CALIFORNIA TROUT

APPENDIX A: PROJECT LOCATION, SITE SELECTION, HABITAT SURVEYS

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SEPTEMBER 1, 2017

Project Location: The South Fork Eel River and Sproul Creek Watershed

The South Fork Eel River, located in Mendocino and Humboldt Counties (Figure A-1), is the focus of CalTrout's Water Conservation Program. The purpose of this program is to **provide scientifically defensible, standardized methodologies for determining instream flow criteria for coldwater species in unregulated coastal California watersheds.** Low summer streamflows are a natural condition in the South Fork Eel River. However, over the past several decades natural low-flow conditions have become severely compounded by human-caused factors, the most critical of which is streamflow diversions (CDFW 2014), both legal and unauthorized. Low summer streamflows is a major cause of temperature impairments (NCRWQCB 2013, 2014). The SF Eel River is on the EPA 303d list for water temperature and sediment impairment. Three native salmonid populations persist in the SF Eel River, and are federally listed as threatened: **SONCC coho salmon**, **North Coast steelhead**, and **Coastal Chinook salmon**. The SF Eel is identified as a salmon stronghold, and sustains one of the largest coho population in the SONCC ESU. Despite this status, adult abundance is at an historical low, currently hovering around 1000 adults annually (CDFW 2015a). Chinook and steelhead populations are also severely depressed. The South Fork Eel River is one of five priority stream systems selected as part of the California Water Action Plan effort.

Sproul Creek is a typical tributary watershed, entering the South Fork Eel River near Garberville, CA, approximately 34 miles upstream from the confluence of the SF Eel River with the mainstem Eel River. The Sproul Creek watershed (24.0 mi^2) is dominated by conifer and mixed hardwood forest – primarily redwood, Douglas Fir, tanoak and madrone, with riparian vegetation along stream channels composed of willow and alder species. Elevations range from 310 ft at the confluence with the SF Eel up to approximately 1,000 ft along the western ridge of the watershed. The watershed is entirely privately owned, with extensive areas of undeveloped working forest lands. Boyle Forests LLP and Wagner Corporation are two large timber landowners. Medium-sized ranches and residential parcels comprise the remaining area. There are approximately 20 rural residential parcels in the Upper South Fork Sproul Creek headwaters, and approximately seven residential parcels along the mainstem Sproul Creek near it's mouth. Sproul Creek has a

history of timber harvest and impacts from the 1955 and 1964 floods. Its forest and riparian canopy have largely recovered from those floods. Sproul Creek has approximately 26 miles of anadromous salmonid habitat (CDFW 2004[Stream Inventory Report]), and supports recently stable runs of Chinook and coho salmon, and steelhead (Renger 2015 Personal Communication). Monitoring access to most stream reaches is good. The CDFW Coastal Monitoring Program began conducting adult spawner surveys in Sproul Creek in 2011.

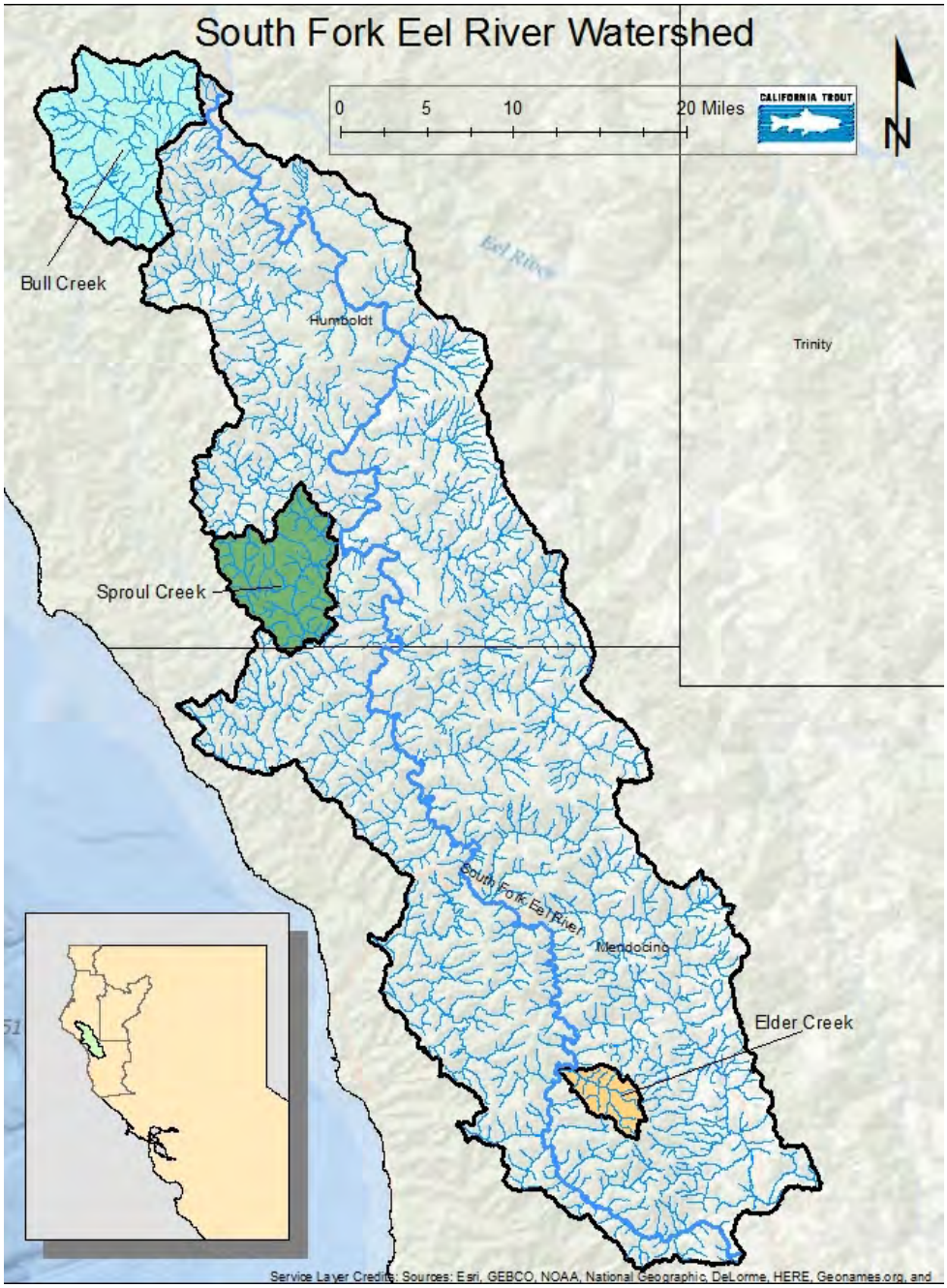

Figure A-1. Location of the Sproul Creek watershed on the western side of the South Fork Eel River Basin, spanning Humboldt and Mendocino Counties. Bull Creek and Elder Creek, two reference watersheds with long-term USGS gaging records, are shown.

Study Reach Selection and Habitat Mapping

The Sproul Creek study has two primary goals: (1) implement a site-specific instream flow study using methodologies espoused by state agencies, to identify a set of flow criteria in Sproul Creek that would support ongoing regulatory efforts in the watershed, and (2) use those flow criteria to assess the applicability and protectiveness of site-specific and regional instream flow methodologies to the South Fork Eel River and other North Coast watersheds.

Selection of streamflow gaging sites and instream flow study sites was tailored to conform with data and analytical needs to meet these primary goals, and within the constraints of land ownership, road access, and the project budget. We conducted field reconnaissance of numerous stream reaches throughouth the Sproul Creek watershed (see Figures A-2 and A-3) during the WY2015 summer low-flow season to locate suitable study reaches. We assessed reaches along the lower West Fork, the upper West Fork near La Doo Creek, the lower South Fork, the Upper South Fork below Cox Creek, the Upper Mainstem below Dry Trib, the Lower Mainstem below Little Sproul Creek, Warden Creek, and Little Sproul Creek. We assessed study reaches of different watershed size, seeking mainstem and headwaters tributary sites that would provide both spawning and rearing habitat for salmonids.

We selected two primary study reaches for intensive instream flow assessments: the 2,626 ft long Upper Mainstem Sproul Creek reach (UMS; drainage area = 17.0 mi^2) (Figure A-4); and the 1,961 ft long Upper South Fork Sproul Creek reach (USF; drainage area = 5.0 mi^2) (Figure A-5). During our field reconnaissance in late summer 2015, we observed these study reaches with consistent riffle-pool hydraulic units along reaches with relatively homogenous gradient. The mainstem Sproul Creek has a gradient of 1.0%; the Upper South Fork gradient is approximately 1.8%. Stream channels were composed of a mix of cobble and gravel, with abundant large wood and exposed bedrock contributing to a high degree of channel complexity. Sites were accessible by vehicle, and had good gaging and streamflow measurement locations. A third reach, the West Branch South Fork Sproul (WBSF; drainage area = 1.1 mi^2), was also selected for a subset of our instream flow assessment methods.

The rationale for selecting these reaches was as follows:

Upper South Fork (USF): this reach was a targeted stream and watershed size and location near the upper end of anadromy, accessible by vehicle at the lower end of the reach, and known to provide habitat for Chinook, coho, steelhead, and lamprey. Most importantly, this reach was a suitable Point of Interest (POI) below Cox Creek and upper South Branch of the South Fork. If water diversions were having an impact, they would be apparent through monitoring of this reach. We also observed that this USF reach became disconnected in summer 2015, and were interested if that effect was caused by drought or water diversion (or both). The USF reach was representative of the anadromous segments of the ~ 3 mile long West Fork and 2.0 mile long South Fork Sproul.

Upper Mainstem (UMS): the larger channel size with mainstem habitat characteristics, important for adult migration/spawining and juvenile/smolt outmigration, was an important channel/habitat type for our assessment. We also sought to identify a suitable reach for 2-dimensional hydraulic modeling, which requires striking a balance between topographic simplicity and habitat complexity. The CDFW (2004) *Sproul Creek Stream Inventory Report* was used to verify that our Upper Mainstem (UMS) reach was representative of the 4.0 mile mainstem Sproul Creek.

West Branch South Fork (WBSF): at 1.1 mi^2, this reach was accessible from the same location as the USF reach, was considered to be unimpaired by any streamflow diversions, and was at the smaller end of watershed size that provides anadromous salmonid habitat, has perennial streamflow in many/most water years, and is a stream type that would be vulnerable to impacts of water diversion if numerous diversions operated in the

low-flow summer period. The West Branch South Fork was thus representative of the numerous tributaries to the West Fork, South Fork, and Mainstem in the range of 0.5-2.5 mi^2 watershed area.

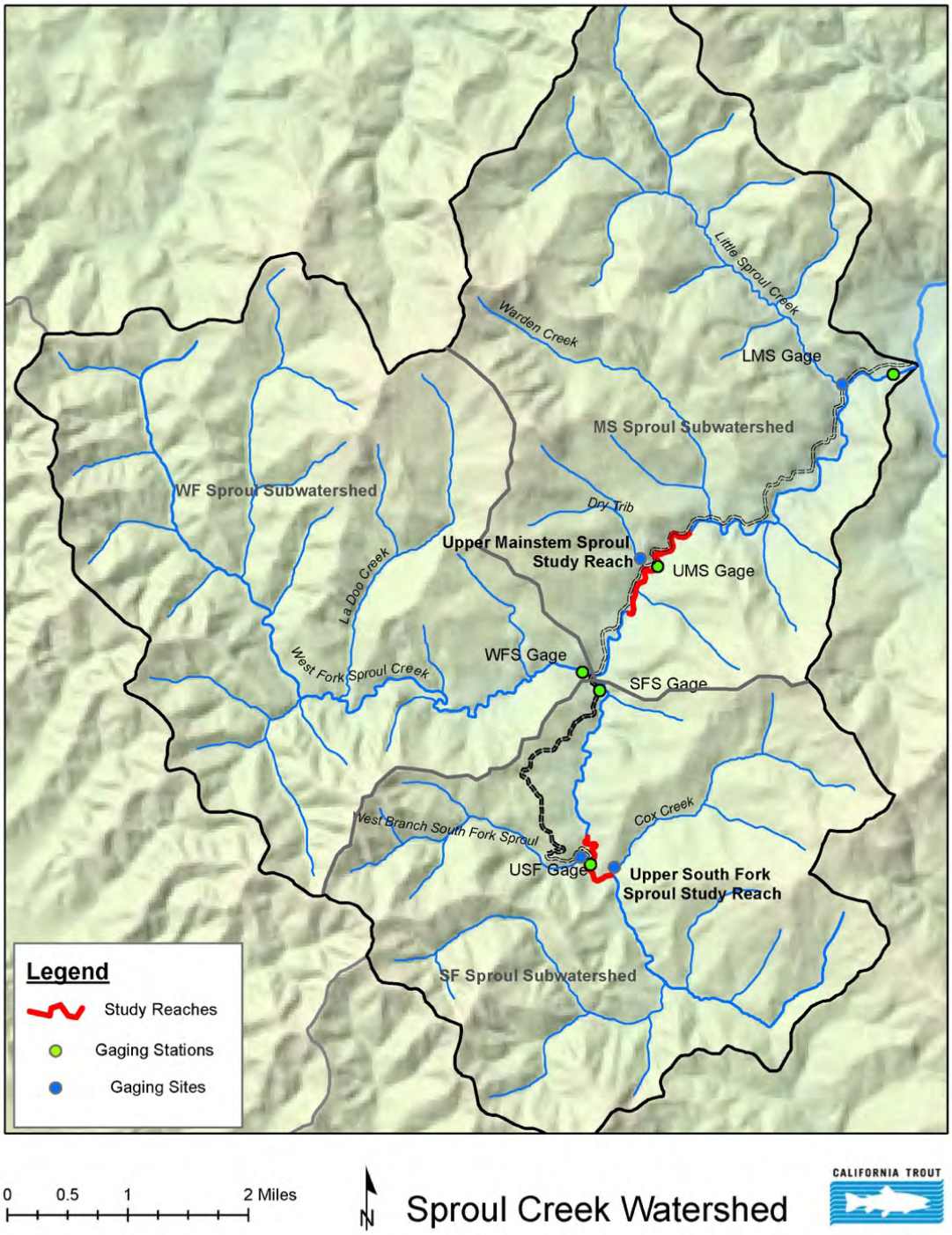

Figure A-2. The 24 mi^2 *Sproul Creek watershed. Two main forks, the West Fork and the South Fork, confluence in the middle of the watershed to form the 4.0 mi long mainstem Sproul Creek.*

The Upper South Fork (USF) and Upper Mainstem (UMS) reaches were surveyed in April 2016 to delineate mesohabitat units, hydraulic units, and channel features. Meso-habitat mapping followed the guidelines established in Flosi et al. (2010) and CDFW (2015b). The habitat surveys identified habitat types, unit length, and average slope using a Trimble Geo 7x optical range finder and prism. Depth of the pool tail crest (referred to as the riffle crest thalweg or RCT), maximum pool depth, and mean width were measured for each mapped pool. Large wood was recorded in each meso-habitat type where it is observed and the dominant and sub-dominant substrate types was identified for each meso-habitat type. Substrate was classified in the field according to standard procedure.

The USF reach was habitat mapped on April 6, 2016 with a two-person crew. Streamflow during habitat mapping was 9.2 cfs. Mapping extended from the road crossing just below the WBSF confluence, upstream to the Cox Creek confluence. The total stream length in this reach was 1,961 ft (Table A-1). An additional 2,193 ft reach below the WBSF confluence was habitat mapped on May 11, 2016, primarily to locate additional critical riffles for fish passage assessment. A total of 63 mesohabitat units were mapped in the 4,154 ft long USF study reach. Five habitat unit types were identified: cascade, high gradient riffle, low gradient riffle, run, and pool. The proportion of each habitat unit type, measured in April 2016, is shown in Table A-3.

The UMS reach was surveyed on April 13, 2016 at a streamflow of 21.4 cfs. The habitat survey extended from the large, distinct corner pool next to the access road upstream 2,626 ft to the confluence of “Dry Trib”, an unnamed 0.6 mi2 tributary to the mainstem Sproul Creek (Table A-2). An additional 3,095 ft section of the upper mainstem Sproul Creek was mapped on May 11, 2016 to locate additional critical riffles for fish passage assessment. A total of 55 mesohabitat units were mapped in the 5,721 ft long UMS study reach. Four habitat unit types were identified: high gradient riffle, low gradient riffle, run, and pool. The proportion of each habitat unit type, measured in April 2016, is shown in Table A-3.

Study Site Selection

Within the study reaches, we selected study sites for detailed hydraulic and habitat measurements, including 1-D and 2-D hydraulic modeling, fish passage analysis, wetted perimeter cross sections, riffle crest thalweg measurements, velocity core measurements, and benthic invertebrate drift collections.

The USF mesohabitat survey was used as a basis for random selection of mesohabitat units for 1-D phabsim analysis. We followed Bovee et al. (1998), selecting a minimum of three representative units of each targeted mesohabitat type, and three cross sections per unit, with one exception. We had observed only pools during the late-summer 2015 low-flow period. We surmised that run unit types prevalent during the early spring 2016 became pools as flow diminished. We thus did not select run units to model separately, and instead lumped pools and runs into one selection category. The result was selection of three pool units and three riffle units within the Upper South Fork study reach, each unit of which had three cross sections per meso-habitat unit.

The 2D model reach in the Upper Mainstem reach was selected based on professional judgment, considering the technical feasibility of adequately surveying topography to enable calibrating a 2-D hydraulic model. We targeted a minimum of two hydraulic units (two riffle-pool sequences), which became the maximum feasible reach length given field survey and modeling budget constraints. The two hydraulic units selected offered a range of habitat types and complexity; one pool unit contained constructed log/boulder habitat features that were of interest.

At the same time the meso-habitat mapping was conducted, survey crews identified hydraulic unit (riffle-pool unit) boundaries Table 1. Riffle crest depths were measured with a statia rod for each hydraulic unit, and were later ranked to identify locations of critical riffles (CDFW 2013a), i.e., riffles with the shallowest riffle crests, for fish passage assessments. Crews identified suitable locations for wetted perimeter cross sections (CDFW

2013b), and marked the heads of pools as a 0.0 ft station for subsequently measuring the length of the velocity core extending into each pool as the seasonal recession proceeded.

In the USF reach, 4 critical riffle sites were identified, 4 wetted perimeter cross sections were installed, 13 riffle crest thalweg locations were maked and subsequently monitored, and 11 velocity core sites were monitored.

In the UMS reach, 3 critical riffles sites were identified, 4 wetted perimeter cross sections were installed, 10 riffle crest thalweg locations were maked and subsequently monitored, and 11 velocity core sites were monitored.

Data and analyses from each of these study components are described in separate appendices.

Table A-1. Habitat Units mapped in the Upper South Fork (USF) study reach. Boxes indicate the location of 1-D hydraulic modeling units.

USF Reach 1 (WBSF to Cox)								
Hyd Unit	**Meso Unit**	**Unit Code**	**Habitat Unit Type**	**Unit Length (ft)**	**Cum Length (ft)**	**RCT Depth (ft)**	**Features**	**Study Sites**
	1	3.3	Run	73	73	0.80		Gaging Section
1	2	5.6	Bedrock Plunge Pool	31.5	105		Pool	Gage Datalogger
	3	3.3	Run	53	158			
	4	4.2	Mid Channel Pool	30.5	188			
2	5	1.2	High Gradient Riffle	21.5	210			
	6	1.1	Low Gradient Riffle	42	252			1-D Model (3xs)
3	7	4.2	Mid Channel Corner Pool	127	379	0.77	Corner Pool w rip-rap	
	8	1.2	High Gradient Riffle	42.5	421			WP-1
4	9	4.2	Mid Channel Pool	58.5	480	0.87		1-D Model (3xs)
	10	1.1	Low Gradient Riffle	94.5	574			1-D Model (3xs) / WP-2
	11	3.3	Run (Log Weir)	64.5	639		Log Weir	
5	12	4.2	Mid Channel Pool	71.5	710	wier		
	13	1.1	Low Gradient Riffle	62.5	773			CR-1 / WP-4
6	14	5	Scour Pool	93	866	0.51		1-D Model (4xs) / WP- 4
	15	1.1	Low Gradient Riffle	22	888			1-D Model (2xs)
7	16	3.3	Run/pool	70.5	958			
	17	1.2	High Gradient Riffle	58	1016			WP-5
8	18	4.2	Mid Channel Log Pool	137	1153	0.70	LWD Pool	
	19	1.2	High Gradient Riffle	42	1195			
9	20	3.3	Run/pool	154	1349			
	21	1.2	High Gradient Riffle	33	1382			
10	22	3.3	Run	46.5	1429			
	23	1.2	High Gradient Riffle	15	1444			
	24	3.3	Run	63	1507			
11	25	4.2	Mid Channel Pool	42	1549	1.15		
	26	1.1	Low Gradient Riffle	125	1674			
	27	2.1	Cascade	18	1692			
	28	3.3	Run	70.5	1762			
12	29	5	Scour Pool	65	1827	0.58	Root Snag	1-D Model (3xs)
	30	3.4	Step Run	69	1896			
13	31	4.3	Cox Creek Confluence Pool	65	1961	0.69	Cox Creek confluence	

USF Reach 2 (WBSF downstream)								
Hyd Unit	Meso Unit	Unit Code	Habitat Unit Type	Unit Length (ft)	Cum Length (ft)	RCT Depth (ft)	Features	Study Sites
	1	1.1	Low Gradient Riffle	78	78	0.50		
14	2	4.2	Mid Channel Pool	107	185			
	3	1.1	Low Gradient Riffle	190	375	0.51		
15	4	5.5	Scour Pool (Boulder)	76	451			
	5	1.1	Low Gradient Riffle	70	521	0.41		
16	6	3.3	Run	98	619			
	7	1.1	Low Gradient Riffle	80	699	0.45		
17	8	4.2	Mid Channel Pool	100	799			
	9	1.1/1.2	High Gradient Riffle	67	866	0.53		
18	10	3.3	Run	33	899			
	11	2.1	Cascade	10	909	0.34		
19	12	4.2	Mid Channel Pool	111	1020			
	13	1.1	Low Gradient Riffle	24	1044	0.44		
20	14	5.4	Scour Pool (Bedrock)	57	1101			
	15	1.1	Low Gradient Riffle	33	1134	0.37		
21	16	4.2	Mid Channel Pool	47	1181			
	17	1.1	Low Gradient Riffle	48	1229	0.62		
22	18	3.3	Run	142	1371			
	19	1.1	Low Gradient Riffle	40	1411	0.38		
23	20	5.5	Scour Pool (Boulder)	32	1443			
	21	2.1	Cascade	42	1485	0.75		
24	22	5.5	Scour Pool (Boulder)	64	1549			
	23	2.1	Cascade	76	1625	0.40		
25	24	4.2	Mid Channel Pool	99	1724			
	25	1.1	Low Gradient Riffle	17	1741	0.61		
26	26	5.2	Scour Pool (Log)	97	1838			
	27	1.2	High Gradient Riffle	51	1889	0.60		
27	28	4.2	Mid Channel Pool	101	1990			
	29	2.1	Cascade	8	1998	0.52		
28	30	4.2	Mid Channel Pool	24	2022			
	31	1.1	Low Gradient Riffle	52	2074	0.62		
	32	3.3	Run	119	2193			
			Total Survey Reach Length	**4,154**				

Table A-2. Habitat Units mapped in the Upper Mainstem (UMS) study reach. The box indicates the location of the 2-D hydraulic modeling unit.

UMS Reach 1 (Corner Pool to Dry Trib)								
Hyd Unit	**Meso Unit**	**Unit Code**	**Habitat Unit Type**	**Unit Length (ft)**	**Cum Length (ft)**	**RCT Depth (ft)**	**Features**	**Study Sites**
1	2-	4.2	Mid Channel Pool (Lg Stump)	130	130	0.8	Stump Pool	
	1-	1.1	Low Gradient Trans Riffle	24	154		Transv Bars	CR-1
	0	3.3	Run	66	220	0.85		
2	1	4.2	Mid Channel Pool	75	295		w Med-Bar	
	2	1.1	Low Gradient Riffle	15	310	0.96	Split Rif	
3	3	4.2	Corner Scour Pool	280	590		Big Corner Pool	
	4	1.1	Low Gradient Riffle	45	635	1.23	RB Gravel Bar	
4	5	4.2	Mid Channel Pool	127	762			2-D Model
	6	1.2	High Gradient Riffle	22	784	0.9	RB Log on Hillside	WP-1
5	7	4.2	Mid Channel Pool (Log Structures)	209	993		BRK Pool w Logs	Gage
	8	1.2	High Gradient Trans Riffle	41	1034		Transverse Riffle	CR-2 / WP-2
6	9	4.2	Mid Channel Pool	237	1271		Along road	
	10	1.1	Low Gradient Riffle	10	1281	0.93	^	
7	11	3.3	Run	50	1331		^	
	12	1.1	Low Gradient Riffle	63	1394	0.96	Along road	
8	13	4.2	Mid Channel Pool	184	1578			Gaging Section
	14	1.1	Low Gradient Riffle	21	1599			WP-3
9	15	4.2	Mid Channel Pool	130	1729			
	16	1.1	Low Gradient Riffle	10	1739	1.23		
10	17	3.3	Run	102	1841			
	18	1.2	High Gradient Riffle	44	1885		HGR w Med-Bar	
11	19	4.2	Corner Scour Pool	200	2085		Bedrock Pool	
	20	1.1	Low Gradient Riffle	95	2180	0.74		WP-4
12	21	3.4	Step Run	145	2325			
	22	1.2	High Gradient Riffle	80	2405			
13	23	4.3	Dry Trib Confluence Pool	145	2550			
	24	3.3	Run	61	2611			
	25	1.1	Low Gradient Riffle	15	2626			

UMS Reach 2 (Dry Trib to Wet Ford)								
Hydr Unit	Meso Unit	Unit Code	Habitat Unit Type	Unit Length (ft)	Cum Length (ft)	RCT Depth (ft)	Features	Study Sites
	1	4.2	Mid Channel Pool	69	69			
14	2	1.1	Low Gradient Riffle	133	202	0.82		
	3	5.3	Scour Pool (RW)	48	250	0.39		
	4	4.2	Mid Channel Pool	215	465			
15	5	1.1	Low Gradient Riffle	24	489		Boulders - no RCT	
	6	3.3	Run	219	708			
	7	1.1	Low Gradient Riffle	24	732	0.62	RB Trib enters ~.3cfs	
16	8	5.3	Scour Pool (Root-wad)	187	919		RB Road-cut	
	9	1.2	High Gradient Riffle	65	984	0.54		
17	10	4.2	Mid Channel Pool	285	1269			
	11	1.1	Low Gradient Riffle	71	1340	0.6		
18	12	5.2	Scour Pool (Log)	90	1430			
	13	1.1	Low Gradient Riffle	14	1444	0.77		
19	14	4.2	Mid Channel Pool	266	1710			
	15	1.2	High Gradient Riffle	13	1723			
20	16	3.3	Run	51	1774		CR	
	17	1.1	Low Gradient Riffle	19	1793	0.52		
21	18	4.2	Mid Channel Pool	110	1903			
	19	1.1	Low Gradient Riffle	27	1930	0.42	CR	
22	20	4.2	Mid Channel Pool	111	2041			
	21	3.2	Glide	290	2331			
23	22	4.2	Mid Channel Pool	54	2385			
	23	1.1	Low Gradient Riffle	63	2448	0.49	CR, road access	
24	24	4.2	Mid Channel Pool	479	2927			
	25	1.1/1.2	High Gradient Riffle	30	2957	0.38	CR	
25	26	5.4	Scour Pool (Bedrock)	118	3075			
	27	1.1	Low Gradient Riffle	20	3095		Ford	
			Total Survey Reach Length		**5,721**			

Table A-3. Sproul Creek study reach habitat unit types and total lengths.

Unit Type	Length	% Total
Upper South Fork (USF)		
Cascade	154	4%
Low Gradient Riffle	978	24%
High Gradient Riffle	330	8%
Run	832	20%
Pool	1861	45%
Total	**4,154**	
Upper Mainstem (UMS)		
Low Gradient Riffle	693	12%
High Gradient Riffle	295	5%
Run	694	12%
Pool	4039	71%
Total	**5,721**	

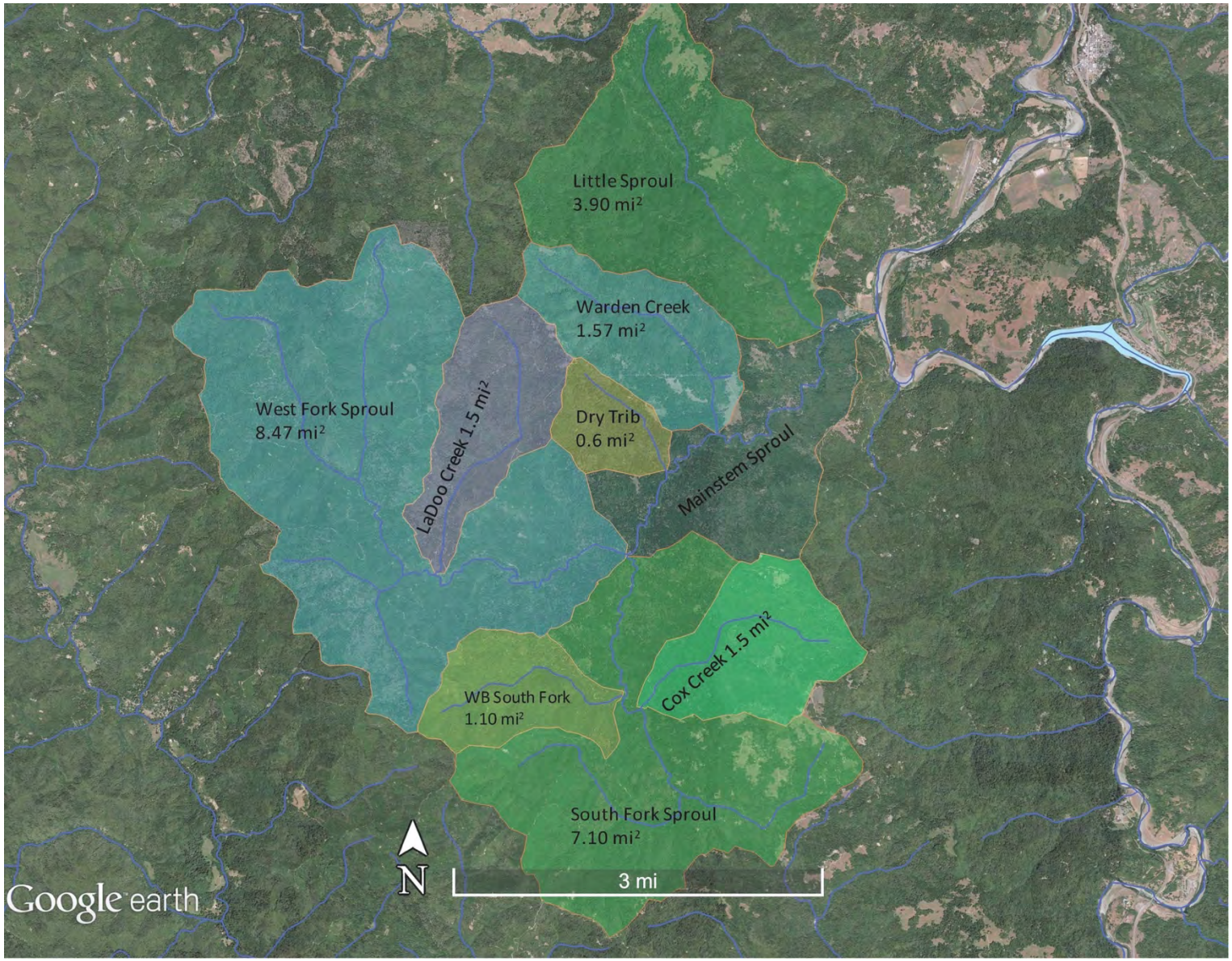

Figure A-3. Google Earth map of the Sproul Creek watershed with sub-watersheds delineated for watershed area.

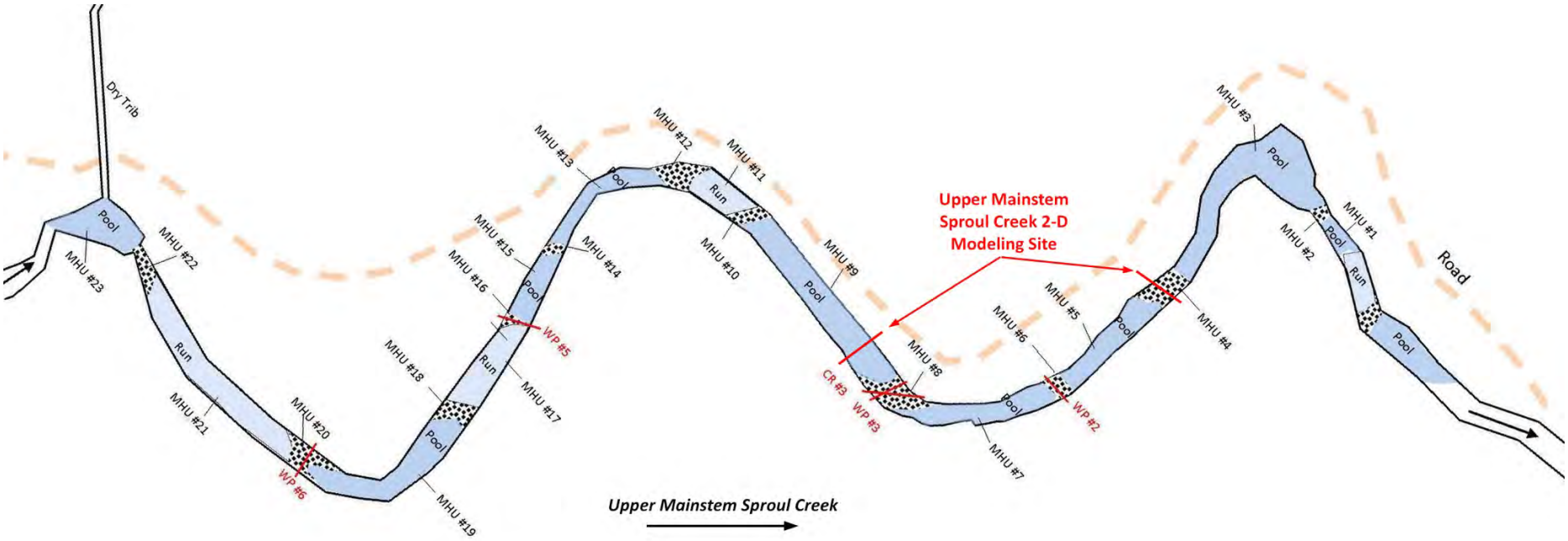

Figure A-4. Sketch map of the Upper Mainstem study reach from the Redwood Stump Pool to the Dry Trib confluence..

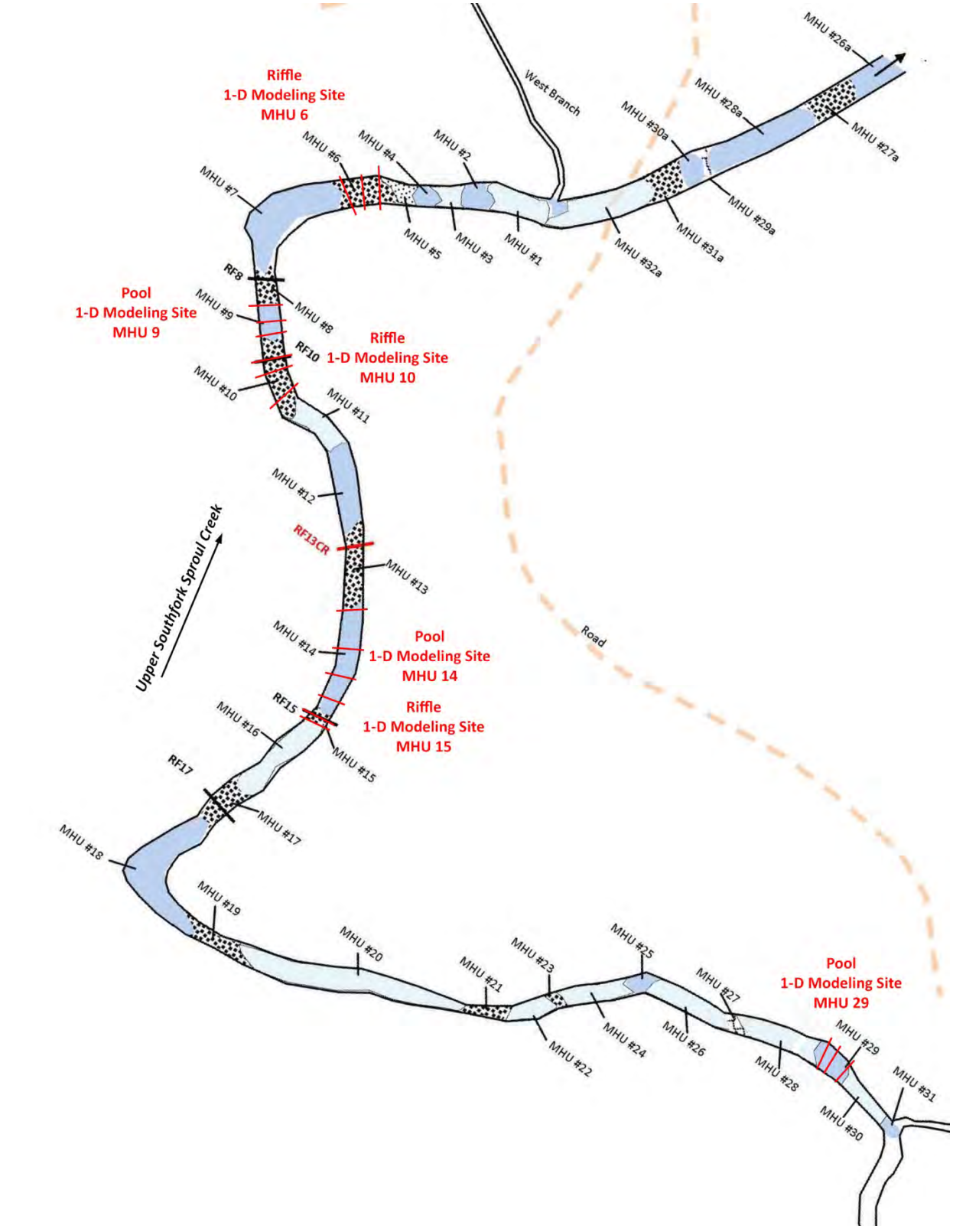

Figure A-5. Sketch map of the Upper South Fork study reach from the West Branch South Fork to Cox Creek.

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