B1-6. Looking downstream from the upper transect (K) at Site EC-B1

FIGURE ES-B1-1. Looking upstream from the bottom transect (A) at Site ES-B1

FIGURE ES-B1-2. Looking downstream from the bottom transect (A) at Site ES-B1

FIGURE ES-B1-3. Looking upstream from the middle transect (F) at Site ES-B1

FIGURE ES-B1-4. Looking downstream from the middle transect (F) at Site ES-B1

FIGURE ES-B1-5. Looking upstream from the upper transect (K) at Site ES-B1

FIGURE ES-B1-6. Looking downstream from the upper transect (K) at Site ES-B1

FIGURE ES-B2-1. Looking upstream from the bottom transect (A) at Site ES-B2

FIGURE ES-B2-2. Looking downstream from the bottom transect (A) at Site ES-B2

FIGURE ES-B2-3. Looking upstream from the middle transect (F) at Site ES-B2

FIGURE ES-B2-4. Looking downstream from the middle transect (F) at Site ES-B2

FIGURE ES-B2-5. Looking upstream from the upper transect (K) at Site ES-B2

FIGURE ES-B2-6. Looking downstream from the upper transect (K) at Site ES-B2

FIGURE NN-B1-1. Looking upstream from the bottom transect (A) at Site NN-B1

FIGURE NN-B1-2. Looking downstream from the bottom transect (A) at Site NN-B1

FIGURE NN-B1-3. Looking upstream from the middle transect (F) at Site NN-B1

FIGURE NN-B1-4. Looking downstream from the middle transect (F) at Site NN-B1

FIGURE NN-B1-5. Looking upstream from the upper transect (K) at Site NN-B1

FIGURE NN-B1-6. Looking downstream from the upper transect (K) at Site NN-B1

FIGURE NN-B2-1. Looking upstream from the bottom transect (A) at Site NN-B2

FIGURE NN-B2-2. Looking downstream from the bottom transect (A) at Site NN-B2

FIGURE NN-B2-3. Looking upstream from the middle transect (F) at Site NN-B2

FIGURE NN-B2-4. Looking downstream from the middle transect (F) at Site NN-B2

FIGURE NN-B2-5. Looking upstream from the upper transect (K) at Site NN-B2

FIGURE NN-B2-6. Looking downstream from the upper transect (K) at Site NN-B2

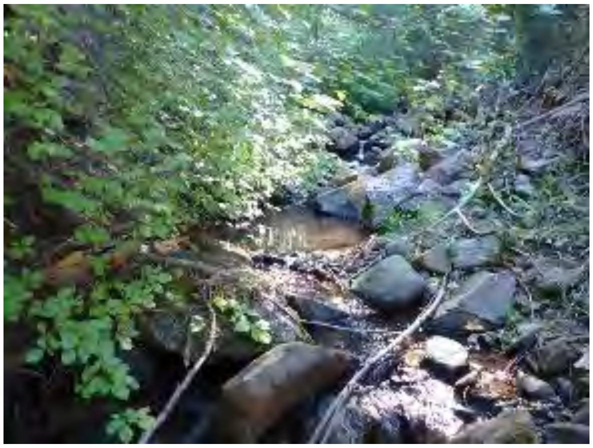

FIGURE OG-B1-1. Looking upstream from the bottom transect (A) at Site OG-B1

FIGURE OG-B1-2. Looking downstream from the bottom transect (A) at Site OG-B1

FIGURE OG-B1-3. Looking upstream from the middle transect (F) at Site OG-B1

FIGURE OG-B1-4. Looking downstream from the middle transect (F) at Site OG-B1

FIGURE OG-B1-5. Looking upstream from the upper transect (K) at Site OG-B1

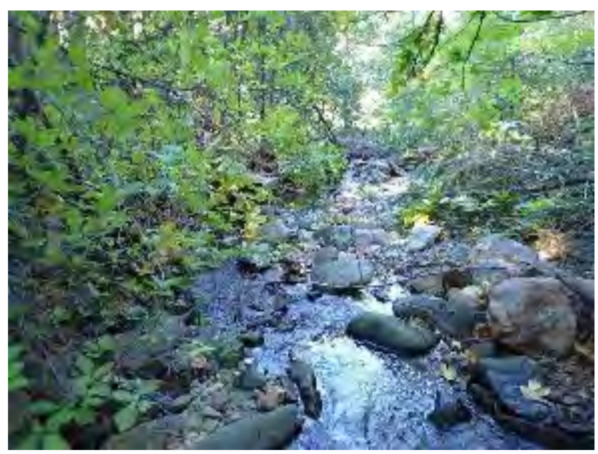

FIGURE OG-B1-6. Looking downstream from the upper transect (K) at Site OG-B1

FIGURE OG-B2-1. Looking upstream from the bottom transect (A) at Site OG-B2

FIGURE OG-B2-2. Looking downstream from the bottom transect (A) at Site OG-B2

FIGURE OG-B2-3. Looking upstream from the middle transect (F) at Site OG-B2

FIGURE OG-B2-4. Looking downstream from the middle transect (F) at Site OG-B2

FIGURE OG-B2-5. Looking upstream from the upper transect (K) at Site OG-B2

FIGURE OG-B2-6. Looking downstream from the upper transect (K) at Site OG-B2

FIGURE PY-B1-1. Looking upstream from the bottom transect (A) at Site PY-B1

FIGURE PY-B1-2. Looking downstream from the bottom transect (A) at Site PY-B1

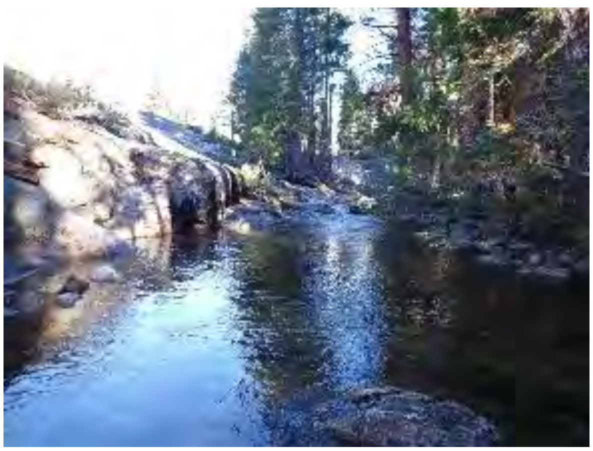

FIGURE PY-B1-3. Looking upstream from the middle transect (F) at Site PY-B1

FIGURE PY-B1-4. Looking downstream from the middle transect (F) at Site PY-B1

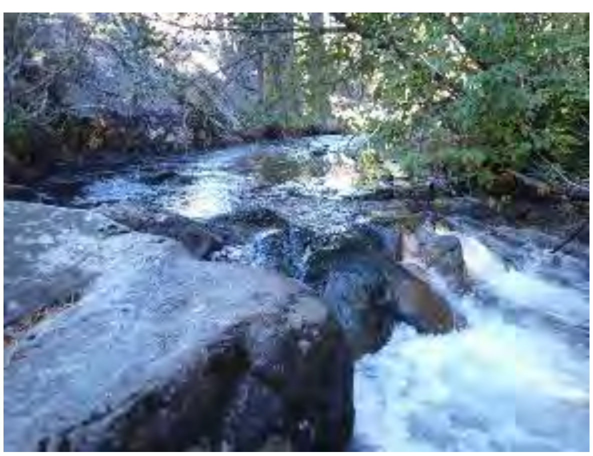

FIGURE PY-B1-5. Looking upstream from the upper transect (K) at Site PY-B1

FIGURE PY-B1-6. Looking downstream from the upper transect (K) at Site PY-B1

FIGURE SB-B1-1. Looking upstream from the bottom transect (A) at Site SB-B1

FIGURE SB-B1-2. Looking downstream from the bottom transect (A) at Site SB-B1

FIGURE SB-B1-3. Looking upstream from the middle transect (F) at Site SB-B1

FIGURE SB-B1-4. Looking downstream from the middle transect (F) at Site SB-B1

FIGURE SB-B1-5. Looking upstream from the upper transect (K) at Site SB-B1

FIGURE SB-B1-6. Looking downstream from the upper transect (K) at Site SB-B1

FIGURE SH-B1-1. Looking upstream from the bottom transect (A) at Site SH-B1

FIGURE SH-B1-2. Looking downstream from the bottom transect (A) at Site SH-B1 (from 2017)

FIGURE SH-B1-3. Looking upstream from the middle transect (F) at Site SH-B1

FIGURE SH-B1-4. Looking downstream from the middle transect (F) at Site SH-B1

FIGURE SH-B1-5. Looking upstream from the upper transect (K) at Site SH-B1

FIGURE SH-B1-6. Looking downstream from the upper transect (K) at Site SH-B1

FIGURE SO-B1-1. Looking upstream from the bottom transect (A) at Site SO-B1

FIGURE SO-B1-2. Looking downstream from the bottom transect (A) at Site SO-B1

FIGURE SO-B1-3. Looking upstream from the middle transect (F) at Site SO-B1

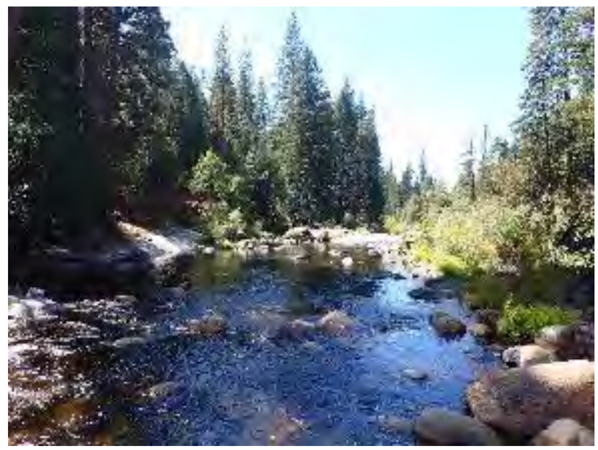

FIGURE SO-B1-4. Looking downstream from the middle transect (F) at Site SO-B1

FIGURE SO-B1-5. Looking upstream from the upper transect (K) at Site SO-B1

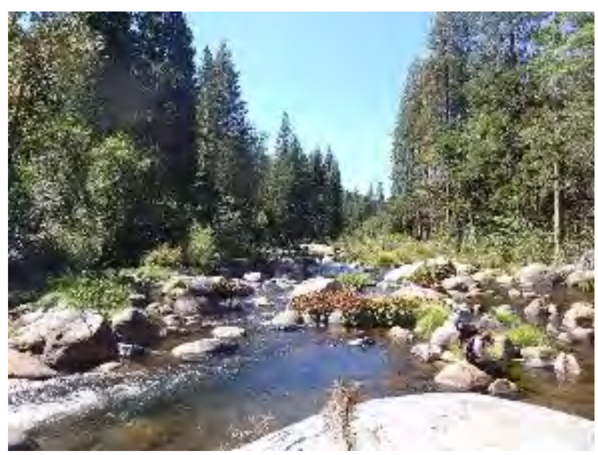

FIGURE SO-B1-6. Looking downstream from the upper transect (K) at Site SO-B1

FIGURE SV-B2-1. Looking upstream from the bottom transect (A) at Site SV-B2

FIGURE SV-B2-2. Looking downstream from the bottom transect (A) at Site SV-B2

FIGURE SV-B2-3. Looking upstream from the middle transect (F) at Site SV-B2

FIGURE SV-B2-4. Looking downstream from the middle transect (F) at Site SV-B2

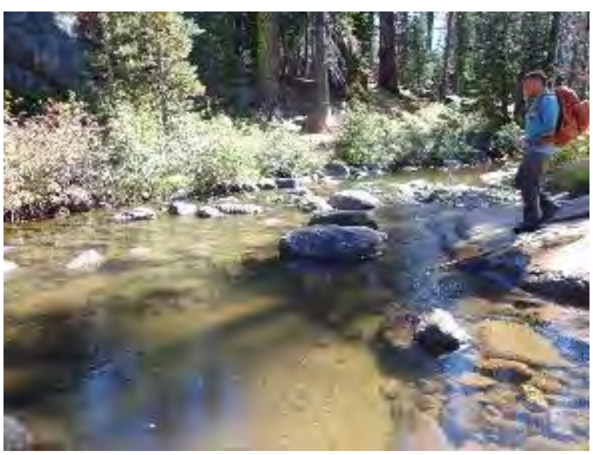

FIGURE SV-B2-5. Looking upstream from the upper transect (K) at Site SV-B2

FIGURE SV-B2-6. Looking downstream from the upper transect (K) at Site SV-B2

FIGURE WC-B1-1. Looking upstream from the bottom transect (A) at Site WC-B1

FIGURE WC-B1-2. Looking downstream from the bottom transect (A) at Site WC-B1

FIGURE WC-B1-3. Looking upstream from the middle transect (F) at Site WC-B1

FIGURE WC-B1-4. Looking downstream from the middle transect (F) at Site WC-B1

FIGURE WC-B1-5. Looking upstream from the upper transect (K) at Site WC-B1

FIGURE WC-B1-6. Looking downstream from the upper transect (K) at Site WC-B1

Appendix C

Copies of 2022 Field Datasheets

Available upon request