Attachment 1
Habitat Mapping Methods

Attachment 1
Study 3.3 – Instream Flow Study
Habitat Mapping Methods

1.0 Introduction

The purpose of the habitat mapping effort is to develop specific, comprehensive, and detailed information on aquatic habitat and channel morphology characteristics of the Bear River downstream of the Project to the confluence with the Feather River. There has been no coordinated approach to habitat map and little is known about the features of the channel and associated habitat. Therefore, there are significant gaps in existing data for the purposes of assessing habitat quantity, quality, and distribution in the stream reaches affected.

SSWD completed some initial habitat mapping and channel characterization prior to filing the NOI and PAD because development of aquatic study plans required a basic understanding of the general physical and biological character of the Bear River. Additional information is needed that extends along the entire Bear River.

2.0 Methods

Habitat mapping generally will follow standard methods similar to those applied in other recent relicensings in California. Habitat will be mapped using ground-based surveys. The River is generally very low gradient and flows through Quaternary alluvium so no reach breaks were noted. It is also confined by levees and highly modified from historical mining, redirection, dredging, diversions, and agricultural development.

The stream longitudinal profile was measured using maps available from Terrain Navigator Pro© (V. 7) software. Distance between contour lines was measured and a longitudinal profile was created. Map-based gradient, while an estimate, is often a good indicator of stream energy and process (Figure 1). The map gradient averages 0.1% and ranges between 0.3% just below the dam to almost flat between RM 13 and 15.5 (2 miles above Highway 65). The slope is fairly consistent throughout the reach.

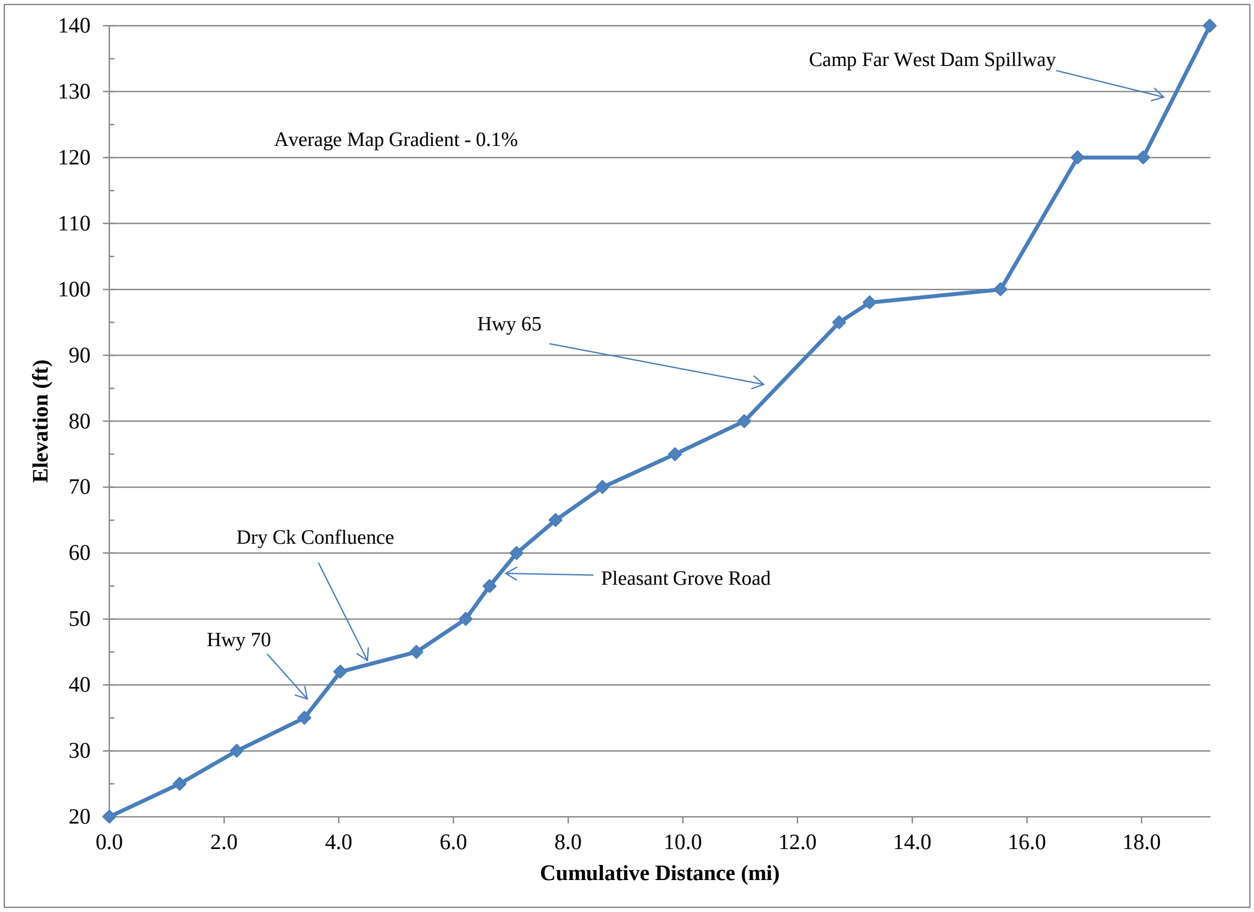

Figure 1. Longitudinal profile (based on 1:24k topographic map) of Bear River from junction with Feather River to Camp Far West Dam.

Initial field data were collected in June 2015 when discharge was controlled by SSWD at 25 cfs to maximize access and safety during fieldwork and evaluate habitat composition during the seasonal period of greatest habitat heterogeneity. Anticipating habitat based on differences in discharge is too subjective so the habitat calls are made at the survey low-flow. Further mapping will be done in the low flow period of 2016.

2.1 Study Area

Habitat mapping will be completed in the Bear River downstream of the non-Project diversion dam to the confluence with the Feather River. The backwater pond between Camp Far West Dam and the non-Project diversion dam will be noted. In 2015, RM 16.3 to 16.9, 12.1 to 12.4, and 6.4 to 7.1 was mapped in the downstream and upstream direction while wading and walking. The 4.7 mile section between Hwy 65 and the Pleasant Grove Bridge was mapped in the downstream direction while floating inflatable kayaks. Additional mapping will be completed using similar methods. No tributaries will be mapped due to dry channels, vegetation (e.g., no flow, and channels dominated by macrophytes), and private ownership.

2.2. Meso-Habitat and Channel Classification

A three-tiered habitat mapping classification system developed by Hawkins et al. (1993) will be used to assist in the identification of individual habitat units in the field. Level III categories are generally modified/adopted from McCain et al. (1990). Figure 2 shows the relationship among the three levels. At the broadest level, Level I categorizes habitats as “fast water” and “slow water.” In Level II, fast water is subdivided into two categories: turbulent and non-turbulent; slow water is also subdivided into two categories: scour pool and dammed pool.

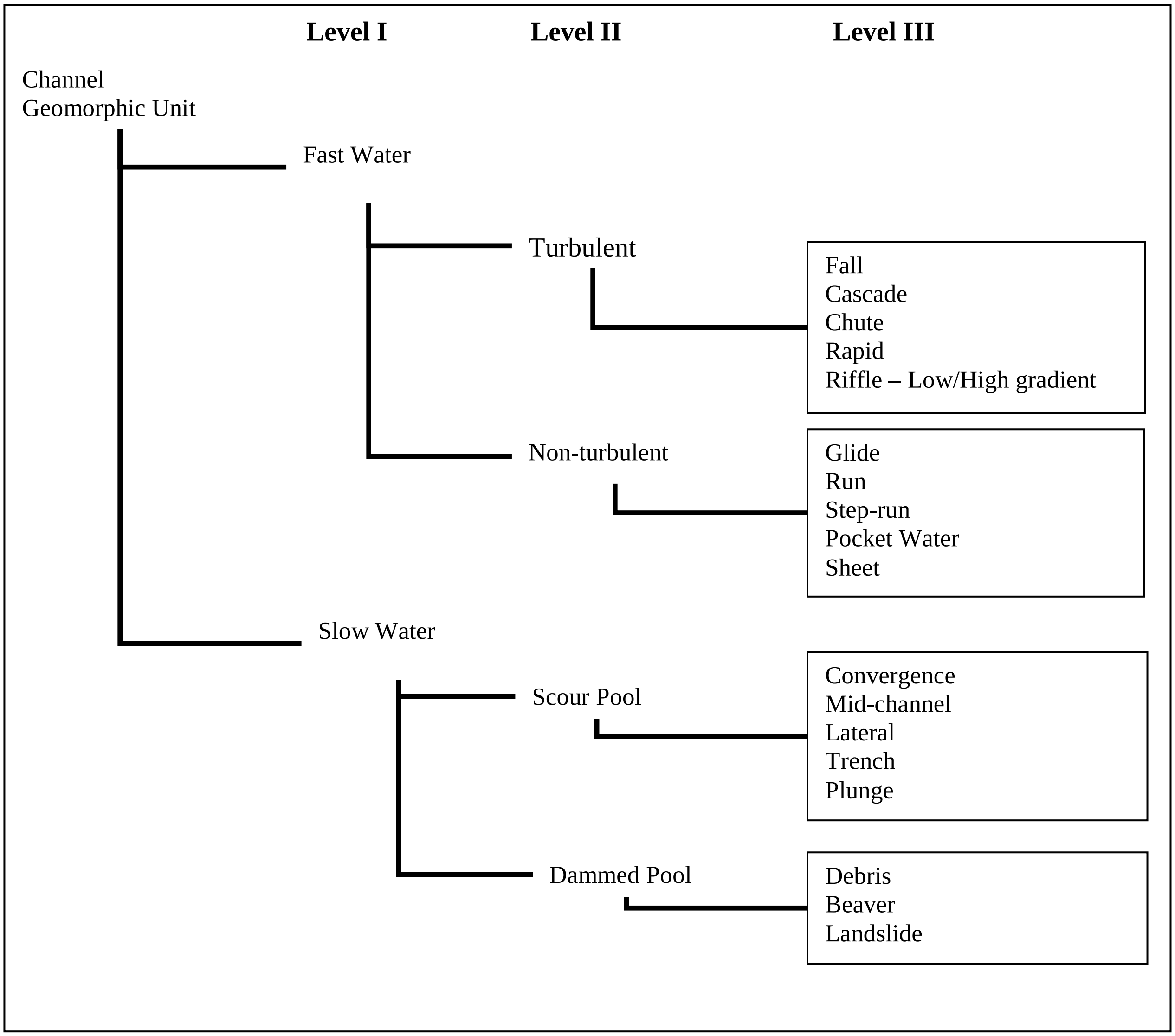

Figure 2. Key to habitat types used in the lower Bear River.

Habitat mapping will use methods developed by Hawkins et al. (1993), McCain et al. (1990) and Flosi and Reynolds (1994). Each distinct habitat unit will be numbered consecutively in the direction of travel during the day of the mapping and for an individual section. Different days or sections will also be numbered consecutively beginning with Habitat Mapping Unit 1 (HMU1) and later combined with previous mapping for data analysis. Habitat type descriptions are listed in Table 1. Any pools created by vegetation, beavers, artificial berms, or other strong downstream control will be noted. Additional data (length, width, height, and function) will be collected for concentrations of giant cane (*Arundo donax*). The base map of the Bear River will be loaded onto a mobile device (e.g., tablet or laptop) and be utilized along with data collection software that can collect features (e.g., polygons, lines, areas, points) from an external GPS source. All cane concentrations will be collected with a differential GPS antenna capable of 1 meter or better accuracy.

Table 1. Habitat types to be used in mapping for the South Sutter Water District Bear River (Adapted from McCain et al. 1990, Armantrout 1998, Payne 1992, McMahon et al. 1996, and Hawkins et al. 1993).

I. Fast Water:			Riffles, rapid, shallow stream sections with steep water surface gradient.
	A. Turbulent:		Channel units having swift current, high channel roughness (large substrate), steep gradient, and non-laminar flow and characterized by surface turbulence.
		1. Fall:	Steep vertical drop in water surface elevation. Generally not modelable.
		2. Cascade:	Series of alternating small falls and shallow pools; substrate usually bedrock and boulders. Gradient high (more than 4%). Generally not modelable.
		3. Chute:	Narrow, confined channel with rapid, relatively unobstructed flow and bedrock substrate.
		4. Rapid:	Deeper stream section with considerable surface agitation and swift current; large boulder and standing waves often present. Generally not modelable.
		5. Riffles:	Shallow, lower-gradient channel units with moderate current velocity and some partially exposed substrate (usually cobble). • Low gradient — Shallow with swift flowing, turbulent water. Partially exposed substrate dominated by cobble. Gradient moderate (less than 4%). • High gradient — moderately deep with swift flowing, turbulent water. Partially exposed substrate dominated by boulder. Gradient steep (greater than 4%). Generally not modelable.
	B. Non-turbulent:		Channel units having low channel roughness, moderate gradient, laminar flow, and lack of surface turbulence.
		1. Sheet:	Shallow water flowing over smooth bedrock.
		2. Run / Glide:	Shallow (glide) to deep (run) water flowing over a variety of different substrates.
		3. Step Run	A sequence of runs separated by short riffle steps. Substrates are usually cobble and boulder dominated.
		4. Pocket Water:	Swift flowing water with large boulder or bedrock obstructions creating eddies, small backwater, or scour holes. Gradient low to moderate.
II. Slow Water:			Pools; slow, deep stream sections with nearly flat water surface gradient.
	A. Scour Pool:		Formed by scouring action of current.
		1. Trench:	Formed by scouring of bedrock.
		2. Mid-channel:	Formed by channel constriction or downstream hydraulic control.
		3. Convergence	Formed where two stream channels meet.
		4. Lateral:	Formed where flow is deflected by a partial channel obstruction (streambank, rootwad, log, or boulder).
		5. Plunge:	Formed by water dropping vertically over channel obstruction.
	B. Dammed Pool:		Water impounded by channel blockage.
		1. Debris:	Formed by rootwads and logs.
		2. Beaver:	Formed by beaver dam.
		3. Landslide:	Formed by large boulders.
		4. Backwater:	Formed by obstructions along banks (Recorded as a comment or note to mapping).
		5. Abandoned Channel:	Formed along main channel, usually associated with gravel bars (Not part of the main active channel - Recorded as a comment or note to mapping).

2.3 Habitat Mapping

Ground habitat mapping will be conducted on foot by teams of two individuals. Habitat units will be designated using the habitat types described in Table 1. Habitat units will be separately identified where the unit length is at least equal to the active channel width (McCain et al. 1990, Flosi and Reynolds 1994), or if the unit is otherwise distinctive. Figure 2 is a copy of the field form used for the mapping. Teams record the length and width of each habitat type unit using a laser range finder. Mapping will be contiguous (i.e., each habitat unit abuts the next unit, except for split channels, which will have the length measured but individual habitat units within each split will not be mapped but may be identified). The beginning and ending of the mapped section, and every fifth mapped unit, and every tenth characterized habitat unit, will have Global Positioning System (GPS) reading recorded in UTM NAD83 datum; locations may also be added to the field laptop as described above in Section 2.2 for identifying giant cane concentrations. Table 2 provides the definitions and description of the data to be collected that would be entered in Figure 3.

STREAM HABITAT TYPING SURVEY DATA (Camp Far West - South Sutter Water District)

Data Sheet # ______________

Stream/Reach/Subreach:____ Page __________ of _________

Team: ____ Date ________________________

UTM: ____**NAD 83 (Habitat unit No**_______**)** PM ___________________________________ Map Gradient:__________

Habitat Unit #																				
Habitat Type [1]	**FALL**	**CAS**	**CHU**	**RAP**	**FALL**	**CAS**	**CHU**	**RAP**	**FALL**	**CAS**	**CHU**	**RAP**	**FALL**	**CAS**	**CHU**	**RAP**	**FALL**	**CAS**	**CHU**	**RAP**
	HGR	**LGR**	**GLI**	**RUN**	**HGR**	**LGR**	**GLI**	**RUN**	**HGR**	**LGR**	**GLI**	**RUN**	**HGR**	**LGR**	**GLI**	**RUN**	**HGR**	**LGR**	**GLI**	**RUN**
	STEP	**POW**	**SHT**	**COP**	**STEP**	**POW**	**SHT**	**COP**	**STEP**	**POW**	**SHT**	**COP**	**STEP**	**POW**	**SHT**	**COP**	**STEP**	**POW**	**SHT**	**COP**
*note if dammed pool	**MCP**	**LAP**	**TRP**	**PLP**	**MCP**	**LAP**	**TRP**	**PLP**	**MCP**	**LAP**	**TRP**	**PLP**	**MCP**	**LAP**	**TRP**	**PLP**	**MCP**	**LAP**	**TRP**	**PLP**
Length (ft)																				
Est. Avg. Width (ft)																				
Est. Avg. Pool Depth (ft)																				
Max. Pool Depth (ft)																				
Pooltail Embedded %																				
Significant Cover?[2]	**INSIGNIF**		**BLDR**		**INSIGNIF**		**BLDR**		**INSIGNIF**		**BLDR**		**INSIGNIF**		**BLDR**		**INSIGNIF**		**BLDR**	
	VEG		**WOOD**		**VEG**		**WOOD**		**VEG**		**WOOD**		**VEG**		**WOOD**		**VEG**		**WOOD**	
SUBSTRATE COMPOSITION																				
Dominant Substrate	**BED**	**BLD**		**COB**	**BED**	**BLD**		**COB**	**BED**	**BLD**		**COB**	**BED**	**BLD**		**COB**	**BED**	**BLD**		**COB**
	GRV	**SND**		**SLT**	**GRV**	**SND**		**SLT**	**GRV**	**SND**		**SLT**	**GRV**	**SND**		**SLT**	**GRV**	**SND**		**SLT**
Subdominant Substrate	**BED**	**BLD**		**COB**	**BED**	**BLD**		**COB**	**BED**	**BLD**		**COB**	**BED**	**BLD**		**COB**	**BED**	**BLD**		**COB**
	GRV	**SND**		**SLT**	**GRV**	**SND**		**SLT**	**GRV**	**SND**		**SLT**	**GRV**	**SND**		**SLT**	**GRV**	**SND**		**SLT**
Dominant Bank Substrate	**BED**	**BLD**		**COB**	**BED**	**BLD**		**COB**	**BED**	**BLD**		**COB**	**BED**	**BLD**		**COB**	**BED**	**BLD**		**COB**
	GRV	**SND**		**SLT**	**GRV**	**SND**		**SLT**	**GRV**	**SND**		**SLT**	**GRV**	**SND**		**SLT**	**GRV**	**SND**		**SLT**
Length of LB and RB Exposed Banks (feet)																				
Confinement[4]																				
Unit Flagged/ Labeled? (Y/N)																				
Tributary Inflow in cfs																				
Landmarks or photos																				
	#	Diameter class		Length class	#	Diameter class		Length class	#	Diameter class		Length class	#	Diameter class		Length class	#	Diameter class		Length class
Large Woody Debris[5] within bankful width		|				|				|				|				|		
		|				|				|				|				|		
		|				|				|				|				|		
No. of LWD Pieces within wetted width																				
Fish Migration Barrier [6] **(y/n)?**																				
Giant Cane Accumulation (length, width, ht)																				
Giant cane function																				
Comments / Observations: Fish? Wildlife? Amphibs? Backwater or side chan. amphib habitat? Riparian? Landmarks, Photo #s, Etc.																				

[1] **FALL** = Falls, **CAS** = Cascade, **CHU** = Chute, **RAP** = Rapid, **GLI** = Glide, **RUN** = Run, **STEP** = Step Run, **HGR** = High Gradient Riffle (>4%), **LGR** = Low Gradient Riffle, **POW** = Pocket Water, **SHT** = Sheetflow ;
Pools: COP = Convergence, **MCP** = mid-channel pool, **LAP** = Lateral, **TRP** = Trench, **PLP** = Plunge
The minimum unit length should be 1x active channel width, unless there is something notable or unique about it.

[2] Note if cover is a significant or dominant feature of the unit:
(e.g., logs in stream, lots of boulders, >25% surface area has instream or low overhanging vegetation, etc.) **Q/C initials:** ______

[4] Channel Confinement: **1**=Confined Shallow; **2**=Confined Deep; **3**=Moderate Confined (<2x wetted channel width); **4**=Unconfined (>= 2 wetted channel widths)

[5] Criteria for LWD is:any downed wood at least partially within bankfull width of channel, exceeding 3' length, minimum diameter of 4" at the large end
Size classes: 4**-12",** 12**-24",** 24**-36",or** 36**"+ x** 3**-25',** 25**-50',** 50**-75',** 75**'+** (ie. 4 | 25 = 4-12", 25-50').
Key pieces (longer than 1/2 bankful, or modify channel morph or hab) mapped on IPAD incl. l, d at large end, rootwad?, jam?, function.

[6] Waterfalls, high velocity chutes or cascades at approx bankful flows. NOTE VERTICAL DROP and IF CONDITIONAL or PERMANENT

Notes regarding access points (road condition, bridge crossings, trails, etc.)

Figure 3. Field form used for ground-based habitat mapping.

Table 2. Description of data collected during habitat mapping.

Stream/Reach	Note on every data sheet
Team	Note initials
UTM	Get UTM every 5th unit (NAD 83) - note if at top or bottom or unit
PM & Map Gradient	Note parent material in assessed reach from geologic map; measure gradient from Terrain Nav Pro (office, before or after).
Habitat Unit #	Numbered sequentially, usually from downstream to upstream. Note if this is not the case
Habitat Type	Circle one of the choices, or write something else in if necessary (e.g., "marsh")
Length (ft)	Measured in feet, with hip chain. Clean up your string periodically
Estimated Average Width (ft)	Average width of entire unit, estimated by eye, periodically checking your estimates with a stadia rod or tape. Usually this is bankfull, but in this regulated system, bankfull is hard to describe. Define the “low-flow active channel” where there is hydraulic connectivity with the low flow channel. The boundary is usually marked by a distinctive change to vegetation more dominated by upland species.
Estimated Average Pool Depth (ft)	Where practical, take some measurements across the channel to help develop your estimate. Particularly interested in whether most of the pool is greater than 3 ft deep or not.
Estimated Maximum Pool Depth (ft)	Measure where practical. Estimate otherwise
Pooltail Embedded	Degree to which gravel or larger substrates are vertically embedded in sand or smaller substrates.
Significant Cover?	Is cover a dominant feature of the unit? Or is it just a bit of veg overhang on the edges, and some boulder substrate?
Dominant Substrate	Dominant particle size, by area. Silt, Sand (<2mm or 1/8"), Gravel (2-64mm or 1/8-2.5"), Cobble (64-256mm or 2.5-10"), Boulder (>0"), Bedrock
Subdominant Substrate	Next most dominant particle size, by area
Dominant Bank Substrate	Dominant particle size, by area. Silt, Sand (<2mm or 1/8"), Gravel (2-64mm or 1/8-2.5"), Cobble (64-256mm or 2.5-10"), Boulder (>10"), Bedrock - for the bank.
Bank Erosion (ft)	If stream banks are exposed and actively eroding and provided sediment to the active stream channel, quantify the total length on both the right and left banks (cumulative distance) as you are walking along and total in this column.
Confinement	Channel Confinement: 1=Confined Shallow (<4'); 2=Confined Deep (>4'); 3=Moderate Confined (<2x wetted channel width); 4=Unconfined (≥2 wetted channel widths)
Tributary Inflow in cfs	Estimate trib inflow, and get water temperature of the trib and mainstem upstream of it. GPS the location.
Unit Flagged/Labeled (Y/N)	Flag units frequently, near a unit boundary, indicating up and downstream unit numbers. Label with metal tags a little less frequently. Frequency depends on length of units. Think about a year from now, how far would you like to hike up and downstream with a group of stakeholders, looking for positive identification of which habitat unit you were in? Generally marking every 5 units is a good idea, but it really depends on how long the units are.
Landmarks	Note if landmarks are near unit, to help relocate it. e.g., trib confluences, roads, bridges, trails, unique rock formations or bedrock outcrops, large trees of an atypical species, man-made structures or quasi permanent debris, campgrounds, waterfalls, old car bodies, etc. "Big rock" or "tall tree" are not very helpful. GPS whenever possible and convenient, particularly if it has been awhile since you were at a good landmark. River Left or River Right is looking downstream.
Large Woody Debris (all or part within bankfull)	Note all of it along the way, by habitat unit number. “All pieces of wood lying within the bankfull width of the channel that exceed 3’ length, and 4” diameter at the large end. Wood must be both downed, and with a portion lying within the bankfull channel, and dead or dying to be considered LWD. Divide into average size classes, and tally the total number of LWD pieces in each size class." Size classes we will use are maximum diameters of 4-12 inches, 12-24, 24-36, or >36 inches. Lengths are 3-25, 25-50, 50-75 and >75 feet. These are total lengths, not just length in the channel. KEY LWD has to measure 1/2 bankfull width or longer or longer to be counted, so which length classes you might use are dependent on stream width (e.g., a 30ft wide stream would only use classes from 10-25ft on up, because the log would have to be at least 15ft to be counted). Additional key pieces may also be deposited in such a manner that alters channel morphology and/or aquatic habitat such as trapping sediment or altering flow pattern. Put key pieces on IPAD and add length, diameter at large end, if it has a root wad, and if it is part of a jam
Large Woody Debris (in wetted width)	Separate category: the number of pieces found within the wetted width
Fish Migration Barrier?	Note significant waterfalls or high velocity chutes, or any weirs or other man-made obstacles. Be sure to GPS it.
Giant cane accumulations	Estimate length, width, and height of giant cane accumulation. Place location on IPAD. Note function: creates backwater, forces pool/scour, traps and sorts sediment, creates side channel, or other (give description).
Comments/Observations	
Fish? Wildlife? Amphibians? Backwater or side channel amphibian habitat? Riparian? Etc.	Did you see some adult or juvenile fish? Idea of species? Any wildlife, such as deer, otters, amphibians, etc. that the wildlife biologists would be interested in? Are there wet backwater or side channel areas, especially with nearby or overhanging cover, that provides good habitat for amphibians, that the amphibian biologists might want to consider for TES species surveys? If you find good amphibian habitat, GPS it. Is the riparian vegetation notably lush, or wide, or are you in a marsh area?
QA/QC	Non-notetaker checks all columns and boxes after sheet is full to make sure everything is filled out.

The habitat attributes defined in Table 2 were quantified and recorded for each unit mapped. Two levels of ground-based mapping occurred:

- "Fully mapped" units which include quantified variables such as bankfull width, pool depth, substrate, large woody debris (LWD), substrate and bank material, etc. (Figure 2, Table 2)
- "Characterized" units which note the meso-habitat type, length, maximum pool depth, and some with photographs and/or comments of notable details such as the existence of frogs, access and mining activity.
- Along the entire length: LWD will be tallied, key LWD pieces will be marked on the IPAD, giant cane accumulations will be marked on the IPAD.

Habitat frequency will be based on the total length of each habitat type as a percentage of the entire length mapped.

Crews will identify potential barriers to upstream anadromous fish movement using professional judgment and used handheld GPS units to record the locations. Significant tributary junctions and potential fish passage barriers will be noted within the habitat unit in which they occur.

Photographs will be taken of each fully mapped and at many characterized habitat units, generally from the bank or center of channel looking upstream. Occasionally, photos may need to be taken from the banks or from the top of the unit looking downstream, but these differences will be noted. Photographs will be organized into a Word document and labeled with the original unit number; within the reach it was mapped. Summaries of the field data will be entered into an Excel data workbook and data will be summarized into tables and charts and provided electronically.

Prior to mapping, the USGS gage at Highway 65 was visited to determine the level of the water at a 1.5 and 2.5 year return frequency. These are return intervals generally associated with bankfull discharge in unregulated systems. However, in a regulated system, the low flow active channel is important hydrologically because the releases from the diversion dam control timing and volume. Since Camp Far West has no sluice gates, Bear River is also subject to higher and more frequent floods than generally seen in other regulated systems. The stage of the 1.5 and 2.5 year frequency floods was noted at the gage site and used in many of the habitat unit measurements to get an idea of where the frequent flood flows were reaching.

Constructed and natural levees have created an incised channel wherein the 1.5 yr. recurrence interval flows (6.45 ft. staff gage, 2,656 cfs, Figure 4) will flood the entire river plain. Figures 5, 6, and 7 show the low flow active channel (about 4.16 staff gage, 916 cfs), the 1.5 yr. stage (6.45 ft. staff gage, 2,656 cfs), and 2.5 yr. recurrence interval (11.45 staff gage, 7,894 cfs).

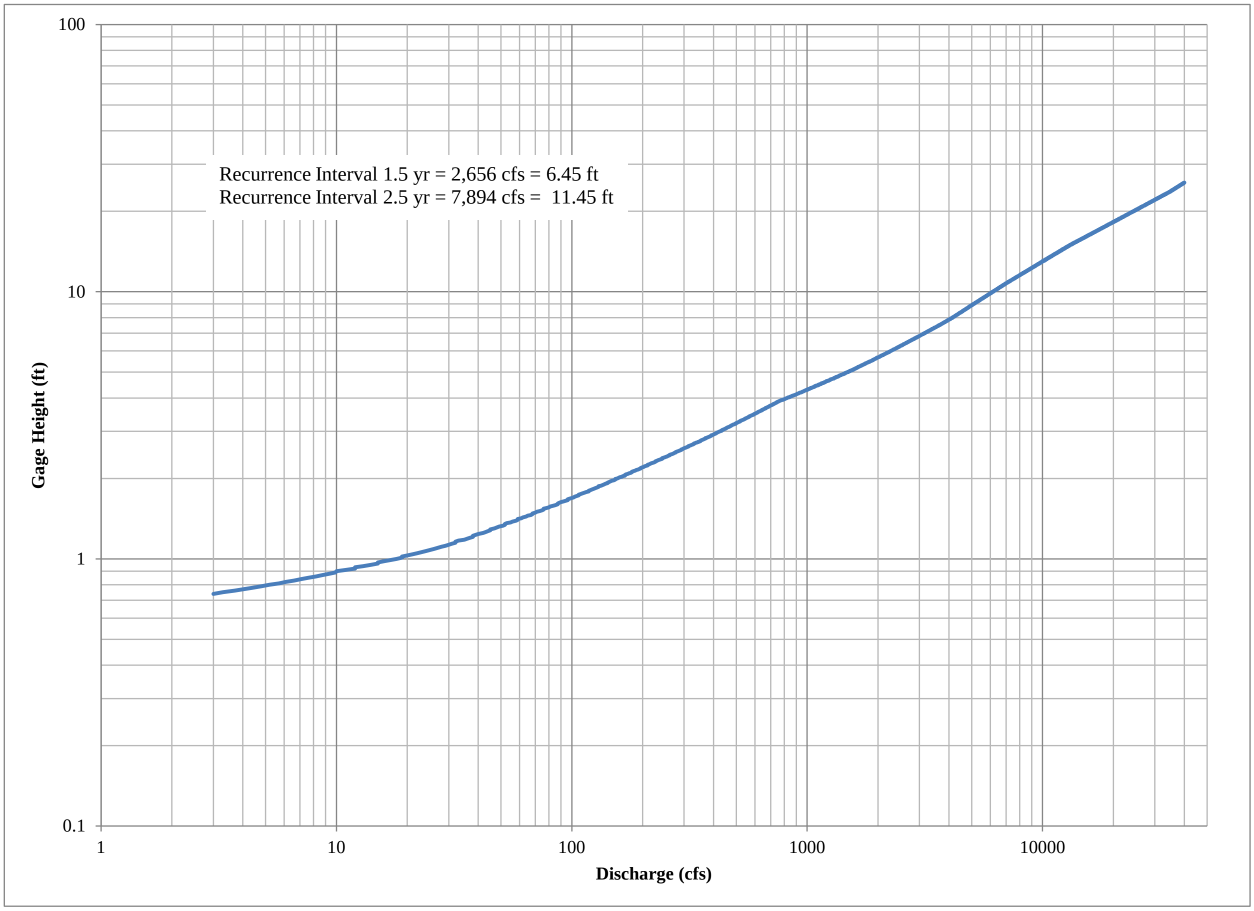

Figure 4. Rating curve for USGS Gage 11424000 near Wheatland at Highway 65 (RM 11.5) based on regulated flow data 1964-2015.

Figure 5. Bear River near Wheatland (RM 11.5, USGS gage 1142400). Stadia rod is being held at the "low flow active channel" where the vegetation transitions from hydric to more terrestrial types. Rough estimate of staff gage elevation is 4.16 ft. (916 cfs). Flow at gage on date of measurement (6-10-15) was 26 cfs.

Figure 6. Bear River near Wheatland (RM 11.5, USGS gage 1142400). Stadia rod is being held at the 1.5 yr. recurrence interval at staff gage elevation of 6.45 ft. (2,656 cfs).

Figure 7. Bear River near Wheatland (RM 11.5, USGS gage 1142400). Stadia rod is being held at the 2.5 yr. recurrence interval at staff gage elevation of 11.45 ft. (7,894 cfs).

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