



Trinity River Restoration Program

Draft 30-percent Design Report Sky Ranch Rehabilitation Project

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Prepared by:

TRRP Federal Design Group

US Bureau of Reclamation (USBR)
National Marine Fisheries Service (NMFS)

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Appendix A: Modeled Inundation Extents and Depths at 12 Discharge Levels

1 **1.0 Background and Purpose**

2 **1.1 Statutory Mandate**

3 In December 2000, the Secretary of the Interior signed a Record of Decision (USDOI 2000) for
4 the Trinity River Fishery Restoration Final Environmental Impact Statement/Report. This
5 decision recognized that restoration and maintenance of the Trinity River’s fishery resources
6 requires rehabilitating the river itself, and restoring the dynamic geomorphic processes that
7 maintain an aquatic ecosystem. Consequently, the ROD included five components to ensure
8 long-term restoration and maintenance of the Trinity River (USDOI 2000):
9

- 10 *1. Variable annual instream flows ranging from 369,000 acre-feet (af) in critically dry years to*
11 *815,000 af in extremely wet years;*
12 *2. Physical channel rehabilitation, including the removal of riparian berms and the establishment*
13 *of side channel habitat;*
14 *3. Sediment management, including the supplementation of spawning gravels below Lewiston dam*
15 *and reduction in fine sediments which degrade fish habitats;*
16 *4. Watershed restoration projects to reduce fine sediment production in the Basin and its*
17 *subsequent delivery to Trinity River aquatic resources;*
18 *5. Infrastructure improvements or modifications, including rebuilding or fortifying bridges and*
19 *addressing other structures affected by peak instream flows provided by the ROD.*
20

21 *“The ROD represents the culmination of over two decades of efforts aimed at understanding the*
22 *necessary instream flow and physical habitat restoration requirements in order to restore the*
23 *Trinity River anadromous fishery. Statutory requirements since 1955, based in large part upon the*
24 *federal government’s trust obligations to the Hoopa Valley and Yurok Tribes, require the*
25 *restoration and maintenance of the Trinity River anadromous fishery resources to pre-dam levels.*
26 *It is clear that restoration must provide for a meaningful fishery, not only for the Tribes, but also*
27 *for commercial, sport, and recreational fishermen. These important resources represent both tribal*
28 *trust and public treasures from which all should benefit - to restore the faith of our tribal*
29 *beneficiaries and to improve the economic well-being of the Trinity Basin and North Coast as a*
30 *whole.”*
31

32 The Trinity River Restoration Program (TRRP) was formed to implement the restoration strategy
33 outlined in the ROD on the 40 miles of the Trinity River between Lewiston Dam and the
34 confluence with the North Fork of the Trinity River within an Adaptive Environmental
35 Assessment and Management (AEAM) framework. The Sky Ranch project will function in
36 concert with the ROD flow regime, which includes five release hydrographs corresponding to
37 five water-year types, to implement the physical channel rehabilitation component of the ROD.
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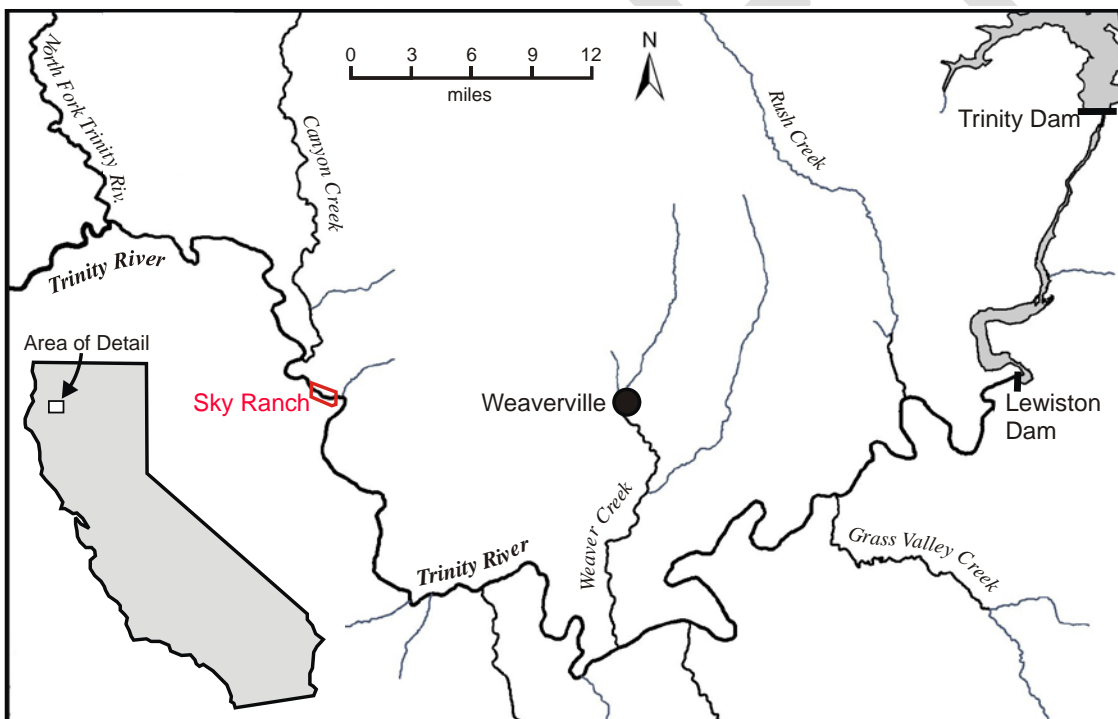
40 **2.0 Site Characteristics**

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42 The Sky Ranch site is within a sequence of six contiguous rehabilitations sites that have
43 collectively been referred to as the “Lower Valley.” As originally defined in a 2010 value
44 engineering study, the Lower Valley consisted, in order from upstream to downstream, of the

45 Chapman Ranch, Deep Gulch, Sheridan Creek, Oregon Gulch, Sky Ranch, and Upper
46 Junction City sites (CH2MHill and Entrix 2010). It was suggest that these six sites might be
47 designed as a single integrated unit. As of 2017, however, the Deep Gulch, Sheridan Creek,
48 and Upper Junction City projects have already been implemented, and an independent
49 Chapman Ranch design has been in development for more than a year. A design for the
50 Oregon Gulch site, which is immediately upstream from Sky Ranch, is currently being
51 developed by the Yurok Design Group. Although coordination and cooperation between the
52 Yurok and Federal designers is anticipated, the two project sites are separated by an active
53 tributary delta at the confluence with Oregon Gulch that limits the potential for continuous
54 design features to span both reaches.
55

56 2.1 Location and Ownership

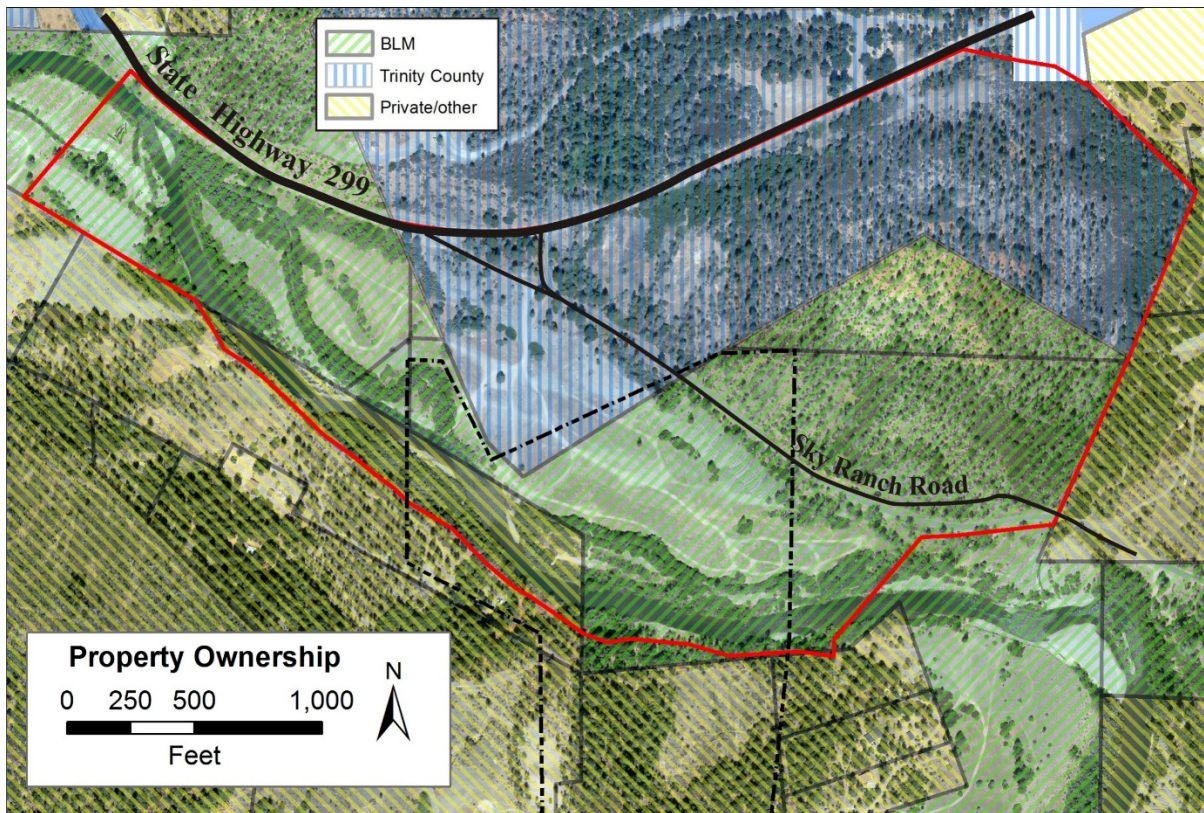
57 The Sky Ranch site overlaps with two of the original 44 channel rehabilitation sites identified
58 in the flow evaluation study (USFWS and HVT 1999, Appendix G). The site is located 0.6
59 miles upstream of the Dutch Creek Road Bridge at Junction City, CA (Figure 1).
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63 Figure 1: The Sky Ranch rehabilitation site is located 0.6 miles upstream of the Dutch Creek Rd
64 Bridge at Junction City, CA.
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67 The site encompasses about 50 acres of mostly publically-owned land, and about 0.65 miles
68 of river from river mile 80.3 to river mile 80.95. It is accessed from Sky Ranch Road, which
69 connects to State Highway 299 near the center of the site. About three-quarters of the land
70 within the Environment Study Limits (ESL) is owned by the Bureau of Land Management
71 (BLM) and most of the remaining quarter is owned by Trinity County (Figure 2). Privately-

72 owned land consists of a portion of single parcel on the south side of the river that extends
73 across the river and covers two relatively small areas on the north side.
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75



76
77 Figure 2: Most of the ESL (outlined in red) consists of public land owned by BLM and Trinity County.
78 The black dashed line indicates the boundary of an active mining claim. Flow is from lower right to
79 upper left.
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82 2.2 Hydrology

83
84 Streamflow at the Sky Ranch site is monitored at USGS gaging station 11526250, Trinity
85 River at Junction City, which is located at the Dutch Creek Road Bridge. The USGS flow
86 record for this gage spans WY2003 to the present, and additional flow records exist for
87 WY1995-2002 when the gage was operated by the Hoopa Valley Tribe (Table 1).
88

89 The gage records for the site include measured peak flows for 17 of the 23 years. Peaks
90 reported for 1997 and 1998 were estimated by HVT and peaks for 2000 and 2001 are absent
91 from the record (Table 2). Estimated peaks for those years are filled in for this report by
92 correlation with the USGS gage near Burnt Ranch (11527000), approximately 27 miles
93 downstream. Linear regression between the 17 peak events that exist in both records show
94 that peaks at Junction City tend to be about 60% of the Burnt Ranch flows during relatively
95 small flood events, and about 45% of the larger Burnt Ranch peaks ($r^2 = 0.89$, root mean

96 square error = 11% of Burnt Ranch mean). Most annual peaks since 2007 have been
 97 associated with spring flow releases from Lewiston Dam. The exceptions are 2014, when the
 98 peak occurred during a fall flow release intended to manage water quality in the Klamath
 99 River, and 2015 when the maximum flow occurred during a brief February storm event.
 100 Eleven of the 12 annual peaks prior to 2007 occurred during winter storm events. These
 101 winter floods account for nearly all the larger peaks recorded at the site, indicating that the
 102 magnitudes of geomorphically significant flows at the site may not conform to dam operating
 103 plans.

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 105

106 Table 1: The period of record at the Trinity River at Junction City streamflow gage. The gage was
 107 operated by the Hoopa Valley Tribe (HVT) prior to USGS operations, which began in WY2003.

WY	Gage Operator	Type of Record
1995	HVT	Partial
1996	HVT	Complete
1997	HVT	Estimated
1998	HVT	Partial
1999	HVT	Complete
2000-2001	HVT	Estimated Partial
2002	HVT	Complete
2003-2017	USGS	Complete

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110 The median value of the 23 peak flows listed in Table 2 is 8,590 ft³/s. That value is taken as
 111 the geomorphic design discharge for the site, that is, a reasonable discharge for evaluating the
 112 geomorphic functioning of the design. The median value is an appropriate estimate for the
 113 geomorphic design discharge because it approximates the 2-year event, which is within the
 114 range of recurrence intervals often used to estimate the bankfull discharge and related
 115 concepts such as effective discharge and dominant discharge. For comparison, a design guide
 116 prepared by program partners (HVT et al. 2011) implies that a discharge between 7,155 and
 117 8,986 ft³/s may be most relevant for geomorphic design at this site.

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120 Although the geomorphic design discharge is moderate in magnitude, much larger flow
 121 events with the potential to substantially alter channel geometry have occurred in the past and
 122 should be expected in the future. Besides the relatively large peaks of 1997 and 1998 listed in
 123 Table 2, the Burnt Ranch record, which begins in 1932, suggests that 6 other peaks at
 124 Junction City are likely to have exceeded the geomorphic design discharge for the site by a
 125 factor of 2 or more. Using the regression relation noted above, the 1956 peak at Burnt Ranch
 126 of 172,000 ft³/s suggests a peak flow at Junction City of 69,200 ft³/s. This estimate is
 127 probably somewhat low, as evidenced by the peak of 71,600 ft³/s recorded 32 miles upstream
 128 at Lewiston during the same storm. The remaining 5 largest peaks at Junction City, as
 129 estimated by correlation with the Burnt Ranch gage are 30,100 ft³/s in 1938, 33,600 ft³/s in
 130 1940, 33,900 ft³/s in 1958, 32,600 in 1965, and 28,700 ft³/s in 1974.

131

132 Table 2: Annual peak flows at the Trinity River at Junction City gage, 1995-2017. H peaks estimated
 133 by HVT; B peaks estimated by correlation with the Burnt Ranch gage.

WY	Date	Peak Discharge (ft ³ /s)
1995	01/09/1995	15,800
1996	02/22/1996	8,800
1997	01/01/1997	30,000 ^H
1998	03/23/1998	17,600 ^H
1999	03/25/1999	3,410
2000	no record	4,700 ^B
2001	no record	2,600 ^B
2002	01/02/2002	8,590
2003	12/16/2002	9,170
2004	02/17/2004	14,900
2005	05/09/2005	8,540
2006	12/31/2005	16,700
2007	05/02/2007	4,490
2008	05/09/2008	7,210
2009	05/05/2009	6,500
2010	05/04/2010	7,660
2011	05/04/2011	13,700
2012	05/07/2012	6,290
2013	12/02/2012	6,340
2014	09/19/2014	3,480
2015	02/7/2015	9,740
2016	5/10/2016	11,200
2017	04/28/2017	13,400

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Streamflows at the project site exhibits seasonal patterns that reflect a combination of flow releases from Lewiston Dam and natural tributary accretion. Flows in the late summer and fall are dominated by releases of 450 and 300 ft³/s from Lewiston Dam with only minor contributions from tributaries. Continued flow releases of 300 ft³/s from the dam are augmented by increased tributary flow from December through April, with the potential occurrence of large floods generated by the tributaries during intense winter storms. In May, peak flows are typically driven by dam releases in the range of 4,500 to 11,000 ft³/s augmented with moderate tributary flows, followed by a long recession limb that extends into the summer.

147 **2.2 Channel and Valley Morphology**

148 *The Junction City Reach*

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150 The Sky Ranch rehabilitation site is located within the Junction City reach of the Trinity
 151 River. One of 24 reaches of the Trinity River between Lewiston Dam and the North Fork
 152 Trinity River defined by Gaeuman et al. (2016), the Junction City reach extends upstream

153 through the Sheridan and Deep Gulch projects, which were constructed in 2017, and
154 downstream through the site of the 2005 Hocker Flat rehabilitation project. It also includes
155 the Oregon Gulch rehabilitation project site that is currently under design by the Yurok
156 Design Group. It is characterized by a lack of floodplain connectivity as measured by the
157 extents of valley bottom inundation during floods and by relatively simple channel geometry
158 except for in local areas where the channel encounters the valley wall. These conditions
159 appear to have resulted from historical mining activities that deposited large quantities of
160 hydraulic mining debris across the relatively wide alluvial valley bottom. Oregon Gulch,
161 which enters the Trinity River just upstream from the Sky Ranch ESL (Figure 2), discharged
162 millions of cubic yards of mining debris from the LaGrange Mine on Oregon Mountain into
163 the Trinity River corridor over a 60-year period ending in the 1930s (Bailey 2008). Mining
164 debris delivered to the Trinity River from the LaGrange mine via Oregon Gulch, as well as
165 debris delivered from numerous other hydraulic mines that operated in the Junction City area,
166 may be responsible for what appears to be a large-scale bulge in the longitudinal profile of
167 the Trinity River that is approximately centered on a large tributary delta at the mouth of
168 Oregon Gulch and spans the entire Junction City reach (Krause et al. 2010). The upstream
169 limb of the bulge has relatively low local channel slopes compared to the average slope for
170 the 40 miles of river between Lewiston Dam and the North Fork Trinity River, whereas the
171 downstream limb tends to have slightly higher slopes (TRRP Federal Design Group 2017).
172 Due to its proximity to Oregon Gulch, the Sky Ranch site is located almost precisely on the
173 apex of the bulge and therefore has a site-averaged channel slope of 0.0023, which is almost
174 exactly equal to the average slope for the full 40 miles.

175
176 The extensive aggradation caused by upslope hydraulic mining coupled with extensive
177 dredge mining in the valley bottom itself and subsequent fluvial incision has produced a
178 canal-like channel that is largely disconnected from its valley (Krause et al. 2010; Gaeuman
179 et al. 2016). Some portions of the Junction City reach, however, exhibit significantly more
180 in-channel topographic complexity. Although the reach occupies a generally wide valley
181 bottom, the channel is often located adjacent to one valley wall or the other. Some of these
182 locations are found in at or near the Sky Ranch site, including at the confluence of Oregon
183 Gulch, where the valley turns sharply to the left, and two locations within the Sky Ranch site
184 itself.

185
186 In their assessment of large scale management objectives for the different reaches of the
187 Trinity River, Gaeuman et al. (2016) recommended that the primary restoration objectives for
188 the Junction City reach should be the conversion of the expansive terraces found in this part
189 of the river to topographically complex floodplains that provide aquatic habitat and
190 ecological services during high flow periods. That caution, however, against actions that
191 inadvertently move the channel away from bedrock valley wall, as these areas typically
192 exhibit high levels of in-channel topographic complexity.

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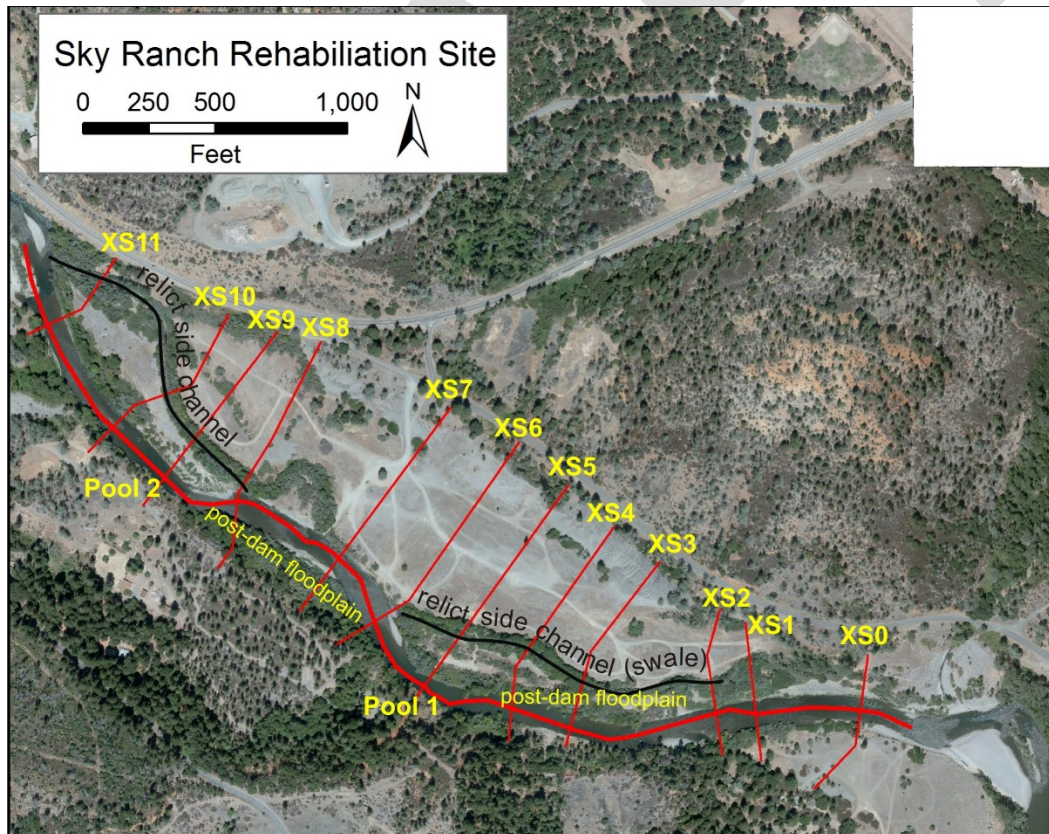
198 *Current Channel and Valley Geomorphology within the Sky Ranch Project Site*

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200 At more than 1000 ft in places, the width of the alluvial valley bottom at the Sky Ranch site
201 is much larger than typical valley bottom areas along the Trinity River (Gaeuman et al.
202 2016). The channel, however, is adjacent to the south (left) valley wall throughout most of
203 the site (Figure 3). There are two important consequences of this proximity to the valley wall.
204 First, nearly all the valley bottom area lies to the north of the river where there is a large and
205 nearly uninterrupted terrace surface throughout the central part of the site (Figure 5; XS5-
206 XS9 on Figure 3 and Figure 4). This surface, which spans approximately 22 acres, is
207 primarily composed of flattened and compacted mine tailings and stands more than 10 ft
208 above the summer baseflow (450 ft³/s) water surface. Preliminary calculations indicate that
209 lowering this terrace to levels thought to promote the development of riparian vegetation (4 ft
210 above the baseflow water surface elevation) would require about 350,000 cubic yards of cut.
211 Much higher tailings piles occupy much of the valley bottom farther to the north (e.g. XSs 3,
212 4, 7, 8 on Figure 4). Preliminary field reconnaissance suggests that it may be possible to spoil
213 a large quantity of material against the valley wall in a set of large hydraulic mining between
214 Sky Ranch Road and Highway 299 (Figure 5).

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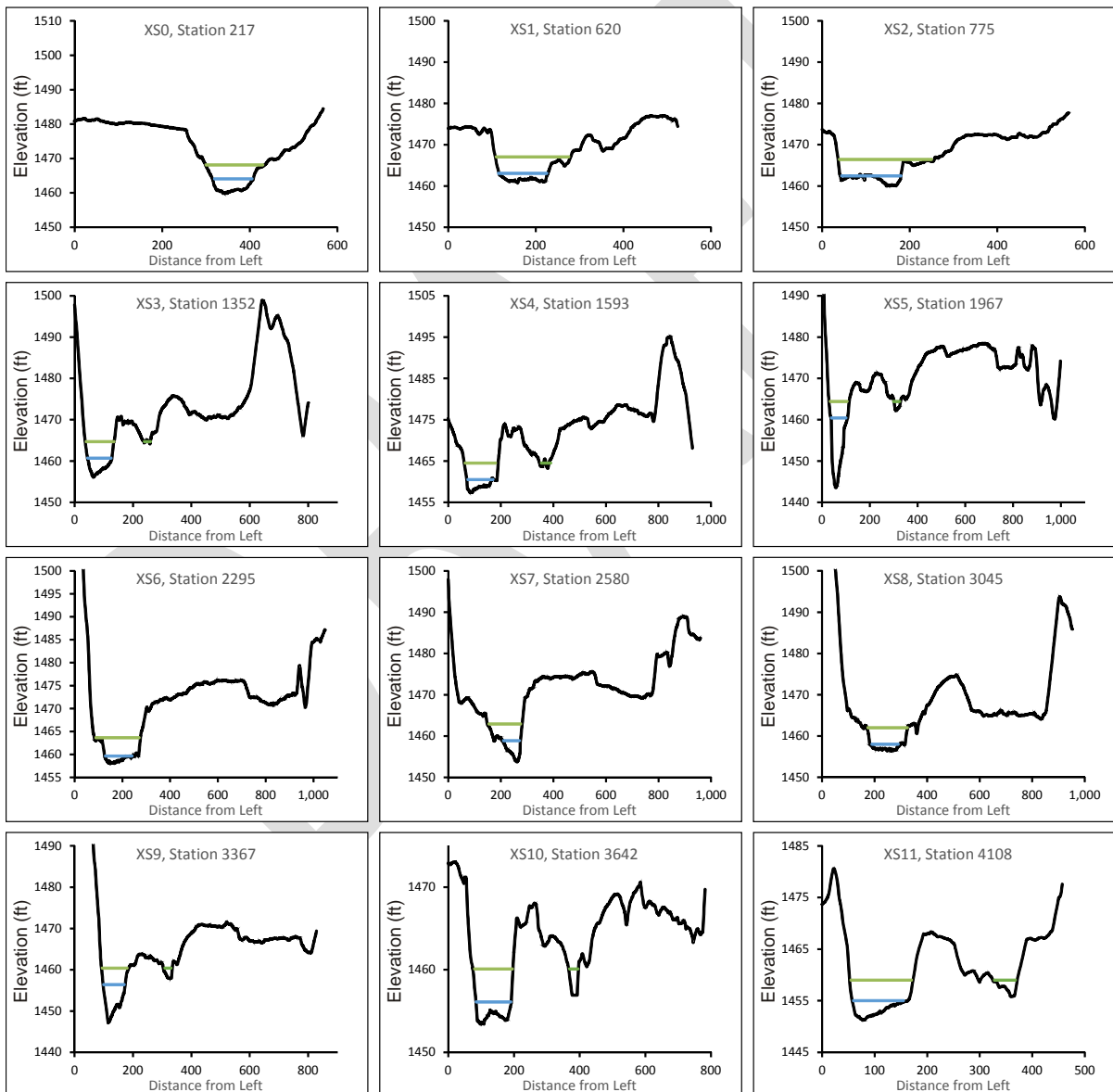
218 Figure 3: Map of the Sky Ranch site, showing the alignments of the cross sections shown in Figure 4,
219 the longitudinal profile shown in Figure 5, and the locations of other features discussed in the text.

220 Flow is from lower right to upper left.

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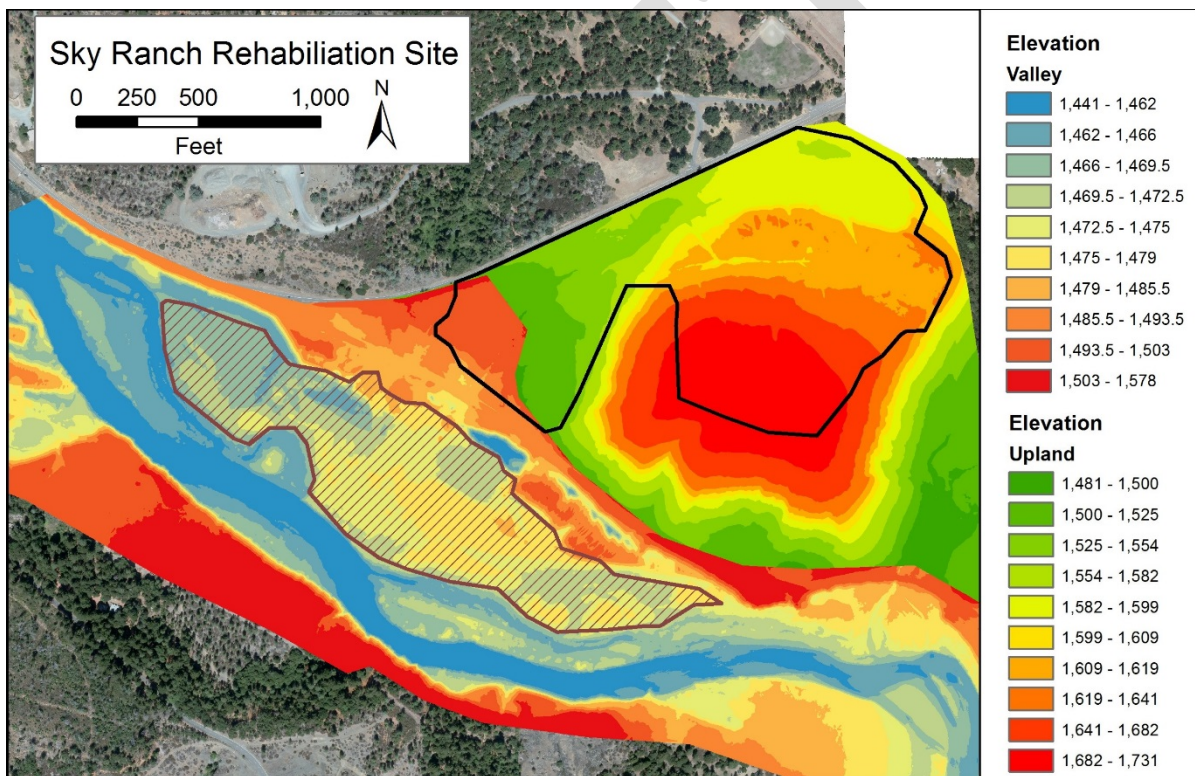
223 Areas that are currently subject to flood inundation are limited to two small floodplain areas
 224 that have developed since dam closure and the immediate vicinity of two relict side channels
 225 that were excavated in the 1990s (Figure 3). Surface water ceases to flow into the excavated
 226 side channel near the downstream end of the site when discharge falls below about 1100 ft³/s.
 227 The more upstream excavated side channel is almost mostly filled with sediment and debris,
 228 and is currently better described as a swale between the terrace and a narrow floodplain in the
 229 upstream half of the site. In general, the area available for frequent overbank flooding is
 230 small: the average width of the potential riparian area on the 12 cross sections plotted in
 231 Figure 4 is just 51 ft, whereas the baseflow wetted channel averages 92 ft and the alluvial
 232 valley bottom averages more than 800 ft in width.
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 236 Figure 4: Representative cross section across the channel and valley bottom at Sky Ranch. The
 237 summer baseflow water surface levels are shown in blue and the approximate vertical extents of the
 238 riparian zone (4 ft above baseflow) are shown in green.

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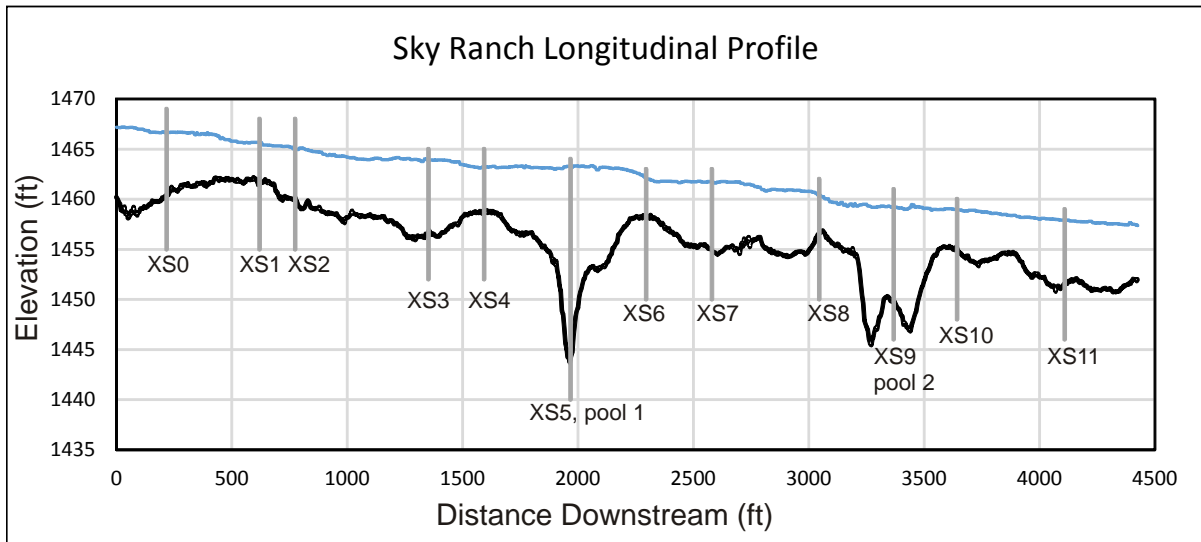
Two final topographic features of note include a large pond (approximately 220 long by 50 ft wide) among the tailings piles along Sky Ranch Road between cross sections 5 and 6, and a swale in the outer edge of the terrace along Highway 299 between cross sections 8 and 11. The pond's location corresponds to the patch of deep blue near the center of the site and just to the right of the brown hatched polygon in Figure 5. The swale along the highway is indicated by a linear patch of blue just to the right of the brown hatched polygon in Figure 5 at its downstream end. The swale is plugged at its downstream end with mechanically-placed fill material that shows up in Figure 5 as a small patch of yellow at the downstream tip of the brown hatched polygon. We speculate that this fill was placed during side channel construction in the 1990s, presumably either as a way to spoil material or perhaps even to intentionally separate the excavated side channel from the existing swale.



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Figure 5: Digital terrain model of the Sky Ranch area. Elevations in the valley bottom area and upland areas to the north are shown with different color ramps, and the upland area where excavated material could potentially be spoiled is outlined in black. Lowering the area shown with brown hatching to within 4 ft of the baseflow water surface elevation would require 350,000 cubic yards of cut.

Another consequence of the channel's proximity to the valley wall is that the collisions with valley wall bedrock are associated with the maintenance of two deep pools within the reach. The locations of the pools are indicated on Figure 3. The more upstream pool (pool 1) approaches 20 ft in depth at a moderate discharge of 2500 ft³/s, and the more downstream pool (pool 2) is nearly 14 ft deep (Figure 6).



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Figure 6: Longitudinal profile of the channel bed and water surface at 2530 ft³/s through the Sky Ranch project area.

272 *Current Hydraulic Conditions*

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274 The fraction of the alluvial valley bottom that is inundated by frequent flows at the Sky
275 Ranch site is very small. The degree to which flows are confined to the immediate vicinity of
276 the channel is evaluated with W_j , the probability-weighted sum of the areas outside the main
277 channel at six moderate to large discharges that span frequent storm flows during the fry-
278 rearing period. The flows considered for this evaluation range from 1500 ft³/s, which is
279 relatively common (exceeded 23% of the time during the fry rearing period) through 7000
280 ft³/s, which approaches the 2-year flood event. To compute W_j , it is first necessary to
281 compute F_j , which is given by:

282

$$F_j = \sum (P_i A_i)$$

283

284
285 Where P_i is the probability of flow with discharge range i during the months of February
286 through April and A_i the area inundated outside the main channel by flow i . This definition of
287 F_j is an adaptation of the similar metric introduced by Gaeuman et al. (2015). W_j is then
288 obtained by dividing F_j by the valley length through the site. The six flows used in the
289 computation of F_j and their probabilities of occurrence are given in Table 3. Areas of
290 floodplain inundation for each flow are estimated from the water surface elevations output
291 from 2-dimensional hydraulic modeling (SRH-2D) with the area of the main channel
292 subtracted from the total (Table 3). The main channel area is objectively defined by the
293 wetted area at a modeled flow of 1500 ft³/s.

294

295 For the Sky Ranch site, F_j is equal to 20608 ft² and the valley length is 3680 ft. Division by
296 the valley length yields a probability-weighted average width of inundated floodplain (W_j) of
297 5.6 ft. This result cannot be directly compared to previously-reported values of this metric

298 because the computation methods have been modified. However, when computed in the same
 299 way, the value of W_j for the Sky Ranch project site is a smaller than W_j any of the 24 reach-
 300 average values reported by Gaeuman et al. (2015).

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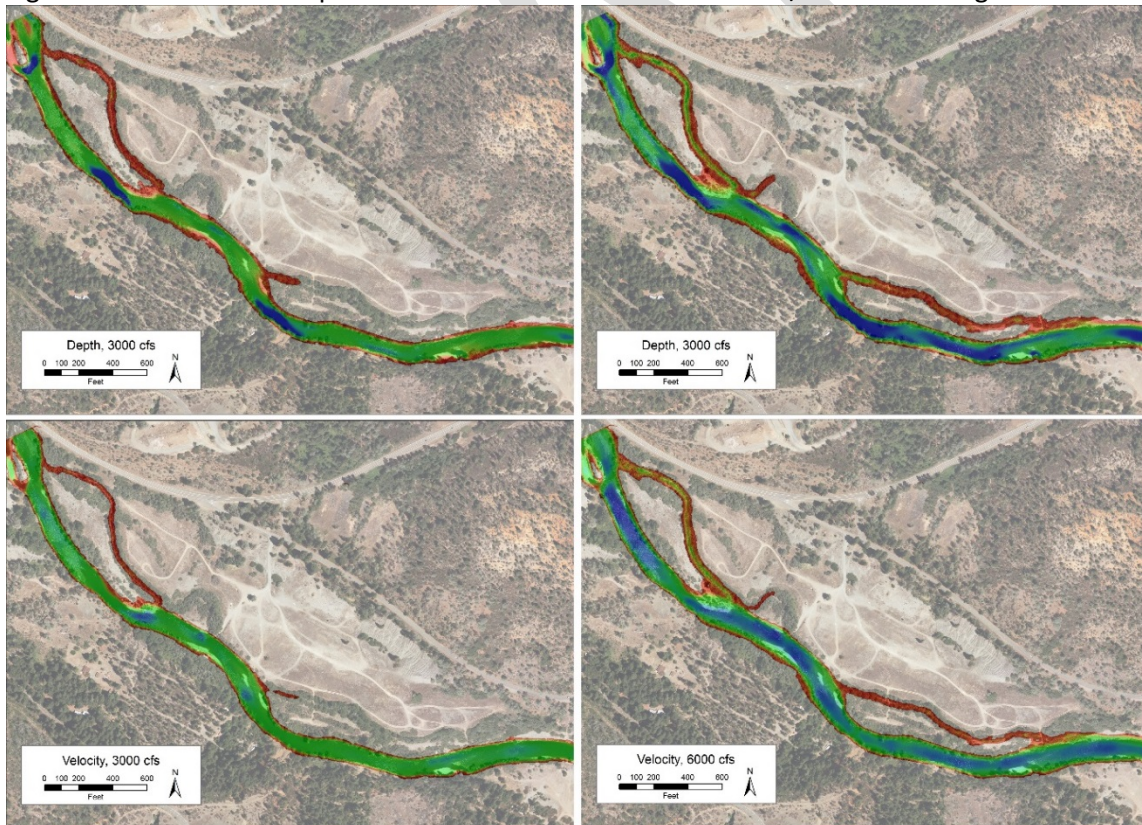
Table 3: Discharges, flow probabilities, and inundation areas used to compute F_j and W_j .

Modeled Q	Q range	P_i	A_i (ft ²)	$P_i A_i$ (ft ²)
2000	1500-2500	0.136	23862	3579
3000	2500-3500	0.046	78573	5657
4000	3500-4500	0.031	122191	4154
5000	4500-5500	0.006	170579	2218
6000	5500-6500	0.005	246621	2466
8500	6500-8500	0.001	422134	2533

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Due to the confinement of higher flows the near-channel region by the tailings terraces that dominate the valley morphology at the Sky Ranch site, flow depths and velocities become large throughout the channel at relatively low discharges. Model results indicate that at 3000 ft³/s most of the main channel is already 5-6 ft deep and flow velocities of 6 ft/s are widespread (Figure 7). At 6000 ft³/s, modeled depths exceeding 10 ft are common and a nearly continuous band of modeled flow velocities greater than 9 ft/s extends through the site.

Figure 7: Modeled flow depths and velocities at 3000 and 6000 ft³/s under existing conditions.



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316 *Valley Bottom Materials*

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318 A geological investigation covering Upper Junction City Valley area from the Chapman
319 Ranch site downstream to the Dutch Creek Bridge was conducted by the USBR Mid-Pacific
320 Region Geology Branch in February of 2010 (Sherer 2011). Of a total of 94 test pits
321 excavated to assess substrate materials and groundwater elevations, 17 were located within
322 the Sky Ranch project area. Groundwater was encountered in all but two pits, and was found
323 to generally coincide with the water level in the river. Sieving of pit materials indicated that
324 dredge spoils and channel deposits in the area consist primarily of gravel and cobble, and are
325 suitable for processing into building materials for in-channel features. It was estimated that
326 about 140,000 cubic yards of coarse sediment suitable for creating salmonid spawning
327 habitat could be produced within the boundaries of the Sky Ranch site. No bedrock was
328 encountered within the Sky Ranch project area.

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330 *Current Bed Surface Conditions*

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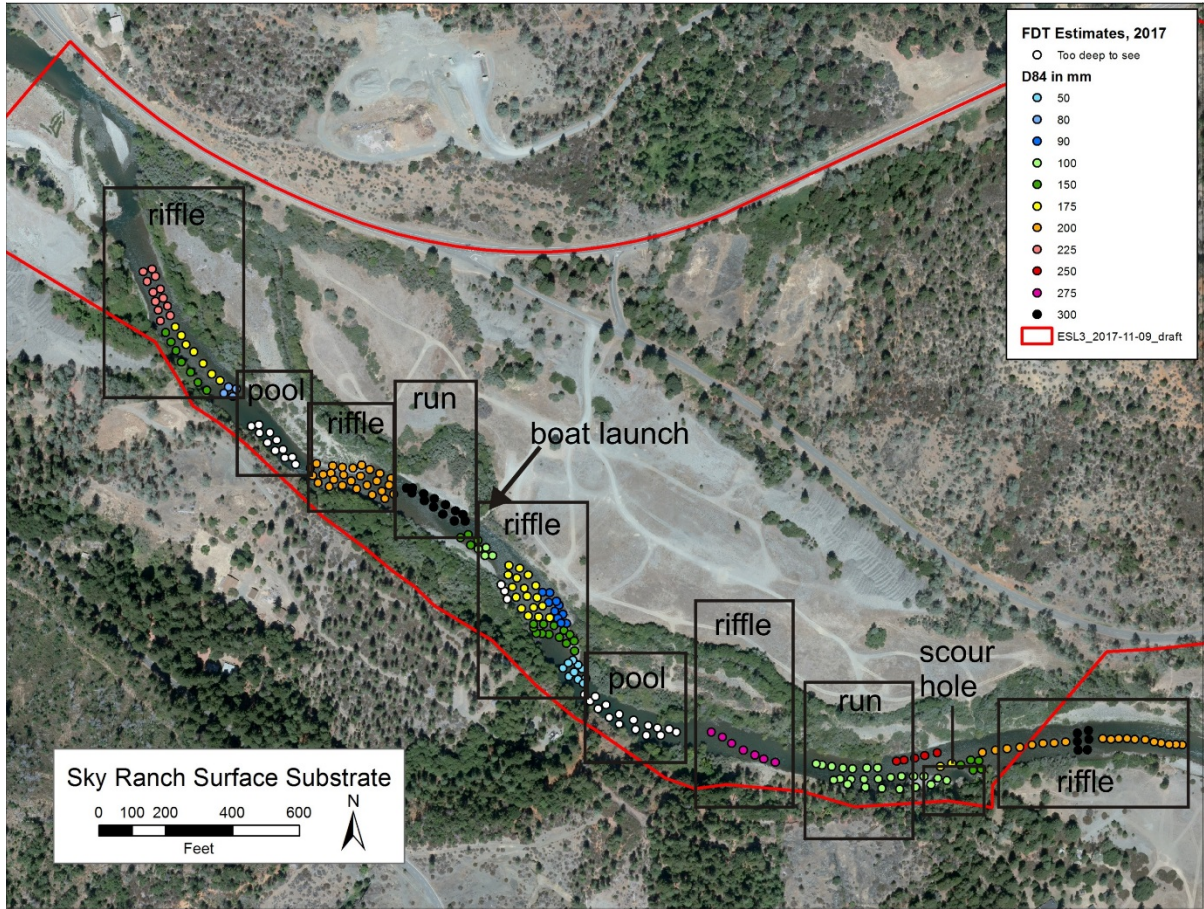
332 Two members of the Federal Design Group assessed the bed surface substrate composition
333 within the main stream channel through the Sky Ranch reach in August of 2017. We entered
334 the Trinity River at its confluence with Oregon Gulch and waded or swam through the site
335 using snorkel gear to observe the channel bed. Each of the two observers visually estimated
336 the 84th percentile surface particle size along zig-zag or roughly parallel paths and noted
337 representative particle sizes on laminated aerial photographs. The mapped observation points
338 were later digitized for display.

339

340 The 2017 assessment revealed that most of the riffle areas within the Sky Ranch reach are
341 coarser than is usually considered optimal for salmonid spawning, which is typically
342 assumed to be gravel and cobbles with a median intermediate diameter less than about 10%
343 of the fishes body length (Kondolf 2000). Of five regions that could generally be classified as
344 riffles, four are dominated by particles in the 200 to 300+ mm range (Figure 8). Only the
345 riffle area located near the center of the site (immediately upstream from the boat launch)
346 consists primarily of particles in the 50-175 mm range, with the finer material appearing on
347 the tailout portion of the riffle. However, that tailout also contained abundant sand and
348 appeared to be in an embedded, or compacted, state (Platts et al. 1983). We speculate that
349 very coarse material (> 300 mm) found along the right bank immediately downstream from
350 the boat launch may have been placed to stabilize the channel during side channel
351 construction in the 1990s. Pools were generally too deep for us to see the bed, so no grain
352 size estimates were attempted in those areas.

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 356 Figure 8: Map showing bed surface particle size at points estimated by members of the Federal
 357 Design Group. Approximate boundaries of basic geomorphic units are indicated.
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360 *Geomorphic Development of the Sky Ranch Project Site*

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 362 Flows in the Trinity River downstream from Trinity and Lewiston Dams have been regulated
 363 since Trinity Dam closed in 1960. Diversion of up to 90% of the Trinity streamflow to the
 364 Sacramento River basin in the 1960s and 1970s led to substantial geomorphic change in
 365 many locations along the river, with the predominant responses being channel narrowing and
 366 vegetative encroachment along the channel margins (Nelson et al. 1987; Wilcock 1996;
 367 USFWS and HVT 1999). Although flow regulation has certainly influenced current
 368 conditions, larger scale historical mining impacts are also important drivers of recent
 369 geomorphic evolution at the Sky Ranch site and throughout the Junction City area.
 370

371 It is hypothesized that the current simplified state of the channel found in the Junction City
 372 area reflects the initial stages of incision into accumulated mining debris. Massive
 373 aggradation during the period dominated by hydraulic mining was followed by dredge
 374 mining of the alluvial valley floor that continued into the 1950s (Bailey 2008). The channel
 375 in some areas was dredged to oblivion, appearing on 1944 aerial photographs as a network of
 376 dredge pits connected by shallow swales amid a maze of tailings piles (TRRP Federal Design

377 Group 2017). The dredged areas were subsequently reworked by the flood of December 1955
378 (172,000 ft³/s at the Trinity River near Burnt Ranch stream gage), leaving an incised channel
379 flanked by armored terraces that can be inundated only by the most extreme floods.
380

381 A sequence of aerial photographs beginning in 1944 provide a basis for reconstructing the
382 geomorphic development of the channel and valley in the Sky Ranch area. In 1944 the valley
383 contains what appears to be a very large delta deposit extending about 2500 ft downstream
384 from the confluence with Oregon Gulch (Figure 9a). This deposit, which is as much as 750 ft
385 wide near its center, pins the river channel against left bank through the upper half of the site.
386 Its surface is generally smooth in appearance, suggesting it was deposited or reworked by
387 flowing water. Tailing piles appear on this surface only along Sky Ranch Road where they
388 are found at present. The extant pond can be seen to be a mining pit amid the tailings. As the
389 1944 channel approached the downstream end of this delta, it angled across the valley and
390 reached the Highway 299 embankment at the far downstream end of the site. This crossing of
391 the channel to the north side of the valley may have been driven by the entry of mining debris
392 from river left – prominent hydraulic mining cuts and sluices are visible in the uplands on
393 that side of the valley. Some tailings piles appear on the left side of the river close to the
394 valley wall at the downstream end of the ESL, and extend into the UJC project site.
395

396 The effects of the 1955 flood can be seen in the next set of aerial photographs, which were
397 taken in 1960. The portion of the Oregon Gulch delta in the valley bend adjacent to the
398 Oregon Gulch confluence was completely stripped away and debris transported by the river
399 from upstream of the confluence deposited to form a large bar-like feature on the convex
400 bank opposite the mouth of Oregon Gulch (Figure 9b). The channel in the downstream half
401 of the ESL switched its course to a new position at the base of the left valley wall. We
402 hypothesize that the shift to the left was made possible by the cessation of hydraulic mining
403 in the hills to the south, which drastically reduced the delivery of locally-derived mining
404 debris compared to delivery rates in the early part of the 20th century. A remaining short
405 length of channel that had started the trend toward the right in 1944 combined with the new
406 course toward the left combined to create a low amplitude bend near the center of the site.
407 This channel realignment also resulted in the removal of a section of tailing pile about 300 ft
408 in length from the left overbank area at the downstream boundary of the site.
409

410 By 1975, Oregon Gulch had again pushed a delta approximately 1250 ft in length and 220 ft
411 in width into the Trinity River channel (Figure 9c). Although this delta was small by pre-dam
412 standards it represent a noticeable change in the post-dam era. Growth of the delta coupled
413 with erosion of the convex deposit on the opposite bank had straightened the course of the
414 channel, and delta deposits accreting to the right bank of the channel had begun to create the
415 extant post-dam floodplain in that area. A large mid-channel bar had also appeared in the
416 backwater upstream from the delta by that time, triggering erosion into the left bank deposit
417 in the backwater area. The mild channel bend that had appeared near the center of site in
418 1960 increased in amplitude as the channel migrated toward the right and the lateral bar on
419 the left bank expanded.
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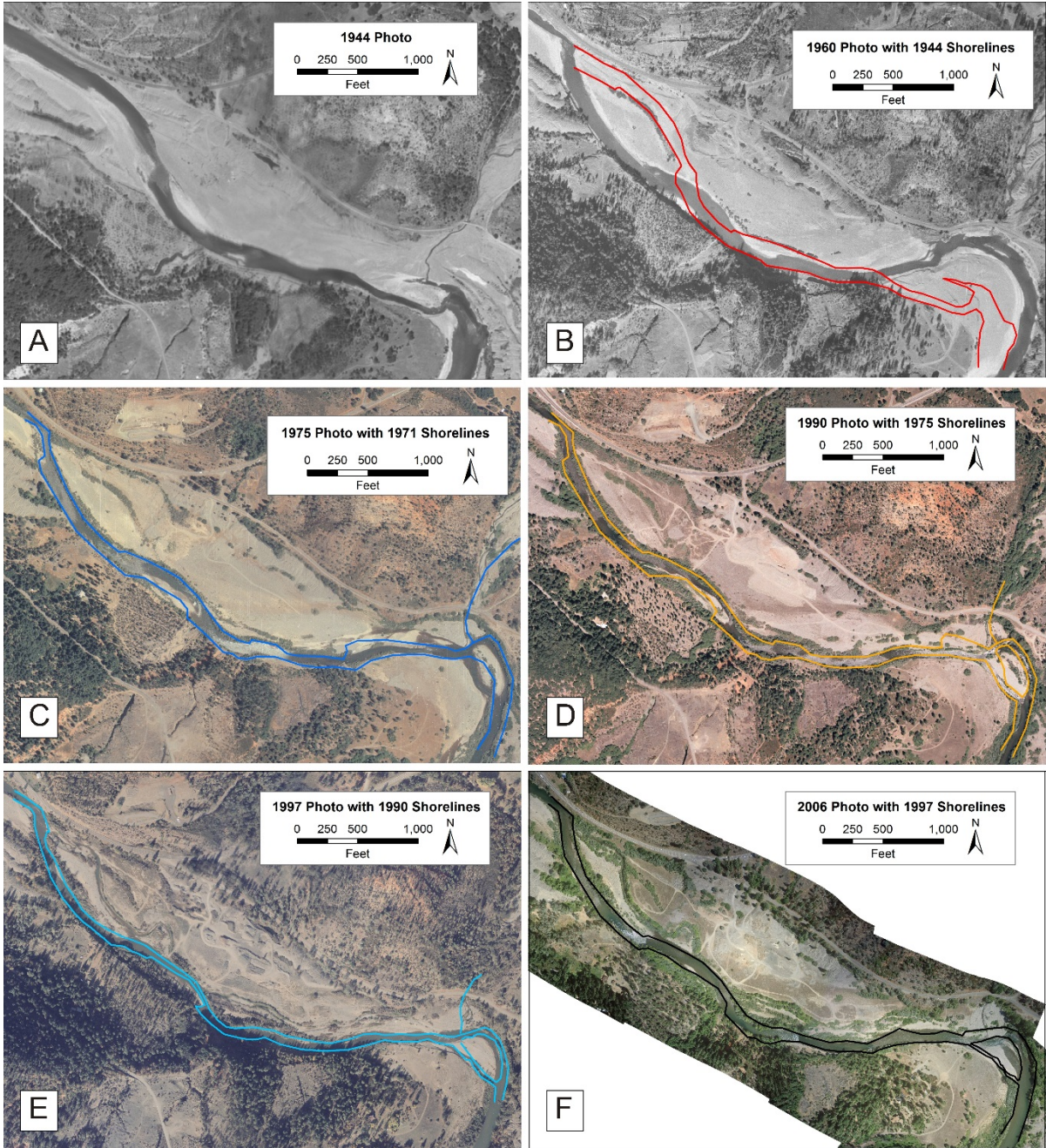


Figure 9: Aerial photographs of the Sky Ranch project site.

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Very little change took place within the Sky Ranch site through the remainder of the 1970s and the 1980s. By 1990 the primary changes were some continued growth of the island bar in the backwater upstream from the delta and the beginnings of the transformation of the left-bank lateral bar in the center of the site into a vegetated floodplain (Figure 9d).

By 1997 the island bar in the backwater upstream from the delta had become nearly attached to the left bank, and the transformation of the left-bank lateral bar in the center of the site to a floodplain was complete (Figure 9e). Both of the constructed side channels appeared during

434 the 1990-1997 interval, and the downstream portion of a pre-existing swale that existed at the
435 base of the Highway 299 embankment had been filled, presumably with spoils from the side
436 channel excavation.

437

438 Very little change took place within the Sky Ranch site after 1997 until 2006, when the
439 Oregon Gulch delta pushed another 70 ft into the channel and the island bar in the delta's
440 backwater was dissected, leaving a small island in the middle of the wetted channel and a
441 larger gravel deposit attached to the left bank (Figure 9f). Other than some mechanical
442 excavation associated with the 2012 Upper Junction City project at the far downstream end
443 of the ESL, very little changed in the Sky Ranch ESL between 2006 and 2016. In 2017 some
444 substantial changes took place in the backwater upstream from the Oregon Gulch delta, but
445 aerial photographs are not yet available and the precise nature of those changes has not yet
446 been documented.

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448

449 **2.3 Biological Significance and Use**

450 *Adult Salmonid Use*

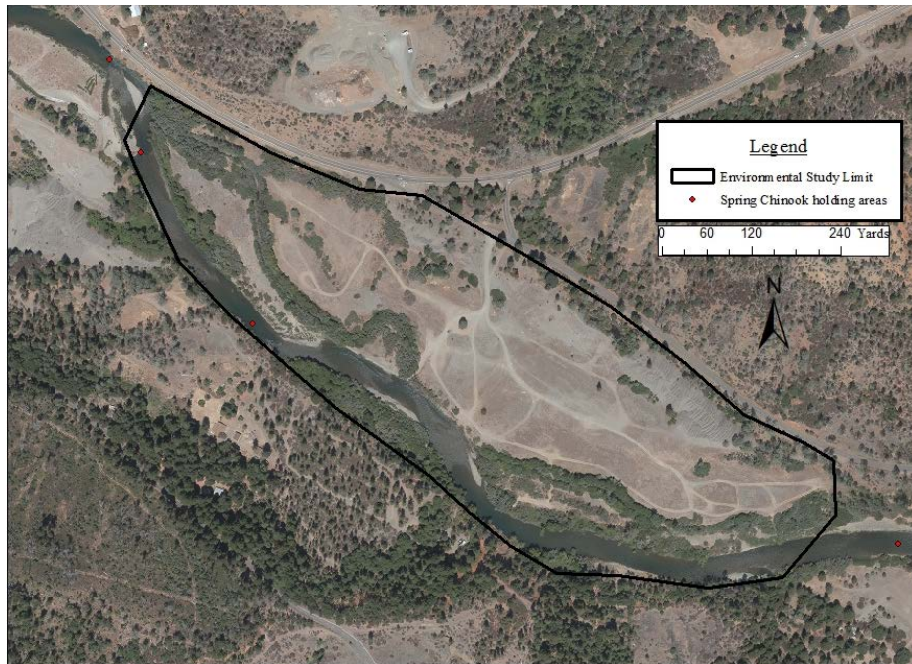
451

452 Adult salmonid holding and spawning occurs within the environmental study limit (ESL) for
453 the Sky Ranch rehabilitation site. Holding habitats surveyed in the Trinity River in July 2014
454 identified two pools in the ESL that were occupied by spring Chinook (Figure 10). The
455 downstream pool was occupied by 4 spring Chinook and the upstream pool was occupied by
456 8 spring Chinook. Spawning by Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon
457 (*O. kisutch*), and steelhead trout (*O. mykiss*) occurs within the Sky Ranch ESL. Redds were
458 constructed by these species at similar locations on pool tails, riffles, and channel margins in
459 the ESL between 2012 and 2016 (Figure 11). The number of redds constructed in the reach in
460 the years 2012-15 ranged from 10 to 68, and the number of redds surveyed in the ESL can be
461 predicted with the total run size estimate for channel areas above Willow Creek weir (Kier
462 and Hileman, 2016) with 95% accuracy.

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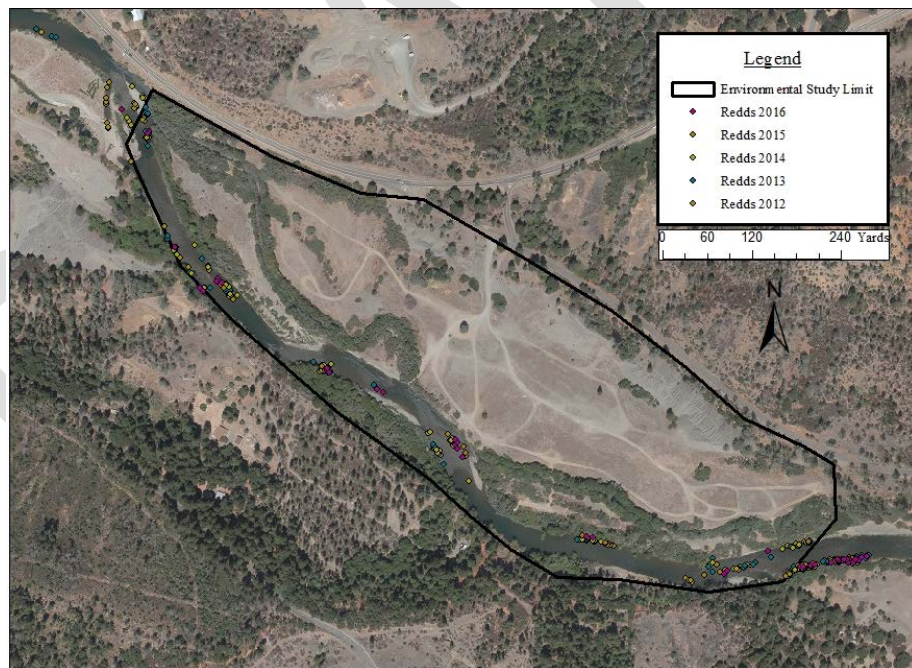
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Figure 10: Pools with spring Chinook salmon holding in them during a survey performed in 2014. Flow direction is to the left.



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Figure 11: Salmon redds surveyed in the Sky Ranch ESL (2012-2016). Flow direction is to the left.

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2.3 Juvenile Salmonid Habitat

Habitat availability for fry and presmolt Chinook salmon was predicted for existing conditions in the Sky Ranch ESL using 2009 topography and bathymetry with a habitat module in SRH2D developed by the Bureau of Reclamation’s Technical Services Center (Bradley, 2016). The habitat module reads water depth (D) and velocity (V) output generated by SRH2D for grid cells in the model to quantify the flow area that meets juvenile rearing habitat criteria in Table 4. For habitat that includes cover (C), the distance to cover is assigned a presence or absence value in the model.

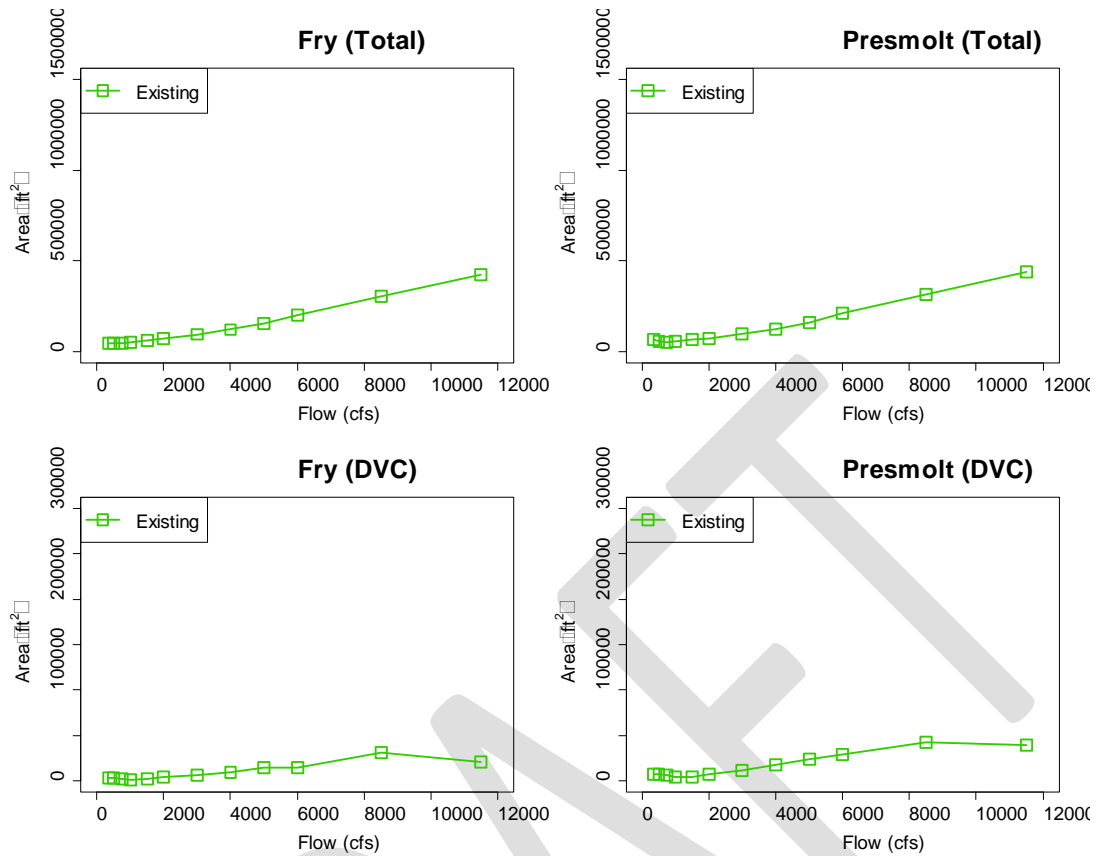
Table 4: Habitat suitability criteria for fry and presmolt salmonids.

Life stage	Flow depth (ft)	Flow velocity (ft/s)	Distance to cover (ft)
Fry (fork length <50 mm)	≤2.0	≤0.49	≤2.0
Pre-smolt (fork length 50 to 100 mm)	≤3.3	≤0.79	≤2.0

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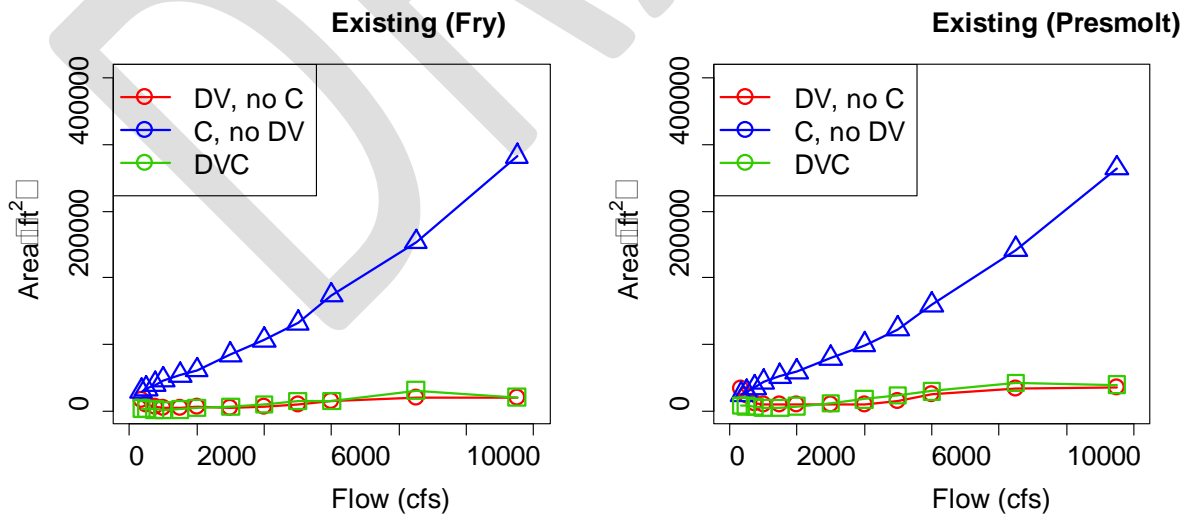
The Sky Ranch site currently provides a similar amount of total fry and presmolt rearing habitat area at all modeled discharges (Figure 12). The relationship between discharge and total habitat area was generally positive. Optimal habitat containing suitable depth, velocity, and cover (DVC), changes little with additional discharge, except at flows in excess of 6,000 CFS, above which optimal habitat increases slightly with increasing discharge.

Currently the amount of rearing habitat area containing a suitable distance to cover (cover only) increases substantially with increasing discharge at the Sky Ranch site. This relationship of the cover only habitat type to discharge is largely responsible for the positive relationship between total rearing habitat area and discharge, as the other two rearing habitat area types (DV and DVC) change very little over the range of modeled flows (Figure 12; Figure 13). While rearing salmonids can be found in habitat types other than DVC, most rearing juveniles are found in the optimal habitats containing DVC. Therefore, the amount of rearing habitat at the Sky Ranch site is currently the same at virtually all modeled flows, particularly at discharges less than 6,000 CFS, which occur 99% of the time on average. As such, rearing salmonids are unlikely to access floodplain habitat or experience a range of habitat diversity throughout a variety of flows.



510
 511 Figure 12: Panel figure showing total fry and smolt habitat area (top) and habitat area comprised of
 512 depth, velocity and cover (bottom) of the Existing condition at discharges from 350 CFS to 11,500
 513 CFS at the Sky Ranch restoration site.

514



515
 516 Figure 13: Panel figure showing habitat area comprised of 1) depth and velocity, 2) cover only, or 3)
 517 depth velocity and cover for the Existing condition at discharges from 350 CFS to 11,500 CFS at the
 518 Sky Ranch restoration site.

519 *Special-status Wildlife Use*

520

521 Birds

522 Yellow warblers and yellow-breasted chats are likely to nest in areas where multi-storied
523 canopies, black or Fremont cottonwoods, or other uniquely vegetated areas exist. Pre-
524 construction avian surveys are implemented to comply with environmental regulations aimed
525 at protecting special-status birds.

526

527 Foothill Yellow-legged Frogs

528 Herpetological surveys conducted by the USGS in recent years have detected all life stages
529 of foothill yellow-legged frogs in the area. Foothill yellow legged frogs have frequently been
530 observed in the Oregon Gulch confluence, located immediately upstream of the ESL; and the
531 Upper Junction City channel rehabilitation site, located immediately downstream of the ESL.
532 Channel rehabilitation activities directed towards increasing aquatic and geomorphic
533 complexity, and increasing the thermal heterogeneity of the channel margin, are expected to
534 benefit foothill yellow-legged frogs.

535

536 Western Pond Turtles

537 Herpetological surveys conducted by the USGS in recent years have detected western pond
538 turtles in the area. The creation of slow-moving pools and off-channel ponds with basking
539 logs is expected to benefit this species. An important predator of juvenile western pond
540 turtles is the introduced American bullfrog. Bullfrog tadpoles require more than a year to
541 metamorphose into adults that can traverse land; and they must rear in lentic waters. So,
542 constructing ponds that can either be flushed periodically by river flows, or that substantially
543 dry out during the summer, can be beneficial to western pond turtles without benefitting
544 bullfrogs.

545

546 Other Wildlife Species

547 Black-tailed deer use Trinity River bottoms heavily year-round, but it is particularly valuable
548 in winter when deer migrate down from higher elevations. Deer forage for annual grasses and
549 forbs, including non-native grasses and forbs, after the fall/winter green-up begins. The open
550 areas in the majority of the ESL could provide valuable winter forage to deer if soils were
551 improved. Resident deer would benefit by focusing vehicular access towards specific parking
552 areas and boat-launching areas.

553

554 *Riparian Conditions*

555

556 Preliminary vegetation and land cover surveys identified stands of various types of
557 vegetation that have implications for implementation. Ten small stands of black and Fremont
558 cottonwood trees were identified. These areas should be avoided, but if they must be
559 removed, the construction activities should be sequenced so that the trees can be salvaged for
560 use in wood structures. Two small stands of black locust were found in the northwest corner
561 of the ESL, adjacent to Sky Ranch Road. This is a non-native tree with very durable wood,
562 and trees can be removed for use in wood structures. Stands of vegetation with three or more
563 canopy layers or other unique vegetation tend to have birds nesting in them, and may need to

564 be avoided during the nesting season. Two such stands were identified in the area, one in the
565 northwestern corner of the ESL adjacent to the left bank of the Trinity River and the other in
566 the floodplain area on the left bank near the center of the site.
567

568 **2.4 Constraints and Limitations**

569
570 Given the height and large areal extents of the terraces that occupy most of the valley bottom
571 in the Sky Ranch area, the availability of space in which to spoil excavated material
572 represents a major constraint to the type of project that can be implemented. The hydraulic
573 mining cuts identified along the northern valley wall have the potential to accommodate a
574 large portion of the spoils that would be generated by terrace lowering, but several
575 unanswered questions remain about whether social constraints will preclude their use.
576 Virtually all of the area of the mining scars is on land currently owned by Trinity County. To
577 date, no information is available regarding whether the County would be open to filling those
578 scars. It is possible that these mining scars could be considered to have historical or cultural
579 value, and should therefore be preserved. A second possible constraint is that transporting
580 spoils to those areas would require crossing Sky Ranch Road, which presumably would
581 require some form of traffic control and could involve difficulties with the use of off-road
582 construction vehicles. Finally, the westernmost portion of the hydraulically mined area
583 continues to the north of Highway 299, which appears to be built on a raised road prism
584 spanning the cut. As a result, a deep cut collects water to the north of the Highway so
585 drainage through the cut area south of the Highway will likely need to be maintained.
586

587 An active mining claim occupies about half of the BLM land within the ESL boundary. The
588 implications of this for potential rehabilitation designs is currently unknown.
589

590 A small portion of the ESL along the stream bank in the center of the site is within a
591 privately owned parcel, most of which lies on the south side of the stream outside of the ESL.
592 It will be necessary to work with the landowner to obtain permission to work in that area, or
593 to avoid that area completely.
594

595 Most of the historical mine tailings piles in the valley bottom area have already been
596 flattened and reworked for various reasons. The remaining tailings piles along the northern
597 margin of the ESL could be determined to have cultural value. This possibility, however, is
598 not considered to be a significant constraint because the potential area of terrace that could be
599 excavated is very large even if the tailings piles themselves are excluded.
600

601 There is currently a boat launch on BLM land in the center of the site, and it is presumed that
602 it will be necessary to maintain boat access somewhere within the site after construction.
603 Boat access is easy to maintain, so this requirement does not present any difficulties.
604

605 Few wetland areas exist within the Sky Ranch site. The existing pond among the tailings pile,
606 the short swale at the base of the Highway 299 road prism, and portions of the relict side
607 channels constructed in the 1990s represent the only potential wetland locations. It is
608 expected that all of these areas will be preserved.

609 **3.0 Proposed Design Alternatives**

610 Two design alternatives are presented. The order of presentation is arbitrary, and should not
611 be interpreted as indicating any preferences on the part of the Federal Design Group. The
612 function of individual design elements may or may not depend on the design of adjacent
613 elements. Thus, it may be possible in some cases to match certain elements from different
614 design alternatives to form additional hybrid alternatives.
615

616 **3.1 Design Objectives**

617 The fundamental objective of the Trinity River Restoration Program is to restore Chinook
618 salmon populations in the Trinity River to pre-dam levels. That objective is to be
619 accomplished by increasing the availability and quality of the physical habitat needed to
620 support anadromous salmonid populations. Although the primary program focus is on
621 increasing rearing habitat availability flows that are frequently exceeded during the fry-
622 rearing period, Program objectives include the creation of habitat for all salmonid life stages.
623

624 In 2013 the Design Team defined three “means” objectives through which the goal of
625 restoring salmonid populations is attainable. Those objectives and performance metrics for
626 assessing them are presented in Table 5. No performance metrics were identified for
627 assessing fluvial process objectives, as the specific processes to be restored depend on site-
628 specific and design-specific considerations. Process objectives are instead defined for
629 particular design elements and local areas within the project site.
630

631 In the case of the Sky Ranch design, fluvial process is encouraged by lowering terrace
632 surfaces to improve the physical and ecological connection between the channel and the
633 valley bottom. In addition to increasing the potential for vertical accretion, scour, and
634 channel avulsion in overbank areas, terrace lowering is critical for attaining objectives related
635 to riparian function and for increasing rearing habitat availability at moderate to high flow
636 levels. Local channel expansions encourage bed material deposition and bar growth, and
637 removal of boulder and cobble armor layers in some bank locations increase the potential for
638 bank erosion and channel migration. See the feature descriptions below for details.
639

640
641 Table 5: Fundamental and means objectives, and metrics developed by the Design Team. Metrics
642 are currently under discussion and are subject to change.

Fundamental Objective: Restore salmonid populations to pre-dam level		
Means Objective 1: Increase/enhance juvenile salmonid rearing habitat	Means Objective 2: Restore fluvial/physical processes	Means Objective 3: Restore more proper riparian function
Rearing habitat metric: Change in area of fry and juvenile rearing habitat at 11 flows levels	Fluvial process metric: No metrics developed by Design Team. See design feature descriptions.	Riparian function metric: Change in floodplain area at elevations less than 4 ft above the baseflow water surface.

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647

648 **3.2 Alternative A**

649 A schematic showing the footprint of design elements proposed for Alternative A is
650 presented in Figure 14 and the design topography is depicted in Figure 15. Alternative A
651 consists of several extensive terrace excavations to create topographically-complex
652 floodplains that greatly increase the extent of inundation during relatively frequent flow
653 events, some local channel expansions to encourage bar deposition and increase sinuosity,
654 and steps to re-activate an existing side channel.

655

656 IC-1 Channel Expansion

657

658 Description: The edge of the existing terrace will be lowered by an average of 5 ft to expand
659 the width of the main channel by as much as 30 ft at a location where a coarse riffle currently
660 exists. About 75% of the excavation will be in the dry and the remaining 25% will be wet
661 excavation.

662

663 Purpose and Function: Increased channel width from the channel expansion will encourage
664 gravel deposition on the existing riffle. This has the potential to improve the potential for
665 salmon spawning by reducing the size of material composing the riffle. Deposition on the
666 riffle also has the potential to increase the hydraulic gradient across the riffle, which can
667 increase hyporheic flow through the substrate.

668

669 Expected Evolution: Deposition on the existing riffle is expected to fine the substrate size
670 distribution and slightly increase the elevation of the hydraulic control.

671

672 Assumptions/Uncertainties: The amount and exact location of deposition induced by the
673 expansion cannot be predicted with certainty.

674

675 Size and Quantities: IC-1 covers 0.2 acres and requires about 1,575 CY of excavation, with
676 about 1180 CY of the dry excavation and 395 CY of wet excavation.

677

678

679 R-1 Floodplain

680

681 Description: The existing terrace will be lowered by an average of 8 ft to create a complex
682 floodplain surface that inundates at discharges between 1500 and 8500 ft³/s. Floodplain
683 topography will include broad, relatively low upstream and downstream areas that begin to
684 inundate as discharges exceed 1500. Those lower areas are separated by an oblique central
685 hydraulic control the limits water conveyance and flow velocities across the floodplain. The
686 hydraulic control consists of two lobes of relatively high ground crossed by swales that
687 convey controlled water flow (Figure 16). Water will also flow from R-1 into R-3 and back
688 to the main channel a short distance downstream. Woody debris and willow clumps will be
689 installed throughout lower portions of the surface to provide cover habitat.

690

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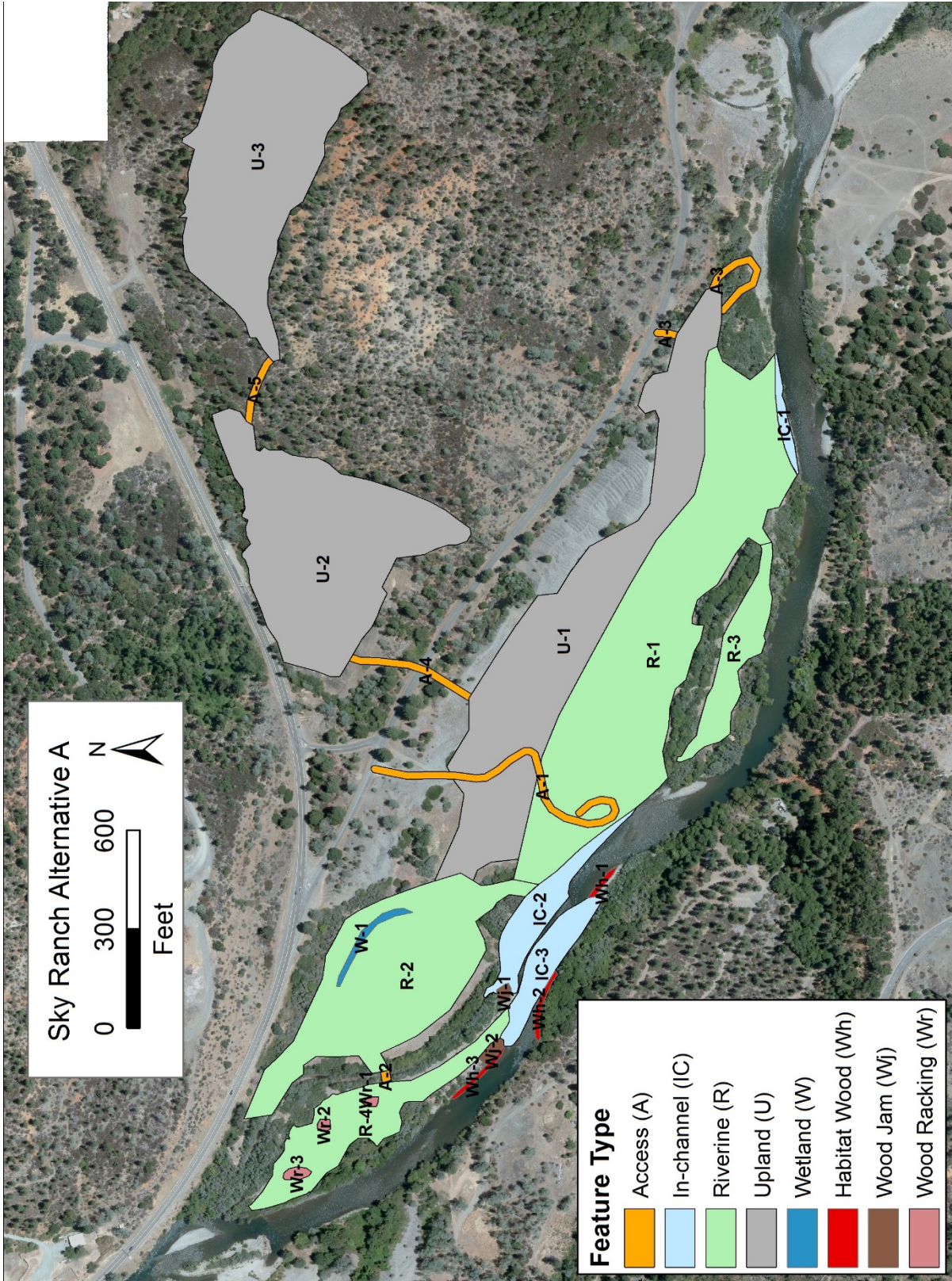
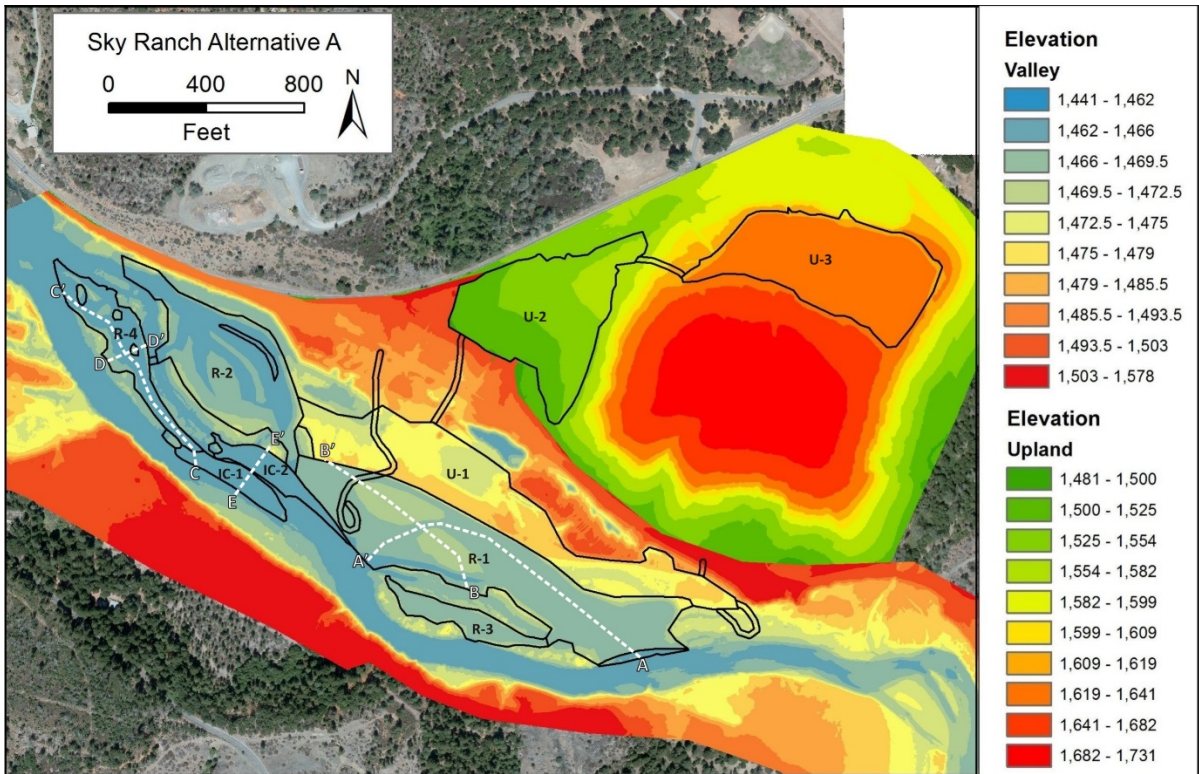


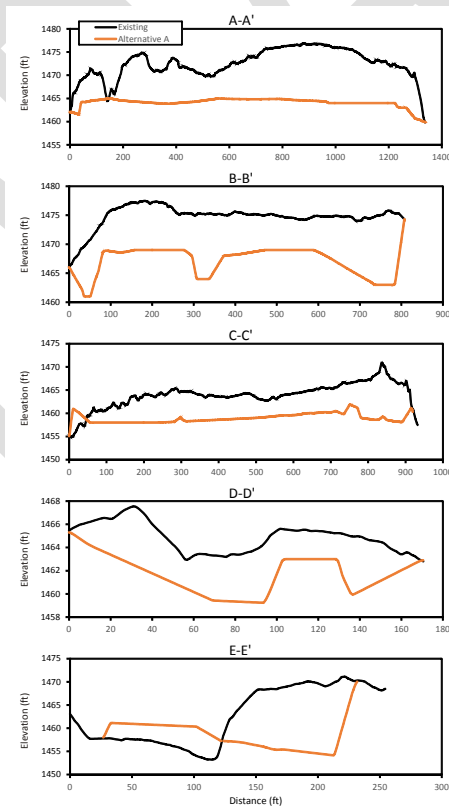
Figure 14: Alternative A design features.

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Figure 15: Topographic rendering of the Alternative A design. The alignments of the profiles shown in Figure 16 are indicated with white dashed lines.



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700

Figure 16: Example design versus existing topographic profiles across selected features.

701 Purpose and Function: R-1 will provide increasingly large areas of slow water habitat with
702 increasing discharge, with nearly complete inundation discharge approaches bankfull stage.
703 The central hydraulic control, however, will ensure low flow velocities through most of that
704 area so that FP1 will provide rearing habitat over a wide range of flows. Limited conveyance
705 over the floodplain will also ensure that sediment transport capacity in the main channel will
706 be maintained. The area will eventually provide wood, allochthonous trophic production, and
707 a variety of other ecosystem services to the riverine environment.

708
709 Expected Evolution: The habitat value of R-1 will increase as it becomes vegetated through
710 natural recruitment and planting.

711
712 Assumptions/Uncertainties: It is assumed that groundwater elevations are controlled by river
713 stage.

714
715 Size and Quantities: R-1 covers 9.9 acres and requires about 127,400 CY of dry excavation.

716 717 R-2 Floodplain

718
719 Description: The existing terrace will be lowered by an average of 6.8 ft to create a complex
720 floodplain surface that inundates at discharges between 2000 and 8500 ft³/s. Floodplain
721 topography will include a low swale along its distal edge that contains a deep, narrow pond
722 (see feature W-1) and ties into a swale at the base of the Highway 299 embankment and joins
723 the downstream constructed side channel three-quarters of the way along its length. R-2
724 topography also includes some smaller swales that originate in the floodplain interior and
725 join the distal swale near its downstream end. Water conveyance over the floodplain is
726 limited by a hydraulic control along its upstream margin. Woody debris and willow clumps
727 will be installed throughout lower portions of the surface to provide cover habitat.

728
729 Purpose and Function: R-2 will provide increasingly large areas of slow water habitat with
730 increasing discharge, with nearly complete inundation discharge approaches bankfull stage.
731 The hydraulic control at its upstream end will ensure low flow velocities through most of that
732 area so that R-2 will provide rearing habitat over a wide range of flows. Limited conveyance
733 over the floodplain will also ensure that sediment transport capacity in the main channel will
734 be maintained. The area will eventually provide wood, allochthonous trophic production, and
735 a variety of other ecosystem services to the riverine environment.

736
737 Expected Evolution: The habitat value of R-2 will increase as it becomes vegetated through
738 natural recruitment and planting.

739
740 Size and Quantities: R-2 covers 5.5 acres and requires about 59,940 CY of dry excavation.

741 742 W-1 Oxbow pond

743
744 Description: Feature W-1 is a narrow, deep pond that simulates the morphology of an
745 abandoned oxbow in a meandering river channel. The pond will be excavated to at least 6
746 feet below the local groundwater stage to maintain temperature stratification, whereas its

747 proximity to the valley wall is intended to capture cold water seeping from the hillslopes to
748 the north. The pond will be connected to the main channel during seasonal floods, at which
749 time salmonid juveniles will have access between the pond and the main channel. Any fine
750 sediment in the banks of the pond will be over-excavated and replaced with gravel or other
751 stable materials. Woody debris will be placed to provide cover from predation.

752

753 Purpose and Function: W-1 is intended to provide off-channel rearing habitat, primarily for
754 Coho salmon.

755

756 Expected Evolution: The habitat value of W-1 will increase as its margins become vegetated.
757 Due to the distance of this pond from flow entering the R-4 floodplain and the removal of
758 fine sediments from its perimeter, sediment inputs are expected to be small and the pond
759 should persist at near its constructed depth for decades.

760

761 Assumptions/Uncertainties: It is assumed that groundwater elevations are controlled by river
762 stage and that sediment inputs to the pond will be small.

763

764 Size and Quantities: W-1 covers 0.14 acres. The 3,125 CY of cut required to create the pond
765 from the existing terrace is included in the R-1 total given above.

766

767

768 R-3 Floodplain

769

770 Description: Higher portions of the existing terrace/floodplain surface to the south of the
771 remnant of the downstream constructed side channel will be lowered by an average about 4.8
772 ft to inundate at flows between 4000 and 6000 ft³/s. R-3 will receive flow originating on the
773 R-1 floodplain, and convey most of it back to the main channel upstream from Pool 1,
774 identified on Figure 3. The downstream half of R-3 will inundate primarily by backwater
775 flooding. Woody debris and willow clumps will be installed throughout lower portions of the
776 surface to provide cover habitat.

777

778 Purpose and Function: R-3 will provide areas suitable for riparian recruitment, and additional
779 slow water habitat for fry rearing during flood events. Conveyance back to the main channel
780 and low conveyance through the downstream two-thirds of R-3 will maintain sediment
781 transport capacity in the main channel and limit overbank flow velocities. The area will
782 eventually provide wood and allochthonous trophic production to the aquatic ecosystem.

783

784 Expected Evolution: The habitat value of R-3 will increase as it becomes vegetated through
785 natural recruitment and planting.

786

787 Assumptions/Uncertainties: It is assumed that groundwater elevations are controlled by river
788 stage.

789

790 Size and Quantities: R-3 covers 1.23 acres and requires about 9,400 CY of dry excavation.

791

792

793 IC-2/IC-3 Meander Complex

794

795 Description: The feature consists of an excavated bend along the right bank of the channel
796 (IC-2 bend extension) combined with a constructed diagonal riffle (IC-3 constructed riffle).
797 The IC-2 bend extension involve excavation to relocated the right bank of the river as much
798 as 90 ft to the north of its current location, thereby approximately doubling the amplitude a
799 the existing channel curvature at that location. Excavation depths in IC-2 average about 7.5 ft
800 and reach as much as 18 ft in some locations (Figure 16). Approximately 75% of the
801 excavation will be above the summer baseflow water surface, and the remainder will be wet
802 excavation. The IC-3 constructed riffle will consists of clean gravel and cobble extending
803 diagonally across the river from the upstream end of the R-4 floodplain to the left bank about
804 300 ft upstream. The crest of the riffle will be approximately equal to the baseflow water
805 surface elevation so that only the upstream end of the structure near the left bank attachment
806 area will be emergent at lower flows. The left edge of the riffle will run parallel to the bank
807 for at least 200 ft downstream from the left bank attachment area, leaving a long alcove along
808 the left channel margin.

809

810 Purpose and Function: Increase bend amplitude associated with the IC-2 excavation will
811 encourage pool scour in the bend apex, while the increased form roughness will help to
812 decrease flow velocities upstream from the bend. The IC-3 riffle creates new low velocity
813 habitat in the alcove along its left (downstream) edge at lower discharge levels and increase
814 water surface elevations on its right (upstream) side, thereby decreasing the discharges at
815 which flow enters the R-4 floodplain and the existing side channel.

816

817 Expected Evolution: IC-2 is expected to result in some additional erosion of the concave
818 right bank, but significant bend migration is unlikely. IC-3 is expected to persist or even
819 grow in size as more coarse material deposits in the area.

820

821 Assumptions/Uncertainties: It is possible, but unlikely, that deposition could occur in the
822 excavated meander bend. It is also possible that the constructed riffle could erode, such that
823 increased water surface elevations upstream from the riffle are not maintained in the future.

824

825 Size and Quantities: IC-2 covers 1 acre and will require a total excavation volume of 11605
826 cubic yards, with about 8705 yards of dry excavation and 2900 yards of wet excavation. IC-3
827 covers 0.86 acres and will require 4115 cubic yards of clean gravel and cobble fill, virtually
828 all of which will be placed in the wetted channel.

829

830 Wj-1 Wood Jam

831

832 Description: The Wj-1 wood jam is located at the downstream end of the IC-2 bend
833 extension immediately to the left of the entrance to the existing side channel that the IC-2/IC-
834 3 meander complex is intended to reactivate. Wj-1 will be a medium-sized jam that overtops
835 at flows near 5500 ft³/s.

836

837 Purpose and Function: Wj-1 will create a local backwater that, in conjunction with the IC-
838 2/IC-3 meander complex, with reactive the existing side channel at that location. The wood

839 jam will help to direct bedload toward river left and promote scour in the immediate vicinity
840 of the side channel entrance.

841

842 Expected Evolution: Wj-1 will be built to persist for 5-10 years and incorporate rock, live
843 wood, and existing shrubs so that a vegetated obstruction remains after the original wood has
844 rotted. Persistence of an obstruction at this location is needed to maintain adequate flow in
845 the existing side channel that will be re-activated as part of this design.

846

847 Assumptions/Uncertainties: It is uncertain whether this wood jam will direct bedload as
848 anticipated; it is possible that the obstruction will erode after the placed wood has rotted.

849

850 Size and Quantities: Wj-1 covers 0.04 acres and requires about 200 CY of excavation and
851 about twice as much wood, slash, rock, and other fill.

852

853 R-4 Floodplain

854

855 Description: The R-4 floodplain occupies the areas between the existing constructed side
856 channel and the main channel. That area consists of a low cobble bar located between the
857 Wj-1 and Wj-2 wood jams at its upstream end, and grades upward in the downstream
858 direction to terrace elevations. The existence of large piles of wood debris in the area
859 suggests that a large share of the floating debris carried by flood flows is directed onto this
860 surface. Excavation of the surface to floodplain elevations will begin at the downstream end
861 of the IC-3 constructed riffle and continue downstream into the right overbank area. The
862 depth of the cut will generally increasing with downstream distance. The final floodplain
863 surface will have complex topography that inundates between 2000 and 4500 ft³/s. The
864 upstream two-thirds of the R-4 floodplain will be relatively flat and will be separated from
865 the downstream third by a central hydraulic control that limits conveyance and maintains
866 slow flow velocities over a range of moderate floods magnitudes (Figure 16). Water passing
867 that hydraulic control drains back to the main channel at the downstream end of the feature.
868 R-4 also contains several relatively high areas with placed vertical members intended to rack
869 floating woody debris (see features Wr-1, Wr-2, Wr-3 below). A small portion of R-4 near its
870 northeast margin is separated from the rest by a low divide so that water reaching that area
871 drains into the existing constructed side channel. Woody debris and willow clumps will be
872 installed throughout lower portions of the surface to provide cover habitat.

873

874 Purpose and Function: R-4 will provide slow water habitat for fry rearing during moderate
875 flood events and additional areas suitable for riparian recruitment. This area is also intended
876 to rack significant quantities of large wood at elevations that are frequently inundated,
877 thereby creating an abundance of especially valuable cover habitat.

878

879 Expected Evolution: The habitat value of R-4 will increase as it racks additional wood and
880 becomes vegetated through natural recruitment and planting. The area will eventually
881 provide wood, allochthonous trophic production, and a variety of other ecosystem services to
882 the riverine environment.

883

884 Assumptions/Uncertainties: It is assumed that groundwater elevations are controlled by river
885 stage; wood may not rack as anticipated.

886
887 Size and Quantities: R-4 covers 2.24 acres and requires about 14,360 CY of dry excavation.

888
889 Wj-2 Wood Jam

890
891 Description: The Wj-2 wood jam is located along the right bank adjacent to the upstream end
892 of the R-4 floodplain. Wj-2 is a medium-sized jam that overtops at flows near 7000 ft³/s.

893
894 Purpose and Function: Wj-2 is intended to constrict flow conveyance and maintain stream
895 power in the vicinity of Pool 2, identified on Figure 3, but also to direct a portion of the
896 stream flow and floating debris onto the R-4 floodplain.

897
898 Expected Evolution: Wj-2 will be built to persist for 5-10 years and incorporate live wood
899 and existing shrubs so that a vegetated obstruction remains after the original wood has rotted.

900
901 Assumptions/Uncertainties: The obstruction could erode after the placed wood has rotted.

902
903 Size and Quantities: BE covers 0.07 acres and requires about 500 CY of excavation and
904 about twice as much wood, slash, rock, and other fill.

905
906 Wh-1, Wh-2, Wh-3 Habitat Wood

907
908 Description: The three Wh features correspond to areas suitable for the placement of woody
909 debris that serves as cover habitat. Placement of this wood will be directed in the field by the
910 project designers or a designated wood placement specialist.

911
912 Purpose and Function: Woody debris is valuable cover habitat for juvenile salmonids, and is
913 a productive substrate for trophic production.

914
915 Expected Evolution: The installed wood could remain in place and slowly decay over time or
916 it could be redistributed to other location during floods. Wood that is frequently wetted and
917 dried will decay over a few year, but fully submerged wood can persist for decades.

918
919 Assumptions/Uncertainties: The locations for wood placement are subject to change
920 according to the judgement of the personnel directing that activity during construction.

921
922 Size and Quantities: The number and size of Wh features is flexible. It is currently projected
923 that these areas may cover about 0.16 acres along the main channel margin. Similar wood
924 placements are incorporated in the other design features.

925
926 Wr-1, Wr-2, Wr-3 Wood Racking

927
928 Description: The three Wr features correspond to relatively high areas within the R-4
929 floodplain where vertical member intended to trap floating wood have been installed. These

930 areas will be at elevations between 2000 and 4500 ft³/s so that the trapped wood is frequently
931 inundated. The vertical members intended to trap wood will be variable in height so that
932 wood can be captured over a range of flood stages.

933
934 Purpose and Function: The Wr features are intended to improve rearing habitat by creating
935 woody debris piles in areas that are frequently inundated.

936
937 Expected Evolution: The installed vertical members that capture wood will likely rot within
938 5-10 years. However, once established and colonized with vegetation, woody debris pile may
939 be effective at continuing to rack more debris.

940
941 Assumptions/Uncertainties: Wood may not rack on these elements as anticipated.

942
943 Size and Quantities: The number and size of Wr features is flexible. It is currently projected
944 that these areas may cover about 0.1 acres within the R-4 floodplain.

945 946 U-1 Terrace Enhancement

947
948 Description: Grading of the U-1 surface to create rolling topography capped by fine
949 sediment, which is likely to be produced as a by-product of coarse sediment processing. The
950 surface will be planted with upland vegetation. Topographic breaks will be used to limit the
951 proportion of the surface that is accessible to motorized vehicles. This surface has not been
952 graded in the current terrain model for this design alternative.

953
954 Purpose and Function: Restore the U-1 area, which has been dredged and mechanically
955 flattened, to a more natural condition.

956
957 Expected Evolution: The goal is to develop upland forest or savannah in the area.

958
959 Assumptions/Uncertainties: Vegetation may have difficulty establishing on this hot dry
960 surface.

961
962 Size and Quantities: U-1 covers 8 acres. Topographic details have not yet been developed for
963 this area, but cut and fill volumes associated with grading are expected to roughly balance.
964 The additional quantity of fine sediment used to cap the surface will depend on the quantity
965 of fine sediment produced as a by-product of coarse sediment processing.

966 967 U-2 Lower Spoils

968
969 Description: Spoils area in which to dispose of excess material excavated from the project
970 site. U-2 occupies a hydraulic mining scar, so fill in will restore the area to a more natural
971 state.

972
973 Expected Evolution: The spoils area will be planted with upland species following
974 construction.

975

976 Size and Quantities: U-2 covers 6.65 acres and can accommodate at least 145,000 cubic
977 yards of spoils.

978

979 U-3 Upper Spoils

980

981 Description: Spoils area in which to dispose of excess material excavated from the project
982 site. U-3 occupies a hydraulic mining scar, so fill in will restore the area to a more natural
983 state.

984

985 Expected Evolution: The spoils area will be planted with upland species following
986 construction.

987

988 Size and Quantities: U-2 covers 7.1 acres and can accommodate at least 130,000 cubic yards
989 of spoils.

990

991

992 A-1 Existing Main Access Road

993

994 Description: Existing Access to site and to a proposed boat launch location.

995

996 Size and Quantities: A section of existing road 480 ft long will be used to access across the
997 U-1 terrace, and 580 ft of new road within the R-1 floodplain will be needed to access the
998 boat ramp location. This launch location would be accessible when stream flows are 2000
999 ft³/s or less.

1000

1001 A-2 Temporary Access Road to R-4

1002

1003 Description: Short road crossing the existing side channel between R-2 and R-4 to provide
1004 access to R-4.

1005

1006 Expected Evolution: Due to its low elevation in the existing side channel, this road will
1007 revegetate rapidly following construction.

1008

1009 Size and Quantities: This temporary access will be about 30 ft long and 20 ft wide.

1010

1011 A-3 Access Road to Alternative Boat Launch Location

1012

1013 Description: Access to an alternative new boat launch location. A-3 will provide a direct
1014 connection between Sky Ranch Road and the east end of the U-1 terrace area, and between
1015 U-1 and the launch. This launch location would be accessible at stream flows exceeding 3000
1016 ft³/s.

1017

1018 Size and Quantities: The section of road between Sky Ranch Road and U-1 will be 60 ft long.
1019 The section from the edge of U-1 to the launch will be a loop with a total length of 350 ft.

1020

1021 A-4 Temporary Access Road to U-2 Spoils

1022

1023 Description: Direct access from the U-1 terrace area to the point where Sky Ranch Road is
1024 crossed to approach the upland spoils areas.

1025

1026 Expected Evolution: A-4 will be decommissioned following construction.

1027

1028 Size and Quantities: The crossing at Sky Ranch Road will approximately bisect A-4, which
1029 has a total length of about 390 ft.

1030

1031 A-5 Temporary Access Road to U-3 Spoils

1032

1033 Description: Access from the U-2 spoils area to the U-3 spoils area.

1034

1035 Expected Evolution: A-5 will be decommissioned following construction.

1036

1037 Size and Quantities: A-5 will be about 210 ft long.

1038

1039 *Materials and Quantities*

1040

1041 Table 6 presents cut and fill quantities for the proposed design, as determined by topographic
1042 differencing between the existing and design terrains. The grain size distributions of the
1043 mineral fill materials are given in Table 7 Wood quantities and ballast volumes for wood
1044 jams Wj-1 and Wj-2 will be determined at a later stage of design, along with a more detailed
1045 account of where and how wood will be used for habitat enhancement throughout the project
1046 site.

1047

1048 Table 6: Cut and fill volumes. Total dry fill in U-1 and U-2 is set equal to the total cut. Cut in areas
1049 Wr-1, Wr-2, and Wr-3 are included in the total for R-4, and cut in W-1 is included in the total for R-2.
1050 Re-contouring in area U-1 has not yet been designed.

Feature	Dry Cut (Cu. Yd.)	Wet Cut (Cu. Yd.)	Dry Fill (Cu. Yd.)	Wet Fill (Cu. Yd.)	Fill Material
IC-1	1180	395			
IC-2	8700	2900			
IC-3				4115	70% CGC, 30% CSB
R-1	127400				
R-2	59940				
R-3	9400				
R-4	14360				
U-2	0		Up to 145000		
U-3	0		Up to 130000		
Total	220980	3295	224275	4115	

1051

1052

1053 Table 7: Material types. Fines are defined as material less than 0.5 inches in diameter.

Material	Description	D_{50} (inches)	D_{90} (inches)	D_{Max} (inches)	Percent Fines
CGC	Gravel and cobble between 0.5 and 6 inches intermediate diameter	2	5	6	0
CSB	Cobble and small boulders between 5 and 12 inches intermediate diameter	7-9	10-12	14	0

1054

1055

1056 **3.3 Alternative B**

1057 The objectives of Alternative B are to increase flow outside main channel areas to provide a
 1058 greater diversity of flow depths and velocities for juvenile salmonid rearing, maintain shear
 1059 stress in the main channel at bankfull discharge (8,500 cfs) to sustain existing large pools in
 1060 the reach, provide diverse shear stresses in off-channel areas to form variable topography for
 1061 aquatic and terrestrial biota, and 4) increase the surface area wetted by 4,000 to 5,000 cfs, for
 1062 riparian plant colonization. These objectives are accomplished through construction of side
 1063 channels, channel expansions to disperse flow, and grading terraces from the existing
 1064 topography to create floodplain surfaces (Figure 17; Figure 18). Alternative B additionally
 1065 involves construction of a meander bend and associated point bar feature. These features
 1066 increase the area of flow inundation with discharge in the reach compared to current
 1067 conditions (Figure 20; Appendix A) and provide a diversity of pathways for flow on existing
 1068 terrace surfaces.

1069

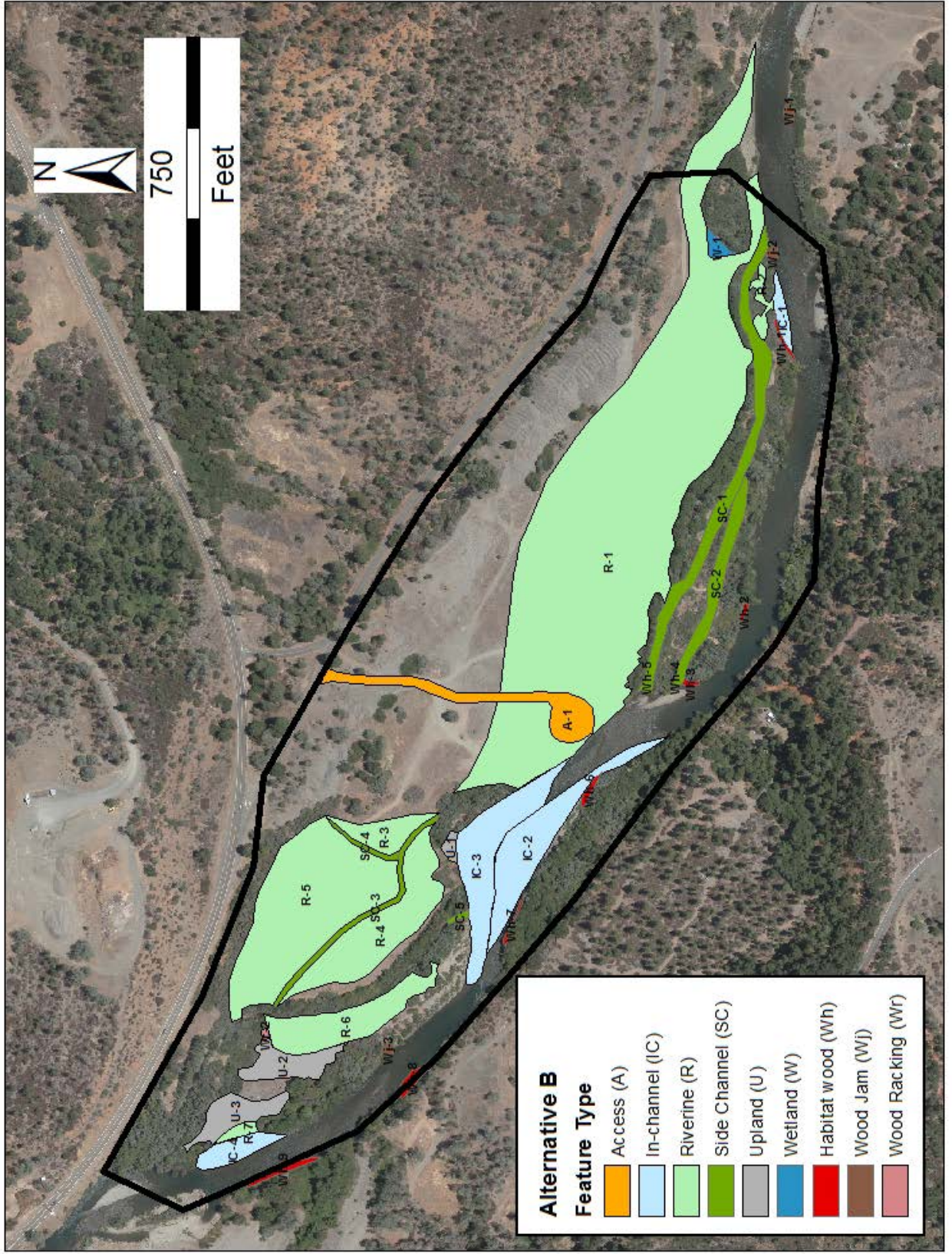
1070 In all cases, constructed floodplains will be enhanced with additions of fine sediment
 1071 (particles <2.8 mm) if they lack this size range of sediment, which is important for water
 1072 retention and storage and uptake of nutrients for growing plants. Additionally, floodplains
 1073 will be “roughly graded”, meaning the design topography will be constructed with roughness
 1074 as minor depressions and hillocks to capture organic material for soil building and provide
 1075 surface discontinuities for hydraulic roughness, among other functions.

1076

1077 Of note is that roughness from large wood jams and habitat wood were not included in the
 1078 hydraulic model that was used to evaluate design features for Alternative B. Therefore,
 1079 discharges at incipient inundation of features will likely be lower in the as-built condition
 1080 compared to the model, as would velocities, depths, and shear stresses in the main channel.
 1081 To create Alternative B, existing topography was graded in AutoCAD using separate
 1082 surfaces for each design feature. This enabled cut and fill volumes to be easily estimated in
 1083 AutoCAD, but a relic of this approach shows in the modeling as odd hydraulics at boundaries
 1084 between wetted features, which should be considered when viewing these results in Section
 1085 4.2. Finally, it should be noted that material excavated to implement Alternative B will be
 1086 spoiled in areas U-2 and U-3 depicted in Figure 14. Descriptions of design elements in
 1087 Alternative B follow.

1088

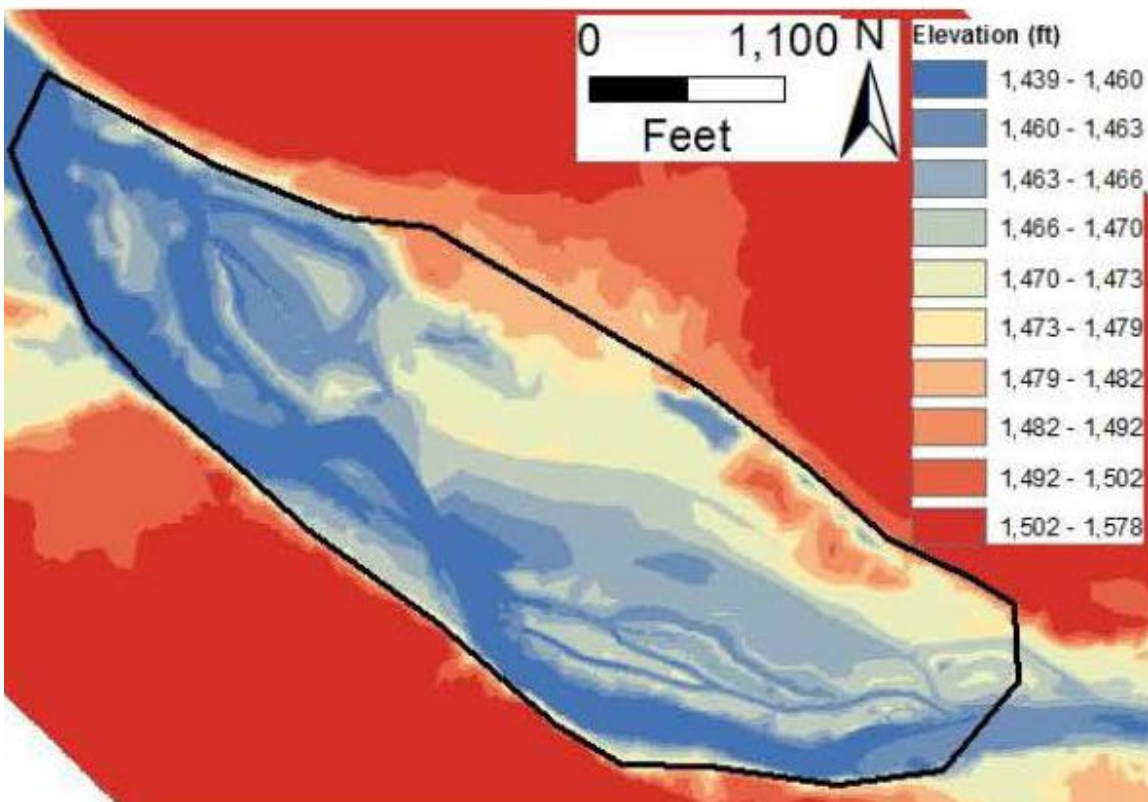
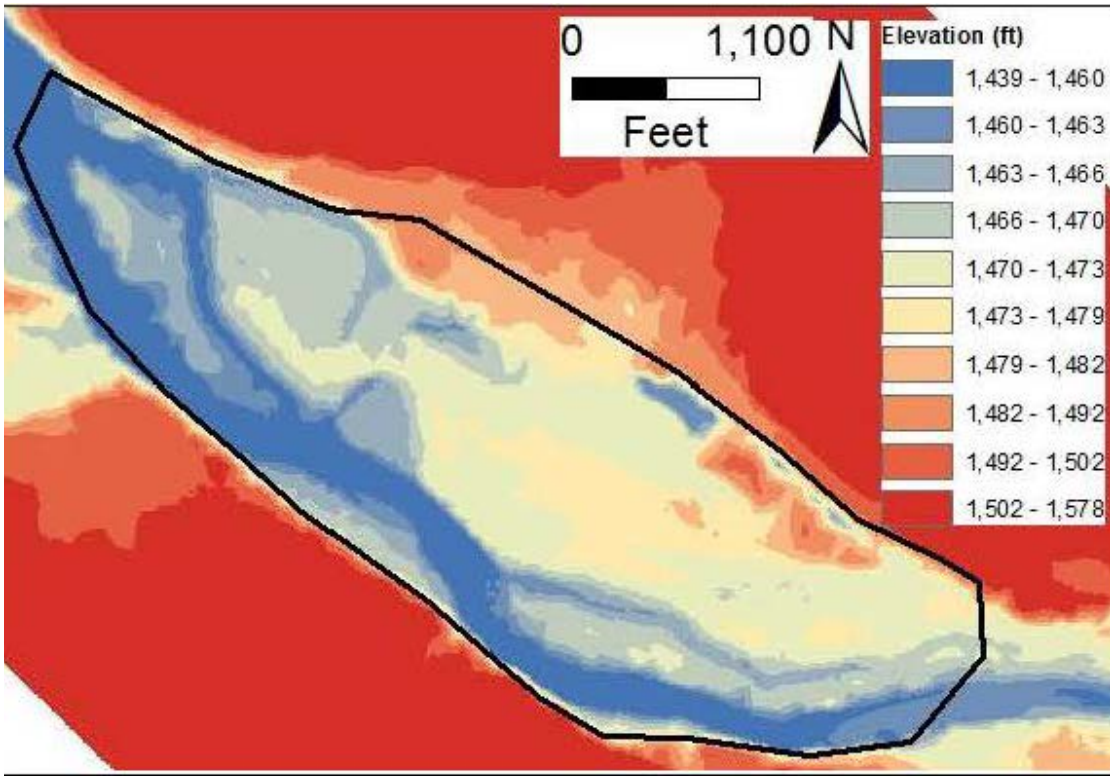
1089



1090
 1091
 1092

Figure 17: Alternative B design features.

1093



1094
1095
1096

Figure 18: Topography of the existing (top panel) and Alternative B landscapes in the Sky Ranch ESL.

1097 A-1 River Access

1098

1099 Description: A-1 is a right bank access road to the Trinity River.

1100

1101 Purpose and Function: A-1 will provide public access to an area of the Trinity River for a
1102 multitude of uses, including boat launching.

1103

1104 Construction Details: A-1 is 720 ft long and accesses a constructed alcove in the river that is
1105 part of R-1. This area is an alcove at discharges up to around 5,000 cfs and experiences
1106 through flow with downstream velocities within 15 feet of shore averaging ≤ 0.5 ft/s at flows
1107 up to around 8,500 cfs.

1108

1109 Expected Evolution: A-1 is expected to remain stable, but require clearing vegetation to
1110 maintain motorized access to the river through time.

1111

1112 Assumptions/Uncertainties: The alcove area may partially fill with fine sediments for periods
1113 of time, but deposition is expected to be minor through time due to scour in the alcove by
1114 turbulence during high flows.

1115

1116 Size and Quantities: A-1 is not expected to require grading outside that performed for the R-1
1117 feature, and its acreage will vary from that depicted as planning for this feature continues
1118 through the design process.

1119

1120 In addition, see A-3 and A-4 in section 3.2 for descriptions of temporary access roads to
1121 spoils areas.

1122

1123

1124 IC-1 Channel Expansion

1125

1126 Description: IC-1 involves excavation of a right bank that is adjacent to a spawning riffle and
1127 immediately upstream of an erodible left bank.

1128

1129 Purpose and Function: IC-1 is inundated at winter baseflow and provides juvenile salmonid
1130 rearing habitat. IC-1 also disperses flow and reduces shear stress on the adjacent spawning
1131 area at all modeled discharges. This will promote fining of the sediment size distribution
1132 there, which is desirable because this spawning area appears to exhibit a grain-size
1133 distribution that is somewhat coarser than what salmon ideally prefer. The feature will also
1134 promote sediment recruitment by helping direct flow at a higher angle against the
1135 downstream left bank, which is composed of consolidated sediments. IC-1 also enables flow
1136 access into the R-2 feature.

1137

1138 Construction Details: IC-1 is arcuate in shape and will increase 2.4 ft in elevation over 30 ft
1139 from the existing channel bed to the right bank at the features widest point. At this location,
1140 the cut will increase an additional 7 ft in elevation to the existing surface at a location 40 ft
1141 from the initial cut.

1142

1143 Expected Evolution: IC-1 will dynamically adjust to the flow regime post construction.
1144 Adjustments may include deposition and storage of fine sediments that may be used for
1145 ammocoete rearing or bank erosion to further increase the channel width at this feature
1146 location, or both.

1147
1148 Assumptions/Uncertainties: The primary uncertainty regards the pathway IC-1 will take in
1149 evolving to equilibrium (scour or fill) with local hydraulics and sediment regime.

1150
1151 Size and Quantities: IC-1 is 0.15 acres and involves 972 cy of cut averaging 4.1 ft in depth
1152 (see Table 9 for a summary of all feature sizes and volumes of excavation or fill).

1153

1154

1155 IC-2 Point Bar

1156

1157 Description: IC-2 is a left-bank point bar that is constructed with imported material.

1158

1159 Purpose and Function: IC-2 will direct flow into IC-3 to promote channel meandering by
1160 increasing shear stress on the outer bank, and will provide edge habitat throughout the feature
1161 for juvenile salmonids. At flows up to 2,000 cfs, the point bar's outer edge experiences flow
1162 velocities and depths that are considered habitat for juvenile salmonids (Table 4). Juvenile
1163 habitat in this area is nearly absent at flows above 4,000 cfs. However, habitat increasingly
1164 occurs in the lee of IC-2 where an alcove is formed between 350 and 1,000 cfs and shoaling
1165 flow occurs in the upstream end of the chute channel between 500 and 1,000 cfs. After
1166 through flow initiates in the cutoff channel at around 1,500 cfs, flow velocities and depths
1167 progressively exceed those designated habitat for juvenile fish as water occupies an adjacent
1168 riparian forest. Besides providing fish habitat, an additional function of IC-2 is to narrow the
1169 existing channel at the feature's upstream end. This will increase shear stress to mobilize
1170 what appears to be excessive fine sediment on the riffle in this area.

1171

1172 Construction Details: IC-2 will be constructed with fill that is 30% (by volume) CSB, 60%
1173 CGC, and 10% sediment <2.8 mm in diameter (see Table 8). The coarse fill will be the base
1174 form of the structure and will enable hyporheic flow through the bar to provide cold, non-
1175 turbid water to the alcove for juvenile rearing and riffle for adult spawning at the downstream
1176 end of IC-2. The main structure of the bar will be in the size range of CGC, which is targeted
1177 by adult salmonids for spawning. These sized materials are expected to periodically erode
1178 from the bar and deposit on the downstream riffle for spawning, and be replaced by mobile
1179 sediment from the channel upstream of the feature. Sediment <2.8 mm in diameter will be
1180 mixed with CGC and placed in the upper portion of the bar in all areas except in areas wetted
1181 by summer baseflow. These small grains are media for water retention and establishment of
1182 riparian plants.

1183

1184 Expected Evolution: The topography of IC-2 will dynamically adjust post construction to the
1185 local flow environment and sediment regime. The bar will additionally expand toward the
1186 right bank as erosion occurs toward IC-3. The cut-off channel on the left side of IC-2 will
1187 generally keep pace with the direction and rate of migration of the bar as riparian vegetation
1188 colonizes the inner portion of the bar. The added roughness from vegetation will promote

1189 fine sediment deposition in this area and increased colonization by plants, which is a driver
1190 of meandering in alluvial streams. Mature evolution of this feature is expected to produce a
1191 chute channel with adjacent vegetation and wood as cover for fish, and a meander bend that
1192 is larger than constructed in this project and exhibits an amplitude and half wavelength that is
1193 in equilibrium with the aforementioned drivers.
1194

1195 Assumptions/Uncertainties: Following topographic adjustments following construction,
1196 substantial evolution of IC-2 depends on right bank erosion on IC-3. The precise extent this
1197 will occur is unknown.
1198

1199 Size and Quantities: IC-2 is 1.06 acres and involves 4,287 cy of fill averaging 2.5 ft in fill.
1200

1201

1202 IC-3 Meander Bend

1203

1204 Description: IC-3 is a right bank meander bend that is excavated from an existing, vegetated
1205 high terrace.
1206

1207 Purpose and Function: Construction of IC-3 will remove oversized material that may have
1208 been placed in the existing outer bend to prevent bank migration from removing a boat ramp,
1209 and enable flow to more forcefully impact and erode the right bank and promote channel
1210 meandering. Such meandering will promote evolution of the IC-2 point bar. Construction of
1211 the bend itself will increase its radius of curvature from 395 ft (existing) to 520 ft, which is
1212 within the average ± 1 standard deviation of the range of curvature for bends on the Trinity
1213 River with alluvial bars and eroding banks (470-690 ft; HVT, 2011).
1214

1215 In addition, flow convergence at the base of the outer bend will scour a pool to provide adult
1216 salmonids holding habitat. The tailout of the pool will provide adult salmon spawning
1217 habitat, and tailout construction will extend downstream on the right bank to end of an
1218 existing spawning riffle to further provide spawning area. The alcove associated with IC-2 is
1219 located adjacent to this riffle so fry that newly emerge from the streambed can immediately
1220 occupy this area for rearing. The bend excavation will also direct flow at a higher angle
1221 against a bedrock wall that is immediately downstream of the aforementioned spawning
1222 riffle. This, in turn, will generate a complex flow environment and deposition of a lobal bar
1223 that will attach to the right bank in the downstream vicinity of the flow impact area.
1224

1225 Construction Details: Following removal of existing vegetation from the area of construction,
1226 IC-3 can largely be excavated “in the dry” by beginning the cut for this feature on the
1227 landward side of the bend. Progressing excavation into the channel may then require
1228 constructing benches for excavator placement as material removal progresses down the steep
1229 (55% slope) outer bank, which is 20 ft from the channel bottom to top of bank. From the base
1230 of the channel at the apex of the bend, excavation will be in the wet to create a flat pool
1231 bottom for 18 ft, and the bottom slope will increase to 8% for 60 ft to gently rise to the IC-2
1232 feature. The remaining areas of excavation for this feature are similarly sloped and would be
1233 accomplished largely in the wet.
1234

1235 Expected Evolution: IC-3 is expected to erode the right bank and increase the amplitude of
1236 the bend until it is in equilibrium with the local channel width, which itself is controlled by
1237 the flow and sediment regimes and valley slope, among others.

1238

1239 Assumptions/Uncertainties: Sediment composing the outer bank of this feature will be
1240 mobilized by shear stresses generated during high flows. If sediment calibers in this area are
1241 oversized to the shear stress available to mobilize them, alternatives for increasing flow
1242 convergence in this area may need to be developed. Evolution of IC-3 additionally relies on
1243 root strength from vegetation remaining that will remain at the top of the cut on the outer
1244 bank will be insufficient to dissuade bank erosion. If this is not the case, vegetation and
1245 associated roodwads may be cleared for some distance from the top of the cut.

1246

1247 Size and Quantities: IC-3 is 1.16 acres and involves 8,984 cy of cut averaging 3.4 ft in depth.

1248

1249

1250 IC-4 Channel Expansion

1251

1252 Description: IC-1 is a right bank excavation near a large, deep scour pool that is associated
1253 with a large wood jam on the left bank.

1254

1255 Purpose and Function: IC-1 will increase edge habitat for juvenile salmonid rearing in an
1256 area that is near a large pool. IC-4 will therefore increase the diversity of flow environments
1257 for fish to occupy for feeding, resting, and roaming activities. This feature also provides flow
1258 access to the R-7 and U-3 features.

1259

1260 Construction Details: IC-4 is arcuate in shape and at its widest point increases its elevation
1261 around 0.7 ft in 58 ft from the existing channel bed to where it adjoins the low point in R-7.

1262

1263 Expected Evolution: IC-3 may experience deposition and storage of fine sediments resulting
1264 from backwater from a downstream large wood structure on the left bank and a bedrock wall
1265 on the right bank. Alternatively, this feature may be increasingly occupied by flow through
1266 local scour of the bed that encourages the channel to migrate toward the right bank.

1267

1268 Assumptions/Uncertainties: As with IC-1, the primary uncertainty regards the pathway IC-4
1269 will take in evolving to equilibrium with local hydraulics and sediment regime.

1270

1271 Size and Quantities: IC-4 is 0.28 acres and involves 1,332 cy of cut averaging 3.0 ft in depth.

1272

1273

1274 R-1 Floodplain

1275

1276 Description: R-1 is a right bank feature that involves substantial grading of existing xeric
1277 terraces to create floodplain surfaces in the area.

1278

1279 Purpose and Function: R-1 will increase the inundation area during elevated flows and
1280 provide substantial benefits to the local hydrology and biology. For example, inundation of

1281 the constructed floodplain will increase groundwater storage for cold water release during
1282 summer and early fall when water temperatures can imperil juvenile fish rearing and adult
1283 spawning. Floodplain inundation will additionally promote storage of fine sediment, thereby
1284 benefitting the quality of gravel for fish and macroinvertebrates in the main and side channels
1285 in the reach. The combination of surface lowering and floodplain deposition of fine sediment
1286 will promote natural recruitment of riparian vegetation and their associated populations of
1287 mammals, birds, insects, and amphibians. Inundation of the floodplain by elevated river
1288 flows will provide juvenile fish high quality rearing habitat in an area that will produce
1289 substantial opportunity for feeding on terrestrial and aquatic insects.

1290
1291 Construction Details: R-1 is graded so that flow inundation occurs in both the up- and
1292 downstream directions. Inundation from the upstream direction is by two primary
1293 connections to the mainstem channel. The upstream connection initiates around 1,000 cfs and
1294 conveys through flow at ~4,000 cfs in a channel that exhibits variable widths and adjacent
1295 surfaces graded to support a diversity of riparian plant species, and includes a 0.28 acre
1296 depression in the floodplain that is expected to remain wetted year-round. A nearby,
1297 downstream connection is a narrow channel that follows a variable line of mature trees, so as
1298 to provide fish overhead cover from predators and shade. This connection initiates around
1299 750 cfs and is a through flow channel at ~4,000 cfs. Inundation of R-1 from downstream
1300 occurs at 350 cfs and higher as a result of the grading of a large alcove that will provide fish
1301 refuge from high flow velocities and fishermen a deep, slow velocity area to launch boats.
1302 Finally, the SC-1 side channel also connects to the R-1 feature at its southern border at
1303 between 1,500 and 2,000 cfs.

1304
1305 Expected Evolution: R-1 will adjust to local flow and sediment conditions by variably
1306 aggrading or scouring within the feature. The feature will establish mature vegetation and
1307 become high quality habitat for all species in the river corridor, including those which
1308 flourish in xeric areas, since these will persist on the margins of the feature.

1309
1310 Assumptions/Uncertainties: Areas for flow to access R-1 from the mainstem channel will not
1311 plug with sediment, but remain open to convey flow onto the feature at around as designed.

1312
1313 Size and Quantities: R-1 is 12.13 acres and involves 153,340 cy of cut averaging 7.8 ft in
1314 depth.

1315
1316

1317 R-2 Floodplain

1318
1319 Description: R-2 is a right bank feature associated with IC-1 that will function as a vegetated
1320 floodplain and provide fish habitat at high flows.

1321
1322 Purpose and Function: R-2 is bifurcate and provides backwater habitat for fish, amphibians,
1323 and reptiles amongst vegetation on the existing terrace and connectivity to SC-1 at high
1324 flows. Additionally, R-2 will provide area for inundation by high flows to reduce shear stress
1325 on the coarse spawning riffle located adjacent to IC-1. Flow initiates on the feature at around
1326 2,000 cfs and it is fully inundated at 6,000 cfs.

1327

1328 Construction Details: The low point in R-2 is at the boundary of IC-2, so construction of
1329 these features should occur in sequence. Construction of bifurcations composing R-2 will
1330 mainly involve excavation of an existing terrace in a manner that minimizes damage to
1331 existing vegetation. In branches of the bifurcate feature, grading of side slopes will create
1332 narrow channels in the lower portions of the branches. The channels widen in the upper
1333 portions of the branches to provide shallow, warm water at around 5,000 cfs, which offer
1334 juvenile fish access to a diverse thermal regime to maximize growth.

1335

1336 Expected Evolution: R-2 will maintain its branched high flow backwater channels and
1337 colonize with riparian vegetation through time. Otherwise, the feature will function as
1338 designed in the absence of significant aggradation by fine sediment depositing in the feature.

1339

1340 Assumptions/Uncertainties: Entrapment of fine sediment by roughness from riparian
1341 vegetation that is expected to colonize this feature with time will not aggrade R-2 to a level
1342 that fish cannot access it in mid- to high flows. Additionally, it is unlikely that bank erosion
1343 by SC-1 will connect it to R-2 and change the function of R-2 from a backwater to flow
1344 through channel.

1345

1346 Size and Quantities: R-2 is 0.12 acres and involves 268 cy of cut averaging 1.4 ft in depth.

1347

1348

1349 R-3 Floodplain

1350

1351 Description: R-3 is a right bank feature graded from a xeric terrace to function as a vegetated
1352 floodplain at moderate to high flows.

1353

1354 Purpose and Function: R-3 is designed to inundate from backwater through R-4 at around
1355 6,000 cfs and receive direct inflow from the mainstem channel via SC-3 and SC-4 between
1356 6,000 and 8,500 cfs. Inundation of R-3 will increase groundwater storage with associated
1357 benefits as described for R-1. Over 43% of its area, the elevation of R-3 is around 6 ft above
1358 the summer baseflow water surface and will support some natural recruitment of willow and
1359 cottonwood and survival of plantings of these species. Once trees are established, the feature
1360 will provide habitat for mammals, birds, and insects, and when inundated by water, optimal
1361 juvenile salmonid rearing habitat.

1362

1363 Construction Details: The left edge of R-3 adjoins the right bank of SC-4 and the feature at
1364 its widest point thereafter maintains a 5% slope for 50 ft, then a 10% slope for 45 ft to the
1365 existing ground surface.

1366

1367 Expected Evolution: R-3 is expected to vegetate with riparian trees, and their leaf litter, along
1368 with turbidity from inundating flows, will develop a soil layer capable of supporting grasses
1369 and forbs. Otherwise, the feature is expected to remain as constructed.

1370

1371 Assumptions/Uncertainties: Vegetation is expected to establish on this feature due to its
1372 elevation relative to the summer baseflow channel. However, it is uncertain whether this will
1373 require irrigation to occur.

1374
1375 Size and Quantities: R-3 is 0.35 acres and involves 1,964 cy of cut averaging 3.5 ft in depth.
1376

1377

1378 R-4 Floodplain

1379

1380 Description: R-4 is a right bank feature graded from a xeric terrace to function as a vegetated
1381 floodplain at moderate to high flows.

1382

1383 Purpose and Function: R-4 will inundate via backwater from SC-3 at around 5,000 cfs and
1384 receive direct inflow from the mainstem channel via this side channel at around 8,500 cfs. As
1385 with R-3, R-4 will increase groundwater storage that will help maintain flow into summer in
1386 an existing side channel located adjacent to this feature. The elevation of R-4 in half the
1387 feature's area is 2-4 ft above the summer baseflow water surface so that natural recruitment
1388 of willow and cottonwood will occur in this area.

1389

1390 Construction Details: R-4 exhibits considerable variability in topography, such that its
1391 downstream portion will grade from an existing surface near IC-3 to the left bank of SC-3 at
1392 a 11% slope for a distance of 83 ft. Upstream of this area, the feature exhibits a 2% slope for
1393 100 ft at its widest point. This relatively flat, low elevation area of the feature occupies 0.64
1394 acres, and grading adjoining it to the existing surface at its border is at a slope of around 25%
1395 for 25 ft.

1396

1397 Expected Evolution: See R-3.

1398

1399 Assumptions/Uncertainties: An existing side channel that adjoins the left edge of R-4 may
1400 erode its right bank and increasingly occupy the floodplain over time. SC-4 may also do the
1401 same. These uncertainties, if realized, are not expected to significantly alter the feature's
1402 design functions (riparian recruitment and habitat for mammals, birds, insects, fish), but
1403 potentially speed plant growth on the feature through delivery of fine sediments.

1404

1405 Size and Quantities: R-4 is 1.34 acres and involves 15,432 cy of cut averaging 7.2 ft in depth.

1406

1407

1408 R-5 Floodplain

1409

1410 Description: R-5 floodplain is a right bank feature that is graded from an xeric terrace to
1411 primarily function as a marshy floodplain at low to moderate discharges and a vegetated
1412 floodplain at moderate to high flows.

1413

1414 Purpose and Function: Similar to other floodplains graded in Alternate B, R-5 will increase
1415 the area of flow inundation for recharging groundwater, provide variable topography for
1416 natural recruitment of riparian vegetation, increasingly provide mammal, bird, amphibian,

1417 and reptiles with the establishment of vegetation, and will provide juvenile fish habitat when
1418 inundated by flows. R-5 is inundated by backwater from an existing side channel and SC-3
1419 between 3,000 and 6,000 cfs. Beyond this, through flow occurs on R-5 by water entering
1420 from SC-3 via conveyance from the outside of the IC-2 meander bend. The entire R-5 feature
1421 is inundated at 11,500 cfs, except a 0.2 acre area of existing terrace that be maintained to
1422 provide upland habitat and refuge wildlife during rare high flow events.

1423

1424 Construction Details: From the existing terrace just mentioned, RC-5 decreases in elevation
1425 from its southwestern side to the right bank of SC-3 at a slope of 6.8% over 105 ft and from
1426 its southeastern side to the left bank of SC-4 at 10% over 55 ft. From the northern side of the
1427 terrace, elevations decrease at a 13% slope over 60 ft to a backwater channel within which is
1428 graded three floodplain/marsh features ranging in area from 0.03 to 0.05 acres. The
1429 floodplain/marsh areas exhibit maximum depths around 3 ft at 5,000 cfs when all are
1430 inundated. The top surface of the existing terrace should be ripped with a dozer to loosen the
1431 ground for receiving nutrient additions to improve chances of riparian colonization.

1432

1433 Expected Evolution: Except the floodplain/marsh features in R-5, all surfaces range ~4 to 7
1434 feet above the summer baseflow elevation. This grading is expected to establish a plant
1435 community of grasses and forbs to willows and cottonwoods and non-deciduous species on
1436 lower to upper surfaces. In the floodplain/marsh areas, the bottom elevation of the
1437 depressions are within a foot above or below the summer baseflow water surface, so the
1438 depressions are expected to support a diversity of hydric plants.

1439

1440 Assumptions/Uncertainties: It is assumed the backwater connection between R-5 and the
1441 existing side channel will not aggrade so that backwater connectivity is maintained.

1442

1443 Size and Quantities: R-5 is 2.82 acres and involves 21,081 cy of cut averaging 4.6 ft in depth.

1444

1445

1446 R-6 Floodplain

1447

1448 Description: R-6 is a right bank floodplain that borders an existing side channel.

1449

1450 Purpose and Function: See R-5. Flow initiates on R-6 from water exiting the left bank of an
1451 existing side channel at flows between 2,000 and 3,000 cfs. The feature is nearly fully
1452 inundated at 6,000 cfs by water from the side channel and contributions from the mainstem
1453 Trinity River. R-6 is fully inundated and flow exits the feature and enters U-2 between 6,000
1454 and 8,500 cfs.

1455

1456 Construction Details: R-6 is graded to increase in elevation from the left bank of an existing
1457 side channel at a rate of 3.7% for 80 ft. At around this distance, the slope transitions to an
1458 11% slope for 20 ft to adjoin this feature to U-2. This grading enables 0.57 acres of the
1459 feature's area to be unundated by flows less than 3,000 cfs.

1460

1461 Expected Evolution: Because 62% of the feature is 2 ft above the summer baseflow water
1462 surface, this feature is expected to rapidly, naturally recruit a functional riparian plant

1463 community. Turbid flows entering the feature will experience roughness from vegetation and
1464 drop their sediment load. This will slightly aggrade R-6 and augment the soil to further
1465 support the vegetation community.

1466

1467 Assumptions/Uncertainties: An uncertainty is the degree to which overbank flows from the
1468 existing side channel will construct a sediment berm on the channel's left bank when
1469 sediment laden water overflows into R-6. The design assumes this potential occurrence will
1470 not greatly impacted the design flows for inundation of the R-6 feature.

1471

1472 Size and Quantities: R-6 is 0.92 acres and involves 4,764 cy of cut averaging 3.2 ft in depth.

1473

1474

1475 R-7 Floodplain

1476

1477 Description: R-7 is a left bank floodplain that is bounded by IC-4 and U-3.

1478

1479 Purpose and Function: R-7 will increase the area of flow inundation for groundwater
1480 recharge, provide variable topography for natural recruitment of riparian vegetation, and
1481 juvenile fish habitat when inundated by flows. R-7 also enables high flow inundation of U-3.
1482 Flow initiates on R-7 at 750 cfs, and the feature is progressively more inundated by flows up
1483 to 4,000 cfs, and conveys water to U-3 between 4,000 and 5,000 cfs.

1484

1485 Construction Details: R-7 is arcuate-shaped and graded at a 12% slope over 32 ft at its widest
1486 point. The long-axis dimension of the feature is 127 ft long.

1487

1488 Expected Evolution: R-7 is graded between 1 and 5 ft above the summer baseflow water
1489 surface, so the expectation is the feature will naturally recruit willows and cottonwoods.

1490 Roughness from this vegetation will have the same effect on feature aggradation as described
1491 for R-6.

1492

1493 Assumptions/Uncertainties: Riparian vegetation will establish as expected without the need
1494 for irrigation to initiate seedlings.

1495

1496 Size and Quantities: R-7 is 0.08 acres and involves 913 cy of cut averaging 7.5 ft in depth.

1497

1498

1499 SC-1 and SC-2 Side Channels

1500

1501 Description: SC-1 and SC-2 are right bank side channels excavated from a partially vegetated
1502 terrace near R-1.

1503

1504 Purpose and Function: SC-1 and SC-2 will provide habitat for juvenile fish rearing, wet
1505 adjacent surfaces for riparian plant growth, and recharge groundwater beginning at around
1506 750 cfs. The fish habitat will be particularly diverse in depths, velocities, and water
1507 temperatures that the channels will provide. These outcomes will result from grading that
1508 enables channel wetting to progressively occur in both the up- and downstream ends of SC-1

1509 and from the downstream end of SC-2 until between 1,500 and 2,000 cfs. Also in this range
1510 of flow, SC-1 and SC-2 connect and flow is also conveyed onto a low area of R-1 from SC-2.
1511 Flow through SC-2 then occurs at flows just over 2,000 cfs, and backwater inundates an
1512 existing side channel that is located between SC-1 and SC-2 and connected to SC-1 at both
1513 ends between 3,000 and 4,000 cfs. Flow through the existing side channel occurs between
1514 4,000 and 5,000 cfs.

1515

1516 Construction Details: SC-1 is 1,300 ft long and SC-2 is 586 ft long. SC-2 branches from SC-
1517 720 ft downstream of SC-1 connection to summer baseflow in the Trinity River. The SC-1
1518 and SC-2 side channels exhibit variable lengths, longitudinal and bank slopes, channel
1519 bottom widths, and bank heights and these are not summarized here. Conspicuous features of
1520 both side channels include alcoves at their downstream ends and 2-3 ft deep pools excavated
1521 periodically throughout their lengths.

1522

1523 Expected Evolution: The side channels are expected to adjust their topography and slope to
1524 imposed flow and sediment regimes through time, and support riparian plants and trees with
1525 surface flow and groundwater contributions to adjacent surfaces.

1526

1527 Assumptions/Uncertainties: The degree of adjustments to channel morphology that will occur
1528 through time is uncertain at this design stage because stability analyses of their form have not
1529 yet been undertaken.

1530

1531 Size and Quantities: SC-1 is 1,340 ft long, occupies 0.98 acres, and involves 4,995 cy of cut
1532 averaging 3.2 ft in depth. SC-2 is 590 ft long, occupies 0.46 acres, and involves 4,076 cy of
1533 cut averaging 5.5 ft in depth.

1534

1535

1536 SC-3 and SC-4 Side Channels

1537

1538 Description: SC-3 and SC-4 are right bank side channels that will border R-4, R-5, and R-6,
1539 and they will be excavated from an existing xeric terrace.

1540

1541 Purpose and Function: Both side channels provide habitat for juvenile fish rearing, wet
1542 adjacent surfaces for riparian plant growth, and recharge groundwater during moderate to
1543 high flows. Fish habitat is first provided on the feature when flow initiates in SC-3 as
1544 backwater from an existing side channel at 5,000 cfs. At 6,000 cfs, backwater extends
1545 upstream far enough on SC-3 to occupy SC-4. Between 6,000 and 8,500 cfs, flow through
1546 both channels from the upstream direction originates from conveyance through an existing,
1547 vegetated low area on the outside of the IC-3 meander bend.

1548

1549 Construction Details: SC-3 and SC-4 respectively exhibit largely uniform 0.5% slopes of 0.5
1550 and 1.2% and widths of 15 ft. For both channels, the banks grade gently to the surrounding
1551 topography so that flow is not steeply bounded by channel banks, but rather provides a range
1552 of depths at a given flow.

1553

1554 Expected Evolution: The side channel's morphologies are expected to evolve into low relief
1555 swales through time. This would result because inundation of the channels is primarily from
1556 backwater, which will preclude scouring flows from entering from the upstream direction
1557 because the channels will already be wetted when this occurs. This, in turn, will enable
1558 formation of a soil layer in the side channel and riverine complex through decomposition of
1559 plant material and the settling of fines from turbid backwater. The soils will vegetate with
1560 grasses and forbs to add diversity to the riparian tree and shrub community that is expected to
1561 establish in the area. Then, as streamflow backwaters, juvenile fish can pace with the
1562 frontward edge of inundation to feed on terrestrial insects in the vegetation.

1563
1564 Assumptions/Uncertainties: An uncertainty is whether soil development will be sufficiently
1565 rapid in the area to evolve the site as expected, preferably within a decade post construction?
1566

1567 Size and Quantities: SC-3 is 723 ft long, occupies 0.25 acres, and involves 3,115 cy of cut
1568 averaging 7.7 ft in depth. SC-4 is 236 ft long, occupies 0.07 acres, and involves 510 cy of cut
1569 averaging 4.3 ft in depth.

1570

1571

1572 SC-5 Side Channel

1573

1574 Description: SC-5 is a right bank opening to an existing side-channel.

1575

1576 Purpose and Function: The purpose of SC-5 is to direct flow into an existing side channel.
1577 The SC-5 feature is inundated and functions as an alcove that elongates in the existing side
1578 channel at flows ranging up to 3,000 cfs. At this upper range of flows, the side channel is
1579 fully inundated and conveys surface water downstream. The difference in flow between that
1580 which inundates SC-5 and the through flow discharge is controlled by the existing bed
1581 elevation for the side channel.

1582

1583 Construction Details: SC-5 is 64 ft long and involves lowering the existing channel bed
1584 elevation by 2 ft to join the right bank of IC-2. The longitudinal slope of SC-5 is flat, the
1585 channel bottom is 5 ft wide, and the side slope of the channel are around 75% and 4 ft long.

1586

1587 Expected Evolution: SC-5 will erode its banks and widen its bed in adjusting to variations in
1588 flow and sediment supply through time as IC-2 itself evolves and modifies the location of the
1589 side channel entrance on this bend.

1590

1591 Assumptions/Uncertainties: It is unclear how the location, dimensions, and bed elevation of
1592 SC-5 will adjust with migration of the IC-2 meander. Some possibilities are the side channel
1593 entrance could partially fill with sediment so that relatively high flows are required to
1594 activate the side channel, the outer bend could also migrate northward and remove SC-5 and
1595 shorten the side channel's length.

1596

1597 Size and Quantities: SC-5 is 0.02 acres and involves 52 cy of cut averaging 1.6 ft in depth.

1598

1599

1600 U-1 Sediment Plug

1601

1602 Description: U-1 is a sediment plug located on the right bank at the apex area of IC-2.

1603

1604 Purpose and Function: U-1 is intended to prevent flow from exiting IC-2 at the location of
1605 this feature's construction, which is desirable so that fluid stress is maximized to promote
1606 channel migration toward the outside of the bend.

1607

1608 Construction Details: Vegetation in the footprint of U-1 should be removed and placed as
1609 habitat wood elsewhere in the rehabilitation site prior to placement of pit-run material to
1610 construct this feature. With the vegetation removed, fill placement should occur with
1611 compaction of material only occurring to the extent that it maintains its position on the steep,
1612 outer bend of IC-2. Riparian tree plantings are not recommended for this feature so that tree
1613 growth does not provide root strength that could dissuade natural meander construction.
1614 Instead, the surface of the feature should be seeded with grasses and forbs.

1615

1616 Expected Evolution: U-1 will erode as channel migration occurs in its direction. The feature
1617 is unlikely to naturally recruit vegetation due to its surface being located 10 ft above the
1618 summer baseflow water surface, so only vegetate with grasses and forbs with time.

1619

1620 Assumptions/Uncertainties: None.

1621

1622 Size and Quantities: U-1 is 0.06 acres and involves 206 cy of fill averaging 2.1 ft in depth.

1623

1624

1625 U-2 Terrace enhancement

1626

1627 Description: U-2 is a right bank terrace feature that will be reduced in elevation from the
1628 existing bare, xeric surface.

1629

1630 Purpose and Function: U-2 will function as a high flow inundation area to increase
1631 groundwater storage and provide an area for establishment of riparian vegetation. Flow
1632 initiates on this surface between 6,000 and 8,500 cfs. The feature is fully inundated between
1633 8,500 and 11,500 cfs.

1634

1635 Construction Details: U-2 will be graded with regularly ascending topography from its border
1636 with R-6. From this location in a westerly direction, excavation will decrease from around 3
1637 ft to zero feet at existing topography over a distance of 66 ft, which yields a 3% slope.

1638

1639 Expected Evolution: The feature is expected to remain topographically stable and become
1640 vegetated with willow, cottonwood, and conifer plantings established with irrigation. Flow
1641 magnitudes that inundate this feature are expected to change with evolution of the IC-2
1642 meander bend and associated, existing side channel.

1643

1644 Assumptions/Uncertainties: Reducing the elevation of U-2 relative to the summer baseflow
1645 water surface from ~11 ft to ~8 ft should enable the expected plant colonization.

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Size and Quantities: U-2 is 0.41 acres and involves 741 cy of cut averaging 1.1 ft in depth.

U-3 Terrace Enhancement

Description: U-3 is a right bank terrace feature in a bifurcate shape that will be constructed from an existing and largely bare, xeric surface.

Purpose and Function: U-3 will provide surfaces for riparian colonization and rearing habitat and refuge for juvenile fish during high flows. Flow initiates on the feature around 4,000 cfs, and enters the southern bifurcation just beyond 6,000 cfs. The northern bifurcation initiates between 6,000 and 8,500 cfs. All except the upper portion of the southern bifurcation is inundated at 11,500 cfs.

Construction Details: As opposed to grading for U-2 exhibiting regular topography, U-3 will be constructed with a relatively low (compared to the surrounding topography), flat area of 0.09 acres. From here, backwater swales will be located in the approximate centerline of the feature's bifurcations. The swale in the southern bifurcation is 120 ft long and ranges in slope from 0.4 to 10%. The swale in the northern bifurcation is 100 ft long and ranges in slope from 1 to 4%.

Expected Evolution: The feature is expected to remain topographically stable and become vegetated with willow, cottonwood, and conifer plantings established with irrigation.

Assumptions/Uncertainties: Similar to U-2, reducing the elevation of U-3 from around 13 ft to ~8-10 ft above the summer baseflow water surface should enable vegetation to colonize the surface.

Size and Quantities: U-3 is 0.41 acres and involves 2,030 cy of cut averaging 3.1 ft in depth.

W-1 Wetland

Description: W-1 is a right bank wetland feature excavated from an existing xeric terrace surface adjacent to R-1.

Purpose and Function: W-1 will exhibit a steep gradient of topography and habitats ranging from hydric to xeric types, and will thus meet its purpose of providing habitat for a diversity of plant, animal, and insect species. By explanation, the bottom elevation of W-1 is within a foot of the local summer baseflow elevation in the Trinity River, and the feature does not capture overland flow until around 11,500 cfs. Consequently, W-1 will exhibit wetland characteristics in its lower elevations, and transition to increasingly xeric habitat in its upper elevations that merge with the existing terrace at on the boundary of this feature.

1691 Construction Details: W-1 will be excavated to a maximum depth of around 8.5 below the
1692 surrounding, existing terrace surface and the bottom of the feature will be ~1 ft above the
1693 summer baseflow elevation. The feature's side slopes and lengths range from 9.3% and 62 ft
1694 to 30% and 24 ft, respectively.

1695
1696 Expected Evolution: The feature will become vegetated with a diverse plant community
1697 ranging from hydric plants at its base to grasses and conifers near its top surface. With time
1698 after vegetation is established, soil development will result in an increasingly diverse resident
1699 populations of flora and fauna. The topography of the feature is expected to remain largely as
1700 constructed through time, since inundation of the feature by overland flow is only likely to
1701 occur after the feature is inundated by groundwater, thus largely eliminating the energy of
1702 surface flow into the feature.

1703
1704 Assumptions/Uncertainties: The impact of periodically prolonged inundation by water will
1705 have an uncertain impact on plant development in the feature.

1706
1707 Size and Quantities: W-1 is 0.07 acres and involves 318 cy of cut averaging 2.7 ft in depth.

1708
1709

1710 Wh-1 through 9 Habitat Wood

1711

1712 Description: Habitat wood placements are targeted in near-bank areas throughout the Sky
1713 Ranch reach.

1714

1715 Purpose and Function: Habitat wood will provide juvenile fish cover and substrate and food
1716 for macroinvertebrates. Habitat wood pieces are not associated with a specific geomorphic or
1717 hydraulic objective, but it is recognized that habitat wood pieces will have a minor influence
1718 on these functions where placed.

1719

1720 Construction Details: Habitat wood will be anchored in place with locally available
1721 techniques using naturally available materials. Some techniques include keying wood pieces
1722 into stream banks or floodplains, burying the end of wood pieces in bars, and/or weaving
1723 pieces between riparian tree boles. Wood pieces will be installed at a variety of angles to the
1724 horizon and downstream flow direction to differentially interact with discharges including
1725 winter baseflow. Wood pieces should be a variety of tree species (e.g., cedar, Douglas fir,
1726 pine, and cottonwood) and diameters so they decay at differential rates to provide variable
1727 habitat for fish and macroinvertebrates through time. Tree boles should have intact bark, and
1728 whether tree boles have rootwads attached and the density of wood placements will be at the
1729 discretion of the habitat biologist directing placements on site.

1730

1731 Expected Evolution: Installed wood will largely remain in place in the absence of local bank
1732 or bar erosion. Where these processes occur, habitat wood will be entrained and transported
1733 downstream. The longevity of pieces that remain in place will be variable depending on
1734 wood species and diameter, and pieces that remain submerged will persist longer than pieces
1735 that are alternately wetted and dried. For these reasons, the persistence of installed wood is
1736 expected to be highly variable.

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Assumptions/Uncertainties: Turbulence generated by wood placements will not increase local bed and bar erosion to an extent that jeopardizes the stability of the wood.

Size and Quantities: Wh placements involve 0.41 acres of the mainstem channel. The quantity of wood placed will be determined at a later stage in the design process.

Wj-1 Wood Jam

Description: Wj-1 is a left bank wood jam near the upstream entrance to R-1 floodplain.

Purpose and Function: Wj-1 will provide roughness to elevate the water surface to promote initiation of flow into the upstream entrances to R-1 and locally increase channel bed complexity by promoting bed scour upstream deposition of sediment downstream of the jam. The structure is not expected to recruit new wood because it is located on the inside of a meander bend.

Construction Details: The Wj-1 structure will be constructed with conifer logs (bark intact) having diameters around 1ft and greater and slash built into the structure. Wj-1 will exhibit low porosity and a steep upstream face for pillowing flow and raising upstream water surface elevations during moderate to high discharges. The structure should overtop around 7,500 cfs. Boulders should not be used for ballast in this structure.

Expected Evolution: Wj-1 will eventually rot and fail, thus contribute wood for transport downstream. This is expected to occur around 10 years after construction, depending on their species, diameter, and time since felled.

Assumptions/Uncertainties: An uncertainty is in the duration the structure will remain in place to meet its intended function.

Size and Quantities: Wj-1 is 0.03 acres and involves 300 cy of excavation and around 400 cy of logs, slash, and fill material.

Wj-2 Wood Jam

Description: Wj-2 is a right bank wood jam located at the entrance to R-1 floodplain and SC-1 side channel.

Purpose and Function: Wj-2 will pillow flow and elevate the local water surface to promote inundation of the R-1 and SC-1 features. Wj-2 will also scour the bed at the entrance to SC-1 to help prevent sediment deposition from closing off the side channel. The structure will likely capture mobile wood due to its position on the outside of a meander bend.

1782 Construction Details: As with Wj-1, the Wj-2 structure is constructed with conifer logs (bark
1783 intact) having diameters around 1ft and greater. The outer structure and additions of slash
1784 will be constructed around large diameter centroid logs that will persist longer than the outer
1785 structure so they may remain intact to capture mobile wood through time. Wj-2 will exhibit
1786 low porosity and an upstream face that is at a 60 degree angle down from the horizon to
1787 enhance the ability of the structure to capture mobile wood while also pillowing flow to raise
1788 the upstream water surface during moderate to high discharges. The structure should overtop
1789 around 6,000 cfs. Boulders should not be used for ballast in this structure.

1790

1791 Expected Evolution: Wj-2 will eventually rot and lose wood, but if key centroid pieces
1792 remain intact, the structure may persist indefinitely by capturing mobile wood during high
1793 flow events.

1794

1795 Assumptions/Uncertainties: Wj-2 may not capture wood as quickly as wood is lost from
1796 decay and failure of the outer fabric of logs.

1797

1798 Size and Quantities: Wj-2 is 0.03 acres and involves 400 cy of excavation and around 600 cy
1799 of logs, slash, and fill material.

1800

1801

1802 Wj-3 Wood Jam

1803

1804 Description: Wj-3 is a right bank wood jam at the upstream end of an incipient riffle.

1805

1806 Purpose and Function: Wj-3 along with habitat wood located across from this structure will
1807 increase local roughness to encourage further development of an incipient riffle that is also
1808 the tailout of a large upstream pool. This structure will likely capture mobile wood due to its
1809 position in overflow path from R-6 and in the vicinity of divergence area associated with the
1810 aforementioned riffle.

1811

1812 Construction Details: The Wj-3 structure is constructed with conifer logs (bark intact) having
1813 diameters around 1ft and greater. The outer structure and additions of slash will be
1814 constructed around large diameter centroid logs that will persist longer than the outer
1815 structure so they may remain intact to capture mobile wood through time. Wj-2 will exhibit
1816 high porosity and an upstream face that is aligned 60 degree from the horizon to enhance the
1817 ability of the structure to capture mobile wood. The structure should overtop around 8,500
1818 cfs. Boulders may be used for ballast in this structure.

1819

1820 Expected Evolution: Wj-3 will eventually rot and lose wood, but if key centroid pieces
1821 remain intact, the structure may persist indefinitely by capturing mobile wood during high
1822 flow events.

1823

1824 Assumptions/Uncertainties: See Wj-2.

1825

1826 Size and Quantities: Wj-2 is 0.05 acres and involves 400 cy of excavation and around twice
1827 that volume of logs, slash, and fill material.

1828

1829 *Materials and Quantities*

1830

1831 Cut and fill volumes for Alternative B were determined by topographic differencing between
1832 the design features and existing topography (Table 9). Similar to Alternative A, wood
1833 quantities and ballast volumes for wood jams and habitat wood will be determined at a later
1834 stage of design.

1835

1836 Table 9: Cut and fill volumes for design features in Alternative B. The total volume of material for
1837 spoiling in areas U-2 and U-3 in Figure 14 is 220,394 cy.

Feature	Surface area (acres)	Dry Cut (cy)	Wet Cut (cy)	Wet Fill (cy)	Dry Fill (cy)
IC-1	0.15		972		
IC-2 ^a	1.06			4,287	
IC-3	1.16	8,984			
IC-4	0.28		1,332		
R-1	12.13	153,340			
R-2	0.12	268			
R-3	0.35	1,964			
R-4	1.34	15,432			
R-5	2.82	21,081			
R-6	0.92	4,764			
R-7	0.08	913			
SC-1	0.98	4,995			
SC-2	0.46	4,076			
SC-3	0.25	3,115			
SC-4	0.07	510			
SC-5	0.02	52			
U-1 ^b	0.06				206
U-2	0.41	741			
U-3	0.41	2,030			
W-1	0.07	318			
Totals	23.14	222,583	2,304	4,287	206

1838 ^aSame size distribution of as CGC material described in Table 8 except with 10% fines.

1839 ^bPit run material

1840

1841

1842

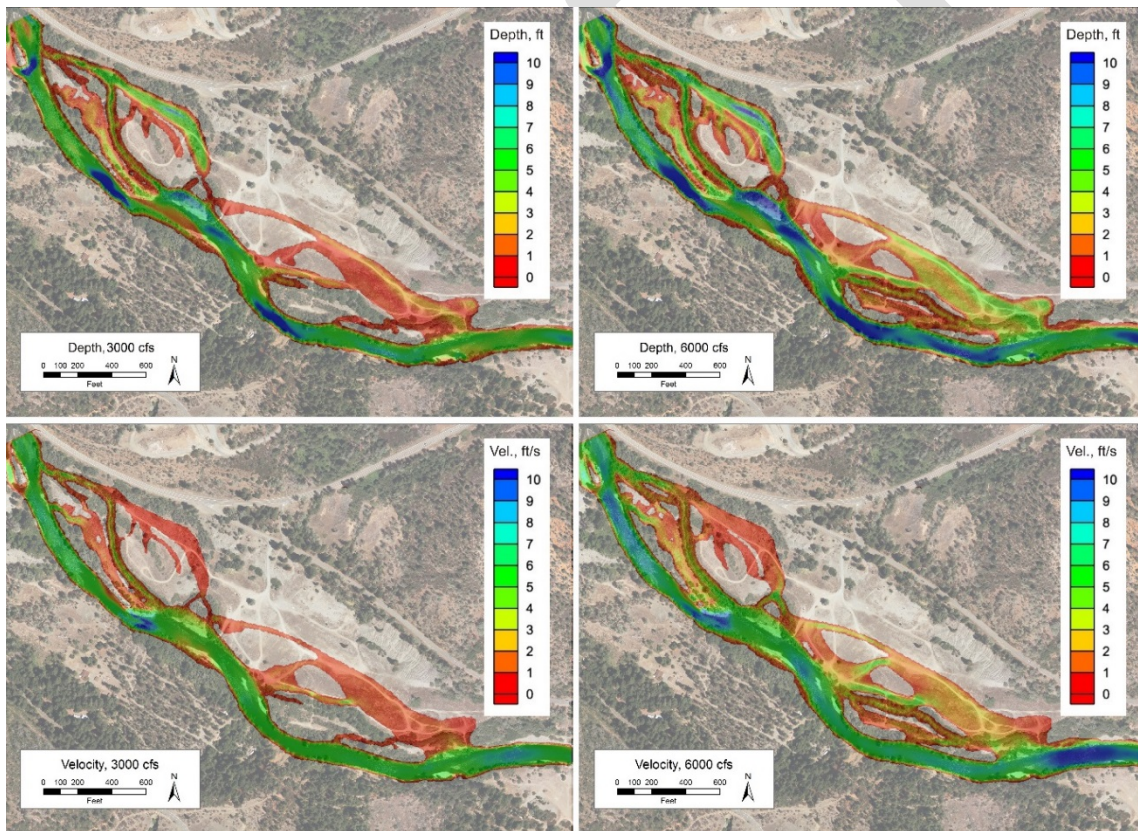
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1844 **4.0 Hydraulic Performance of Design Alternatives**

1845 **4.1 Alternative A**

1846

1847 A primary restoration objective at the Sky Ranch site is to replace the expansive tailings
1848 terraces in the area with floodplains that are inundated frequently and provide a range of
1849 habitat during relatively frequent flow events. The general success of design alternative A in
1850 achieving that objective is illustrated in Figure 19, which shows the extents of inundation
1851 associated with the 3000 and 6000 ft³/s flow events. Comparing Figure 19 with Figure 7
1852 makes it clear that the design greatly increases floodplain inundation. The extent of the
1853 increase can be quantified by the weighted mean width of inundated floodplain (W_j), which
1854 for the design condition exceeds the existing condition by a factor of 6.7 (37.6 ft versus 5.6
1855 ft). The mean wetted width of the area inundated by a range of flows provides a perhaps
1856 more intuitive comparison – as shown in Figure 20, the design increases that mean wetted
1857 width of the valley floor by between 51% and 96% for flows between 350 and 11500 ft³/s.
1858



1859

1860 Figure 19: Modeled flow depths and velocities at 3000 and 6000 ft³/s for design Alternative A. See

1861

Appendix A for inundations extents and depths at other flows.

1862

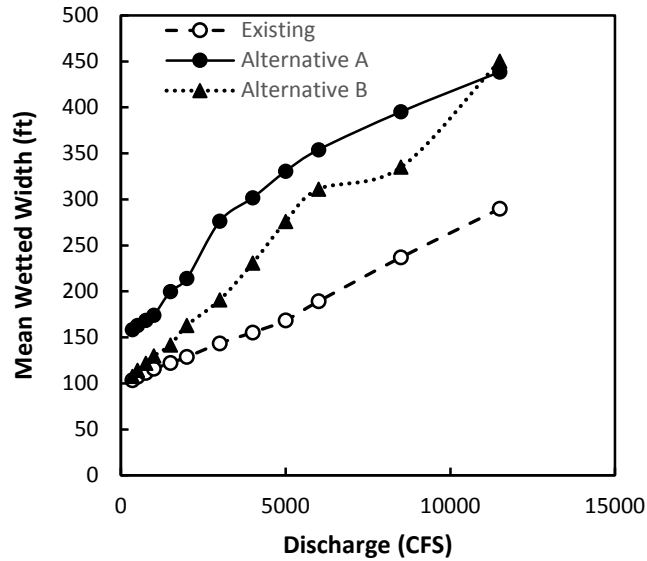
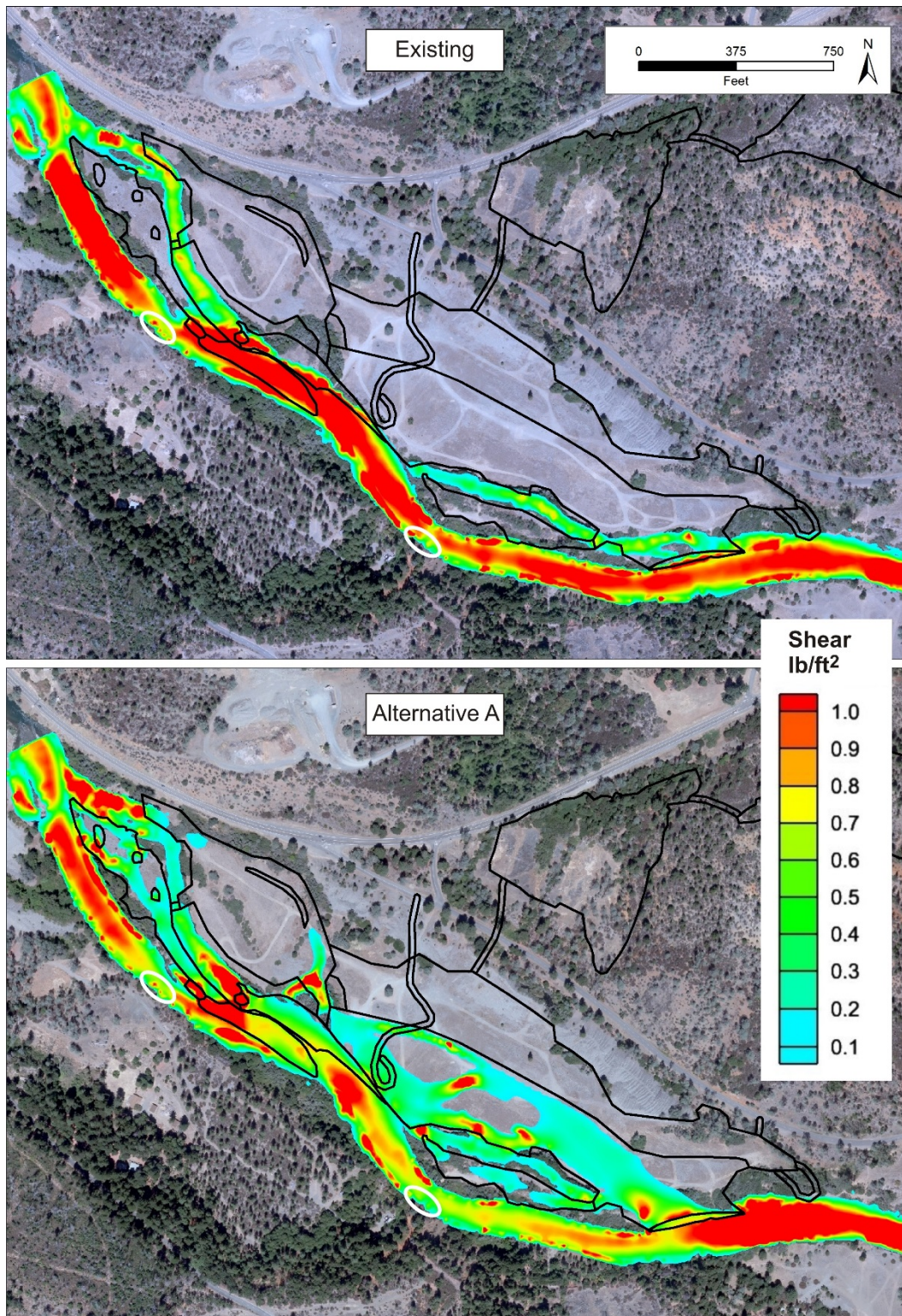


Figure 20: Mean wetted width over a range of flow for Alternatives A and B and for the existing condition.

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Another physical objective of the design is to increase hydraulic variability within the channel, thereby increasing in-stream habitat diversity as well as driving spatial gradients in sediment transport and fluvial activity. As can be seen in Figure 21, shear stresses during channel forming flow events (taken here to be 8500 ft³/s) are uniformly high (> 1 lbs/ft²) almost everywhere in the main channel. This magnitude of shear stress is sufficient to begin to entrain gravel size suitable for salmonid spawning, and can lead to bed surface coarsening or even to bed incision. By increasing the width of the main channel and by spreading flows across new floodplains, the design reduces shear stresses to much lower levels in some areas while maintaining high shear stresses in other areas. Such hydraulic diversity is likely to facilitate the development of corresponding diversity in stream substrate conditions and local channel geometry. Although the design substantially reduces shear stresses in many areas, the differences from existing conditions at the locations of the two holding pools in the reach are relatively small. Those locations display smaller shear stresses shown in green that break the otherwise continuous band of red extending through the existing model output, whereas those same location show a similar shade of green in the design output (Figure 21). The relatively low existing-conditions shear stresses at those locations at this flow level suggest that those pools are maintained primarily by turbulent secondary circulation generated when flow impinges on bedrock outcrops along the valley margin. Such turbulence cannot be represented in a 2-dimensional hydraulic model, so it is uncertain if and how the design might impact pool morphology.



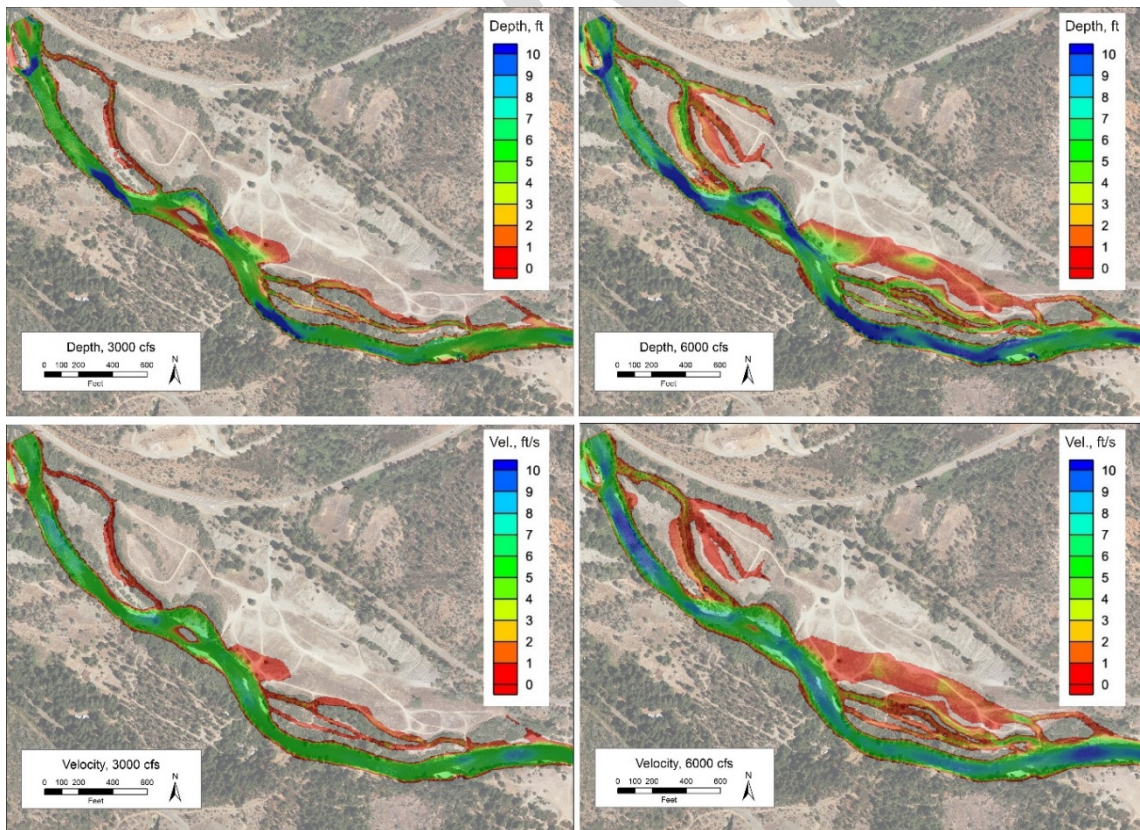
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Figure 21: Modeled shear stresses at $8500 \text{ ft}^3/\text{s}$ for design Alternative A. Shear stresses smaller than 0.1 lbs/ft^2 are not shown. White ellipses indicate the locations of two deep pools in the reach. Shear stresses less than 0.1 lbs/ft^2 are not displayed on the maps.

1897 **4.2 Alternative B**

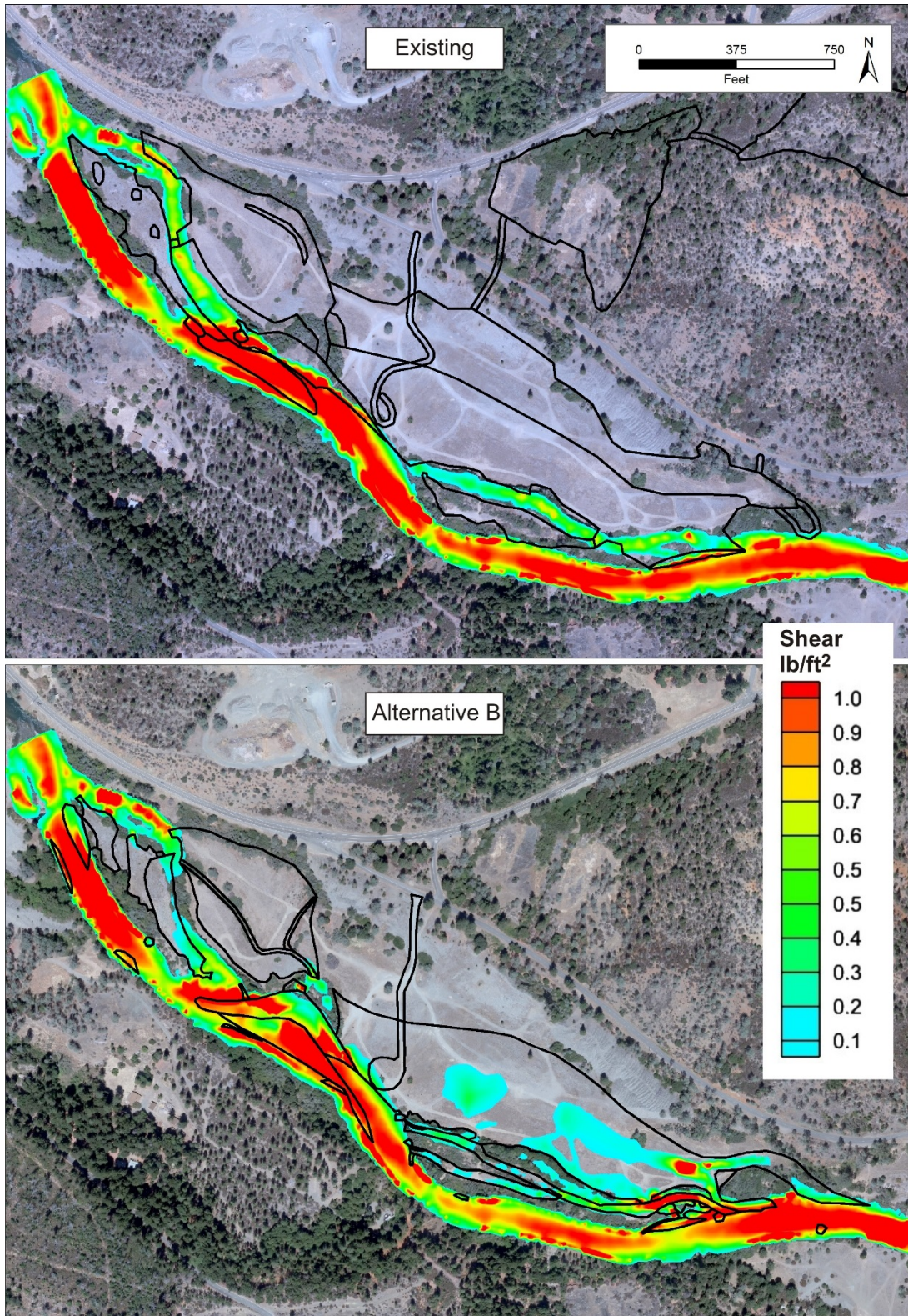
1898

1899 Objectives of Alternative B are to 1) increase flow outside main channel areas to provide a
1900 greater diversity of flow depths and velocities for juvenile salmonid rearing, 2) maintain
1901 shear stress in the main channel at bankfull discharge (8,500 cfs) to sustain the existing deep,
1902 large pools in the reach, 3) provide a range of shear stresses in off-channel areas to form
1903 diverse topography for aquatic and terrestrial biota, and 4) increase the land surface area
1904 wetted by 4,000 to 5,000 cfs, which are considered floodplain elevations for riparian plant
1905 colonization. Evidence for 1) being met is indicated in the range of flow depths and velocities
1906 that are generated on constructed surfaces at all discharges, as exemplified in Figure 22 for
1907 3,000 and 6,000 cfs. Additional evidence is the reach-average width of flow through the
1908 reach is increased in Alternative B by 44% to 115% for flows between 500 and 11,500 cfs
1909 over that for the existing topography (Figure 20). Objective 2) is met as shown in Figure 23,
1910 which indicates that shear stress is at or above the approximate threshold for sediment
1911 mobility at bankfull discharge in most areas of the main channel under alternative B. In
1912 support of objective 3) under Alternative B, a diversity of shear stresses is generated in the
1913 main and side channels and floodplain surfaces at 8,500 cfs in comparison to the existing
1914 design (Figure 24, compare to the upper panel in Figure 23). Finally, objective 4) is met by
1915 topographic lowering associated with all features increases the surface area that is wetted by
1916 4,000 to 5,000 cfs under Alternative B by 48% or 6.9 acres compared to the existing terrain.
1917
1918



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1920
1921

Figure 22: Modeled flow depths and velocities at 3,000 and 6,000 ft³/s for design Alternative B.



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1924
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1926

Figure 23: Modeled shear stresses at 8,500 cfs for design Alternative B compared to shear stress at this flow on existing terrain. Shear stresses smaller than 0.1 lbs/ft² are not shown.

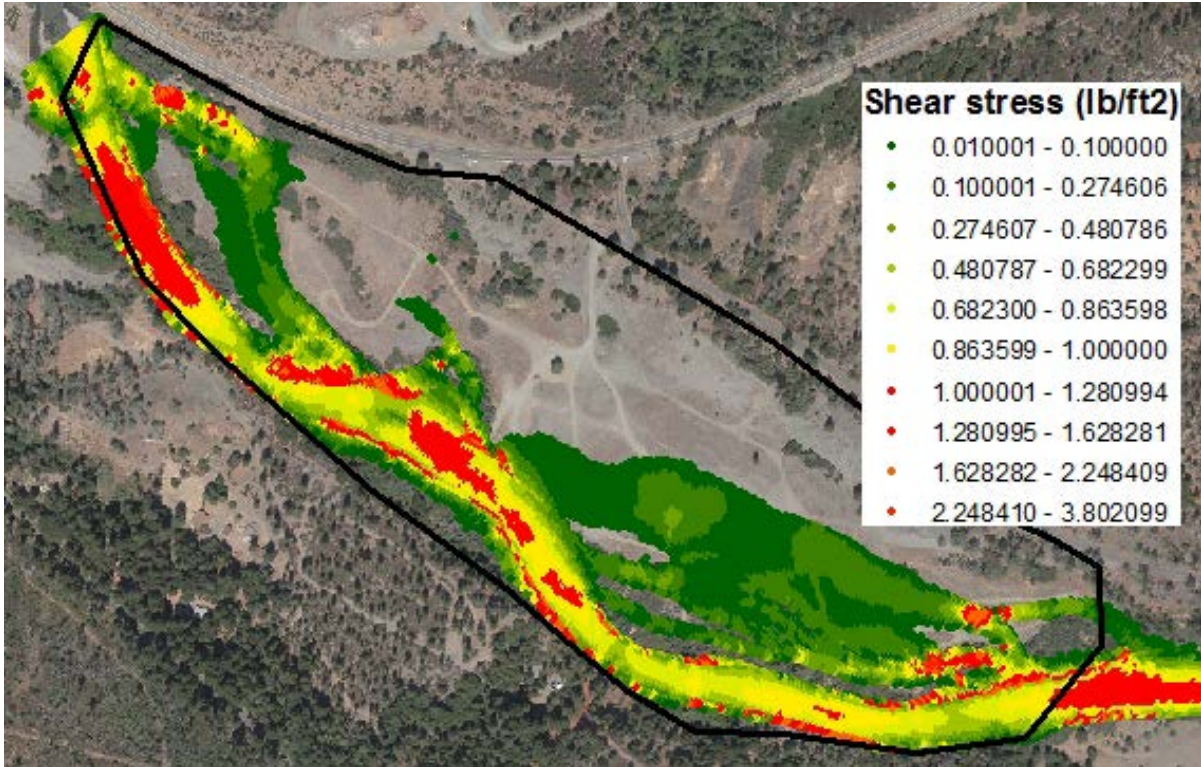


Figure 24: Modeled shear stresses at 8500 ft³/s for design Alternative B.

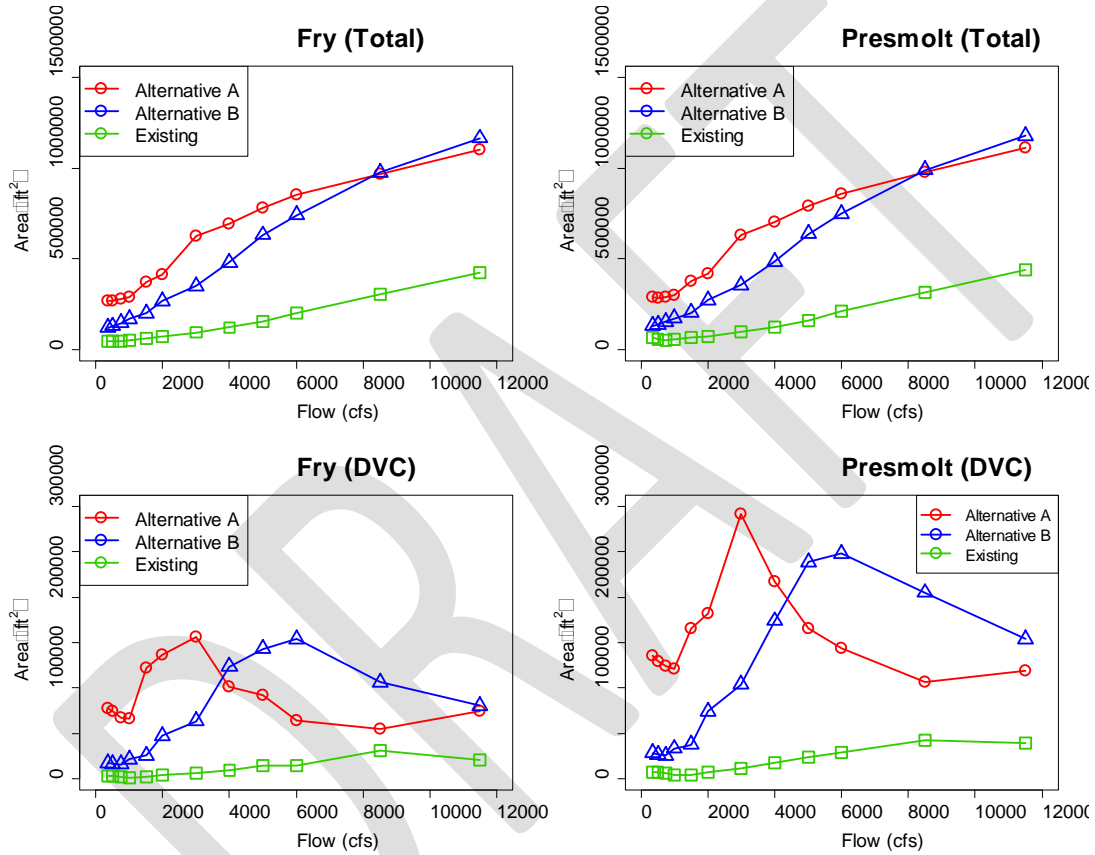
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An additional objective of the design is to increase the potential for natural processes to adjust the area to be in sync with local flow and sediment regimes. On this point, topography constructed under Alternative B is expected to evolve in several important ways. For example, side channels are expected to erode their banks and transport sediment to the main channel in the process of widening and creating expansive floodplain areas. The constructed meander and point bar are expected to migrate northward and eventually occupy constructed floodplains that are located in this direction. In the meantime, establishment of riparian trees will occur on floodplains that are in the migration path of the channel so that when the river meanders into these surfaces, large wood will be recruited to the channel. The point bar is expected to keep pace with channel migration and form a cut-off channel at its left side when the meander amplitude exceeds the channel's capacity to maintain the bend. The main channel will then modify to a side channel or oxbow floodplain or marsh and the main flow will be conveyed through the cut-off channel, which will enlarge and access the bedrock wall on the left bank, where high channel diversity is expected to occur due to the occurrence of a bedrock wall adjacent to an alluvial area.

1951 **5.0 Biological Performance of Design Alternatives**

1952 **5.1 Fish Habitat**

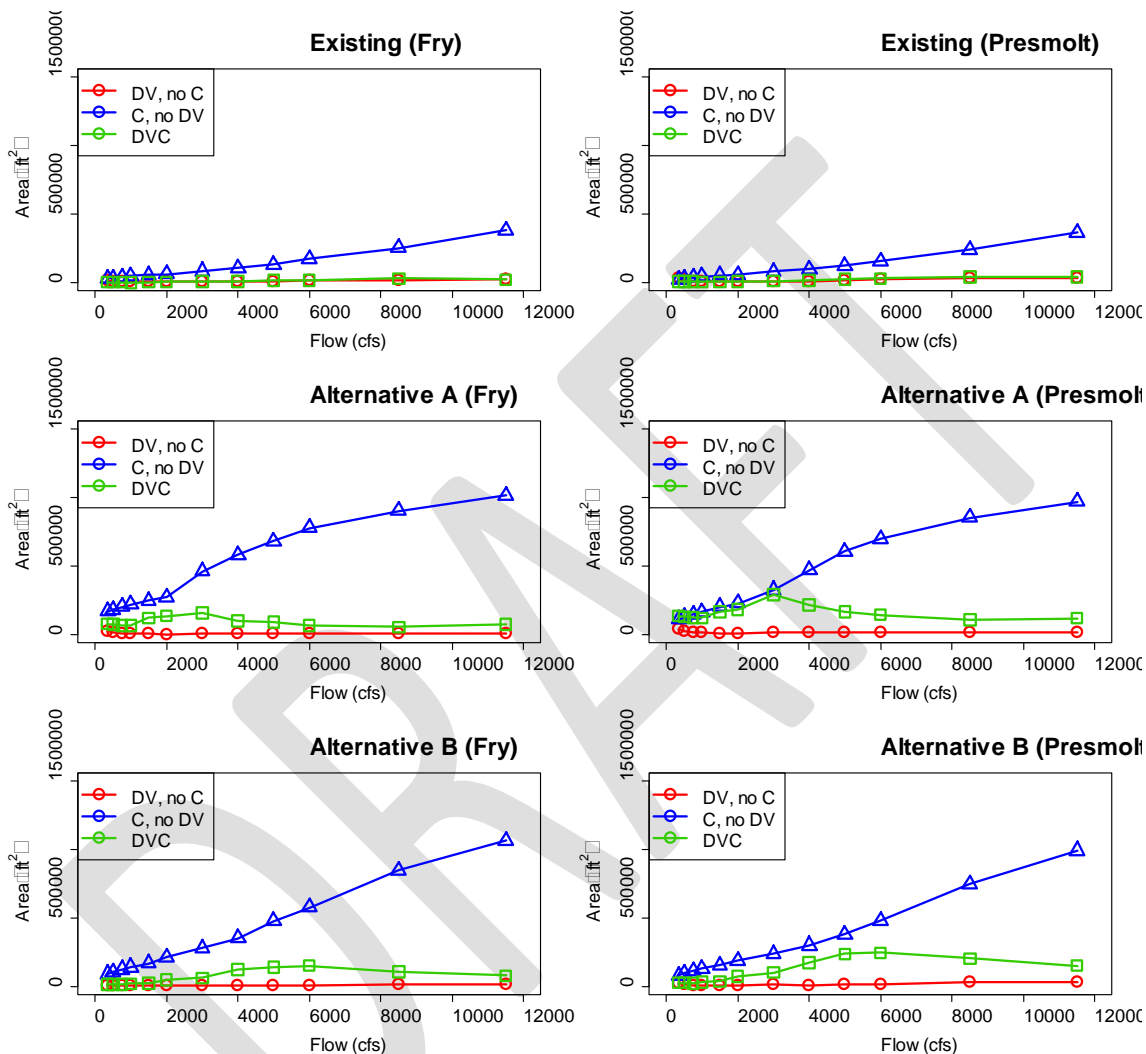
1953 SRH2D hydraulic model output showed substantial gains in the total habitat area at all flows
 1954 for both Alternatives A and B over the existing condition (Figure 25). Similar to the model
 1955 results from the existing condition, total rearing habitat results of the modeled alternatives
 1956 show a positive relationship with increasing discharge, but habitat type 2 (cover only) is
 1957 largely responsible for this relationship (Figure 25; Figure 26).
 1958
 1959



1960
 1961 Figure 25: Panel figure showing total fry and smolt habitat area (top) and habitat area comprised of
 1962 depth, velocity and cover (bottom) of Alternative A, Alternative B, and the Existing condition at
 1963 discharges from 350 CFS to 11,500 CFS at the Sky Ranch restoration site.

1964
 1965 Both alternatives resulted in substantially greater levels of optimal habitat containing suitable
 1966 depth, velocity, and cover (Figure 25; Table 10). Alternative A resulted in greater habitat
 1967 gains than Alternative B at discharges between 350 CFS and 4,000 CFS. However, the
 1968 modeled flow to habitat relationship for Alternative A becomes negative at discharges greater
 1969 than 3,000 CFS, and additional flows result in a shrinking amount of available rearing habitat
 1970 for both fry and presmolt life stages (Figure 25; Table 10). Alternative A also showed a slight
 1971 decrease in the amount of optimal rearing habitat from 350 CFS to 1,000 CFS, before
 1972 increasing. While model results for Alternative B show less habitat gains initially than

1973 Alternative A for the fry and presmolt life stages, the amount of optimal habitat that contains
 1974 suitable depth velocity and cover increased throughout a range of flows for both fry and
 1975 presmolt life stages to 6,000 CFS. After 6,000 CFS, the amount of optimal habitat decreased
 1976 slightly with additional flows.
 1977
 1978



1979
 1980 Figure 26: Panel figure showing habitat area comprised of 1) depth and velocity, 2) cover only, or 3)
 1981 depth velocity and cover for the Existing condition, Alternative A and Alternative B at discharges
 1982 from 350 CFS to 11,500 CFS at the Sky Ranch restoration site.

1983
 1984 Both alternatives resulted in substantially more optimal habitat than the existing condition.
 1985 However Alternative A resulted in significantly more optimal habitat gains than Alternative
 1986 B at discharges less than 4,000 CFS, which are only exceeded 3.4% of the time. Therefore,
 1987 Alternative A is likely to result in more habitat available to rearing fry and presmolts for a
 1988 longer duration of time throughout the year. At high flows, the amount of optimal rearing
 1989 habitat for Alternative A does begin to decline, however it is still greater than the existing
 1990 condition (Table 10).

1991
1992

Table 10. Existing habitat area (ft²) and the change in habitat area (%) for design alternatives A and B for the Sky Ranch restoration site.

Flow (CFS)	Existing area (ft ²)		Alternative A change (%)		Alternative B change (%)	
	Fry	Presmolt	Fry	Presmolt	Fry	Presmolt
350	3,769	7,823	1,965	1,637	372	263
500	3,237	7,264	2,203	1,680	418	271
750	2,307	6,652	2,815	1,761	602	293
1,000	1,559	4,661	4,182	2,498	1,312	618
1,500	2,424	4,616	4,956	3,488	961	719
2,000	4,794	7,019	2,748	2,495	897	961
3,000	6,872	11,953	2,178	2,336	826	769
4,000	9,975	17,531	918	1,137	1,140	892
5,000	14,567	23,760	536	599	882	904
6,000	14,895	29,524	332	388	934	740
8,500	30,914	42,418	78	151	245	383
11,500	20,817	39,367	257	202	288	291

1993
1994

1995 **6.0 Constructability and Level of Effort**

1996 Constructability of the proposed alternatives is evaluated by comparing the level of effort
1997 needed for the design to be implemented and the expected benefit to the fishery. The level of
1998 effort to build a design is estimated as a multiplier of the volume of material that is cut or
1999 filled and where these activities take place. This earthwork generally comprises the greatest
2000 expense in implementation activities, so can be a reasonable way of estimating the effort
2001 required in a design alternative.

2002
2003 The level of effort required for these designs is calculated as the product of the volume of
2004 earthwork required and a multiplier that corresponds to one of three types of earthwork.

- 2005 • The first category of earthwork is for material that is excavated or filled outside the
2006 wetted river channel. Volumes of this type of earthwork are multiplied by 1.
- 2007 • The second category of earthwork is for excavation of material from the wetted
2008 channel. Wet excavation volumes are multiplied by 2 due to the time and additional
2009 steps required when working in the water. More time/effort is needed due to the
2010 added weight requiring more hauls, machines move more slowly when in the water
2011 and the need to contain areas of wet excavation from the river in order to comply with
2012 turbidity standards.
- 2013 • The third category of earthwork is for fill in the wetted channel. Wet fill volumes are
2014 multiplied by 3 because, in addition to loading, hauling and grading, the material is
2015 generally cleaned and sorted into required sizes before placement in the river.

2016
2017 Earthwork quantities, the multipliers used, and expenses in terms of effort are given on a
2018 feature-by-feature basis for Alternatives A and B in Tables 11 and 12, respectively.

2019

2020
2021

Table 11: Earthwork quantities and level of effort rating for proposed Sky Ranch Alternative A. Cut and fill volumes are as presented in Table 6.

Feature	Cut Volume (cy)	Fill Volume (cy)	Multiplier	Effort Expense
IC1 (dry)	1,180		1	1,180
IC-1 (wet)	395		2	790
IC-2 (dry)	8,700		1	8,700
IC-2 (wet)	2,900		2	5,800
IC-3		4,115	3	12,345
R-1	127,400		1	127,400
R-2	59,940		1	59,940
R-3	9,400		1	9,400
R-4	14,360		1	14,360
TOTALS	211,100	4,115		239,915

2022
2023
2024

Table 12: Earthwork quantities and level of effort rating for proposed Sky Ranch Alternative B. Cut and fill volumes are as presented in Table 9.

Feature	Cut Volume (cy)	Fill Volume (cy)	Multiplier	Effort Expense
IC-1	972		2	1,943
IC-2		4,287	3	12,861
IC-3 (dry)	8,984		1	8,984
IC-3 (wet)	2,965		2	5,930
IC-4	1,332		2	2,664
R-1	153,340		1	153,340
R-2	268		1	268
R-3	1,964		1	1,964
R-4	15,432		1	15,432
R-5	21,036		1	21,036
R-6	4,764		1	4,764
R-7	913		1	913
SC-1	4,995		1	4,995
SC-2	4,076		1	4,076
SC-3	3,115		1	3,115
SC-4	510		1	510
SC-5	52		1	52
U-1		206	1	206
U-2	741		1	741
U-3	2,030		1	2,030
WL-1	318		1	318
TOTALS	227,807	4,493		246,142

2025

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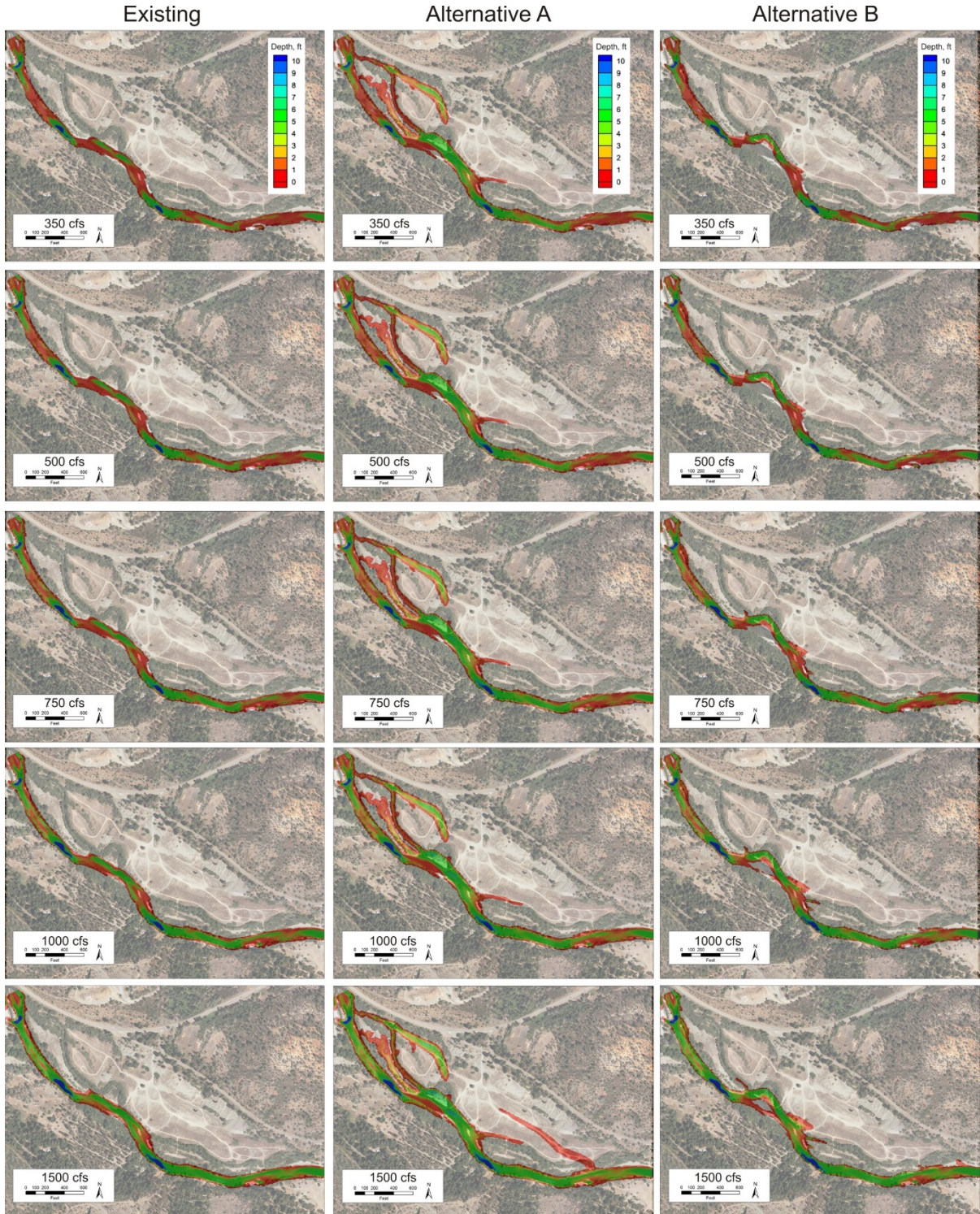
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Appendix A

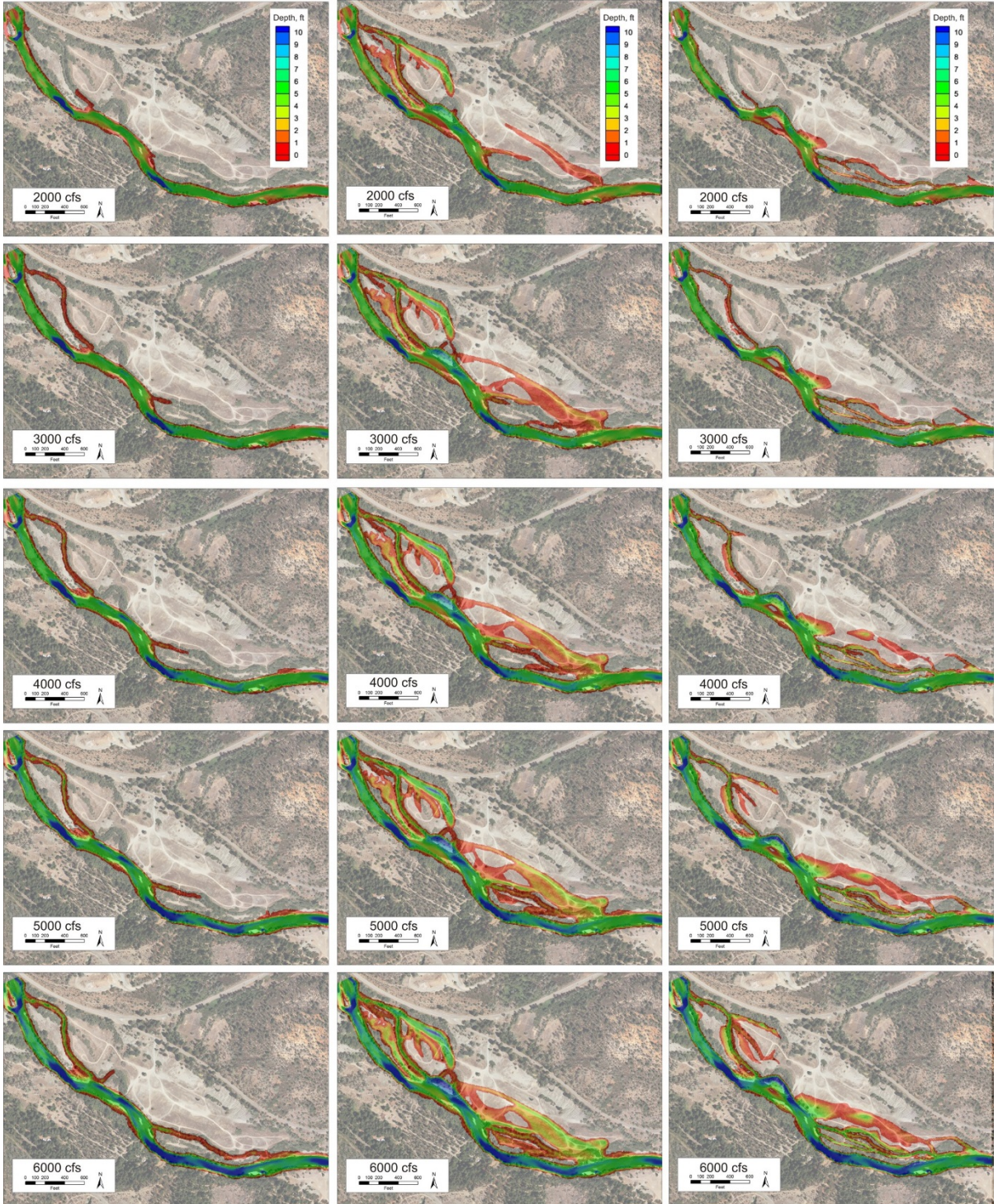
Modeled Inundation Extents and Depths at 12 Discharge Levels



Existing

Alternative A

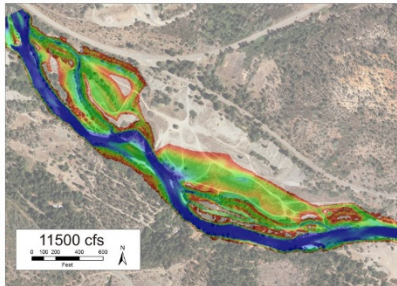
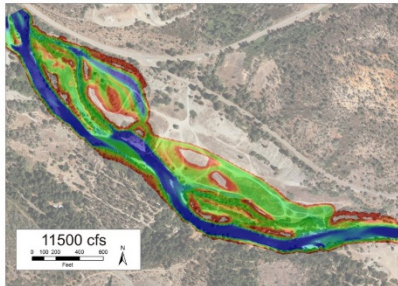
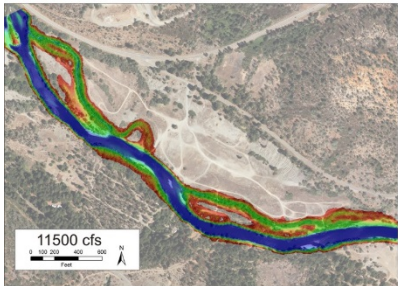
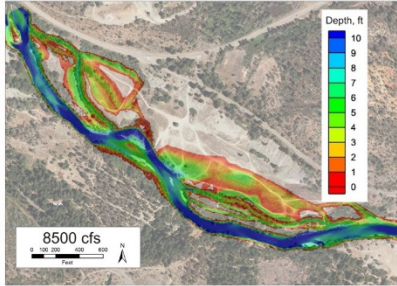
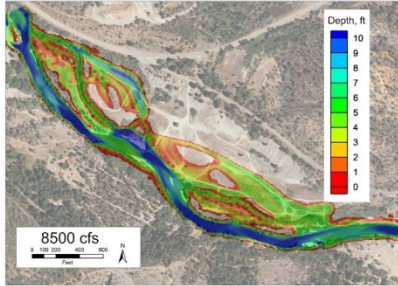
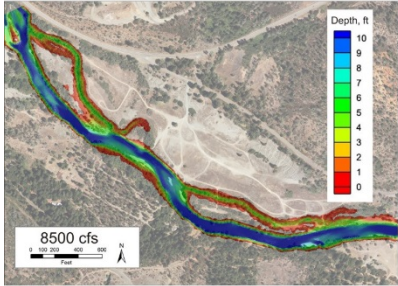
Alternative B



Existing

Alternative A

Alternative B



DRAFT